

# ScienceScope

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FACILITIES FOR WORLD-CLASS INNOVATION

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Affordable pain relief drug

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Mossel Bay wastewater *E. coli* down 10 000-fold

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Sink and sync with novel  
underwater Wi-Fi



science, technology  
& innovation

Department:  
Science, Technology and Innovation  
REPUBLIC OF SOUTH AFRICA



# FACILITIES FOR WORLD-CLASS INNOVATION

The performance of an economy is driven by the capability of the state, the quality of its institutions, as well as the performance and competitiveness of its industries. This is underpinned and enabled by a country’s capabilities and ability to harness the power of science, technology and innovation through cutting-edge capabilities. Capabilities comprise skilled human capital and facilities for research, development and innovation.

Competitive local innovation rooted in world-class facilities allows ideas to **be tested, proven and translated into solutions** for South Africa, Africa and beyond. In this edition of *ScienceScope*, learn how fibreglass composites used in automotive trims like boot liners can now be replaced with hemp fibre composites following testing of fibres and materials developed at



the Natural Fibre Hub in the Eastern Cape at the CSIR’s laboratories in Pretoria (page 06). Also learn about a novel wound-healing technology that is making its way from the laboratory to the Supercritical CO<sub>2</sub> Micro-encapsulation Facility, where interested businesses can scale up its manufacturing (page 20).

First-rate facilities are also central to the **verification of performance against standards**, enabling independently tested claims made by original equipment manufacturers and other producers. The CSIR’s wind

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tunnels – after 60 years of service to the aerospace industry – will soon become invaluable to the wind energy sector, as the need for affordable, local anemometer testing rises in the wake of investment in offshore and onshore wind energy. Only nine laboratories around the globe are accredited to the international standards required for the anemometer testing that wind farms need (page 44). The CSIR is also home to the only facility in southern Africa to offer the full suite of internationally recognised solar photovoltaic module quality and performance tests (page 80). Since 2022, we have been able to scientifically test plastic products in line with international standards at our biodegradability testing laboratories, which provide assurance that products can be composted under home or industrial conditions (page 16).

**Capital-intensive infrastructure underpinning complex, high-value niche capabilities** offers advantages that cannot be afforded by any single industry player – they become the rising tide that lifts all boats in the harbour. Examples from our world-class biomanufacturing facilities include the upscaling of the production process of a growth factor for a local biotechnology firm (page 36), while a new continuous-flow microwave food processing unit for pulping and sterilising fruits and vegetables is empowering manufacturers to make products with improved shelf life and nutritional value (page 40). In advanced manufacturing, the recently commissioned Hot Isostatic Press (page 48) forms part of a broader ecosystem that supports aerospace, automotive and high-performance engineering research, allowing products to be tested and optimised under demanding, real-world conditions.

The Covid-19 pandemic – with its massive shortages not only of vaccines, but also of antibiotics and many other active pharmaceutical ingredients – was a powerful reminder of **the importance of sovereign capabilities** for the state in fulfilling its duty to its people. Six years later, the CSIR's new FuturePharma

Facility is home to Africa's first large-scale continuous-flow pilot plant, providing a leapfrogging advantage over legacy investments in batch facilities. Using this facility, researchers have produced Celecoxib, the active ingredient in a common anti-inflammatory pain drug that is currently only available to private-sector patients (page 32).

The meteoric rise of **artificial intelligence and modelling** calls for facilities such as the Centre for High Performance Computing, with its massive parallel processing capabilities. It powers a range of data-driven platforms, such as the new Logistics Observatory (page 92). And while earlier predictions suggested modelling might replace physical testing, the combination of the strengths of digitalisation (speed and cost) and real-world modelling offers unparalleled benefits. The domain of coastal engineering is one such example, where costly construction and repairs at ports and harbours are preceded by simulations, as well as three-dimensional physical models in an 11 000 m<sup>2</sup> coastal and hydraulics laboratory (page 102).

Also read about how the CSIR Transport Safety Laboratory **supports national efforts** to reduce road fatalities and improve transport infrastructure (page 88) and how researchers at the CSIR's energy storage testbed developed a practical recycling protocol for Mintek (page 86).

As you explore this edition of *ScienceScope*, I invite you to see these facilities as engines of possibility. The CSIR is a space where science, infrastructure and people come together to shape a more resilient, inclusive and innovative future for South Africa and the continent. I also invite you to contact our experts to explore how these specialised facilities can support your own innovations and strengthen your competitiveness.

**Dr Thulani Dlamini**  
**CSIR Chief Executive Officer**

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# HEMP “AS GOOD AS GLASS” FOR CAR TRIM

*Grow-A-Car yields first plant fibre-based boot liner*



**F**ibreglass composites used in automotive trims like boot liners can easily be replaced with hemp fibre composites, say CSIR researchers. This follows testing of fibres and materials developed at the Natural Fibre Hub in the Eastern Cape.

The Natural Fibre Hub is a joint facility of the CSIR and the Coega Development Corporation (CDC), featuring two factories in the Coega Special Economic Zone (SEZ) outside the city of Gqeberha.

“It’s a facility that produces different types of customised non-wovens, which can be used as a reinforcement in composites, and then we can use these as interior trim structures in automotives,” says the CSIR’s Dr Maya Mathew. “These are non-load bearing parts currently made from glass fibres and polymers, and the glass fibres can be easily replaced by plant fibres.”

She says the technical properties of hemp and other plant fibres are highly similar to glass, but they offer the added benefit of being lighter, leading to fuel savings. Hemp is also a renewable resource and sequesters carbon while growing.

These benefits, along with a rise in local hemp farming, led researchers to start the Grow-A-Car project in Coega. The project will create a new value chain of car parts in which local farmers, factories and everyone in between can actively take part.

“Earlier on, we had a lot of restrictions on the growth of hemp plants because of the connection to cannabis,” says Mathew. “But now the restrictions have been lifted, and we see that there’s a lot of farmers, a lot of SMMEs, who are involved in growing these hemp plants.”

Andy Radford, who manages the Natural Fibre Hub on behalf of the CSIR and the CDC, says the process for growing a car part starts in the field, with fast-growing summer crops of hemp, which are naturally resistant to pests and weeds.

“The fibres grow for approximately two-and-a-half to three months,” he says.

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Once they're harvested, the fibres lie on the ground to be retted, a process of semi-rotting that breaks down the harder lignins.

