CONNECTED

MAGAZINE

AUTUMN 2020

VISIT AT THE SWISS TIME FACTORY

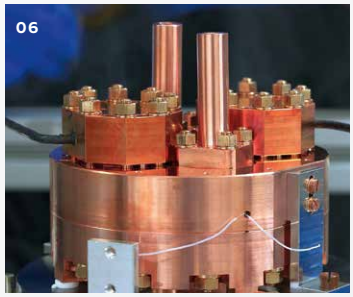
PHONAK'S SECRET CONVERSATIONS

THE RACE TO CRUSH
THE SAILING SPEED RECORD

LEMO

15

IN THIS MAGAZINE



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TECHNOLOGY AT THE SERVICE OF SCIENCE

The year is almost over, but the pandemic is reluctant to leave. The challenging times we are living have shown us more than ever how much the future of people and society relies on science. Science must follow its mission without buckling under any political or emotional pressure.

LEMO, like all technology companies, is nourished by science and nurtures science in return. We equip instruments that help researchers to push the limits of their perception and so their understanding of reality. We equip medical devices to help specialists save lives around the world.

In this issue of CONNECTED, we will present some more applications at the crossroads of science and technology: a Swiss atomic clock, one of the most precise clocks around the world, which contributes to the definition of the second; a kiteboat that keeps control of cavitation to beat the world speed record; a system that can pick up a policeman's voice even against the racket of a stadium and agricultural robots that contribute to softer land farming.

These applications are an incarnation of a fragile evidence. Together, science and technology will open up new possibilities for developing controlled-impact solutions. Together, they will help us out of this pandemic. Let's continue with our efforts.

Alexandre Pesci
CEO LEMO

TECH-BITS FROM AROUND

© Spot image courtesy of the researchers, edited by MIT News

N°1

Medical robot dog to examine patients

COVID-19 is a constant reminder of the fact that continuous proximity with patients may represent a major risk for medical workers. Especially while taking patients' vital signs. Researchers from MIT, Boston Dynamics and Brigham and Women's hospital propose a contact-free solution for doing the job, to avoid contamination. Their idea is to equip Boston Dynamics four-legged robot dog, Spot, with a system of simultaneous measurements. An infrared camera for measuring body temperature and (through temperature variations in the mask) the breathing rate. Three monochrome cameras measure heart rate and blood oxygen levels (through minute skin colour changes). Contacts are not completely dehumanised: the patient and the doctor can communicate with the help of a tablet via videoconference. Intended for diagnosis areas, the solution could then be used in hospital rooms for patient monitoring.

© SkyDrive

N°2

Japan joins the race for flying taxis

In late summer, Japanese startup SkyDrive's SD-03 flew for four minutes. The pilot of this eVTOL (electric vertical take-off and landing) made it hover at 2 m above a Toyota test field. It was the first public demonstration of SD-03, a small 4 m aircraft weighing 400kg, propelled by four pairs of rotors. According to SkyDrive, it will be deployed as of 2023 in Osaka Bay. The pilot will be able to transport a passenger from an airport to the city centre or from one tourist attraction to another. They target ten-minute flights equivalent to those planned by dozens of companies working on flying taxis around the world (see our special feature in CONNECTED 13). SkyDrive's agenda is aligned with "Public-Private Conference for Future Air Mobility", bringing together government, university and private stakeholders. Automotive giant, Japan established it in 2018 to also secure its position among "flying vehicles".

THE WORLD

N°3

On the way to more sustainable batteries

The cathodes of most current lithium-ion batteries for electric vehicles contain a lot of cobalt. As this element can cause serious environmental damage, its replacement by nickel is a prime concern. However, cathodes containing a lot of nickel tend to "deteriorate" faster in long-lasting applications. Researchers from Cambridge, Liverpool and Diamond Light Source (British particle accelerator) have understood why, through observing materials at the atomic level for several months. Their discovery, published in *Nature Materials*: with the cycles of charging and discharging, a growing number of atoms rearrange on the material surface. They form new structures that prevent the material from extending and contracting as the lithium ions enter and exit – the batteries recharge less and less. Measures to counter this process (namely, protective coatings) can now be sought.

N°4

The exoskeleton that will not let you down

Tripping can be dangerous, especially for elderly people. In the USA only, the direct medical costs of falling over is estimated at 50 billion dollars a year. A team from Stanford School of Engineering have been working on a robot solution to the problem: a semi-rigid exoskeleton around the hips. Its artificial intelligence will directly analyse the various accelerations of the body. Whenever it detects a body imbalance that may provoke a fall, it will command the exoskeleton to gently stimulate the muscles necessary for correcting the position. For instance, by shortening or extending the following step. The main difficulty lies in defining the rebalancing reflexes by software simulation (if the exoskeleton pushes the body in the wrong moment or with inadequate force, it will provoke a fall instead of preventing it). The system could be subsequently adapted to help people open doors or carry loads.

SP SERIES IN THE SPOTLIGHT

The sales of REDEL SP Series plastic connectors have shot up during the last few years. The success story started in 2012, thanks to combined efforts of several LEMO Group entities. Close-up on a solution that has become a reference in the medical field.

To say that REDEL SP connectors have been a success would be quite an understatement. The series – one of the two circular "all-plastic" connectors produced by the LEMO Group – has seen its sales explode by 600% these last five years, North America being its largest market, with Japan and North Europe runners-up.

The success of the SP Series does not only rest on the legendary quality and reliability of LEMO solutions. It is also thanks to a combination of unique product qualities, resulting from two years of research.

Firstly, SP (Small Plastic) connectors stand out due to their compact design. Their unique internal latch mechanism is very space efficient and therefore they can accommodate a higher contact density in the same footprint as the Redel P standard with up to 22 contacts.

Their housing is made of FDA certified PPSU (polyphenylsulfone), five times lighter than steel and highly resistant to sterilisation cycles, cleaning agents and high temperatures. The patented internal latch mechanism offers even higher protection from liquids (sterilisation and splashes), and, at the same time, higher resistance to mechanical shock and impact.

Ease of use is another distinctive quality of the SP range, which is particularly pertinent in the medical field, as easy handling is a prerequisite rather than a benefit. In addition to its ergonomic design and intuitive Push-Pull latch system, there are three guide keys, enabling "blind mating" as well as colour coding for instant identification of what connects where.

High density, compact design, resistance to sterilisation cycles and ease of use: everything was there to convince medical technology companies. Combined with a dedicated high-performance cable – NORTHWIRE's BioCompatic, for example – SP connectors offer THE ideal solution for hospital environments. These characteristics have managed to convince other demanding sectors, such as test & measurement, automotive and industrial applications. It embodies the extraordinary experience of REDEL in plastic connectors. An experience rooted in "Made in Switzerland". In fact, REDEL was created in 1986, when LEMO acquired, in the Swiss Jura region, the injection moulding and screw-machining units of a typewriter factory that went bankrupt. It was a winning investment: relying on its vast know-how in micromechanics and injection moulding, the subsidiary has never stopped developing. Internally, it has become the Group's "centre of excellence" for precision machining. Externally, it has positioned its brand as a reference for the medical sector.

Before the SP Series, the P Series has already left a strong impression. Designed since 1984 in 3P size, and then in 1P (1988), it has already been recognised for its innovation and superior quality. As with any product that shapes the market, copies were inevitable, but this has not deterred the company. As they say, "imitation is the sincerest form of flattery" and it is this encouragement that drives the development cycle on. REDEL has proven – and continues to do so – that plastic deserves to be at the high end of the market.

The SP Series' journey has not come to an end yet. LEMO engineers are currently working on developing new variants. With even higher performance and resistance. Even more SP, even more spectacular. ■


REDEL
REDEL
REDEL

THE SWISS TIME FACTORY

Visit to the laboratory where Switzerland is creating time, where a complex timepiece, unique in the world, is juggling with atoms to capture light and fragile seconds are flirting with millions of years.

