CONNECTED

MAGAZINE

SUMMER 2022

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TOWARDS A BETTER WORLD

"Make this world a better place" may sound clichéd, but it is indeed a fundamental quest for tech companies like LEMO.

The feeling of contributing, however modestly, to such improvement is an incredible source of motivation. It helps us overcome the discouragement and hopelessness often provoked by crises such as the ones we have been living with. And no other sector can bring as strong satisfaction as healthcare. Saving and preserving lives every day, what could be more concrete and immediate?

LEMO can feel this sense of pride. We have been privileged partners for medical technology companies for decades. We have been accompanying and helping their spectacular development in an array of fields, including those which are pushing the boundaries like medical robotics, to which we are dedicating a special feature (pages 06 to 15).

This CONNECTED also presents you other contributions to make this world a better place. In transportation (Hyperloop and solar boat), in research (the world's largest telescope). We pay a visit to the iconic Nagra brand and their quest for the perfect sound. We will also tell you how LEMO contributed to a better television.

Never stop moving forward and progressing. This is the reason why we have printed our magazine on 100% recycled paper and covered the roof of our global headquarters with 1600 solar panels. Large or small, every step counts.

Alexandre Pesci
CEO LEMO

TECH-BITS FROM AROUND

© Climeworks

N°1

Carbon capture plants to reverse climate change

Excessive carbon in the air is the main cause of climate change. Reducing CO_2 production or planting trees is fine, but this approach can be very slow. For faster results, Swiss start-up Climeworks proposes installations that capture CO_2 from the air and return it underground "where it belongs". Among its fifteen active "direct air capture" installations, Orca is the first large-scale processing plant in the world. Launched last September near Reykjavik (Iceland) and powered by a geothermal power station, Orca can capture approximately 4000 tons of CO_2 a year, cleaning the equivalent to 850 cars' emissions out of the atmosphere. Climeworks claims to be able to build processing plants capable of capturing millions of tons of CO_2 every year. Many people have been convinced: the start-up has just raised an extra 600 million Swiss francs and Time magazine has added it on its 2022 list of "100 Most influential companies".

© Honda

N°2

After 22 years' loyal services, Asimo retires to the museum

Famous and much beloved Asimo has been sent into retirement by Honda. Together with Sony's Aibo dog, it had become an icon of Japanese domestic robotics. Launched in 2000, Asimo (Advanced Step in Innovative Mobility) was the 10th version of a bipedal robot produced back in 1986. The small humanoid (1m30, 54 kilos) has given many public performances in Japan and abroad. Regularly enhanced, it was capable of running, walking upstairs, pouring a cup of coffee, hopping, kicking a ball or shaking hands (for instance with Barack Obama). It was also increasingly capable of capturing its environment (sounds, gestures, objects, faces...). The robot had become obsolete, and Honda announced in 2018 that it would stop developing it. Last March, the company presented an Avatar Robot project which is planned to be commercialised in 2030. A fortnight later, Asimo stepped down during an emotional farewell ceremony.

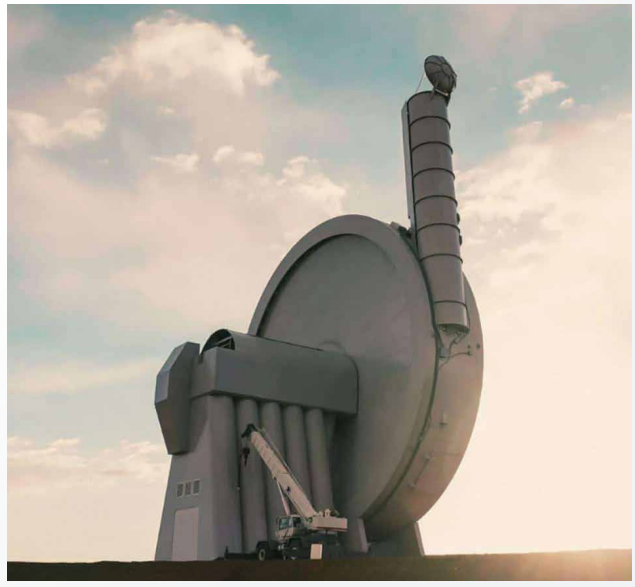
THE WORLD

© FIA Formula E

N°3

Faster, stronger, cleaner : the new Formula E car

In late April in Monaco, the FIA presented the car that will run in the 9th Formula E (FE) season, as of next winter. The electric car, a third generation since the start of this competition in 2014, has surprising futuristic looks, inspired by fighter jets. It weighs 760 kg (143 kg lighter than the previous model) and can reach a top speed of 320 km/h. A laboratory for sustainable mobility, the FE has further enhanced all environmental aspects. For example, a front powertrain has been added to boost break energy recovery. Thanks to this, more than 40 % of the energy consumed during the race will come from this recovery. *"This is the most energy-efficient race car of all time"* says the FE. Among other improvements : the important use of recycled material (the shell and the wheels) and the sustainably extracted minerals for the batteries (equally new).



© Spinlaunch

N°4

David among the Goliaths of space launchers

Using a sling to launch a satellite ? NASA will test this year the astonishing idea of the company Spinlaunch. Its installation, built in New Mexico, looks in fact like a giant centrifuge (91 m in diameter). In its vacuum chamber, a carbon fibre arm makes a shell-form projectile spin around before releasing it. The NASA test will send off a projectile at 1600 km/h, which is rather modest compared to the next step planned by Spinlaunch as of 2025 : launching a projectile at the speed of 8000 km/h into the upper atmosphere, where a rocket engine will take over to place the satellite in orbit. According to the start-up, this system is ecological, since it reduces the fuel load by 70 %, in addition to phasing out the first stage of a classic launcher. It would also divide by a factor of 20 the costs of putting into orbit. This particularly violent launch technology has its own constraints as well : the load is limited to 200 kg, and the satellite must resist 10,000 G.

THE NEW COMPACT POWERHOUSE

The capability of the iconic LEMO M Series has been further extended this spring to include a new range of high-power options. There has never been such a compact solution for carrying such power.

Robots, drones, land, sea and air vehicles, without fuel or polluting emissions...

Hi-tech electric-drive platforms have multiplied along with the enormous progress achieved in battery technologies. Ever more ambitious, these applications require more and more power. As a long-standing partner of the engineers developing these platforms, LEMO has been at the forefront of understanding what new features were required to enable such an evolution. The Swiss company has provided the solution this spring by launching its M Series High Power connectors.

As its name implies, the new solution is a variant of the M Series, a global reference for extreme environment interconnect solutions. The already proven qualities of this series have been combined with brand-new high-power contacts.

These gold-plated copper contacts have been developed by LEMO entirely in-house. Their unique design maximizes the contact working surface to transport the highest current (from 140 to 430 A rated current) whilst limiting resistance heating. Extremely reliable and secure, these contacts also offer high durability: guaranteeing over 3000 mating cycles.

New contacts and M Series form a unique combination indeed: there are no smaller connectors on the market capable of transporting as much power. Therefore, they are ideal for applications requiring compact, lightweight solutions. Be it for a Formula E car engine, where every gramme counts or the power supply of a drone where every cubic centimetre matters.

A worthy member of the M Series family, this High Power variant stands out by its rugged, durable shell. Tested according to MIL standards, it is waterproof (IP68 when mated), shock, vibration, oil and fuel resistant, and withstands a temperature range of -55 to +200 degrees. All of this without losing the legendary ease-of-use of LEMO solutions (quick blind mating, visual marking...). A successful mission also relies on ergonomics.

The new connectors are available in a wide range of different models, sizes (for 10 to 50 mm^2 cables) and configurations (unipole, multipole), to perfectly meet all the requirements of an array of electronic equipment, electric vehicles and other demanding applications.

Extra options have also been designed for applications requiring even higher spec connectors. The brass-bodied variant guarantees 1000 hours' resistance to salt spray; IP68 watertightness can be extended when unmated; its robustness can be further reinforced (according to the MIL-DTL-38999M standard) by adding threading on the housing.

The outstanding qualities of the High-Power connectors are no coincidence. They are the result of a two-decade-long story.

In early 2000, the FIA was looking for new connectors adapted for direct connection onto Formula One engines, exposed to severe vibration, shock and heat. Abandoning, for the first time, its original Push-Pull latching system, LEMO went for a ratchet prototype designed for aeronautics, integrating Formula One and defence requirements. The M Series (for "motorsport" and "military") was launched in 2006.