"Thereafter, it gets into a decortication process, which takes the fibre off the core or hurd, and is then ready to be baled and brought to a facility such as ours," he says. "Our facility cleans the fibre as well as cottonises it. Cottonisation turns the tough hemp fibres into a cotton-like form suitable for dry spinning.

"Once cottonised, it can be blended with plastic – typically 30% natural fibre and 70% plastic – and can be put through our non-woven line."

From there, the non-woven product goes into a thermo-compression moulding process to shape it into the parts required by the automotive industry.

Prototypes and materials that are being developed at the Coega pilot facility, including a new boot liner designed for a specific vehicle brand, will undergo quality and durability testing at the CSIR's Polymer Characterisation Facility and its Textile Testing Laboratory in Pretoria. These facilities, which are supported by the Department of Science, Technology and Innovation and the Department of Trade, Industry and Competition, ensure that products meet specific industry standards.

"We can test the properties of the non-wovens, like the tensile strength and water vapour permeability," says Mathew. "We can look at the chemical composition, and the abrasion and peeling resistance of the fibres."

While the boot liner prototype will be absorbed as a local product supplying a major automotive company, several other customised product lines are currently in development at the Natural Fibre Hub as part of the Grow-A-Car initiative.

"Effectively, it's linking the farmer, right through to the factory for the first time," says Radford, adding that the project provides a platform for fundraising to take the project from the Eastern Cape to a national level.

"It will prolong the life of the auto industry in many respects, for the simple reason that it's ticking the localisation box," he says. "It's also creating jobs,



Non-woven hemp composite material goes into a thermo-compression moulding process to shape it into parts required by the automotive industry, such as the boot liner prototype being inspected by facility manager Andy Radford.



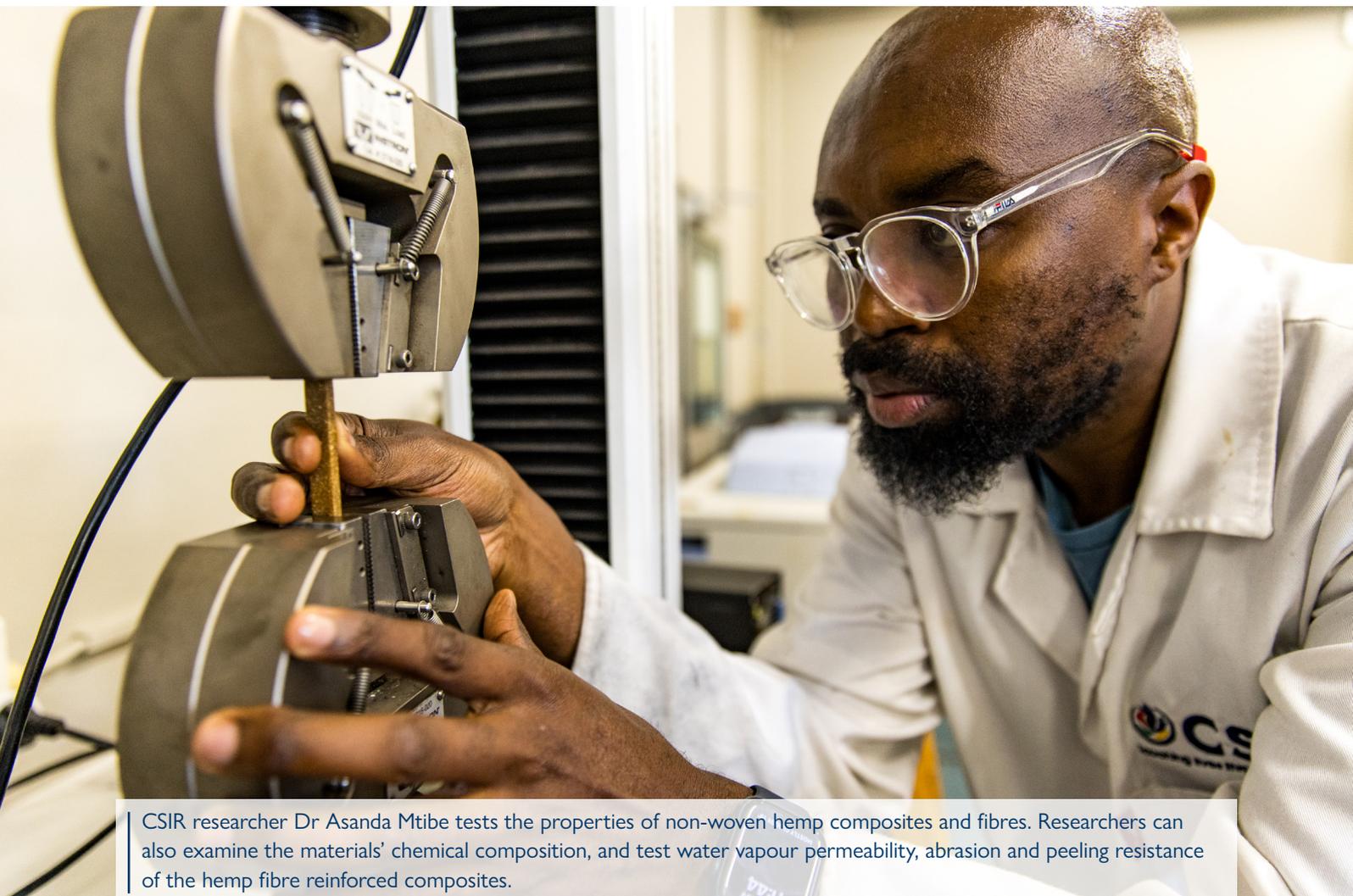


After harvesting, hemp fibres lie on the ground to be retted, a process of semi-rotting that breaks down the harder lignins. Thereafter, it gets into a decortication process, which takes the fibre off the core or hurd, and is then ready to be baled and brought to a facility like the Natural Fibre Hub in Coega, Eastern Cape. Facility workers then clean the fibres and convert the tough hemp fibres into a cotton-like form suitable for dry spinning (above).



Researchers at the CSIR's Polymer Characterisation Facility inspect various samples of non-woven hemp composites manufactured at the Natural Fibre Hub in Coega, Eastern Cape. These materials will be used as interior trim structures in automobiles. "These are non-loadbearing parts currently made from glass fibres and polymers, and the glass fibres can be easily replaced by plant fibres," says the CSIR's Dr Maya Mathew (left).