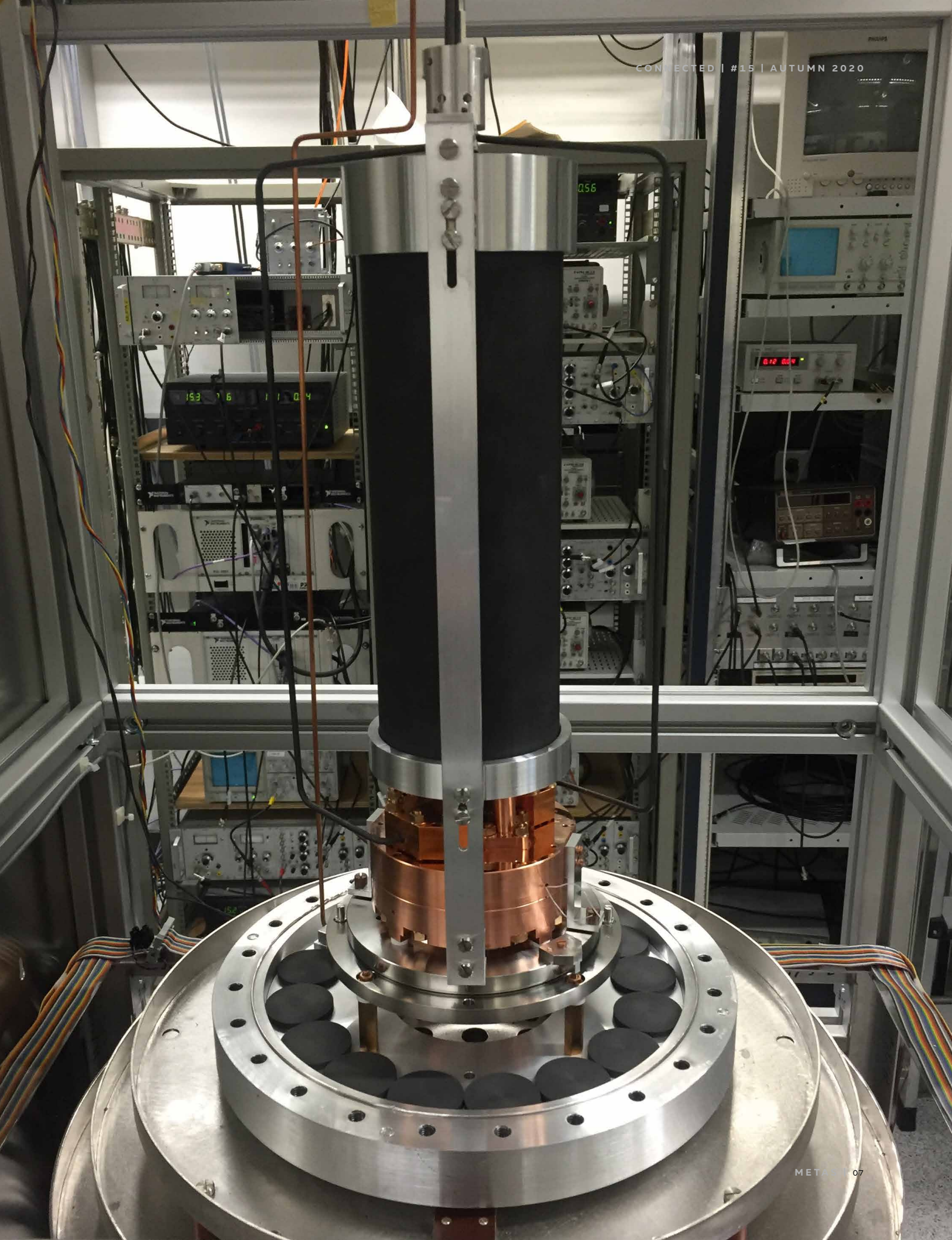
In the heart of the country of precision, there is a place that claims to be the most accurate of all: the rather official METAS, Swiss Federal Institute of Metrology.

The institute is nestled on the outskirts of the capital city of Bern, in a quiet, green valley. It was built there on purpose, away from the urban noise and vibrations that could interfere with the measurements carried out in the laboratories.

The red-brick buildings date back to the sixties. From the top of their tower, you can see the Federal Palace, the headquarters of the Swiss Government. The green copper buildings of modern minimalist design were inaugurated in 2000. In front of the main entrance, a 60 cm square and 24 m high obelisk, covered with golden sheets, was erected, alluding to seconds, minutes and hours.

Time is exactly what we have come for.

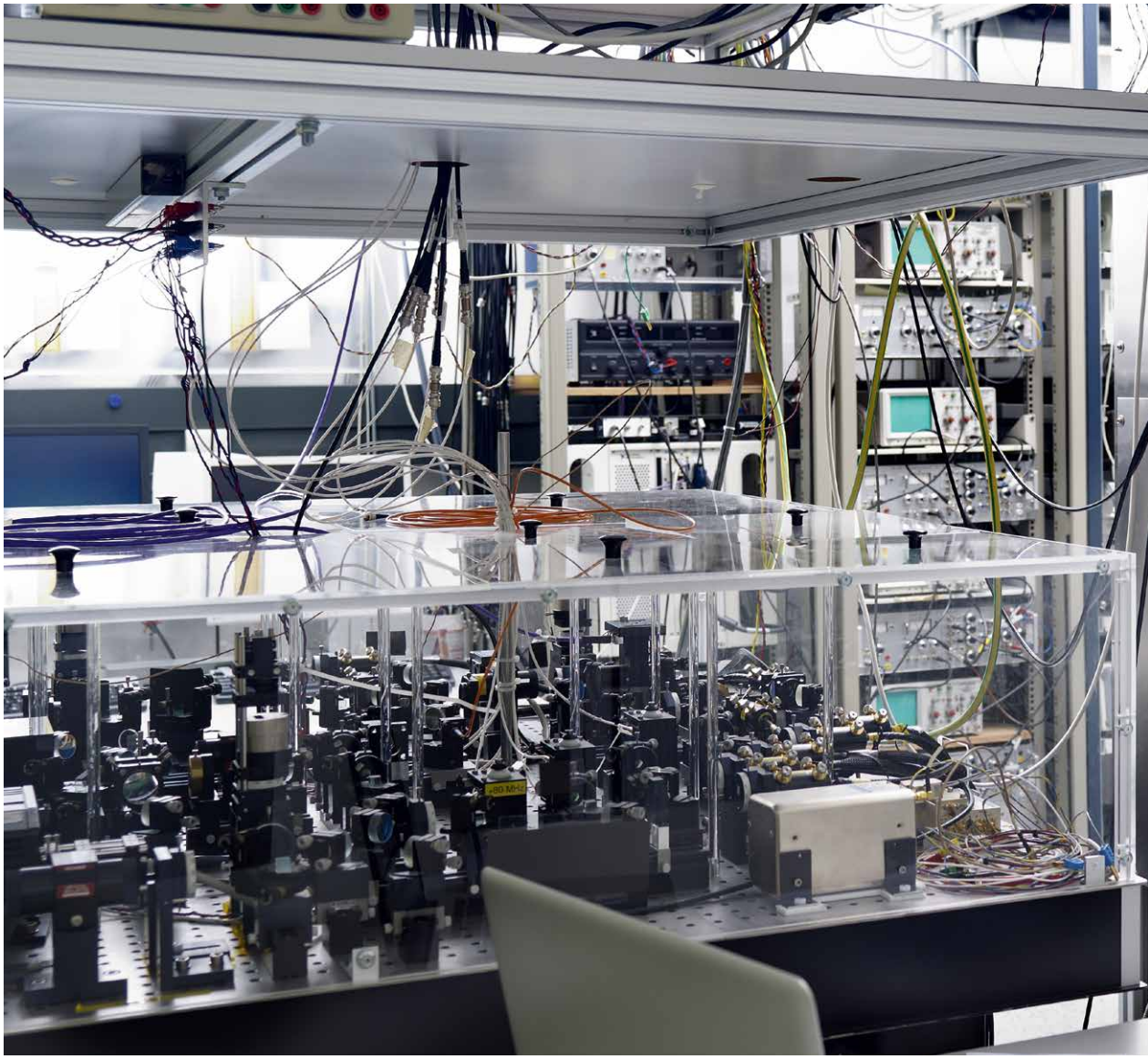
At METAS, time and frequency are the business of the photonic laboratory: a team of eight people, including our guide, the physicist Antoine Jallageas. Their mission is the same as that of their 230 colleagues: to define and share measurements so that everyone can use them, coupled with the verification values measured by the others and, where appropriate, issue certifications.



However, time is a rather peculiar value, since it flies, by nature.

For a long time, measurements were based on astronomy. The second was defined as a fraction of the revolution of the Earth around the Sun. However, the rotational speed of our planet is subject to natural variation, so it is impossible to fix a stable second. In the middle of the 20th century, such uncertainty became intolerable for a variety of needs (science, space, telecommunications...). So, like for other metrological values, scientists were looking to define a second by an unchangeable constant.

"An English team worked on it for four years", says Antoine Jallageas. *"They laid down the definition of the second, adopted in 1967 by the General Conference on Weights and Measures"*. Created in 1875, this institution is metrology's decision-making body.



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▼

Researcher Antoine Jallageas is checking the laser beams generated by the optical table.

The selected constant comes from atomic physics: the transition frequency of the caesium 133 atom. "*When this atom passes from an energy level to a lower energy level, it releases a wave*", explains the physicist. The frequency of this wave is 9 192 631 770 Hz. This is the number of times the tiny wave – frequency wave in scientific language – recurs every second. "*Thus, the second is defined as 9 192 631 770 periods emitted by the caesium atom.*"

The definition is precise, but only theoretical. It doesn't give you time, nor does it enable you to time your kid's runs. No more than the definition of metre – based on the speed of light – makes it possible to measure the size of your apartment. The measurement standard needs yet to be produced and then shared, used to measure, compare and verify. This is what metrologists call "realising the definition".