M Series connectors have conquered all Formula One cars (they are still on board), but the reliability and ruggedness of the series have also conquered a number of other fields of application, from aerospace to robotics, from drones to medicine.

Twenty years later, the M Series has become one of the greatest LEMO success stories. Each new variant – like the High Power this spring – have contributed to consolidating its status as the iconic series for extreme environments. ■

Increasingly powerful electric vehicles (hereunder a race car developed by the Swiss Federal Institute of Technology in Lausanne) require ad hoc connector solutions.

© EPFL Racing Team

DR. ROBOT WILL OPERATE ON YOU

Robotic surgery (also known as robot-assisted surgery) is one of the fastest-growing specialities in surgical medicine today: a multitude of companies have set out to conquer this rapidly evolving niche market. CONNECTED will present two of them, very different, but equally ambitious. We have also interviewed an expert on the use of robots in the intimate setting of the human body.

PAGE 08

© DistalMotion

The unconscious and seriously injured hero is rushed onto the operating table. Straightaway, robotic arms start spinning around him, cutting away his clothes and treating his multiple wounds.

Surgical robotics is not quite there yet, but it is increasingly present in our daily lives. Surgeons have been using it in more and more procedures – in orthopaedics, gastro-intestinal and cardiovascular surgery, urology and gynaecology.

This seemingly science-fictional technology has a longer history than we might often imagine: robotics has entered surgery almost forty years ago.

Arthrobot was developed and used in Vancouver in 1983 in orthopaedic surgery, for dozens of arthroscopies (minimally invasive joint operations). From the mid-eighties, robots have officially entered operating theatres. The pioneers were Puma 260 (Unimation), Scara and Robodoc (the concepts were developed by IBM and California University, today under Think Surgical), and also Aesop and Zeus (Computer Motion).

Computer Motion merged with Intuitive Surgical, and Zeus was replaced by the Da Vinci system, the first version being launched in 1998. Two years later, Da Vinci became the first complete system approved by the FDA. For many years, Intuitive benefitted from an almost total monopoly in this new sector. Even today, Da Vinci is still largely dominant.

© Distalmotion

Just like GPS and the internet, surgical robotics is a concept initially developed by the military sector (more precisely by US agency DARPA). The aim was to enable surgeons to operate wounded soldiers from a distance. Therefore, the console, handled by the surgeon, is separated from the robot which reproduces his operating movements on the patient.

Limited by communication technologies, telesurgery has not taken off yet. However, surgical robotics has convinced several areas. Tool miniaturisation (they pass through tubes, trocars that are approximately 1 cm) and their high degree of articulation makes it possible to reach low-access areas (current in gynaecology and urology), much easier than for human hands. This advantage makes the robot a natural tool for laparoscopy, this minimally invasive technique, widespread since the nineties, which involves passing instruments and a camera via small incisions.

Robotic arms smoothing any potential shaking of the surgeon and the field of vision magnified by 3D high-definition views provide unprecedented precision. An ideal solution for particularly critical surgery (brain) or meticulous implant procedures. German researchers announced in early 2020 a successful "super-microsurgery" operation. With Musa, a robotic device developed by Microsure, they performed an operation on 0.3 to 0.8 mm blood vessels, which substantially outperforms the best surgeons (even with the assistance of a classical robot).

For doctors, robotic assistance brings great comfort (see our interview with a surgeon, page 10). For patients, there are surprisingly few documents on or proof of the benefits. A multitude of research studies even conclude that there isn't any significant difference in efficiency (length of stay, eventual complications) between classical and robotic surgery. However, there are substantial extra costs for hospitals (as well as insurance companies and patients).

This grey zone does not hinder market momentum. Analysts estimate that it should rise from the current 5 billion to 15 billion by the end of the decade. For the past few years, a multitude of start-ups and companies have been launched, positioning themselves with better targeted and accessible solutions than Intuitive's "Rolls Royce".

THE CONNECTOR FOR MINIMALLY INVASIVE NEW SURGERY

A few months ago, the LEMO Group launched a new high-voltage variant of its REDEL P Series connectors. It was promptly adopted by medical equipment manufacturers. High-voltage is indeed at the heart of several recent developments in minimally invasive surgery, such as precision endoscopy or pulsed-field ablation.

Lightweight and robust (IP66), the new REDEL connector transports, in total safety, up to 10,000 volts (AC). Its characteristics make it a perfect solution for innovative medical applications, but not only.

The high-voltage P Series was designed to meet the needs of other sectors as well, including the test & measurement industry. Among other applications, it has already found its way into electric vehicle battery test equipment. ■

Among these, the English company CMR Surgical proposes its Versius system, the Spanish Rob Surgical ready to launch its Bitrack. Swiss Distalmotion has launched its Dexter (see our article on page 14). Canadian Titan Medical is working on Sport, its single-orifice system. US companies Stereoaxis and Zimmer Biomet have been selling Genesis (a magnet-system to guide magnetic catheters) and Rosa (following the acquisition of French start-up Medtech), respectively.

Things have been moving a lot with big technology companies as well. Stryker has launched its Mako robot; Medtronic its Hugo. Johnson & Johnson created Verb Surgical (initially with Google) and proposes the Ottawa system. Siemens acquired the Corindus system. Medicaroid, founded by robotics leader Kawasaki Heavy Industries, has introduced its hinotori, first surgical robot "Made in Japan" (see our article on page 13) on the Japanese market.

All of them contribute to accelerating the development of surgical robotics, which also benefits from progress in miniaturisation, medical imaging (and telecommunications for telesurgery). Artificial intelligence and machine learning have also started to be used. By digesting a huge amount of physiological and operational data, they provide better "knowledge" of the human body and surgical movements, helping to better prepare and guide operations.

The fantasy of the robot surgeon remains.

Doctors and manufacturers underline that current solutions are only tools for live and obedient reproduction of human movements. They postpone to a distant future the prospect of autonomous robots. Just like only 10 years ago the idea of autonomous vehicles in chaotic road traffic was rejected.

Today, many people think that traffic would be much safer without human drivers. Thus, it is hard not to imagine that robot surgeons will once also overcome technological, legal and psychological obstacles to perform all alone or almost, more and more procedures. ■

"WITHOUT ROBOTS, MEDICAL PROGRESS COULD BE HINDERED"

AN INTERVIEW WITH PROFESSOR HANNES NEEFF

© University Hospital of Freiburg

How does robotics change a surgeon's job? CONNECTED has asked professor Hannes Neeff, deputy chief medical officer of the University Hospital of Freiburg (one of the largest in Germany). A specialist in visceral surgery and surgical oncology, he regularly operates with the assistance of Da Vinci and he is training young surgeons to use the robot.

Professor Neeff, what are the benefits of robotics for surgery?

Pr Hannes Neeff: In my case, it is mostly accessibility and easy handling in limited operating space – the pelvis, for instance. To be able to reach these areas, often large incisions are necessary. On the other hand, if we can use minimal invasive surgery (laparoscopy), handling and freedom of movement are often limited. The instrument mounted on a robotic arm has a wider articulation angle than a human hand or a laparoscopic instrument. I can easily access small spaces and bypass obstacles, such as bones or other organs.

How about precision?

The robot stabilizes movements and makes it possible to operate with a very high degree of precision. It also stabilises the field of vision, which is even more beneficial for me personally.

How come?

The camera is held by the robot, so the image is stable. It is guided by me, I know where it goes. In classical laparoscopy, our "eyes" are held by an assistant. It is less stable and there is a delay compared to what we would like to see. We need to guide the assistant – "More to the left, higher..." If the assistant is not well-trained or doesn't know you well, it can be tiring and even make you sea-sick!

The robot brings you comfort…

A great deal of comfort indeed. The most important is position : with the console, we work sitting upright, instead of standing, bent over the operating table. Just imagine the difference it makes for a six to eight-hour operation ! With the robot, ergonomics are a million times better… but many surgeons do not like to mention it because it is not a genuinely medical benefit. You can hardly convince someone to pay for the surgeon's comfort. Therefore, this criterion has been rather neglected until now in the "for-or-against-the-robot" debate. I hope it will be better recognized in the future.

You've said that the system helps you to see better. On the other hand, you lose the sense of touch…

Indeed, there is no tactile feedback. It will be interesting to see if the manufacturers manage to implement it. However, I don't miss it and it was much easier to adapt than I had thought. When a surgeon pulls on a tissue with tweezers, he knows by experience when it will be torn. The visual feedback compensates for the absence of tactile feedback.

You are also cut off from your team – staying apart, eyes firmly fixed on your glasses… Some say that this can cause emotional distance, which is a problem, since a successful operation also depends on the complicity between the healthcare team members.