*(continued overleaf)*



CSIR researcher Dr Asanda Mtibe tests the properties of non-woven hemp composites and fibres. Researchers can also examine the materials' chemical composition, and test water vapour permeability, abrasion and peeling resistance of the hemp fibre reinforced composites.

but primarily jobs in the field, where there are great opportunities."

Mathew agrees that in the long run, the Grow-A-Car project will help revive both the agricultural and manufacturing sectors of the country. Plans are in place to set up community cooperative groups that will supply hemp to decortication plants, which will then feed into facilities like those at the Natural Fibre Hub.

While the Grow-A-Car initiative focuses on the automotive industry, Mathew and Radford say their facilities will also diversify to support other sectors over time.

"Currently, the Natural Fibre Hub processes hemp on a toll manufacturing basis for partners, and it will be fully

commercialised and scaled as applications are developed in future," says Mathew.

The CSIR invites farmers and manufacturers to open discussions on new product lines for development and testing.



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**SCAN TO WATCH**

## HEMP “AS GOOD AS GLASS” FOR CAR TRIM

South Africa’s Grow-A-Car project yielded its first plant fibre-based boot liner prototype. The CSIR’s testing confirmed that fibreglass composites used in automotive trims can be replaced with hemp fibre composites, which are lighter and eco-friendly. The prototype was developed alongside an automotive supplier at the Natural Fibre Hub, a joint facility of the CSIR and the Coega Development Corporation. It was tested for quality and durability at the CSIR’s Polymer Characterisation Facility and its Textile Testing Laboratory in Pretoria, which are supported by the Department of Science, Technology and Innovation and the Department of Trade, Industry and Competition.

This boot liner prototype is destined to be absorbed as a local product supplying a major automotive company. Several other customised product lines are currently in development at the Natural Fibre Hub in Coega, Eastern Cape, as part of the Grow-A-Car project. CSIR researchers who have tested these prototypes say fibreglass composites used in automotive trims can easily be replaced with hemp fibre composites.

# WE ENSURE LOCAL TEXTILES ARE DURABLE AND SAFE

*CSIR Textile Testing Laboratory supports industry with scientific performance testing*





**S**outh African textile manufacturers, retailers and researchers now have access to advanced scientific testing that helps ensure textile products are safe, durable and compliant with international standards before they reach consumers. Through its specialised Textile Testing Laboratory, the CSIR provides performance evaluation and material characterisation services that assess how textile materials behave under real-world conditions.

The CSIR Textile Testing Laboratory conducts a wide range of tests to evaluate the quality, durability and safety of textile materials and finished products. These services include fibre identification, colour fastness testing, mechanical strength evaluation, flammability testing and chemical analysis, as well as verification of compliance with national and international standards.

For manufacturers and textile companies, such testing is essential before products enter the market. Fabrics may lose colour, shrink, tear or degrade when exposed to washing, light, friction or heat. Without proper scientific evaluation, manufacturers risk releasing products that do not meet customer expectations or regulatory requirements.

“Textiles are used in many areas of everyday life, from clothing and uniforms to protective equipment and household products. It is important to ensure that these materials perform as expected and meet recognised quality and safety standards,” says Enn Fortuin-Billings, a textile expert at the CSIR.

The testing process begins with fibre identification and composition analysis, which determine the types of fibres used in a material, such as cotton, polyester, nylon or blended fabrics. This helps verify whether a textile product matches its specifications.

Colour stability is another important performance factor. The laboratory conducts several colour fastness tests, including colour fastness to washing, rubbing, light and perspiration. These tests determine whether dyes fade, bleed or transfer when fabrics are washed, worn or exposed to environmental conditions.

*(continued overleaf)*



Mechanical strength testing is also critical. Tensile strength testing measures how much force a textile can withstand before breaking, while tear strength testing evaluates how resistant a fabric is to tearing during use. These tests are particularly important for products such as garments, bags, workwear and industrial fabrics.

To evaluate long-term durability, the laboratory performs abrasion resistance testing, which measures how well a fabric withstands wear and friction. Dimensional stability testing assesses how much a material shrinks or changes size after washing or drying, while measurements of fabric thickness and weight help determine comfort, durability and performance.

“For functional textiles such as sportswear, our laboratory conducts moisture and water absorption testing to determine how fabrics absorb and release moisture. Fire safety is evaluated through flammability testing, which measures how easily a textile ignites and how quickly it burns when exposed to flame,” says Fortuin-Billings.

Chemical testing is used to identify dyes, finishes and other chemical treatments present in textile materials, helping to detect harmful substances and ensure compliance with safety regulations. In addition, advanced thermal and material characterisation techniques allow researchers to study how textile materials behave when exposed to heat or other environmental conditions.

All testing is conducted according to recognised standards such as those of the International Organization for Standardization, American Society for Testing and Materials and South African National Standards, ensuring that the results are credible and internationally comparable.

The CSIR Textile Testing Laboratory is equipped with specialised instruments and has the flexibility to apply additional analytical approaches where needed, including methods drawn from international scientific research. This enables the laboratory to support not only routine quality control but also more complex research and product development challenges.

According to Fortuin-Billings, manufacturers benefit by ensuring their products meet performance requirements before they are sold, reducing the risk of product failure



Specialised instruments measure tensile (page 14) and tear strength (above) to determine how much force a fabric can withstand before breaking or tearing.



Scientists conduct advanced performance testing to evaluate the quality, durability and safety of textile materials and finished products, using specialised equipment and internationally recognised testing methods.

and costly recalls. Retailers gain confidence that the textile products they stock are reliable and compliant with standards.

Researchers and universities can use the laboratory's facilities to study textile materials and develop improved fabrics and technologies, while regulatory bodies rely on accurate testing data to ensure that textile products meet national and international requirements.

While laboratory testing provides valuable insights into textile performance, researchers emphasise that results are obtained under controlled conditions and may not always represent every real-life scenario. Factors such as how products are used, maintained or exposed to environmental conditions can influence their performance.

Another consideration is that the laboratory evaluates the samples submitted for testing. If samples do not represent the full production batch, results may not fully reflect the quality of all products.



A CSIR scientist conducts chemical analysis tests to help ensure that textile materials meet national and international safety and quality requirements.