Antoine Jallageas leads us along METAS' maze of corridors. Straight corridors lined with wooden cupboards and hundreds of doors. One of them opens into a huge cubic isolation room, fitted with cones made of foam. An engineer installs the microwave oven and controls its emissions. Elsewhere, in a display case, there are breathalysers used by the Swiss police, certified by METAS as complying with legal requirements. Further on, posters present to visitors how decibels are measured. The institution covers every aspect of our daily lives, which is only natural: rules and regulations, standards, technical descriptions and user guides, drug dosage or quality controls are studded with units of mass, length, current and temperature... Metrology is the guardian of a world of numbers, so omnipresent that we tend to forget about it.

A staircase leads us to the basement of the modern aisle of METAS, where some of the most sensitive laboratories are sheltered, away from the interferences of the outside world. "*The floor rests on an independent concrete slab, which reduces vibration*", explains Jallageas. "*Temperature, which is the most sensitive factor for us, is stabilised at 22°C and does not deviate more than 0.1°C over the year. Laminar air flow prevents variations and draught.*"

One last door and we arrive in a narrow corridor. This is the hallway to the two time-laboratories, each one unveiled through a large pane of glass.

In the first laboratory, there are rows of tables with five suitcase-sized rectangular machines on them – atomic clocks. More precisely, two caesium clocks, two passive hydrogen masers and an active hydrogen maser (which stands for microwave amplification by stimulated emission of radiation).

"*It is with these clocks that we generate UTC-CH, the Swiss time. Also, for the past 30 years, we have been contributing to UTC (Coordinated Universal Time) by sending to BIPM their status, the measurement of their deviations!*"

The BIPM (International Bureau of Weights and Measures) located in Paris, gathers and compares data from hundreds of these atomic

clocks located around the world, guaranteeing high measurement stability. It then translates it into International Atomic Time (TAI, from the French name temps atomique international), resulting in UTC time, which determines time zones, enabling the world to coordinate our clocks and our lives.

Do these atomic clocks create "the" second? *"Oh, no! Creating "the" second requires much more precise clocks than these commercial devices."* These clocks are much more rare and are called primary frequency standards. *"There are only about twenty of them in the world"*, adds Jallageas stopping in front of the glass pane of the second laboratory. *"And here is one of them!"*

In the room, there is a multitude of instruments and dials, as well as a forest of cables to connect them. Two elements stand out: a 2-meter high metal cupboard protecting a large cylinder – the actual clock; as well as a rectangular table, topped with a Plexiglas case filled with black elements and small mirrors – the optical table.

These eclectic elements form the "Fontaine Continue Suisse" (FoCS), one of the most precise caesium clocks in the world.

The FoCS was developed in the early nineties, in cooperation with the University of Neuchâtel. It is no coincidence, for the canton of Neuchâtel has amassed centuries of expertise in time management. Namely, it is the birthplace of many major watch brands and a world-renowned competence centre for atomic clocks. 20 years of research and millions of Swiss francs were necessary to design the FoCS and to get it approved by the exclusive club of primary frequency standards. *(Contd. on page 12)*

© METAS

METAS was built in the countryside to limit interference with its measurements.

SEEMINGLY PREPOSTEROUS, BUT NECESSARY PRECISION

Why spend millions on developing primary frequency standards? Why waist a month creating a second and then start it all over again? Why push accuracy as far as 14 zeros after the decimal point? Not only for the sake of scientific beauty. Even if, as Antoine Jallegeas readily admits, it is also a matter of prestige.

The extreme precision of the second – the greatest of all the International System of Units – is pivotal, for more than one reason.

First of all, the second is indispensable for creating other units like the metre, the kilo, the ampere, the kelvin and the candela. An inaccurate second could make the whole of metrology falter.

Secondly, an important number of applications, necessary for our societies' normal functioning, require such a level of accuracy.

Geo-positioning is the most recurring example. "*One nanosecond of inaccuracy is translated into several dozens of centimetres on the ground*", says Jallageas. "*There would be no GPS without atomic clocks in satellites.*" Other sciences, such as spectroscopy and geodesy also need exact time to be able to push their current limits.

By unifying the world and extending exchange, globalisation has also generated a need for finetuning the coordination of time. Telecom technologies and infrastructures (from smartphones to satellites), for example, could not function without precisely synchronised time.

With multiplying and accelerating financial transactions, it has become hard to ensure traceability. The European Union has enforced timestamping with microsecond precision to be able to identify and authenticate them (MiFID directive II). Banking institutions are equipped with accredited data centres and they can benefit from services provided by control bodies, such as METAS, in order to verify their time scales.

Even an everyday action like switching on your bedside lamp is subject to the accuracy of the second. Without precise and coordinated time, electric networks – now interlinked on a continental level – would be much more unreliable. For instance, it would be impossible to detect unbalanced production between Northern and Southern Europe at an early stage, to avoid a blackout or any major network failure.

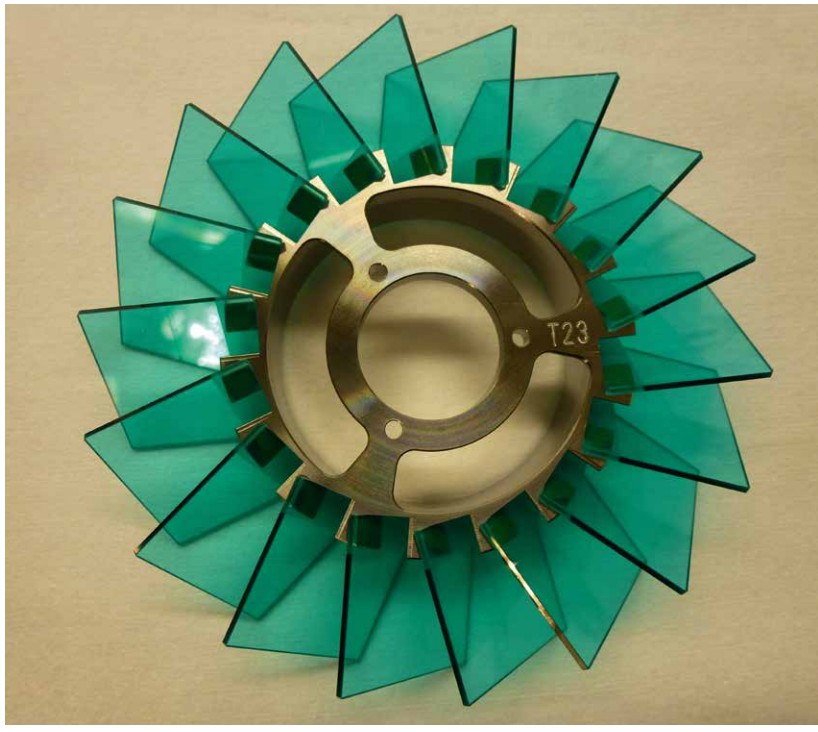
Tomorrow, our societies will need an even more accurate second.

New clocks, using transitions in the field of optical frequencies (light frequencies), are able to reach 10^{-17} or 10^{-18} accuracy, which means a deviation of one second in 3 billion or even 30 billion years! These clocks, which are still at an experimental stage, have not been recognised as primary frequency standards. However, their very promising performance makes them seriously eligible for a new definition of the second.

Other devices, such as nuclear clocks, could even exceed their capabilities. In a nuclear clock, frequency transitions are measured directly inside the atomic nuclei. The atomic nucleus ensuring better insulation against external disturbance, frequencies could ensure higher levels of accuracy than those of optical clocks. However, these developments are still at a very early stage.

So, it will take a little longer before we get the new second. Meanwhile, it is the current 53-year-old one that continues ticking away. ■

A light trap, unique in the world, lets caesium atoms pass through, but blocks the light.