You may feel somewhat alone with the console, it is true. The system is of course designed to make up for this, by enabling constant communication with the team. Directional microphones and speakers transmit whatever is being said – I can even hear the others whisper. Indicator lights show which tools are active. The screens show the others what I am doing and an arrow on my screen shows me what the others want me to see. And if I feel lonely, I use short breaks – for example when changing an instrument – to reconnect to people for a chat.

Does training in surgical robotics further extend the surgeons' already lengthy training ?

Not really. We surgeons are handymen and we already learn about a multitude of movements and instruments. Moreover, the systems are designed to render our usual movements (rotation of the wrist, pinching with two fingers…), so sensations are quite natural. Controlling the switches is less intuitive. You need to be able to use them without looking, because the robot stops as soon as you look up. But it can be learnt quickly. Have you seen how fast children learn to use a new game console ? It is the same ! *(chuckles)*. Young surgeons are used to joysticks, screens or even 3D environments. They are naturals. And they do not complain about having to use a robot, they *want* to learn.

Will robotics become a standard ?

In the early nineteen-nineties, laparoscopy was also expensive and training the whole team was required. Still, it became generalised. Today, some of my young colleagues do not even know how an "old-fashioned" appendectomy used to be done ! Robotic assistance will follow the same path.

In spite of the high costs of the equipment, the consumables and maintenance ?

Comprehensive and very expensive, the Da Vinci was the only approved solution in Germany for a long time, as in other countries. But, the more simple and accessible solutions will be available, the sooner the technique will become a standard. Some hospitals will have high-end technology, some others will adopt more limited solutions - such as an arm to hold the camera – but in 10 to 20 years from now, they will all have a robot. Working without them would mean foregoing medical progress. Robotics will soon be widely used in laparoscopy and in all operations difficult to access. In my hospital, there are already certain types of procedures which are conducted only with robots. For instance, I wouldn't operate a regular low rectal carcinoma without a robot. Robotic assistance would also be useful for small procedures – hernia, appendicitis, gall bladder – but almost no one uses it.

Why ?

Because the decision to use robotic assistance is based on the cost-medical benefit ratio. In the case of such small procedures, like easy-access operations, the robot's extra cost is not "cost-effective".

… even if there is greater precision ?

The robot's real benefit for the patient – a shorter stay in hospital, fewer complications, or recurrences – has not been scientifically proven. Besides, it would still be difficult to prove, because the efficiency of a surgical intervention depends on a combination of factors – the healthcare staff, medication, equipment, methods… how do we know what the robot's contribution is ?

Is it important to know it exactly ?

Patient benefits are often considered by those who pay for it – in particular insurance companies. The question they ask is "Why pay more, if the benefits are not proven ?"

In other fields, robots save time and money by replacing humans…

A robotised operation often requires fewer assistants since the robot holds the camera and tools. So, the economic calculation "More robots, lower salary costs" will perhaps be considered in the future. However, fewer surgeons is not an option that we, surgeons, like to consider!

What will future solutions be like?

Current technologies (arms, instruments, interfaces…) will progress. Tactile feedback will enable surgeons to better "feel" their movements. Augmented reality will provide an improved overview of the operating field – for instance by indicating the location of a tumour. New technologies will be integrated: artificial intelligence and machine learning will process masses of physiological and operational data, they will recognise recurring patterns, help surgeons to prepare the procedures. On the other hand, I don't see machines handling surgical instruments on their own.

Why?

When operating, it is not always a question of life or death, but almost. Every incision, even small, may have serious consequences. And every incision is much more than a technical task: it is the result of instant decision-making, involving a value judgement. An operation is in fact a series of instant value judgements.

… like driving a car…

Yes, but we realise that autonomous vehicles are progressing much slower than we thought. And, to me, decisions taken during a surgical intervention are more complex and subjective. We decide to make an incision here to avoid damaging something there. We must often choose between two negative consequences: we cut a nerve and with it the tumour is gone, fine, but bladder function will be affected. To expect a machine to make such a decision is a bit like, in case of an inevitable crash, expecting an autonomous vehicle to make a split-second decision to run over a child or a grandmother. It will take a lot longer before a machine will be capable of such a decision or before a human being will let a machine take such decisions.

Will robots then stay "simple" assistants?

Surgical robots in movies – which draw a diagnosis and operate all on their own – will continue to belong – for a long time - to the world of science-fiction. That said, short-term progress in medical robotics is highly promising and I look forward to discovering it. ■

▼

Professor Hannes Neeff with the console of a Da Vinci. Sitting upright – much more comfortable than standing and bent over the operating table, as required by classical surgery.

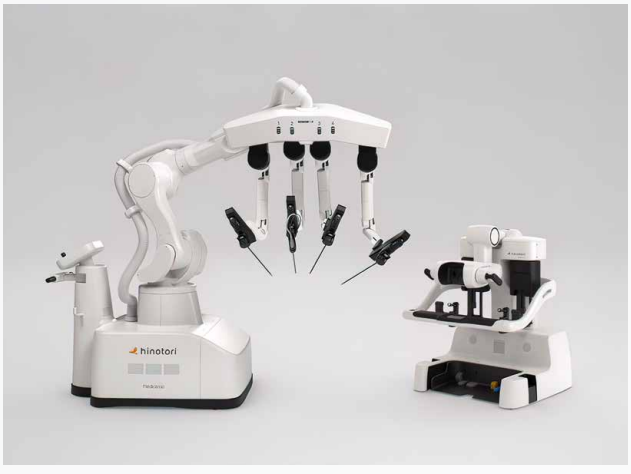
THE JAPANESE PHOENIX RISING

It would be hard to think of robots without thinking of Japan.

The Land of the Rising Sun has been a pioneer of industrial robotics since the late 1960s. Today, it is believed that more than half of the world's industrial robots were made in Japan. Meanwhile, Japan has also made the robot a hero of its popular culture, which in turn has also been widely exported.

Nevertheless, the historic leader stayed absent for a long time from the booming market of robotic-assisted surgical systems. It wasn't until December 2020 that the very first "Made in Japan" robot was launched on the market. It was the hinotoriTM (phoenix in Japanese), surgical robot by Medicaroid.

Following the market introduction, Kobe University announced that the first prostatectomy using hinotori was successfully performed at Kobe University Hospital. A few months later, in April 2021, Medicaroid demonstrated telesurgery using hinotori in a medical institution fitted with state-of-the-art equipment, via NTT Docomo's 5G network, which proved the concept of remote surgery.



© Medicaroid

Much of these successes go back to the company's origins. Medicaroid was established in 2013 as a joint venture between two giants, Kawasaki Heavy Industries (KHI), manufacturer of the first Japanese industrial robot and industry leader, and Sysmex, a haematology specialist and a leader in the Japanese healthcare industry for the past 50 years, providing services in approximately 200 countries.

Today, Medicaroid employs a staff of over 100, including KHI engineers and Sysmex service staff.

Telesurgery will be developed in the future, but for the time being, hinotori has been used in the same operating room where the patient is installed. Medicaroid confirms that, thanks to its compact size, the system fits in a standard operating theatre.

The armrest height, the foot pedal depth and the angle of the 3D viewer are adjustable to fit individual postures and reduce fatigue, *"even during lengthy surgical operations."* Surgeons can visualise the operating field in 3D high-resolution images. Integrated microphones and loudspeakers make it possible to communicate effortlessly with the surgical team.

According to Medicaroid, the greatest technological challenge was to capture and reproduce the surgeons' movements and gestures. Medicaroid involved the surgeons in the development project since the early stages, using their feedback and advice to shape the design. *"Eventually, we were able to complete a robot that can reproduce the movements of the surgeons' hands."*

To perform such precise tasks, hinotori's arms are articulated around 8 axes. They are compact, human-sized arms, a design chosen to reduce interference between them and the bedside assistants.

Hinotori is only an assistant in surgery, insists Medicaroid. This was the guiding principle of every aspect of its design. *"Surgeons do not want robots to perform surgery. They want the robots to fully replicate their own surgical skills."* This affirms Medicaroid's vision on robotics in general: the ideal robot is one that coexists with humans, serves humans, and extends the ability of humans.

Hinotori is equipped with six instruments and can be used for five different urology procedures, covered by insurance in Japan only. It is of course just the beginning, since the robot can operate in other minimally invasive surgical fields as well. Last November, Medicaroid filed an application for regulatory approval of the use of hinotori in gynaecology and gastroenterology in Japan.