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Fabrics are tested under conditions such as light exposure to evaluate how well their colours remain stable during use and care.

# CONSUMER PROTECTION: IS THAT PLASTIC COMPOSTABLE?

*CSIR pushes for testing and certification of biodegradability claims*





The CSIR has called for official measures to give consumers confidence in plastic materials labelled as biodegradable and compostable. Researchers say that the CSIR can scientifically test plastic products in line with international standards at its biodegradability testing laboratories, which will provide assurance that products can be composted under home or industrial conditions.

“Our laboratory is moving towards ISO17025 accreditation, which would allow traders or manufacturers to obtain certification stickers or logos on their products based on independent test reports from the CSIR,” says Sudhakar Muniyasamy, who heads up the CSIR’s biodegradation testing laboratory. “This would give the public a sense of trust in the biodegradability claims of a product.”

He says South African consumers should be wary of compostable microwavable containers, carrier bags, pet food packets, as well as takeaway boxes, straws and cups, that claim to be compostable.

“Compostability labelling is a major step towards combatting misinformation about biodegradability,” he says. “This is because many products are currently mislabelled as plastic-free, eco-friendly, earth-friendly or sustainable. Some products also do not clearly indicate whether a product may be safely composted at home, or if it must be binned for specialised industrial composting.”

In some cases, this mislabelling may be intentional “greenwashing”, where companies deceptively market their products as more eco-friendly than they really are. However, Muniyasamy cautions that in South Africa’s nascent industries, mislabelling is often not malicious, but rather because manufacturers, importers, distributors and consumers lack awareness and knowledge about the different standards of biodegradability.

Muniyasamy says labelling will therefore protect both consumers and suppliers. He adds that in general, biodegradability testing and certification help to reduce landfill waste by recycling organic materials, to decrease methane emissions and to improve soil health.

*(continued overleaf)*



CSIR researchers perform a carbon dioxide mineralisation test on bioplastic sheets under compost and aqueous media conditions, using automated respirometric techniques. The CSIR biodegradation testing facility can test the biodegradation conditions of any single-use plastic products beyond packaging, including how long the material will take to biodegrade in compost, soil, freshwater, marine water or anaerobic digestate.



“The CSIR biodegradation testing facility is the only one of its kind in Africa and we work closely with regulatory bodies like the South African Bureau of Standards (SABS) to ensure both environmental and consumer protection, and to support the local biodegradable plastics manufacturing industry,” says Muniyasamy.

“In fact, our team assists SABS in developing national standards for biodegradation in South Africa.”

The facility can test the biodegradation conditions of any single-use plastic products beyond packaging, he says, including how long the material will take to biodegrade in compost, soil, freshwater, marine water or anaerobic digestate.

“We are also training young people in the science of biodegradation under these different conditions, and on the importance of certifiable biodegradation standards to protect consumers,” he says. “This is so that as a country, we can make sure these standards are actually brought into local manufacturing with those young people who enter the job market.”

Muniyasamy says the laboratory has already confirmed the compostability of several prototype single-use plastic materials developed at the CSIR, including [mulch films used in pineapple farming](#), [medical diagnostics kits](#) and [surgical aprons](#) and [heat-stable food packaging](#).

When these products are licensed to local manufacturers, the CSIR’s independent and scientific test results will provide an endorsement of biodegradability claims to put the public at ease.



CSIR researcher Nomvuyo Nomadolo performs tests in the biodegradation laboratory.

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# HEALTH, COSMETIC INDUSTRIES WELCOME AFRICA'S FIRST MICROENCAPSULATION DEVELOPMENT FACILITY

*Local manufacturers now less reliant on similar but costly overseas facilities*

**T**he CSIR has launched a facility that will, for the first time, help local manufacturers develop their own microencapsulation technologies on home soil. Microencapsulation is a way of protecting sensitive components in health and cosmetic products, such as probiotics and essential oils, thereby improving shelf-life and efficacy.

The Supercritical Carbon Dioxide Encapsulation Facility was set up following an investment of R25.9 million by the Department of Science, Technology and Innovation.

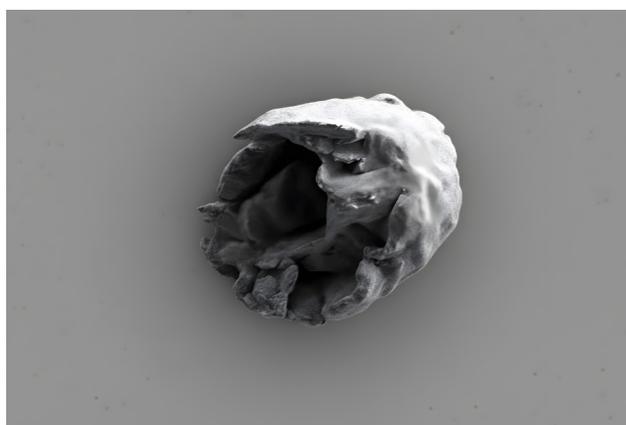
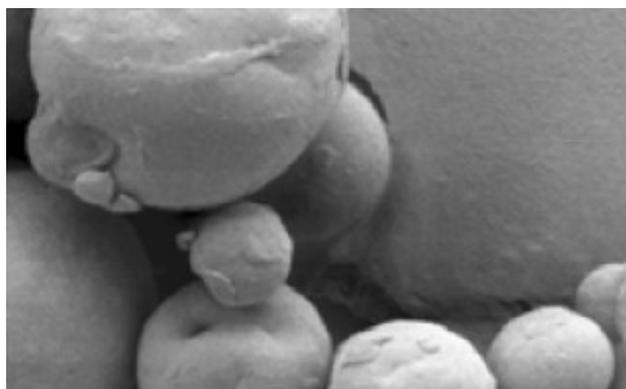
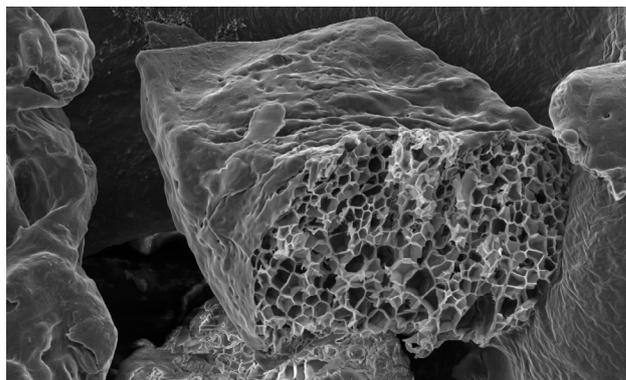
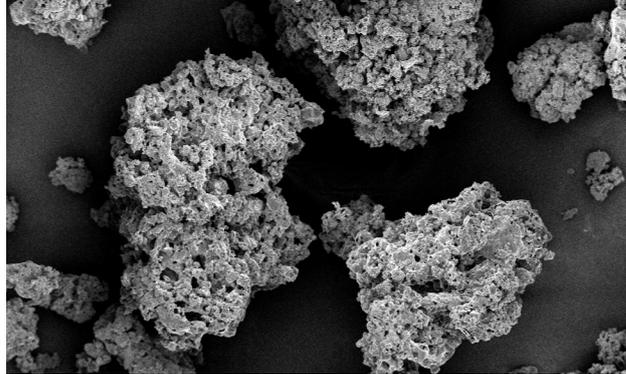
At the launch event in 2025, CSIR Chief Executive Officer Dr Thulani Dlamini, said the facility “opens the door for local researchers, entrepreneurs and manufacturers to develop, refine and scale new innovations right here at home, reducing reliance on international facilities and accelerating the path from laboratory to market.”