© METAS

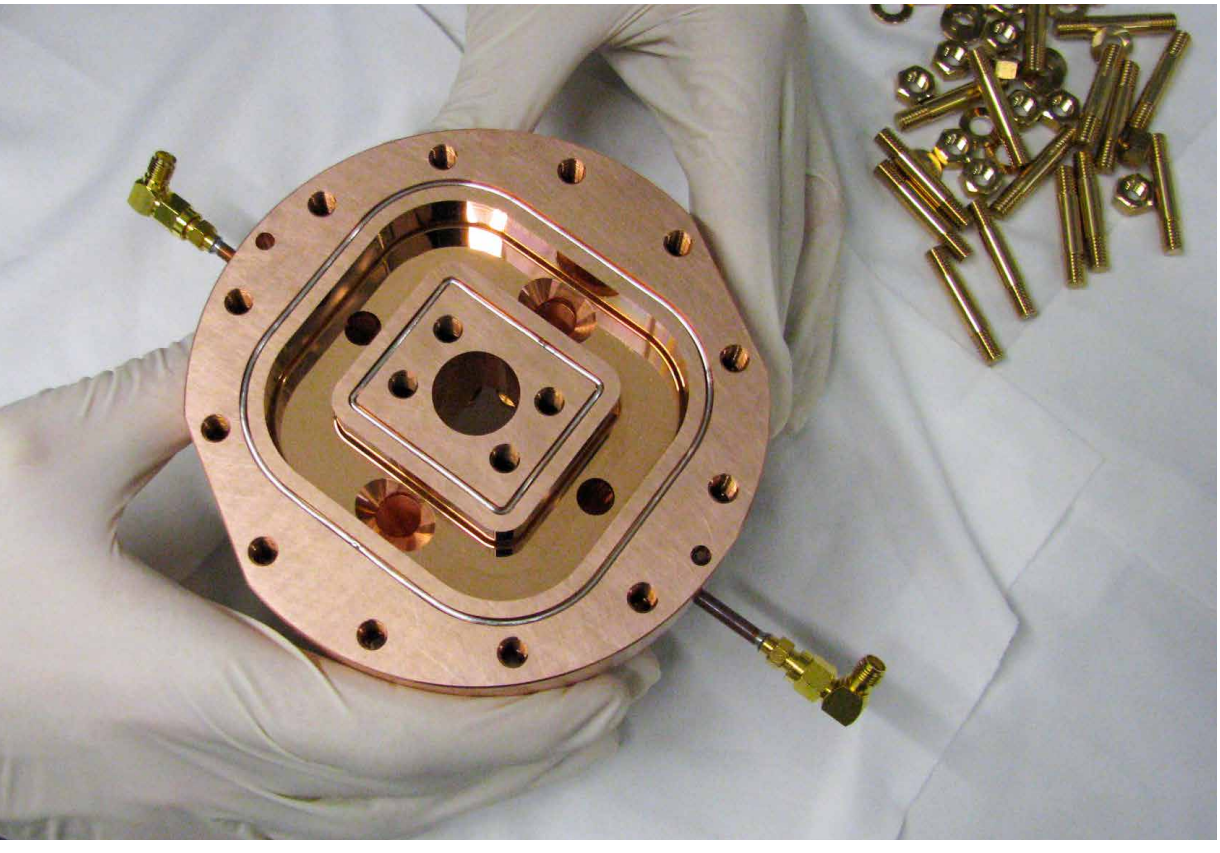
How does such a clock work ? In a nutshell : caesium atoms are tossed upwards along a parabolic trajectory and the frequency of their transitions is measured. It can be the subject of a physicist's entire career. Antoine Jallageas, enthusiastic and inspiring, described it for at least 20 minutes, interspersed at regular intervals with a polite "*I won't go more into the details, since it's a bit technical!*", but here's an attempted summary.

On the optical table, seven lasers generate sixteen infrared beams (852 nanometres). These beams, transported by fibre optics to the fountain, decelerate the caesium atoms, which cools them down to a temperature close to absolute zero. A laser tosses them upwards. They pass through a microwave cavity where they are exposed to a frequency close to their transition frequency.

When the atoms fall back, they go through a laser, where the atoms that will have transitioned, emit light, measured by a sensor.

Little light means that only a few atoms have transitioned, so the frequency is corrected to increase transition probability. Then it starts all over again, until the sensor indicates that a maximum of

The microwave cavity where caesium atoms are "activated" to make them transition.



© METAS

atoms have transitioned. Once we get there, it means that the frequency in the microwave cavity is equal to the transition frequency of the caesium atom. Bingo : the second is realised.

The name "fountain" was given to this type of clocks with reference to the fact that the atoms are tossed up vertically, like water in the fountains of ornamental ponds (or the famous "jet d'eau" fountain of Geneva). Behind the innocent name, there is an incredible technological complexity. Observing the behaviour of atoms implies blocking at least twenty physical effects. *"More or less everything in the universe is there to perturb atoms!"* concludes the physicist with a laugh.

Therefore, the fountain is placed under vacuum to ensure that there is only caesium inside. It is surrounded by a mu-metal magnetic shield, that makes it possible to get free from the Earth's magnetic field. There is only the field created to ensure that the clock is operational, a strictly vertical 70-nanotesla magnetic field (+/-0.2 nanotesla). Temperature is controlled to the mini-kelvin. The microwave cavity is made of oxygen-free copper with roughness limited to 12 nm. A graphite cylinder protects the atoms from microwave leakage during their trajectory. Total darkness is ensured in the fountain, since light – an electromagnetic wave in itself – would perturb the atoms.

The Swiss fountain is a "fontaine continue" – the only continuous fountain among primary standards, which seriously complicates keeping the necessary darkness.

In "classic" fountains, successive atom clouds are tossed up and lasers are switched off once a cloud is projected. In the FoCS, there is a continuous atom jet, so the lasers stay active. How is it possible to prevent their light from perturbing the experience ? METAS and Neuchâtel University have created a light trap, *"by far the most complicated element to elaborate for this clock!"*

The trap, placed in front of the microwave cavity, is a turbine with blades made of special glass. It is actuated by an electrostatic engine *"which works in a vacuum – a performance in itself – and does not generate any magnetic fields. As far as I know, it is a unique piece in the world."* The engine is fitted with high voltage LEMO connectors, selected for their exceptional reliability and because they generate very little "noise" and do not perturb the signal.

The speed of the turbine is set to let the caesium atoms pass through, whilst stopping the light. It works : *"Only 15% of the atoms are blocked, whereas light is reduced by an enormous factor of 10,000! This is a perfectly acceptable compromise."* So, inside the microwave cavity, it is pitch dark and atoms are only exposed to the adequate frequency.

Or almost.

Frequency is corrected to compensate the very little light that still passes through. Likewise, a budget of uncertainty is estimated to compensate for the other remaining physical effects. Measurements are repeated during a whole month to ensure that the results are stable.

"After a month of measurements, I obtain the frequency of definition of the second, as well as its uncertainty" says Antoine Jallageas. *"We are then sending these data to the International Bureau of Weights and Measures."* The other contributors do the same. The Paris office gathers them all, calculates a weighted average and publishes a corrective value which makes it possible to correct the atomic time scale.

Now, let's take a deep breath to be able to digest two extraordinary figures.

The first one : yes, it takes a month to measure a second.

The second one : the accuracy obtained by the FoCS is 10^{-15} (which is 0.000000000000001 second!). In other words, you would need to wait 30 million years before two such clocks would deviate by one single second.

Despite the important investments in these technological jewels, the primary frequency standards do not operate continuously. In a nano-world, the optimum situation gets easily out of hand. Namely, the optical table requires regular maintenance. Its lasers need to be adjusted to the right frequency (they lose it little by little). Laser polarisation needs to be corrected. The position of mirrors needs to be adjusted. Each of these fine adjustments require the clock to be stopped.

There are also inevitable breakdowns, considering the complexity and the number of elements involved. Engine failure for instance may block the clock for weeks, or even months. The vacuum needs to be broken in order to repair or replace the part, vacuum re-applied (which takes 2 or 3 weeks in itself). Once maintenance and repair have been carried out, you need to wait until the beginning of the following month before you can launch a new measurement cycle.

The FoCS is one of the primary standards contributing to the calibration of International atomic time since the end of 2018. It has sent seven monthly contributions to Paris. There is nothing abnormal about this : *"Only the French and the Germans manage to operate their machines throughout the year. Of the twenty odd contributors, the BIPM gets only five or six measurements a month."*

A few years ago, recalls the physicist, the number of contributions dropped sometimes to two per month.

Human measurement of the second has been seriously wavering, to the total indifference of Time, that continues to fly. ■

BLACK BOXES FOR LAND FORCES

For decades, aircraft and helicopters have been thoroughly monitored to ensure flawless preventive maintenance. On the other hand, no similar solution has existed for military land vehicles, so ILIAS Solutions created one.

How many tanks, trucks or vans do I need to deploy for a military operation? Which ones are in good condition? How many spare parts do I need to embark to ensure their maintenance?

These are questions Lars Dybdahl Nielsen used to go through while working for the material service of the Danish armed forces. Air forces get continuously surveyed data through rigorous monitoring processes, whereas he had to make decisions based on personal instinct and previous years' numbers. So, the officer and engineer decided to create a device precisely recording the extreme life conditions of tanks, trucks, or military vans. He launched his startup Northern Vehicles Operations (NVO) in the northern suburbs of Copenhagen.

In 2011, the startup was acquired by ILIAS Solutions, a company proposing a fleet management software suite for air forces (NATO, Belgium and Chile are among their current customers). They were just about to enlarge their field of application and had no "data logger" for land vehicles. NVO's solution was just what they were looking for.