Further application fields will follow. Since 2018, fourteen surgical fields have been approved for health insurance coverage in Japan. Therefore, hinotori's progress on the Japanese market seems to be assured. Moreover, if everything goes as planned, Medicaroid's phoenix of surgical robotics should soon be rising beyond its borders. ■

STREAMLINED, SCALABLE & SWISS

Every year, in Europe alone, millions of surgical operations are being performed using traditional open surgery, even though they could benefit from a minimally invasive approach. Why? First and foremost, minimally invasive surgery can be rather difficult and challenging. Robotics solutions provide significant support to surgeons, especially for the most delicate parts of the surgical procedure, highly complex and precise movements in confined, hard-to reach spaces, thus empowering surgeons to perform more, safer and better minimally invasive surgery. Such solutions, however, are the Rolls-Royce reserved for wealthy institutions.

This is the market – and user – problem that Distalmotion, a Swiss medical device company founded in 2012, managed to tackle. Today, its Dexter solution currently being marketed, the quest is finally taking shape: *"We will contribute to turning surgical robotics into a standard of healthcare"*, promises its CEO Michael Friedrich.

To get there, Distalmotion did everything to remove the two major obstacles hindering the widespread adoption of robotics solutions: complexity and cost. First of all, by distancing from the sector's founding concept.

"Robots currently used in minimally invasive surgery often apply the 'remote surgery mindset' originally developed to facilitate surgery in scenarios where the surgeon and patient are spatially separated and not necessarily in the same operating theatre", explains Friedrich. The idea was to make it possible for specialists to operate wounded soldiers remotely, using robots capable of performing the complete operation. Current solutions deriving from this approach require complex equipment, designed in a way that ultimately distances the surgeon from his patient and team.

Usually, the robotic console via which the robot is controlled is located in the same operating theatre as the patient – not only in Dexter's case, but all other soft tissue robots as well. In some sense, this makes traditional, remote surgery technology and design even more paradoxical, i.e. the surgeon is in the same operating theatre, yet distanced from the patient and surgical team, because the console is not sterile and standard workflows are inhibited.

For Friedrich, this distancing does not make sense in the case of standard operations, where proven, successful workflows exist, including clear gestures and complicity in the healthcare team. Separating the surgeon from the rest breaks processes and requires additional ones.

Dexter was designed to achieve exactly the opposite: *"to reduce complexity and integrate robotics into the standard operating process as naturally as possible."*

With Dexter, the surgeon stays with his team and his patient in the sterile field. Moreover, he doesn't have to choose between "a robotic operation" or "traditional laparoscopy": he can use both at his convenience. Distalmotion enables switching from the robot's console to the patient in 20 seconds, including instrument changes. *"Dexter integrates the best of two worlds"*, concludes the CEO.

The robot's design is a direct expression of this quest for simplicity, with its compactness and low floor space requirement. The three robotic arms – two driving the operating instruments and one driving the endoscope – are mounted on separate mobile units and designed to guarantee easy access to the operating site.

Dexter uses an open robotic platform. It is also compatible with various existing laparoscopy instruments as well as all 3D medical imaging systems. The aim is obviously to respect user habits and choices.

Last but not least, Distalmotion has overcome the prohibitive price obstacle and proposes an innovative financing system: various *"transparent and flexible"* financing models, ranging from capital expenditure (purchase) options to rental and pay-per-use, including training and maintenance as well as support services. Variable costs are based on the consumption of single-use proprietary equipment.

A spinoff of the Swiss Federal Institute of Technology (EPFL) Robotic Lab, Distalmotion employs a staff of more than 80. It has stayed on the shores of Lake Geneva, where it benefits from a favourable environment. The area referred to as the "Swiss Health Valley" is home to hundreds of companies, research centres and other institutions active in biotechnologies, pharma and medical technologies.

At the end of 2020, Dexter obtained the CE European label, opening the way to its clinical application. In June 2021, Distalmotion announced its successful first use *"the World's first hybrid robotic surgery"*. Distalmotion is now looking to roll out Dexter in Europe via an "Early adopter programme", as a first step. The company has also set eyes on the US, where the submission process for the US FDA is underway.

Distalmotion is targeting hospitals of all sizes, including small and medium-sized, for which robotics has been out of reach until now, as well as large institutions to make the move from a single robot to one robot for every floor.

"Dexter makes robotics accessible to more indications and surgeons, more hospitals, healthcare systems and patients" concludes Friedrich. The democratisation of minimally invasive surgery can now start. *"The market is ready for a new approach, with a user-friendly and patient-centric solution."* ■

With Dexter, the surgeon doesn't have to choose between robotic or classical surgery: he can do both simultaneously, switching from the robot's console to the patient in a matter of seconds, and vice versa.

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INGENIOUS ASYMMETRY

To optimise the efficiency of their concept, the students of the Swiss Solar Boat team are proposing a rather unusual design. They are aiming for victory this summer at a competition in Monaco.

Last July, in Monaco Harbour, the 8th edition of the Energy Boat Challenge was in full swing. Engineering students from all over the world are welcome to participate in this challenge where about a dozen boats competed in the "Solar" class. Among the monohulls and catamarans, there was the Dahu, a boat with a somewhat incongruous design. With its two hulls of different width and length, its asymmetry is even more surprising when it "flies" on its three hydrofoils. Astonishing but efficient, since the Dahu won the second place in its category.

© Swiss Solar Boat

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As of 18 km/h, the Dahu takes off on its hydrofoils, reducing its energy consumption by one third.

© Swiss Solar Boat

All aspects of the project – from administration to piloting – are handled by the students themselves.

A few months later, we went to see the boat, dry in its storage area on the EPFL (Swiss Federal Institute of Technology) campus. Its designers, the students of the Swiss Solar Boat team, have been busy working on it, firmly determined to win the Monaco challenge this summer. We can at last ask them why such unusual design? *"To shake up the codes"*, answers a smiling Simon Tychyi, the team's technology manager. There was of course a reason behind the choice: *"We wanted our boat to be as stable as a catamaran when she's on the water, but also as lightweight as possible when lifted on its hydrofoils – this is why the secondary hull is smaller."*

With its asymmetrical structure, the Dahu is like a cousin of the proas, a traditional outrigger canoe of the Pacific and Indian Ocean. It also explains the witty name the students have given her: the Dahu is an imaginary quadruped from Alpine folklore, whose right and left legs are not the same length!

The secondary hull was not the only component to be streamlined. The structure (sandwich with a foamed body and as few supporting elements as possible) and the materials (pre-impregnated carbon, Airex foam) were selected to maximise the weight/rigidity ratio.

All in all, the 7-m boat weighs only 190 kg and its main hull resists potential shocks up to 2G.

The same obsessive attention was paid to energy efficiency. Several students of the Swiss Solar Boat team have worked at the CSEM (Swiss Centre for Electronics and Microtechnology) in Neuchâtel, a technological excellence centre, renowned in the field of renewable energies. Thanks to this experience, they have contributed to the design and production of their solar panel.

EXPERTISE FROM MULTIPLE HORIZONS

A technological as well as an educational project, Swiss Solar Boat involves EPFL students in all its aspects. Just as much in its development (electronics, hydrodynamics, structure) as in its management (administration, communication…). The core of the team is made up of about fifteen people, but all in all, about sixty students have contributed so far.

The young engineers can also rely on impressive know-how. The EPFL has extensive naval experience (it was a partner of Alinghi, two-time winner of the America Cup). Taaroa, a company specialised in hydrofoils, has equipped the Dahu. Décision SA, who built the Solar Impulse plane (the first non-stop around the world flight using solar energy) has provided its equipment for the design of the hull and the deck.

Supporting young engineers on a regular basis, LEMO has also been convinced by Swiss Solar Boat. Among the components supplied: T Series solutions to connect electronic components and sensors. Designed for harsh environments, these small connectors are robust and watertight. They are simple and safe to use (Push-Pull system, keying) making it easy to mount and dismount the modular components of the Dahu. ■

This latter, made up of 150-300-micron monocrystalline silicon cells, for a total thickness of only 0.4 mm, is in fact a foil to be bonded onto a surface. Its energy efficiency? *"Not in the same league as the solar panels used in space, but still high-class!"* answers Simon Tychyi with a note of satisfaction.

A thinner foil also means less silicon to be extracted from the ground, explain the students, who endeavoured to reduce grey energy for every aspect of the development process. By the way, this effort was honoured by an eco-design award last summer.