He was referring to innovations in product formulations that use supercritical carbon dioxide as a process medium to create microcapsules that protect delicate ingredients. The carbon dioxide used in this microencapsulation process is not in gas or liquid form, but rather somewhere in between, in the so-called supercritical fluid state of matter.

The CSIR’s Dr Philip Labuschagne says the process works by first dissolving supercritical carbon dioxide into a mixture of active ingredients and coating materials. The solution is then rapidly sprayed through a nozzle, releasing the carbon dioxide for later re-use, producing a fine powder of microcapsules (the active ingredient, encapsulated within the coating material).

“In your final powder product, you get tiny particle sizes of between 10 and 100 microns, and your active ingredient, whether it is a vitamin or even an oily liquid, is then dispersed within the particles,” he says.

Labuschagne says products that could benefit from a supercritical carbon dioxide-based encapsulation technology include nutritional health supplements that are sensitive to oxygen, moisture, heat or stomach acid such as probiotics, phytochemicals and volatile essential oils or plant extracts that evaporate easily.



Scanning electron microscope images of microparticles produced using supercritical carbon dioxide. At the CSIR’s new facility, local cosmetic and health companies can now develop their own new product formulations to protect sensitive ingredients, thereby improving shelf-life, efficacy and stability.

*(continued overleaf)*

Adelia Pimentel, executive director of the Cosmetic, Toiletry and Fragrance Association of South Africa, says that her industry body foresees several benefits of microencapsulation for local businesses and consumers, including better product stability, efficacy and shelf-life.

“The specific types of companies that will benefit from this particular facility would be anti-ageing and skincare brands,” says Pimentel, adding that the technology will boost innovation in fragrance, personal care, sensitive skin, make-up and other premium products.

“And then, of course, the sustainability and safety factor is always something that is important,” she said.

Labuschagne explains that the microencapsulation process requires no toxic organic solvents and takes place at relatively low temperatures, usually below 40 degrees Celsius. “It’s really a green and safe process, and most of the carbon dioxide, which is sourced and recovered from waste processes, is recycled back into the system,” he says.

Local gut health supplement business Velobiotics already uses the CSIR’s facilities to produce microencapsulated formulations of probiotics. The process ensures that their products can survive the highly acidic stomach environment on their way to the intestines where they are active.

Successful microencapsulation and protection of probiotics were confirmed by the CSIR using various in-house analytical techniques.

“The CSIR is one of the biggest stakeholders we have, because this facility is the only one available in Africa,” says Velobiotics CEO, Dr Chomba Chuma, who now sees several of his company’s gut health products on major retailers’ shelves.

In his view, the new facility is a “beacon of African excellence” and a “launchpad for African biotech”.

“I want to thank the CSIR for believing in innovation, and the DSTI for supporting it,” says Chuma. He also says that without the CSIR’s scientific support, scaling his business would have been unaffordable.



The CSIR’s Dr Philip Labuschagne (right) and the CEO of local gut health supplement business Velobiotics, Dr Chomba Chuma, discuss the microencapsulation of probiotics at the CSIR’s Supercritical Carbon Dioxide Encapsulation Facility.

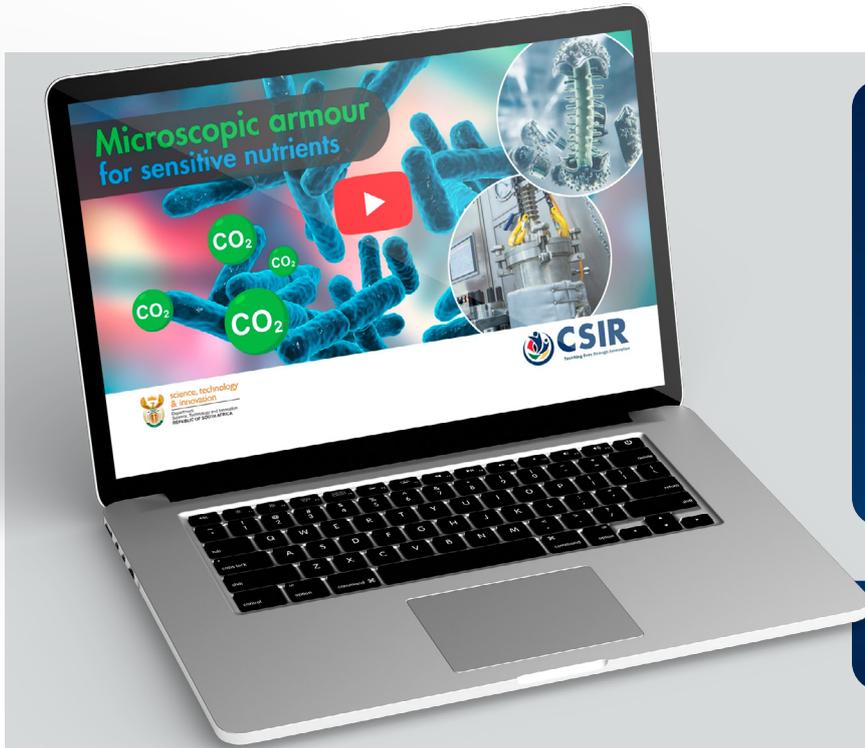


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**SCAN TO WATCH**

## MICROSCOPIC ARMOUR FOR SENSITIVE NUTRIENTS - SUPERCRITICAL CO<sub>2</sub> MICROENCAPSULATION TECH NOW AT CSIR

Health and cosmetic industries have welcomed Africa's first microencapsulation development facility located at the CSIR in Pretoria. Microencapsulation using supercritical carbon dioxide (CO<sub>2</sub>) as a process medium is a way of protecting sensitive nutrients in products like probiotics, essential oils, supplements and medicines, thereby improving shelf-life, bioavailability and efficacy. This CSIR facility helps local manufacturers develop their own microencapsulation technologies on home soil, rather than relying on expensive overseas facilities.