Today, after several years of preparation and cooperation with hardware/software integrator Prevas, the measurement device is ready. Simply named ILIAS I-HUMS (for "intelligent health and usage monitoring system"), the black box takes up barely more space than two packs of cigarettes one on top of the other. It is watertight, dustproof and resists paint and the type of shock that tank equipment is exposed to. Its connectors are also compact and robust: the LEMO 2T Series.

▲ *The size of two packs of cigarettes, I-HUMS was designed to resist anything.*

▲
I-HUMS measures shock and acceleration, and identifies even the type of terrain crossed.

Inside the box, a GPS records the vehicle's speed, whilst an inertial unit and gyroscopes measure triple axis acceleration. Thus, *"all the movements of the vehicle, bends, shock and jerks are recorded"*, explains Søren Theodorsen, Technology & development manager at I-HUMS. *"By connecting it to the on-board computer, it is possible to integrate internal factors as well (engine speed, oil temperature…). We then have a comprehensive recording of what the vehicle has actually endured."*

The software ensures data protection. They are asynchronously encrypted before memory storage and transmitted upon return from deployment (up to 6 months later) by similarly encrypted messages. During the operations, the unit stays mute – no communication can be intercepted.

At the same time, ILIAS Solutions has been working for four years on transforming raw data into maintenance information. Multiplying measurements, using machine learning to improve its algorithms, and comparing results with external tests.

Once the vehicle is calibrated, the solution henceforth delivers a clear and detailed image of every vehicle's condition, which is a big step forward compared to the engineer's simple personal instinct.

It is possible to learn for instance about the general wear of the vehicle and schedule appropriate maintenance (neither too much, nor insufficient). Or else identify which vehicles are in the best condition ready for deployment. More specifically, it is possible to know when the brake pads need to be changed – not only based on mileage, but also on the brake force and frequency, possible overload and even the type of terrain covered (identified by algorithms). It is possible to control whether all-terrain vehicles are actually used elsewhere than on road. Or to determine precisely and separately when it is necessary to change the costly military oil.

"All this contributes to increase availability and, first and foremost, to cut maintenance costs", concludes Theodorsen. *"You need fewer vehicles to do the same job."* Fewer vehicles, so less transport, spare parts on site, less equipment, staff, administration…: *"the entire logistic footprint is reduced."*

The benefits are not only logistic or financial, points out the specialist. A vehicle that breaks down can cost the operation's success, even human lives.

So, I-HUMS has major sales arguments, but its success needs yet to be ensured. *"Everything goes rather slowly on the defence market, where it's all about public money and political decisions"*. They also need to convince land forces to adopt a process that they have not requested so far. These last years, ILIAS Solutions has increased the number of demonstrations and loans of I-HUMS. *"We keep training and informing, so that potential customers can measure the actual interest of these data"*.

Not only armies are canvassed, but OEMs as well. The very first customer is by the way Nexter, the French military vehicle manufacturer. OEMs do not measure wear and tear to schedule maintenance *"but to improve vehicles under development"*, which can help to meet the ever-increasing requirements of defence, as well as offer protection in case of defective claims by the clients.

ILIAS Solutions banks cautiously on annual sales of several thousand I-HUMS. With armies using hundreds, or even thousands of vehicles, the figures could rapidly increase. ■

SECRET CONVERSATIONS

Invisible to the eye and clear to hear, discreet communication is used by police forces around the world. A niche market where Phonak Communications has brought 30 years of know-how combined with the resources of the Sonova group.

Blurred or disrupted vocal communication is always annoying. But when it affects an undercover policeman, it can have dramatic consequences. It is out of the question to lose contact when the agent is following his suspect across a lively bar or on public transport. A discreet communication system must be able to pass through both sound and magnetic disturbance. Roger Covert C, designed by Phonak Communications, provides a solution.

With this cutting-edge system, the policeman can leave his too obvious mobile phone (or radio) at the bottom of his pocket. The device is linked to the main unit Roger Covert C by Bluetooth or by cable, the audio signal, secured by 128-bit encryption, is transmitted wirelessly to the invisible earpiece. Crammed with miniaturised technologies, the earpiece includes an amplifier, a processor as well as a zinc-air battery, offering 20 hours of autonomy. When the policeman wants to talk, he uses a small PTT (push-to-talk) remote control. Clipped on the inside of his jacket, a minimalist microphone picks up his voice, that the main unit transmits to the phone (or the radio).

At the heart of the system, there is Roger, a proprietary digital communication protocol designed by Phonak Communications in early 2010, more robust and energy-saving than public protocols like Bluetooth. Above all, points out Florian Bachmann, Product Manager, it makes it possible to do without an inductive loop. *"By the way, Roger Covert C is the only discreet communication system without an inductive loop."*

The Roger Covert C system (with its directional microphone, PTT remote control and main unit) is connected to the earpiece and to the agent's mobile phone.

Precision is important. This loop, materialised by a "necklace" around the wearer's head, is used for sending the signal to an analogue wireless earpiece. It is not only uncomfortable, but also extremely sensitive to electromagnetic disturbance. *"In an urban environment, the signal can be seriously disturbed by "electrosmog" and become unstable. Roger Covert C is not subject to such disturbance."*

As for "Noise cancelling", it starts with sound recording via a microphone which is actually composed of two microphones. *"This makes it directional and contributes to signal processing"*, explains Florian Bachmann. *"It is possible to separate speech (getting first to the microphone closer to the mouth) from ambient noise (that gets to both microphones at the same time)."* Signal processing – another area of expertise for which Phonak has become known - is intense: no fewer than seven different algorithms work on isolating the voice from its sound environment.

The result, according to Phonak, is the exact opposite of the crackling radio contacts of detective films. *"You can hear the voice perfectly clearly. Even if the speaker is in a very noisy environment, even if he whispers, even if he can't hear himself speak!"* During a conversation with several people, communication is so clear that it is possible to recognise each person's voice, *"which is impossible with inductive systems."*

The earpiece includes an amplifier, a processor as well as a battery offering 20 hours of autonomy.

Designing such technologies requires a solid experience in wireless solutions as well as significant resources (developing Roger alone cost dozens of millions of dollars). Phonak Communications can benefit from both.

The Swiss company was created in 1992 and over half of the staff of 120 are engineers. Its headquarters are in Morat (or Murten in Swiss German), at the heart of an area which has become a global reference in the field of microtechnologies. The name of the brand new building they have recently moved in – Sonova Wireless Competence Center – is a perfect reflexion of their role: a competence centre of the Sonova Group (ex Phonak, since 1947), a global leader in solutions for hearing-impaired people, which now achieves almost 3 billion in turnover.

The solutions designed in Morat are used by all the group companies. They are adapted to meet the great variety of requirements of potential markets.

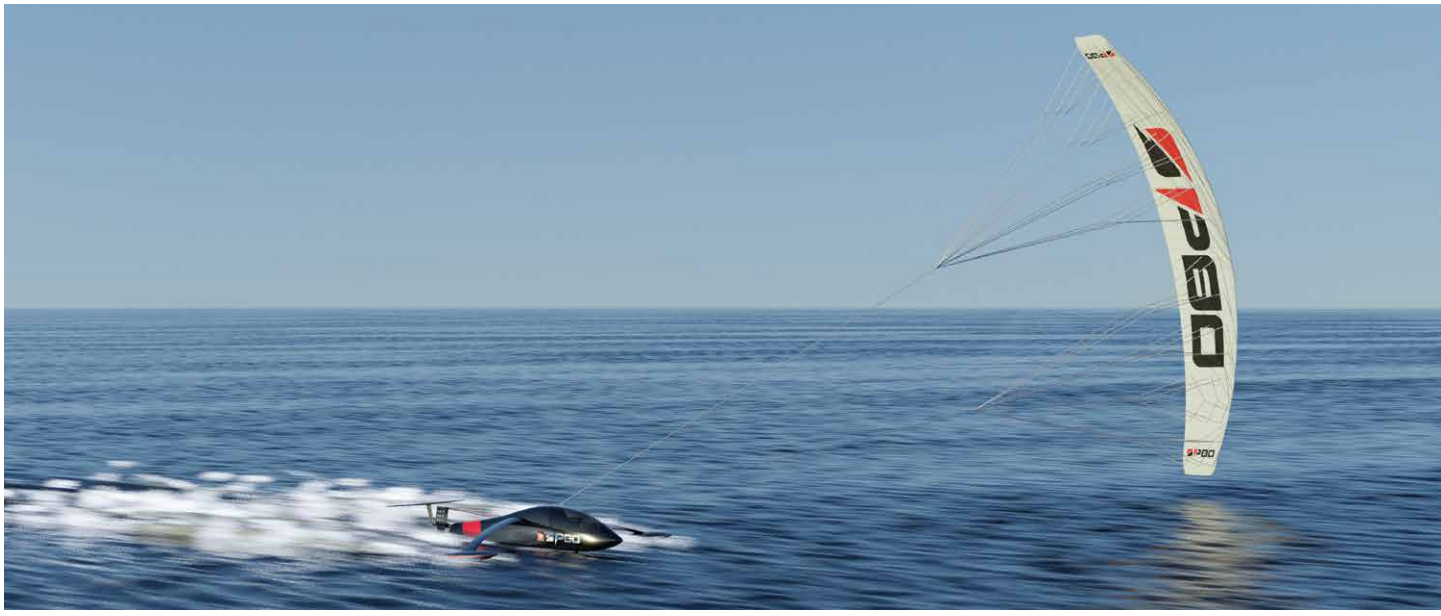
The Roger system, for instance, was originally developed to help hearing-impaired school children. The aim was to create a communication protocol which is fast enough, clear and easy-to-use, so that children can hear their teachers perfectly against the usual classroom racket.