THREE "LEMO TEAMS" IN MONACO

This summer in Monaco, Swiss Solar Boat will be in direct competition with another LEMO-sponsored team. The Técnico Solar Boat (from the Instituto Superior Técnico, Portugal) will also compete with SR03, its third solar prototype.

The Iberian team will also enter the competition in the "Hydrogen" category with its SM01 boat. Just like the Dutch team TU Delft Hydro Motion, also supported by LEMO!

It is no coincidence. The Swiss group has been regularly supporting young engineers for a long time. The idea is to give a little help to the most innovative projects by offering the best connectors available on the market. It is a win-win partnership, as the students' demanding and original requests also boost LEMO's innovation. ■

© Técnico Solar Boat

The rules of the Energy Boat Challenge limit the solar surface to 6 m^2, but each competitor is free to spread out the solar cells at will. Swiss Solar Boat used computer simulation to identify the best exposed spots on the boat, adapted to the position of the July sun in Monaco, the path of the course and even the shadow cast by the pilot's head.

Then, the power needs to be distributed with as little loss as possible. The Dahu uses maximum power point trackers, an electric converter, to optimise the power extraction and distribution of the solar panels. Energy management is part of the strategy. For instance, for the endurance race, it is not possible to race full speed ahead. The students have programmed "energy saver mode" to be able to keep up with the four-hour race. On the other hand, they have programmed "sprint mode" for the speed contest.

The Dahu's two engines produce 800 N. Its inverted rotary propellers are placed one behind the other: the rear propeller recovers the hydrodynamic vortex produced by the front propeller, altering the waterflow to optimise performance. The solar boat can speed ahead at 45-50 km/h (25 knots). It is all the more efficient, since as of 18 km/h (approximately 10 knots), it takes off on its T-shaped hydrofoils. *"This reduces its energy consumption by one third"*, explains Simon Dorthe, responsible for electronics.

The boat's balance is also electronically controlled, which is necessary, because its asymmetrical form makes it rather unstable. *"The sensors record the data 50 times every second, which makes it possible for the on-board computer to correct the hydrofoils' angle and the height of the boat continuously for maximum efficiency."* In fact, the three hydrofoils are not rigid: their supporting surface pivots like the ailerons of aircraft.

All the data captured by the sensors are continuously transmitted onshore. This communication is bidirectional: the team can optimise the adjustments of the Dahu on-the-fly. It also adapts them according to changing weather conditions.

Clearly, every detail contributes to winning a few percent efficiency. However, to be able to measure and optimise, you need to navigate and test as much as possible. And this is exactly what Swiss Solar Boat was missing last summer, since the students finished building the Dahu in the last moment.

This year, the boat does not need to be built. *"So, we will have much more time for testing!"*, confirm happily Simon Tychyi and Simon Dorthe. *"We will be able to know more about the boat, to enhance its reliability and finetune the algorithms."* Over fifty hours' sailing were planned between April and June.

Then, in early July, it will be time to transfer thirty members of the Swiss Solar Boat team to the Principality of Monaco. For some of them, it will be the end of their contribution to the project. For all of them, it will be an *"outstanding experience"*, shared with hundreds of passionate and united students. Victory would of course be the icing on the cake... ■

TIME TRAVEL THROUGH SOUND IMMERSION

Nagra has acquired a special status in the audio world. Its first vinyl turntable, in production, is the embodiment of an obsessive quest launched 70 years ago. Visit and listen where all the Nagra are being designed.

Eyes shut ; we are listening to a passing storm. Raindrops crashing on the ground, thunder rumbling in the distance, its vibrations all around us. Suddenly, a bass guitar hits the beat of a heady melody. From behind, to the right, discrete percussions. Close to us, to the left, Ray Manzarek's keyboard enters with light, jazzy notes. Finally, Jim Morrison, slightly set back, adds his eerie vocals : " Riders on the storm, riders on the storm... "

The Doors are right around us ; the ceremony is about to begin.

© ATS

70 YEARS OF HIGH-FIDELITY

It was back in 1951 that Stefan Kudelski invented the first portable high-quality recorder. The Nagra brand ("I will record" in Polish, the founder's native language) was thus born. It quickly became a key reference. A Nagra slung simply around the shoulder replaced a team loaded with heavy material. Robust and capturing sound with unprecedented fidelity, it has accompanied TV and movie sound engineers, radio reporters, astronauts, and scientists on all terrain. From the depth of the oceans to the Moon, over the peaks of the Everest.

This technological revolution brought a multitude of rewards, including several Oscars and Emmy awards.

Since the late nineties, the Nagra brand has also made its way to the obsessional world of audiophiles. At first, it proposed preamps, amps and converters – all of them high-end – which brought further success from critics and markets alike. The hi-fi sector currently represents two thirds of its turnover. ■

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Created by extraordinarily clear and tangible sound, the illusion is fascinating. It is quite normal, as we are in the studio of Audio Technology Switzerland (ATS), the company that designs the products of the legendary Nagra brand. The hi-fi equipment around us must be worth almost half a million dollars.

Nagra's latest creation is displayed at the side of the room: the Reference Anniversary vinyl turntable announced in December. Only a few customers have already received it. It will only be produced in a limited edition of 70 units, to celebrate the brand's 70th anniversary.

It took four years' R&D to develop these 80 kilos of precision and pureness. The turntable, latest embodiment of ATS' perfectionism, proudly displays its origins. Aluminium case, timeless design, the red-bar button and the modulometer's pointer already used on the Nagra I back in 1951.

In view of the limited edition, it also displays certain unique refined features. "*We wanted to honour Swiss horological expertise, which is part of our identity*", explains Mathieu Latour, ATS Audio director. Like on certain timepieces, a transparent "skeleton" case back makes the superb movement visible, some of its parts decorated by typically watchmaking finishing (Geneva waves). In its own way, the jewel's price – 175,000 dollars – also reminds of Swiss luxury watchmaking.

Why a vinyl turntable, a first for Nagra? "*We were wondering what new product we could launch for this anniversary*", answers Mathieu Latour. "*We decided to come back to an analogue system and show our know-how in mechanics.*" The idea had been around for a while. "*Stefan Kudelski, founder of the brand, had already considered launching a turntable. He went even as far as depositing a patent for a tonearm. The 70th anniversary was a good opportunity to go ahead with the idea.*"

The fact is however that a turntable is technically more distant from the original recorders than the amps and preamps produced by the brand so far. ATS has therefore started from a blank page, more than usual. The first challenge met by the engineers was to objectify: "*There is a fair amount of fantasy, exotism and esoterism linked with audiophile turntables. We first had to identify the elements that make a genuine contribution to good sound. Then define how we could improve them.*"

ATS quickly realised that it had to tackle a multi-layer project. "*Power supply was a project on its own. Each mechanical element was also a separate project. Every decision taken had an impact on the others...*" Mathieu Latour compares working on a turntable of such precision to metrology. "*Audio signals are so weak and sensitive, mechanical ranges so small, that anything can disturb them. Even the smallest factors may be crucial.*"

For instance, it required to combine skills in mechanics, electronics, material sciences and applied physiques to control sound quality's number one enemy, parasitic vibrations. Multiple solutions were applied: an alternation of aircraft grade aluminium and polymer layers for the chassis and the sub-chassis as well as a combined mechanical and hydraulic suspension. The 6.5 kg platter is made of EXIUM® AM, an alloy that is 60% more dense than the titanium developed for space and used in the Insight Martian probe mission. The surface of the platter is made of antistatic methacrylate. The carbon fibre tonearm wand includes a layer of wood with a silicone damping system. The motor drive system was designed to be at the source of demand and not permanent unlike certain competitors' solutions. The power supply is in a 20 kg external housing.

All the above contributes to detach the turntable from external vibration - bass from the speakers or someone's steps next door. If you are watching it turn with surreal stability, you get the impression that even the end of the world wouldn't make it tremble.

To make it possible, ATS covered every detail with a "no matter what it costs" approach. Not at all excessive *"since every option has an influence on the sound"*, swears Matthieu Latour. *"Everything is audible."*

Everything is audible. *(Continued on page 22)*

The Reference Anniversary vinyl turntable and its visible "movement", a tribute to Swiss horology.

© ATS

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This is why, regardless of the time spent on engineering, it is listening that represents the most important and most time-consuming part of development. *"The technical part is not the end of our work, since sound is always emotional."* In this world of sophisticated materials and objective measurement units (Hertz, Ohms…), the most precious tool is still the highly subjective human ear.

Correct, listen, reset and start it all over again and again.