Supercritical carbon dioxide encapsulation technology yields a fine powder of microencapsulated product. First supercritical carbon dioxide is dissolved in a mixture of active ingredients and coating materials. The solution is then rapidly sprayed through a nozzle, releasing the carbon dioxide for later re-use. Products that could benefit from this microencapsulation technology include probiotics or nutritional supplements that could be vulnerable to stomach acid, and volatile essential oils or plant extracts that evaporate easily.

# TAKE OUR WOUND-HEALING SALVE TO THE SHELF

*Slow-release oxygen tech for diabetic wounds ready for small pharma*





CSIR technician Thandubuhle Kweyama removes a cylinder of wound-healing powder from the supercritical carbon dioxide microencapsulation machine. Once supercritical carbon dioxide has been dissolved into a mixture of active ingredients and coating materials, the solution is rapidly sprayed through a nozzle. This produces a fine powder of microcapsules containing the active ingredient, calcium peroxide.

**C** SIR researchers have created market-ready protective microcapsules containing a novel wound-healing formulation. Studies confirm that the microcapsules, which can be used as a powder, in ointments or as a film lining for plasters, allow for a sustained, slow release of oxygen that promotes cell growth and repair.

Dr Lerato Hlekelele, a material scientist at the CSIR, says it is well documented that chronic or severe wounds, such as diabetic ulcers, heal slower due to a lack of oxygen at the wound site. This is often caused by impaired circulation, leading to hypoxemia (low blood oxygen).

He says his team began investigating polymers that could supply oxygen directly to injured skin after seeing the devastating effect that severe wounds had on a former colleague. “A gentleman who used to work here with us on polymer processing was diabetic and both of his legs had to be amputated because of wounds that wouldn’t heal,” he says.

“If the product we have now was well-known and available in the market, I’d like to believe that perhaps this gentleman may still have had his legs.”

Hlekelele’s team pinpointed calcium peroxide as an ideal source of oxygen early on, but the problem was that it would react very quickly with moisture in the wound, releasing oxygen too fast. Their slow-release solution, developed in just 18 months, was to encapsulate this sensitive ingredient at the microscopic level using a CSIR-patented method that relies on supercritical carbon dioxide (CO<sub>2</sub>).

Natural, food-grade biopolymers common to many skin products are used to encapsulate the calcium peroxide, forming a protective barrier that prevents oxygen from being released too quickly.

“The process works by first dissolving supercritical carbon dioxide into a mixture of active ingredients and coating materials,” says the CSIR’s Dr Philip Labuschagne, the man behind the patent. The solution is then rapidly sprayed through a nozzle, releasing the carbon dioxide for later re-use and producing a fine powder of microcapsules (the active ingredient, encapsulated within the coating material).

*(continued overleaf)*

“Once the oxygen is released when applied to a wound, the calcium part of the calcium peroxide interacts with the polymer coating to form a gel, which enables the material to congeal nicely on the wound,” says Hlekelele. “So, we have killed two birds with one stone, so to speak, in that this product has the dual action of oxygenation and gelation.”

Microbial testing further showed that the combination of these ingredients prevents the growth of bacteria and fungi, which in turn prevents a potentially deadly antibiotic-resistant biofilm forming on the wound.

Tests at the [CSIR's bioengineering facility](#) also confirmed that the powder stimulates wound closure and does not damage skin cells. Scientists compared the powder with other wound-healing products on the market, as well as a control where no product was applied.

“We specifically tested the product on human dermal fibroblast cells that were donated to the CSIR. These cells make up a key layer of skin that produces collagen and elastin, which help with structure and elasticity,” explains Hlekelele. “They are essential for wound closure because they migrate to the injury site, proliferate and synthesise new molecules for tissue repair.”

In the lab, researchers grew a consistent layer of cells and then created a scratch, leaving a gap that mimics a physical wound.

“We then monitored how effectively the cells migrated and proliferated to bridge that gap,” says Hlekelele. “By measuring the rate at which the space closes, we can quantify exactly how much our technology speeds up the natural healing process.”

With microencapsulation, safety and efficacy confirmed, the next task was to ensure that local companies interested in commercialising the product would have something customers would readily buy at their local dispensary.

The team's market research showed that while the synthesised powder product would appeal to some patients, others may prefer to apply a salve or a plaster.



CSIR researchers have created market-ready protective microcapsules, which can be used as a powder (top), in ointments (middle) or as a film lining for plasters (bottom). The formulation consists of calcium peroxide encapsulated within a coating of natural polymers. When applied to a wound, oxygen releases slowly to boost cell growth and repair, while the calcium component interacts with the polymer coating to form a gel; this enables the material to congeal nicely on the wound.



Tests at the CSIR's bioengineering facility confirmed that the powder stimulates wound closure and does not damage skin cells. Researchers grew skin cells and then created a scratch using a pipette tip. This leaves a gap that mimics a physical wound. They then monitored how effectively the cells migrated and proliferated to bridge that gap. By measuring the rate at which the space closes, they could quantify exactly how much the wound-healing product speeds up the natural healing process.

"We have now designed three ways to apply our material," says Hlekelele. "It can be used directly as a powder, which would, for instance, work well as a dry product for soldiers or others working in remote environments. But we have also incorporated it into an ointment that applies very smoothly. Lastly, we used the [CSIR's compression moulding facility](#) to create a film that can be placed on the wound underneath a plaster."