Roger was then integrated into a multitude of products for "communication in difficult environments". Products adapted for TV presenters, politicians... Roger Covert C is only one of the "Security" products, a range also including solutions for rapid intervention brigades or the motorcycle police. So many niche markets that, if alone, would not have benefited from such important resources. ■

** The cable connecting the main Roger Covert Dual C unit to the policeman's radio or telephone, is equipped with a LEMO connector. And a Northwire cable, provided by LEMO's US subsidiary, connects the microphone.*

AT 150 KMPH POWERED BY WIND ONLY

The sailing speed record has been held for 8 years. A team of students and young engineers is in the process of developing a kiteboat to smash this record in 2022. Projected speed : 80 knots. The story of an audacious project told by two of its co-founders.

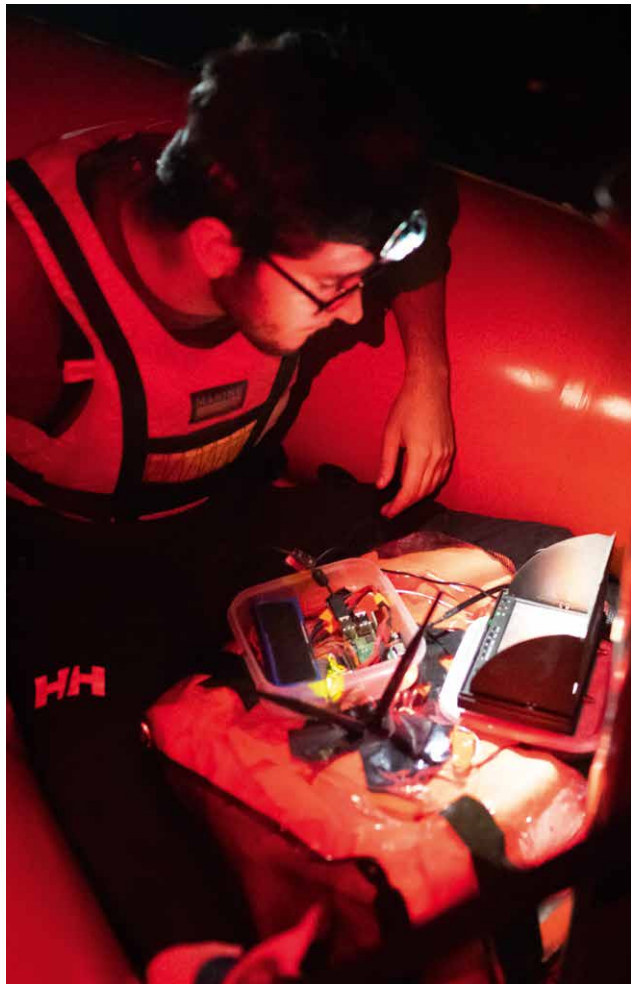


© SP80

At 3.30 a.m. on Lake Geneva in early July, under clear skies the air is fairly warm. Along the shoreline, you can see the lights of the town of Morges.

On board small boats, protected from indiscreet eyes in the half-light of dawn, a dozen young people are intently watching the behaviour of a 4 m long shape, pulled by a Zodiac, cutting smoothly through the dark water. The technical problems revealed during the first test, five nights earlier, have been corrected. This time, the zodiac can accelerate, the shape follows it obediently. Data collected by the sensors confirm the impressions : everything goes according to the simulations.

Carefully measured, the prototype's behaviour is compared to the simulations.



▲
For confidentiality reasons, the multiple tests of the 1:2-scale prototype were carried out in the middle of the night.

This is excellent news for the three initiators of these night tests, Mayeul van den Broek, Xavier Lepercq and Benoît Gaudiot. Yet another step towards realising their crazy dream – to beat the world sailing speed record. However, this will have to wait another two years if it all goes as planned. The sun is rising over the Mont-Blanc, unveiling its outline over the south shore of the lake: it is time to return the prototype discreetly into its shed.

Lepercq, van den Broek and Gaudiot were made to meet.

All three are French, sailing lovers and have decided to study engineering. Each of them has chosen the Federal Institute of Technology (EPFL), convinced by its naval competence. The prestigious institute had been a partner to the Swiss syndicate Alinghi (winners of the Americas Cup in 2003 and 2007) and of the "Hydroptère" the first large "flying boat" (sailing speed record in 2009).

Lepercq was already working and van den Broek finishing his Master's degree in 2017, when they met Gaudiot, a first-year student. Their complicity was immediate. In the newcomer's notebook, there were even sketches of kiteboats quite similar to theirs. Moreover, their interests were complimentary: engineering, materials, mechanical design, fluid dynamics... and Gaudiot, as an ex-member of the French national kitesurf team and Under-18 sailing speed record man, could be the ideal test pilot. When chances are all on your side to form a "dream team", you must seize the opportunity. The three men thus decided to work together on a kiteboat project to make their speed world record dream come true. Their eyes riveted on the current record, set in November 2012 on Namibian waters by Paul Larsen. The Australian, at the helm of Vestas Sailrocket 2, beat two confirmed world records: on 500 m at the speed of 65.45 knots (121.06 kmph) and on the nautical mile (1852 m) with 59.37 knots (109.94 kmph). A real sporting feat, given that until then the 50-knot barrier seemed impassable for a vessel without an engine.

Just like the sound barrier, this limit is also dictated by the laws of physics. *"At such speed, water pressure on the keel or the fin drops so rapidly that water starts boiling at ambient temperature"* explains Mayeul van den Broek. *"This change increases drag and makes navigation very unstable – further acceleration becomes impossible."*

This phenomenon is called cavitation. Its powerful effects can blow into pieces the steel blades of a hydroelectric turbine. Their "scorch marks" can also be seen on the fins of tuna fish or dolphins, having paid painfully for their bold desire for speed.

"Paul Larsen used an innovative super-ventilating fin. This profile is used by hydroplanes, these engine-propelled boats flying at 350 kmph, but was unprecedented in the world of sailing." With its triangular shape and straight edges, this fin does not avoid cavitation, but manages to control the disturbing effect. *"At high speed, the air bubbles remain stable"*, explains Benoit Gaudiot, *"there's no more drag and so it is possible to continue accelerating."*

For the three friends, this is the key to Larsen's record, rather than the asymmetrical design of Sailrocket 2 which had attracted full attention so far. They wanted to know for certain, so, in early 2018, they produce super-ventilating fins, in order to become familiar with the technology. They fitted them on a readily available support vessel that they knew well, a kitesurf. After three test runs on the Mediterranean, Gaudiot reached 41 knots (almost 80 kmph). It is a proof of concept: combining a kitsurfing sail and a super-ventilating fin is the winning formula indeed. *(Contd. on page 25)*

SP80 KITEBOAT

LENGTH
7 M

WEIGHT WHEN EMPTY
150 KG

MATERIAL
CARBON/ EPOXY

TARGET SPEED
>80 KNOTS (~150 KM/H)

KITE SURFACE
FROM 20 TO 50 M^2

CABLE LENGTH
FROM 40 TO 90 M

In view of the target speed, the boat's design is inspired more by motor-boats than by sailing boats. It weighs more, using materials and structures to withstand higher loads. Sailing speed record regulations (drafted when the record stood at only 26 knots!) require human presence, but do not specify anything with regard to the pilot's security. The SP80 pilot will be protected like offshore pilots: closed cabin, six-point harness seat belt, oxygen mask in case of capsizing.

1 **Cockpit**
This is where the pilot is steering the boat and controls the kite. Since regulations forbid assisted steering, sensors and instruments only provide information to the pilot. They inform him for example if he must immediately drop the kite.

2 **Hulls**
Always on the water, they ensure lateral stability and buffer the impact of waves. They slow down the boat a little bit, but are necessary for the pilot's comfort.