This "tuning" – which makes ATS reputation as much as its products – targets the aim of the "hi-fi" formula: to reproduce the instrument or the voice as close to reality as possible. A quest claimed of course by many other audiophile brands. Nagra makes the difference by its experience from its origins, highlights Latour. *"We are the heirs of the Nagra recorder sound, which, by definition, must be transparent. High fidelity is in our DNA."*

ATS experts participate in a multitude of listening, individually or in groups. These expert "golden ears" are often musicians themselves, just like Matthieu Latour. *"It is important to stay immersed in genuine sound, to keep in touch with the source – a symphonic orchestra, a jazz guitarist… source is our reference, our tuning fork. It helps us recognise and respect the tone, the original colour."* Various, regular cooperation with for instance the Montreux Jazz Festival and the Stradivarius Foundation also contribute to the projects.

In spite of ATS experience and know-how, there is no shortage of pitfalls.

First of all, the very human tendency to embellish. *"Am I listening to the original piano or am I adding a little bit of sugar and vanilla to sweeten the sound?"* Such "improvements" are often chosen by popular loudspeakers and headphones manufacturers. For audiophile brands, *"they are capital sins"*.

Back and forth between listening and engineering corrections are multiple – this is the second trap. Choosing the viscosity of fluid contained in the chassis suspensions took weeks. Identifying the material and form of the record weight (finally pure copper) took months.

"Accepting to stop finetuning is our greatest challenge!", admits Latour with a chuckle. *"I've known passionate people who have been finetuning their loudspeakers for 40 years. We are just as crazy as they are, but we have to launch a product on the market."*

To control parasitic vibrations, the carbon fibre tonearm wand includes a layer of wood with a silicone damping system.

ATS employs around thirty such crazy people – sorry, staff – in the Lausanne area (Switzerland). A third of which in R&D. *"We want to discard standard solutions, since they will not be able to assure the required quality or originality."* explains the director.

Recorders are still part of the Nagra offer, even if, just like hi-fi, another range has generated a larger turnover: security. ATS has been designing ultra-miniature solutions for a number of governmental agencies. They are the successors of recorders ordered by the CIA in the early sixties.

Those who revere Nagra's very Swiss design (sober, aligned) will be surprised by the company premises. No white coats, nor neat laboratories. The 2000 m^2 occupied by the company make you think of the rather oversized and chaotic attic of a genius inventor. A maze of shelves covered with boxes overflowing with material. Worktables cluttered with equipment, parts and tools. Test & measurement done on one side, a large 3-axis CNC cutting the Nagra panels on the other. *"We produce a maximum of components ourselves"*, mentions the director, *"and we control most of the production steps."* Further, in another space among the shelves: two female colleagues are assembling the turntables.

© ATS

Manually, of course. Everything is handmade.

Many Reference Anniversary turntables have been delivered. Meanwhile, ATS engineers and designers have already been working on their next hi-fi products. Other turntables will be proposed. One for the HD range and another for the classic, more accessible range, *"but not before a year or two!"* Vinyl is in fact only the first step towards a return to analogue systems. Nagra will propose solutions using its iconic support, magnetic tapes. Between heritage and innovation, the brand has not finished perpetuating the myth.

In the ATS studio, "Riders on the Storm" comes to an end. The last notes go silent, thunder moves away, the rain calms down. For a brief moment, we were with The Doors and The Doors were with us. This deep emotion of "live music" is both the aim and the reward for Matthieu Latour: making it possible for a past performance to unleash its reality in the present. *"What we make here are time machines"* he concludes. ■

IDEAL COOPERATION

An absolute perfectionist, ATS is keen on controlling every step of the design process of Nagra devices. A maximum of components are produced in-house, but it also uses a number of high-end suppliers, almost all of them Swiss. LEMO is one of them, having developed connectors for Nagra for several decades.

The "timecode" modules (synchronisation between sound and image), introduced in the seventies with Nagra IV, have always been fitted with LEMO. The power supply of digital recorders (launched in the nineties) as well. Just like all hi-fi equipment (launched in 1998), the Reference Anniversary being its ultimate expression.

Vinyl turntable of all superlatives, the Reference Anniversary features two highly specific B series connectors. The first one on the cable connecting the tonearm to the audio output, a critical point since the signal is extremely weak (millionths of Volts!) and the cable highly fragile. The second LEMO connector equips the power supply located in a separate housing to minimise interference. ■

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A GIGANTIC EYE OPEN TO THE UNIVERSE

An Extremely Large Telescope (ELT) has been growing on top of a Chilean Mountain. The European South Observatory (ESO) has been leaning on a multitude of partners, among them Procon Systems, to create this installation of all superlatives.

The more light a telescope captures, the better it "sees". Therefore, billions are spent on building ever larger telescopes. With its almost 40 m diameter, the ESO's Extremely Large Telescope, under construction in Chile, will mark a new record. Everything about it is astronomical.

The ELT will capture twenty times more light than the current largest installations (of the Very Large Telescope range), which is 100 million times more than the human eye. More than enough to delight Galileo, the father of astronomical observation who discovered satellites around Jupiter through a 3 times magnifying instrument.

The ELT is composed of four Zerodur glass ceramic mirrors and one in Silicone Carbide, SiC. Of various sizes, forms and roles, they will work in unison to deliver images of the universe with greater precision and clarity than ever before. They will be held by a structure (with 30 million nuts) sheltered in an 80 m high and 88 m diameter hemispherical dome.

The main mirror marries extremes: a 39 m, 132-ton Zerodur monster, whose 798 segments will be aligned with a precision of tenths of microns.

Whether giants or not, telescopes become myopic when even the slightest disturbance occurs. Preventing and controlling require an array of scientific, technological and industrial solutions. The mirrors' design and polishing, as complex as they may be, constitute only one element.

The choice of the location is another and the top of the Cerro Armazones provided many advantages. Right in the middle of the Atacama Desert, which has a hyper-arid climate offering an annual 350 cloudless nights. The not-too-distant ocean mitigates temperature variations. Isolation limits disturbance caused by human activities (air- and light pollution). Moreover, the area is well-known to the ESO, since its Cerro Paranal VLT stands at about 20 km as the crow flies.

The altitude of the site, at 3000 m, reduces disturbances due to atmospheric turbulence, but not completely. Such turbulence changing rapidly, it may cause aberrations that must be corrected rapidly. Large mirrors not being as agile, small, flexible "deformable mirrors" are being used. To correct the blur caused by local atmosphere, it is measured with the help of a reference star, bright and close enough to the object being studied. To make sure that there is such a star, it is created: astronomers send a powerful laser beam into the upper atmosphere. The ELT will have 8 such lasers.

This solution, already used with the neighbouring VLT, is called adaptive optics. It will make it possible for the new ground-based telescope to capture images sixteen times sharper than the Hubble Space Telescope.

Another major, intrinsic disturbance: the enormous weight of the mirrors exerts incredible force that deforms their surface. In order to correct this, the ESO uses another solution, active optics: an array of electric and hydraulic actuators that modify mass distribution, to counter local surface distortions.

On top of the Cerro Armazones in Chile, the world's largest ground-based telescope, as it will be, once its construction is completed in 2027.

Once "That obscure clarity that falls from the stars" is captured, corrected and stabilised, the instruments step in. Several ultra-sophisticated cameras and spectrographs transform the visible and infrared light into information.

The ELT will make it possible to observe better than ever all the "grails" of astronomy and cosmology: extra-solar planets, the origin of the galaxies (it will "see" them 380,000 years after the Big Bang, a blink of the eye on a cosmic scale), as well as their evolution, supermassive blackholes, potential traces of life elsewhere in the Universe... enough to provide quite a few answers and to raise new questions, since every new large telescope brings its unexpected findings.

Such objectives would be impossible to achieve without large-scale cooperation.

Founded in 1962, the European South Observatory (ESO) is an intergovernmental organisation involving 16 Member States. The mission of the ESO is to build and operate world-class ground-based astronomical facilities, as well as to foster cooperation in astronomy. The ESO has its headquarters near Munich in Germany, and it operates three observing sites in Chile: La Silla, Paranal and Chainantor. The ESO's ELT is currently being built on Cerro Armazones, near Paranal.

Developing these massive installations, the instruments they will incorporate and the scientific programmes they will serve involves hundreds of public and private institutions. The construction of the ESO's ELT in Chile, for instance, implies over forty industrial contracts worth more than 500,000 euros each.

Among the partners, Spanish company Procon Systems was commissioned for the assembly, integration and verification of 132 electronic cabinets which will house electronic components for the control, communication and power supply of ELT's primary mirror. It is for the second time that ESO has turned to Procon, as they have already contributed to the revision of VLT's control system.