He says the CSIR calls on small but established local pharmaceutical businesses to [formally express their interest in licencing these three products](#). "The CSIR would then assist the business to establish and scale up its manufacturing at our Supercritical CO<sub>2</sub> Microencapsulation facility, which is the only pilot facility of its kind in Africa."

The facility was established to support local health and cosmetic industries, thanks to an investment of R25.9 million by the Department of Science, Technology and Innovation.

Speaking at the [facility's launch in 2025](#), CSIR Chief Executive Officer, Dr Thulani Dlamini, said that the facility "opens the door for local researchers, entrepreneurs and

manufacturers to test, refine and scale their innovations right here at home, reducing reliance on international facilities and accelerating the path from laboratory to market."

One such innovation already on the market is a microencapsulated probiotic sold by local company Velobiotics.

"Being part of [the CSIR team assisting with Velobiotics' product](#) and seeing the response, seeing that these products are helping people, makes me want to see this wound-healing technology out there as well."



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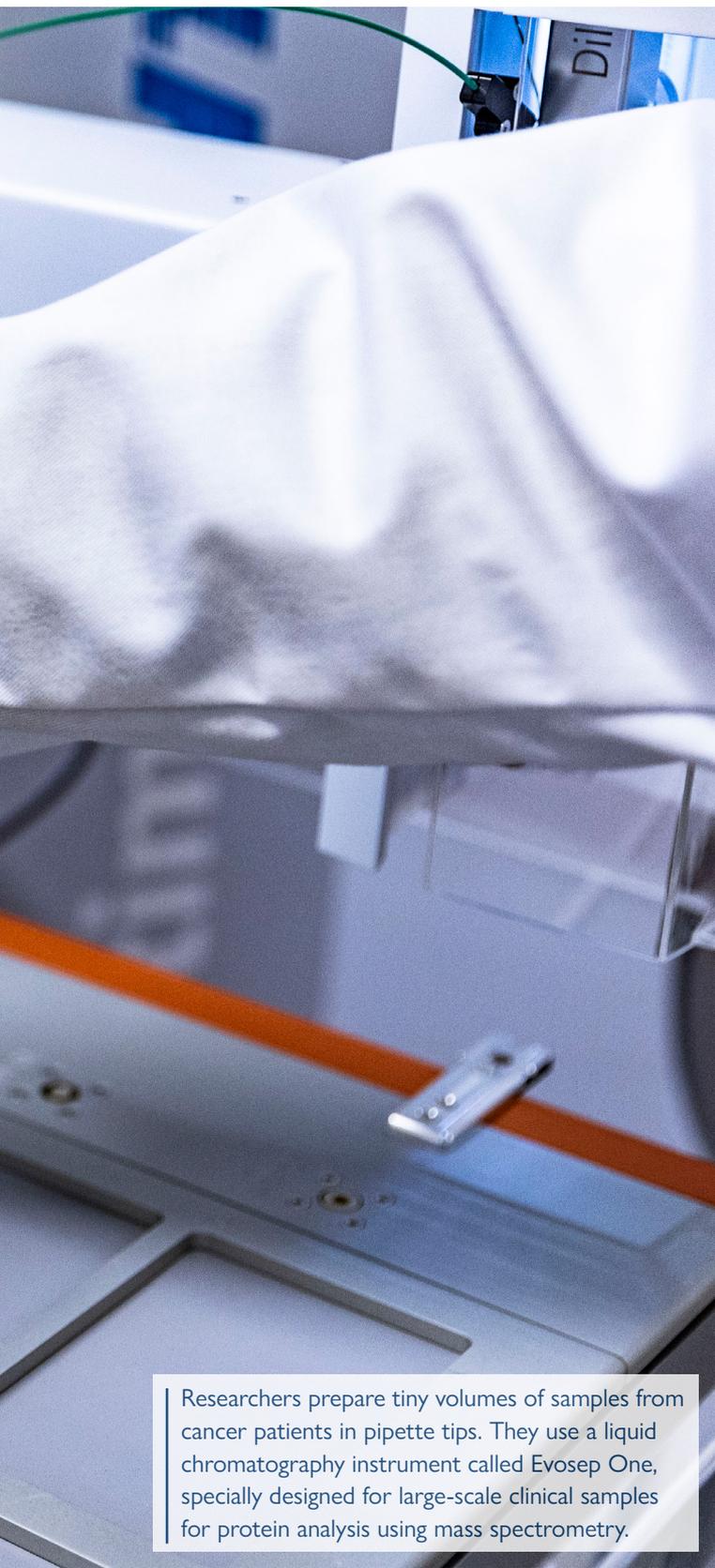
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# AFRICAN RESEARCHERS TO MAP BIODATA OF AFRICAN CANCER PATIENTS

*CSIR Clin-MAP platform centres African diversity in healthcare*





Researchers prepare tiny volumes of samples from cancer patients in pipette tips. They use a liquid chromatography instrument called Evosep One, specially designed for large-scale clinical samples for protein analysis using mass spectrometry.

## The CSIR has partnered with Ghanaian biotech firm Yemaachi to map African cancer patients' DNA, RNA and proteins.

In February 2025, Yemaachi and global pharmaceutical giant Roche initiated a project called The African Cancer Atlas (TACA) to address the lack of African genomic data in global cancer research. The CSIR has now joined TACA's effort to collect biological and health data from up to 7 500 African cancer patients.

The resulting database will help scientists and clinicians discover new cancer biomarkers and targets for drug development, ultimately improving outcomes for patients of African ancestry.

"We've recently signed a memorandum of understanding with Yemaachi to begin a pilot study focused on breast cancer across diverse African geographies," says Dr Jerolen Naidoo, one of the lead scientists behind the [CSIR's African Clinical Multiome Atlas Platform \(Clin-MAP\)](#).

The collaboration with Ghana on the TACA project is ideal, he says, because the CSIR has an established clinical research network covering southern Africa, whereas Yemaachi's reach extends into eastern, western and northern Africa.

"We're coming together to look at how we get representation; how do we accurately capture the mosaic of diversity that is representative of our continent? Our continent is so diverse geographically, so we need to have multiple clinical sites," says Dr Tracey Hurrell, a Clin-MAP co-lead.

"The African Cancer Atlas is not just about filling a data gap; it is about creating a model for inclusive and equitable research," said Yaw Bediako, CEO of Yemaachi Biotech, in a [public statement](#).