3 **Main hydrofoil**
Strongly curved, it "anchors" the boat into the water by opposing its force to the force of the kite, preventing the boat from lateral drag. Its profile is super-ventilated, limiting disturbance from cavitation and enabling the boat to exceed 50 knots.

4 **Rudder**
The boat's rudder is in an unusually forward position. It also has a super-ventilated profile to control the effects of cavitation.

5 **Power management module**
This is where the flying kite's cables are attached and that all forces are concentrated. The articulated system ensures passively the balance of forces between kite and fins, conferring power and preventing capsizing.

6 **Kitesail**
The prototypes are in the design process. As for kitesurf and paragliding, they should be made of fabric, possibly nylon. Among the available kites (between 20 and 50 m^2) the best adapted to wind conditions will be selected. This will also define the cable length (between 40 and 90 m).

OPPORTUNITIES ON THE HORIZON

Smashing the current record of 65 knots to exceed 80 would be a great achievement. However, it is not the only objective of SP80: *"We would like to break codes and make the sailing world progress!"*

What would be the opportunities for the sophisticated technologies worked out by the team? After all, super-ventilated fins have existed for decades, but their use has remained confidential. Kiteboats have existed for centuries (the Hawaiian people used them more than 1000 years ago already!). Can they be adapted for larger, heavier vessels?

Only 10 years ago, highlights Benoit Gaudiot, the sailing world was not at all concerned by 50 knots. Super-ventilated fins - underperforming at lower speed – seemed irrelevant.

"Today, offshore racing boats – Americas Cup, Route du Rhum... - come regularly close to 50 knots and hit the cavitation barrier. The teams we have consulted are interested in our work. We can imagine that, in 5 to 10 years, their boats could take off the super-ventilating fins when the trade winds are strong and regular, and reinstall them when necessary."

Mayeul van den Broek confirms *"there was a big delay between the release of the Hyroptère and the generalisation of "flying sailing boats". It is still hard to tell which applications will be developed, but we expect some opportunities."*

SP80 – through its main partner P&TS, an intellectual property law firm – has already deposited a patent for the general concept of the boat and the kite. Other patents could follow. ■

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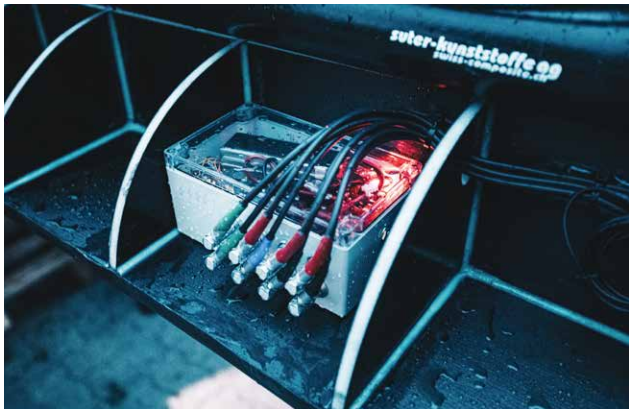


© SP80 Guillaume Fischer

Students and engineers do everything themselves, from super-ventilated hydrofoil tests on a kite surf, through design and materials, to prototype production (the sensors fitted with LEMO connectors…)

(Continued from page 21)

However, 41 knots are not fast enough to benefit from the real potential of the super-ventilating fins: 50 knots should be the target speed. "*We needed more power, so a larger kite*" explains van den Broek. A kite that Gaudiot would not be able to hold with his arms. "*This is when we came back to our idea of a boat.*"

Between September 2018 and early 2019 the first concepts were drafted. Their sailing behaviour had to be simulated. As Velocity Prediction Programs (VPP) used by naval architects are too costly, Lepercq spent several months programming their own. As for van den Broek, with his Master's degree in hand, he spends his time looking for sponsors and developing cooperation with the EPFL.

The VPP confirmed the design's stability and the project's feasibility. During the following months, the dream started taking shape. The EPFL recognised the project, gave access to its infrastructures and authorised students to participate in the project as part of their studies. In October 2019, a student association was created, along with the SP80 company, the project owner. The project was officially launched and presented to the public. It was a success: the technical challenge was met, the exciting record-setting race and the spectacular kiteboat could be launched.

With its streamlined 7 m hull, its closed cabin, its "wings" fitted with floats and a rear tailplane, the SP80 looks more like a jet than a boat.

Using composite materials, it weighs only 150 kg when empty. At the end of a several-dozen-meter cable, a huge kite – sized between 20 to 50 m^2, depending on the needs. The power-to-weight ratio is absolutely amazing, "*never reached before in the world of sailing!*" highlights van den Broek.

It is so powerful, that the weight of the cabin does not even count in the equation. It doesn't join the kite in the skies because its curved main hydrofoil "anchors" it into the water. These two opposing forces have also been used by Sailrocket 2. "*This avoids capsizing: the stronger the kite pulls, the more the hydrofoil pulls to the opposite side.*"

This permanent balance, created passively, is ensured by what SP80 calls the propulsion module. "*It is the heart of the boat's power, the place where all the forces are centred. The main idea of our design is to separate the rear module pushing the boat, from the cockpit that ensures the pilot's stability and security.*"

The design of the propulsion module, both mobile and robust, has taken up most part of the design phase. "*We found solutions that were stable at certain speeds, but not at others. We had to find the best compromise.*" The module being the key element of the boat, SP80 keeps these details confidential.

The design of the kiteboat completed, now it had to be tested in real conditions to prove the VPP simulations. A 1:2-scale prototype was designed and assembled by the students. It was this prototype that the SP80 team took for night testing in early July on Lake Geneva. About ten similar sessions have taken place until October.

Every session, several series of tests are run, returned on land in between, for adjustment and modification. The Zodiac pulls the prototype with a mast, simulating the kite and its cable. On the prototype, an inertial system records speed and acceleration and sensors follow the rotation speed, which is all you need to be able to verify the boat's behaviour. The sensors are connected by robust IP68 LEMO connectors (K and E series) to the navigation system, collecting the data.

Early morning, the boat's taken out of the water, dismounted and returned to the SP80 shed, the team analyses the videos and measurements. The aim is to make sure that no element of the boat is overcharged and no unnecessary force is generated. *"For instance, that the immersed part of the rudder is not overloaded"* explains Gaudiot, *"since it is for the pilot to compensate, to be able to steer the boat."*

Lake Geneva does not offer optimal conditions (still waters, regular strong winds would be necessary to beat the record), but the tests are working out very well. As the design of the kiteboat is finally stabilised, SP80 has now started developing the ultimate boat.

The construction of the boat is scheduled to start early 2021, to be launched at the end of 2021. The world record attempt is planned for 2022.

By a strange coincidence, this agenda corresponds exactly to the plans of Syroco. Co-founded by French kitesurf star Alex Caizergues (the first to exceed 100 kmph in sailing), this startup is also working on a kiteboat designed for beating the record and exceeding the 80 knots. However, competition does not intimidate SP80. *"On the contrary"*, say Gaudiot and van den Broek. *"Why not organise a shared event ? It would be a spectacular "first"!"* ■

LITTLE ROBOT ON THE PRAIRIE

Agricultural work is hard and there is a shortage of manpower. The weeding robots designed by Naïo Technologies may very well contribute to solving these problems. Their technologies also provide an environmentally friendlier form of farming.

▲
Oz, the weeding robot in full action.

Oz, Dino and Ted are three robots. Agricultural, electric, autonomous robots that work diligently in hothouses, vegetable fields and vineyards.

Oz, Dino and Ted have been designed and assembled in the South-West of France, by a startup named after a Hawaiian plant, Naïo Technologies. Founded in 2011, the company employs a staff of about 70, most of them at its headquarters in Toulouse. It is in the business development phase and expects to generate a profit in the near future.

A NEW TYPE OF FARM WORKERS

© Naïo Technologies

Oz
Weeding robot for vegetable crops
Dimensions : 40 cm x 60 cm x 130 cm
Total weight : 150 kg
Navigation : GPS RTK
Marketed since 2014

Dino
Straddle robot for weeding vegetable beds
Dimensions : 250 cm x 130 cm x 150-200 cm
Total weight : 1,2 t
Navigation : GPS RTK and cameras
Marketed since 2016

Ted
Straddle robot for vineyard weeding
Dimensions : 230 cm x 150-200 cm x 150-200 cm
Total weight : 1,8 t
Navigation : GPS RTK and sensors
Marketed since 2018

All it took was a simple discussion, 10 years ago, for the seed to be planted. Back then, Gaëtan Séverac and Aymeric Barthes, two robotics engineers, were listening to an asparagus producer's complaints about the difficult working conditions and the shortage of manpower. As the problem has become a global one, in an increasingly abandoned agricultural world, the two engineers, convinced that robotics could provide at least a partial solution, decided to launch their project. Not by creating a robot for collecting asparagus, as they had initially planned, but by automating weeding, a tedious job affecting many more farmers (and potential customers).