The equipment assembled by Procon systems is fitted with LEMO solutions. It is not a first-time for the Swiss group, as its connectors had already been selected for several telescopes, including the DAG in Turkey (CONNECTED n°8) which should be inaugurated this year. There will be over 10,000 LEMO connectors on the American Thirty Meter Telescope (CONNECTED n°11), in construction in Hawaii.

In the meantime, in the Martian-like landscape of Cerro Armazones, the construction of the ESO's Extremely Large Telescope is progressing. Since 2014, the mountain top has been reduced by 18 m in height and 220,000 m^3 rocks have been removed, freeing up a flat surface of 150 m by 300 m. The impressive foundations have been laid and in 2021, the building of the structure and the dome began. It should be finished by 2025. Once the ESO's ELT sees its "first light" (first capture of photons from the sky) in 2027 it will become the world's largest eye on the sky opened by humankind. ■

Follow ELT's construction: https://elt.eso.org/about/webcams/

WHEN HYPERLOOP MEETS REALITY

Test runs are about to start in the Swiss hyperloop tube, a first in Europe. Its circular loop, a world first, will make it possible to measure and optimize the efficiency of "the train of the future" over thousands of kilometres.

A magnetic levitation pod flying up to a speed of 1200 km/h in a tube under partial vacuum. This is hyperloop, a public transportation concept which is "greener" than aircraft or even trains, and could bring, in theory, Paris within an hour's reach from Rome or Los Angeles within thirty minutes from San Francisco.

The idea is not new (the very similar "vactrain" was already imagined in the early 20th century), but it stagnated for a long time. It was not until the release of a white paper in 2013 promoted by Elon Musk, that it became the focus of an extraordinary technological race (see our article in CONNECTED n°11). The billionaire has also stimulated research by organising, from 2016 to 2019, a "hyperloop pod competition" for technical schools around the world. The Swiss Federal Institute of Technology of Lausanne (with LEMO among its partners) also entered competition for the last two editions. Encouraged and supervised by Professor Mario Paolone, responsible for the Distributed Electrical Systems Laboratory (DESL), the EPFLoop team has won several engineering prizes.

Musk's competition involving a short straight-line acceleration is in no way a proof of feasibility of a real hyperloop. So, Mario Paolone supported a thesis dedicated to the quantified evaluation of a vast array of practical questions. Is it really possible to reach 600-700 km/h with an energy-saving solution (condition to ensure the economic viability of hyperloop)? How many shuttles would be necessary to ensure optimal service between two major cities? What capacity? At what frequency? Is it more efficient to let the vacuum system function during off-peak hours? Etc. etc.

By the way, this thesis concluded that hyperloop was an appropriate means of intracontinental transport. Reason enough for the DESL to launch two concrete projects.

The first one is particularly visible: the EPFL has built on campus Europe's first hyperloop tube! *"We want to prove that hyperloop is possible, namely in terms of energy efficiency"*, explains André Hodder, one of the "senior" members supporting EPFLoop. *"To be able to do this, we need to compare the results of the thesis with reality."*

Test tubes built so far by Virgin HyperloopTT and other players in the field, measure 400 m to 4 km, too short for studying energy efficiency. *"In reality, vehicles will travel for hours over thousands of kilometres. So, we have chosen the only form capable of simulating: a ring."* Designed on a 1:12 scale, this world-first circular hyperloop measures 40 m in diameter. Finished in July 2021, civil engineering works have given way to the installation of the tube's equipment.

Once completed, the ring will be equipped with a multitude of sensors (connected with LEMO solutions) to record the pod's position as well as a host of other factors. The infrastructure and its use, the low-pressure quality in the tube (how to maintain and repair leaks...), thermal expansion, condensation, failures (and their solutions) will all be evaluated. Along with the best way to communicate with a vehicle moving at high speed in a vacuum-tight tube (necessary for acquiring and transmitting live data).

The tube will obviously also make it possible to test and improve the vehicles themselves. It will be possible to analyse the behaviour of different types of pod, the efficiency of the various engines, the acceleration profiles (bearable for humans) as well as their energy efficiency... All of this, for as long as necessary.

The EPFL will use the results to verify one of its recommended options, which is to power the vehicles with batteries and not through the infrastructure. *"Railways are very large electricity consumers, such as a rail-powered hyperloop would be"*, adds André Hodder. *"By equipping the pods with batteries that we would replace by full batteries – recharged by solar, wind or hydraulic energy - at the end of each trip, the electric networks wouldn't be impacted."*

The DESL will also use the tube for progressing with its second concrete project, which involves fine-tuning its linear induction motor. This motor was launched in 2019 during the second participation in Elon Musk's "pod competition". Accurately named LIMitless ("LIM"

▼

The EPFLoop team in the centre of its test tube. The circular loop will make it possible to simulate the thousands of kilometres that Hyperloop "trains" may some day run.

for "linear induction motor"), the project was launched together with Professor Mauro Carpita from the HEIG-VD, another Swiss technical school.

The choice of linear induction may sound surprising, since, according to scientific literature, the performance of such an engine is limited to way below the 1000 km/h targeted by hyperloop. However, EPFLoop has an idea which could help to bypass these limits. An idea which is promising enough to obtain funding from Innosuisse for a dedicated PhD thesis.

▲

Assembling the elements. Once completed, the test tube (designed on a 1:12 scale) measures 40 m in diameter.

The LIMitless project also benefits from an industrial partner: Swisspod Technologies. This startup was created by Denis Tudor and Cyril Dénéréaz, two former students who were greatly involved with pod competitions and are still members of the EPFLoop.

As indicated by its name, Swisspod works on the development of a vehicle tested on a circuit in the US. Its aim is to validate this type of technology for freight transport. A crucial step, according to Cyril Dénéréaz: *"The infrastructure for a hyperloop network will be gigantic. No one will invest billions in technology that hasn't been tried and tested."*

The history of Hyperloop could follow that of civil aviation. At first, freight transport (think of the adventures of French airmail company Aéropostale!), then, once the technologies and the safety are mature enough, upscaling to embark passengers.

Meanwhile, the EPFL continues to focus on research, mobilising the best brains to solve scientific or technical problems. EPFLoop involves six "senior" members and a dozen students. About a dozen projects gravitate around hyperloop. *"There's a great atmosphere"*, says André Hodder. *"They are all enthusiasts, with a very positive long-term vision."*

Hodder thinks that there is no time for hesitating. *"Energy transition is a must; the situation needs to be urgently improved!"* It would take little (soaring oil prices, problems with continental aviation, bottlenecks in the distribution network...) to swing the situation in favour of hyperloop. The EPFL would then be ready.

Late February, the equipment of the tube was finalised, the first pressure tests were carried out and set up for running. By June, a pod could be launched for the first of many thousands of kilometres. ■

1995 – HOW THE TV REVOLUTION STARTED

The last Technology & Engineering Emmy Awards recognised the pivotal role LEMO played in the creation and development of HDTV. The key players told us how, 30 years ago, a normal tender became the first step towards a new era.

Comparing today's TV images with those from the past shows a shocking contrast. No need to go back too far: when people in their forties watch their childhood programmes from the early nineties, HD was nowhere around yet. Screens display excessive grain, approximate colours, and irregular slow-motion replay.

Copper cables seemed sufficient to relay data captured by the cameras. But Marcello Pesci, LEMO's CEO felt that fibre optics could shake up the broadcast industry. He decided to set up a dedicated team and, in 1991, he hired the expert who would become its leader.

Glen McFarlane, an Englishman of Jamaican origins, had just spent a decade working on fibre optics for Philips. LEMO wanted to offer connectors adapted for such applications, so the expert started by developing new contacts.

The challenge was huge, remembers McFarlane. "*In the field, broadcast cables are being dragged on the ground, stepped on and rolled all over. The connectors are exposed to enormous load, pressure, shock, vibration and temperature variations. I had to create contacts that – in such extreme conditions – keep two fibres, that are smaller than 10 microns, perfectly aligned and connected.*"

Months of work led to the launch of the F2, contacts that "*outperformed anything that existed at the time*". Panasonic was among those who adopted it in the first half of the nineties. These cameras were still filming in standard quality, but the broadcast giant was already preparing a revolution. "*In 1994*" explains McFarlane, "*their rep informed me that Japanese manufacturers were planning to propose, for the very first time, broadcasting full events in high definition.*"

The 3K.93C Series now equips practically all TV studios around the world.