"*Whenever it is not chemical, weeding specialised crops, such as vegetables or vineyards can represent up to one third of the production costs*", explains Gaëtan Séverac. "*These costs are often the main obstacle to a conversion to organic agriculture, as the farmers prefer to continue using herbicides.*"

Like other agricultural machines, the robots must be all-terrain, water resistant, dust-proof and operational in a wide temperature range, across bumps and slopes. The sturdy chassis carries the cutting-edge technology that enables them to work autonomously. A combination of laser, ultrasound and physical sensors make sure that the robots do not present any risk to human safety nor infrastructures. The quality of weeding is ensured by a GPS RTK* that

Two Dino robots in the fields. Each capable of weeding some thirty hectares autonomously.

guides the chassis within a few centimetres of accuracy. For working with vegetables, which requires even greater precision, a camera is added to guide the tools.

Once the robot configured, the plot mapped and the users trained (all by Naïo Technologies), the farmer is ready to go. All he needs to do is transport the robot to the starting point and validate the settings. The machine locates itself, loads the required map and sets off for up to 10 hours of work.

Oz weeds 1000 linear metres an hour *"and our two big ones are capable of managing up to an average of 30 hectares."* While the robots are weeding, the farmers can carry out more added-value jobs. Once the machine has completed its work, it then sends them an SMS.

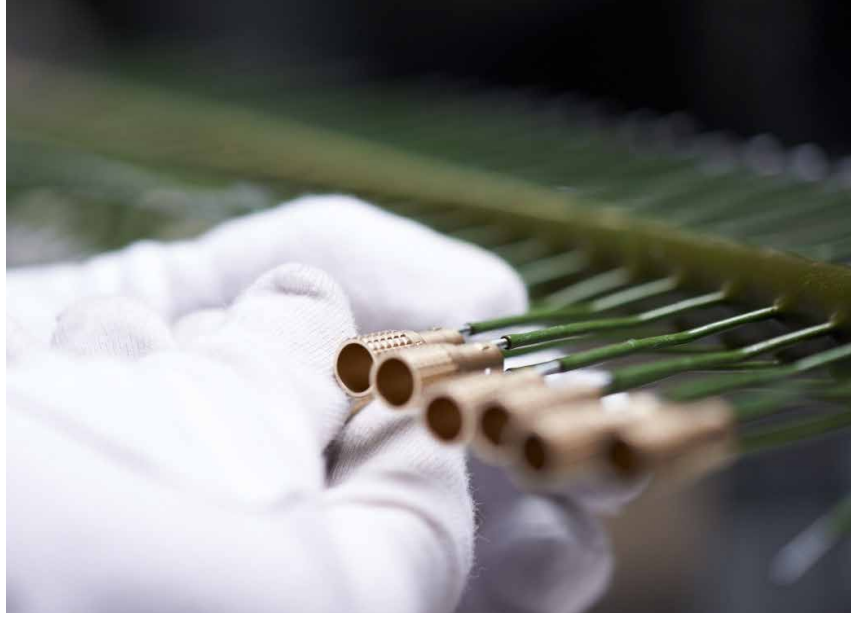
Improving working conditions and providing a solution to labour shortage are not the only advantages, mentions Gaëtan Séverac. The robots do preventive weeding (like mowing robots, they pass regularly and prevent weed from growing at an early stage). *"It is 3 or 4 times cheaper than corrective manual weed control."* Moreover, *"as weeding quality is better, the plot provides a better yield"* Oz (150 kg), Dino (1,2 t) and Ted (1,8 t) being lighter in weight than a tractor, they compress the soil less, which also improves productivity.

There are environmental advantages in addition to the economic benefits. *"There is an increasing demand for eco-friendly agriculture and our robots make it possible to move in this direction"* adds Séverac. Hoed more regularly, the soil evaporates less and so it needs less watering. *"Electric and efficient, our robots use less energy than heavy machines and do not emit any CO_2"*. There is an even greater advantage for nature: mechanical weeding reduces, or even completely eliminates chemical weeding.

Now it is proven technology, reckons the French startup that keeps forging its success. It has sold over 150 robots in about twenty countries, mainly in Northern Europe and North America. They have just launched the latest version of Ted, capable of passing greater obstacles and carrying heavier tools.

In their pipeline, there are additional new functionalities for already existing robots, as well as new robots for other types of crops. To be announced in the coming seasons. ■

** The Septentrio GPS and the robots' remote controls are equipped with B Series LEMO connectors.*



1990
WHEN LEMO MET ISO

The first quality certification, 30 years ago, marked a milestone in a quest that has been continuing for three quarters of a century.

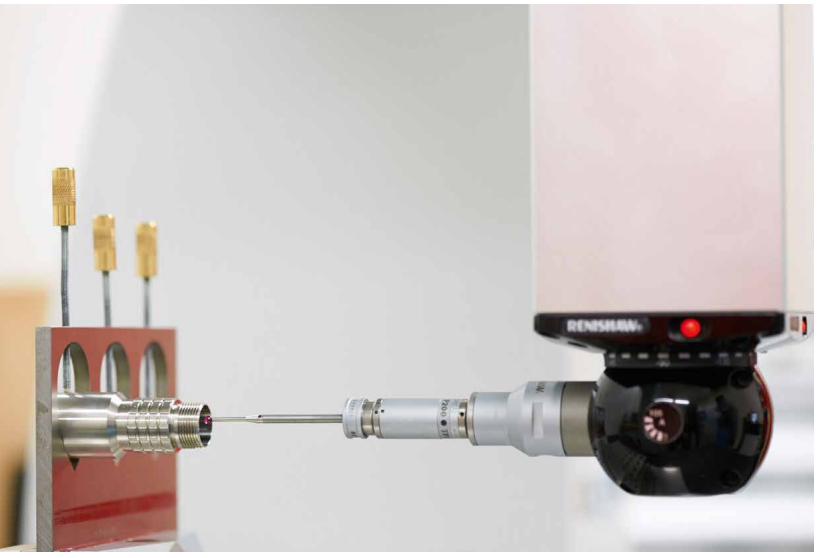
Exactly 30 years ago, LEMO was a pioneer in obtaining its very first certification – ISO 9001 issued by SQS (The Swiss Association for Quality and Management Systems).

It is hard to imagine today, but quality management and its ubiquitous international certifications were in their early stages in 1990. The first standards – ISO 9001 (design, development, production, installation and servicing), ISO 9002 (without design and development) and ISO 9003 (quality assurance in final inspection and test) – were launched in 1987. Three years later, only 75 companies, including LEMO, were certified by SQS. Today, there are over 25.000 in Switzerland only.

LEMO has chosen to integrate quality management at a very early stage for a simple reason : to enable formalising and structuring the quest for excellence that it has spontaneously pursued since its creation.

▼

High-precision machining and strict controls are key to the renowned quality and reliability of LEMO solutions.



In fact, the pursuit of quality was inspired and imposed by LEMO's perfectionist founder, Léon Mouttet, as early as 1946. His successors continued in his footsteps and the Swiss brand is now a recognised leader in high performance interconnection solutions. Quality and reliability have also enabled the company to become a global reference for demanding applications in extreme environments.

In a nutshell, "Quality" is not a simple brand value for the company: it is LEMO's history and market.

LEMO has always strived to improve quality. For instance, by reinvesting a major part of its annual revenues in the development of production and control equipment. Or else, by verticalising its know-how in order to control every element of its solutions. And, of course, by using quality management best practices, in terms of products and processes.

Over the decades, LEMO has become a group and its quest for quality has naturally been extended to its subsidiary companies. Today, all production sites and subsidiaries have been certified ISO 9001/2015.

The quest is also achieved through more targeted certifications. For instance, in the medical field with ISO 13485 (which LEMO has obtained in USA, China and the United Kingdom), in aeronautics with EN 9100 (for the cables of US subsidiary Northwire) or else for occupational health and safety with ISO 45001 (REDEL in Switzerland and LEMO UK). There are also certifications issued by other institutions: UL (compliance of North American products with international market standards) or CSA Testing (North-America).

Respect for nature and human beings has not been put aside either. Several LEMO sites have also been certified ISO 14001 (environment). The Group meets the REACH European requirements (on the use of chemical substances commercialised in Europe) and RoHS (limiting dangerous substances in electric and electronic equipment). LEMO has also been committed to refusing conflict minerals.

There is of course still a lot to be done: quality improvement is a continuous process (it is no coincidence that it is represented by a wheel!) The Group has stepped up efforts to further integrate quality in its production chain. By the way, it has included its process control (anticipating non-conformity) and procedure control (steering) among its six priority axes. Its continuous actions will no doubt continue strengthening and preserving the position of LEMO Group products and brands. ■

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