In early 1995, the – still confidential – project was confirmed by LEMO's Japanese subsidiary. It would be led by the ARIB (Association of Radio Industries and Businesses, the Japanese standardisation organisation for telecom, including TV channels and camera manufacturers). Targeted deadline: the Atlanta Olympic Games in the summer of 1996. LEMO was the only non-Japanese company participating in the bid.

Supported by his CEO, McFarlane made many trips to understand the needs and define the requirements. At the CNN headquarters in Atlanta, he was reminded that a 10-second signal interruption could deprive a billion television viewers from the flagship event of the Olympic Games, the 100-metre finals.

The product was defined as a hybrid six-contact connector – two optical fibres, two high voltage (camera power supply) and two low voltage contacts (communication between the camera and the control unit). Glen McFarlane teamed up with René Moreillon, LEMO's product director at the time, to integrate F2 contacts into connector housings very similar to those developed for extreme environments. The new solution, named 3K.93C, underwent intense internal testing. In late spring 1995, it was sent to Japan to be tested by Panasonic and Sony.

On 29th July, McFarlane flew to Tokyo with Jean-Claude Hubert, LEMO's recently appointed Technical Director, to receive the test results. *"Our product came out best"*, says McFarlane. *"The Japanese found only one weak point, in the anchoring device."*

Ironically, this weakness had nothing to do with connection quality, it was mechanical: the connector and the cable had to be able to stop a camera (worth hundreds of thousands of dollars) from falling off a platform.

LEMO's Japanese subsidiary and the fibre optic team in the UK (six people by then) reacted immediately. The time zone on their side, McFarlane and Hubert worked through the night in their hotel room in Tokyo. They spent hours on the phone with England. *"We redesigned the anchoring practically over a single night!"*, remembers the FO engineer Alan Brooks. Prototypes and tests were performed in the days that followed. The proposed solution was accepted by the ARIB.

The working group's final decision came in early November: LEMO's solution was selected. The Olympic Games coming up, the project turned from "confidential" to "operational".

Some 200 3K.93C connectors were produced, which was enough, since only part of the cameras would be equipped for high definition. LEMO also created maintenance and repair kits, so that engineers could take quick action, if necessary. The final tests and audits were performed.

In July 1996, everything was ready for the Atlanta Olympic Games.

"I watched the opening ceremony with my fingers crossed," chuckles McFarlane. Brooks felt confident. He didn't even fly to the US to provide assistance: the 3K.93C performed as well as the athletes. No breakdowns, zero problems.

After the Olympics, the connectors and cables were sent to Japan to be tested. McFarlane took part in the tests. *"Everything was worn out and covered in Atlanta red dirt. But the connections were flawless!"*

Thanks to this successful operation, the 3K.93C did not simply stay a product for long. In 1997, the ARIB decided to make it a standard for HDTV (LEMO edited the standard). Immediately thereafter, its US equivalent, the SMPTE adopted it as well. Then in 1999, the European EBU.

LEMO's 3K.93C became the de facto global standard.

The series gradually made its way into TV studios around the world. It has equipped broadcast cameras at the Olympic Games or soccer world cups. It equips, among others, the new German parliament in Berlin, the stadiums of the Premier League, New York's Madison Square Garden or London's BBC studios..

Meanwhile, TV-sets converted to high definition. In addition to all the advantages for the studios (more data over longer distances) there are all the benefits for TV viewers (comprehensive and vivid images, perfect slow-motion).

Television entered a new era.

This type of revolution is exactly what distinguishes the Technology & Engineering Emmy Awards granted by the American television.

Early 2021, LEMO learnt that it would be recognised for its role in the "Standardization and Commercialization of Television – Broadcast, Hybrid, Electrical and Fibre-Optic Camera Cable and Connectors".

LEMO officially received its Emmy last autumn, at the same time as its partners, the ARIB, the SMPTE and the EBU. The famous golden statuette has found its place in the reception area of LEMO's Swiss headquarters.

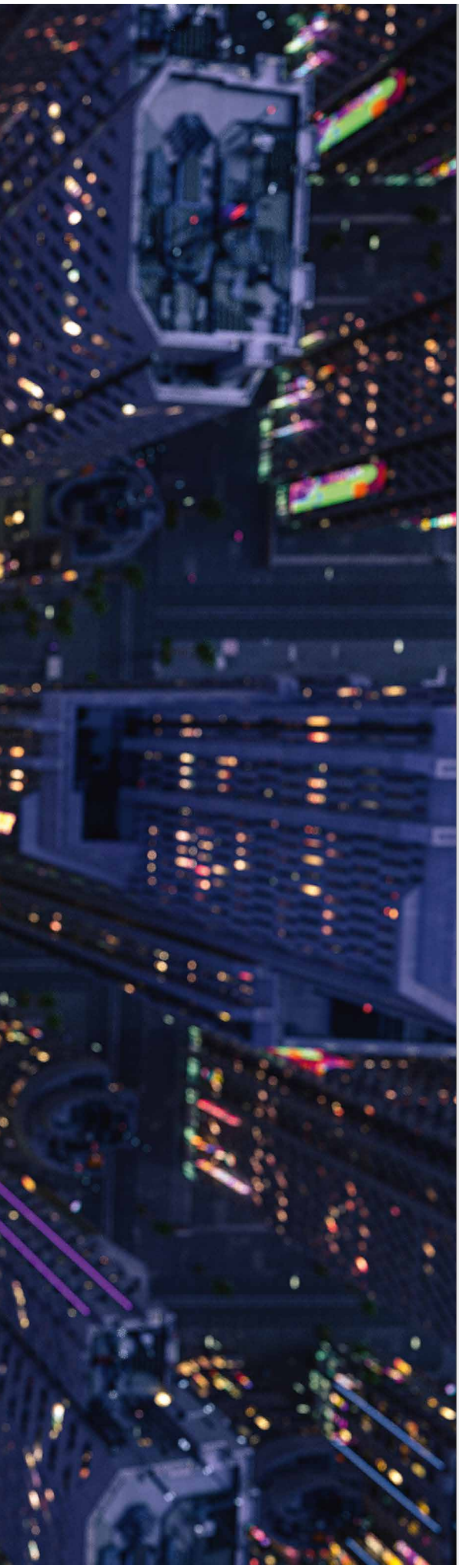
"Who would have imagined this fantastic adventure in 1995?", comments Jean-Claude Hubert. Alan Brooks confirms: *"We weren't conscious of what the 3K.93C would become, but we worked hard on it. It is the result of fantastic team effort. We were really at the forefront of broadcasting."* Glen McFarlane says he put his heart into it and proudly concludes: *"It is an excellent product that deserves the honours it received!"*

The Emmy Award is the Hollywood fairy tale ending of this story, but not that of the connector Series.

Designed almost 30 years ago for the "simple" HD, the 3K.93C perfectly supports the 4K provided today by television channels. It will just as well support tomorrow's 6K or 8K.

In parallel, LEMO launched the 3K.93C.Y, a compatible but totally re-engineered variant (including its contacts). LEMO's US subsidiary NORTHWIRE designed a dedicated SMPTE cable, which makes it possible for LEMO to propose a complete solution.

The show must go on. ■



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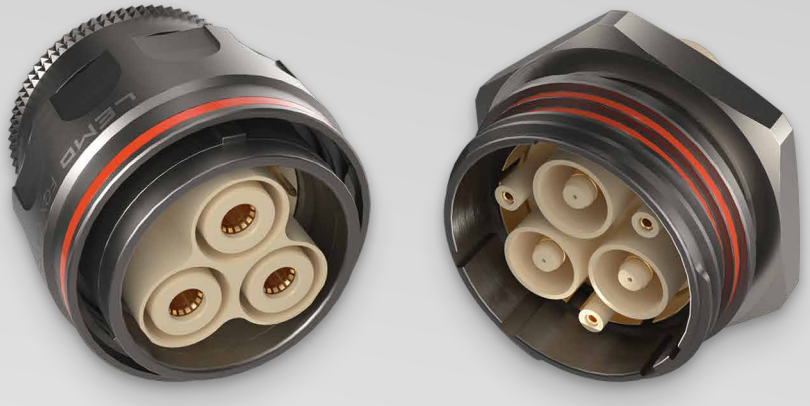
ALL NEW HIGH POWER CONFIGURATIONS



The M series new configurations were developed to satisfy the most stringent connection requirements for high-power distribution of electronic devices and electric drive vehicles. Reliable, safe, lightweight, rugged and fully waterproof, they are suited to the most demanding environmental conditions and mission-critical solutions.

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