Using patient samples derived from clinical sites linked to university hospitals and other research institutes across Africa, CSIR researchers will contribute to TACA in this pilot study by mapping the proteomic signatures of disease by analysing how proteins like enzymes, hormones and antibodies (the proteome) interact to dictate a patient's clinical state.

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“The CSIR’s proteomics facility is a core national research centre equipped with a state-of-the-art mass spectrometer,” says Dr Ireshyn Govender, a Clin-MAP co-lead and head of the CSIR proteomics platform.

The CSIR is currently one of the only institutions in South Africa with the additional facilities and expertise in-house to overlay this protein data with DNA (genomics), RNA (transcriptomics) and microbiomics data. This generates what scientists call the multiome (multiomics).

“Our unique offering as the CSIR is that we have all of the different technologies to profile and study genes, proteins and gut microbes in one place,” adds Hurrell. “And, through additional international partnerships with a US-based pharmaceutical company and a US-based artificial intelligence (AI) analysis platform (PromptBio), we will go even further by integrating single-cell multiome and organoid technologies with AI-powered analytics for deeper insights.”

Naidoo says that in the same way Google Maps layers live-traffic data, satellite imagery, road maps and user reports to help drivers navigate from A to B, Clin-MAP layers genomics, transcriptomics, proteomics and microbiomics data to help researchers and clinicians navigate disease from diagnosis to treatment.

“What we’re doing is creating multiple layers of information to go from a basic and static atlas of disease to a dynamic, interactive and multilayered digital map of clinical data,” he says.

Govender says the TACA cancer multiomics pilot study, like other studies the Clin-MAP team have undertaken around tuberculosis and autoimmune disease, will help advance Clin-MAP’s two main goals: to support researchers and clinicians, and to enable the development of diagnostics, prognostics and treatments tailored to Africa’s unique genetic and clinical diversity.

“Clin-MAP prioritises ethical data stewardship and real-world impact, aiming to translate scientific discoveries into tangible health benefits for African communities,” he says. The team has also made a point of responsible data categorisation by focusing on geography and clinical subtypes rather than simplistic ancestry labels for different populations.





The CSIR's Clin-MAP platform is led by Dr Tracey Hurrell (top left), Dr Jerolen Naidoo (top middle) and Dr Ireshyn Govender (top right). The platform relies on the CSIR's proteomics facility to map the signatures of proteins like enzymes, antibodies and hormones in disease.

The data and insights generated by projects like Clin-MAP and TACA are expected to extend beyond research into industry: they can support local drug and diagnostic discovery and manufacturing, while offering Africa-specific data to local biotech startups and global players without compromising data sovereignty or ethics.

 More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/health/genomics/multiomics>

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# WE CAN MAKE PAIN RELIEF DRUGS MORE AFFORDABLE

*New pharma tech yields first local batch*

The CSIR's FuturePharma facility is home to Africa's first large-scale continuous flow pilot plant, which will produce Celecoxib, the active ingredient in a common anti-inflammatory pain drug. This CSIR active pharmaceutical ingredient innovation project is supported by the Department of Science, Technology and Innovation and the Technology Innovation Agency. The CSIR works with companies to develop their process for kilogramme-scale production, after which the company would set up their own continuous flow facility and begin manufacturing.

**S**outh African researchers have successfully used a new technology to produce Celecoxib, the active ingredient in a common anti-inflammatory pain drug that is currently only available to private sector patients.

The production process for this active ingredient was recently scaled up at the CSIR's new FuturePharma facility in Pretoria, using an emerging technology called continuous flow chemistry. This builds on foundational research conducted by the University of Pretoria.

"In the private sector, Celecoxib is a routine treatment but in the public sector people don't readily have access to it," explains CSIR chief researcher Dr Jenny-Lee Panayides. "So, if you have an inflammatory disease like rheumatoid arthritis, you are often given alternatives that don't provide adequate relief."

She says this problem originally prompted researchers at the University of Pretoria to devise an affordable way to produce Celecoxib locally. With funding from the Department of Science, Technology and Innovation, they patented a continuous flow process at laboratory scale and then partnered with the CSIR to establish the industrial-scale process.

Continuous flow production has many advantages over traditional batch manufacture and this ultimately lowers the cost of drugs. Instead of a single bespoke factory that produces one active pharmaceutical ingredient *en masse* in giant vats, in a continuous flow facility the chemical reactions occur in a continuously flowing stream through tubes. The reactions can be tightly controlled, so the process is safer, more efficient and more precise.

The facility also has a much smaller footprint, both in terms of space and environmental impact. "We've measured these green chemistry parameters for our Celecoxib production, for instance; you use less electricity, less water and there are fewer by-products and less wasted solvent."

Critically, a single plant can also produce many different types of drug ingredients, in any amount required.

While Celecoxib is a molecule potentially required in huge quantities to help treat arthritis, menstrual cramps and other inflammatory pains, the same continuous flow facility can even produce drug ingredients required in small amounts for rare disease therapies, without needing massive additional investment from the manufacturer.

"Big Pharma typically produces low-volume drugs at a high cost because they've got to have a whole production facility for a very small run," says Panayides.

Even for hazardous or toxic drugs, like highly potent cancer chemotherapies, continuous flow offers advantages. "Those typically must be manufactured under extreme conditions, with workers wearing hazmat suits and self-contained breathing apparatuses to avoid exposure. With continuous flow, you only ever handle small amounts, so it is much safer than batch manufacture."

The CSIR's FuturePharma facility is home to Africa's first large-scale continuous flow pilot plant.

"We've invested heavily in the localisation of this technology. The active pharmaceutical ingredient manufacturing industry is limited in the country and on the continent, so continuous flow gives us a leapfrogging advantage over legacy investments in batch facilities," says Panayides. "It's an industry that we want to establish and we want to allow for backward integration of existing companies and new entrants that can fill this gap."

She says that the CSIR works with companies to develop their process for kilogramme-scale production, following which the company would set up their own continuous flow facility and begin manufacturing.

"They will have access to all our data to build a good business case for investment in their own production facility. They would then buy commercial equipment that is similar, if not the same as what we've got," she says. "We would then do a direct technology transfer, with no additional scaling up required."

Panayides says the Covid-19 pandemic was a wake-up call for Africa to establish its own pharmaceutical manufacturing sector and become less reliant on imports.

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“With borders closed at that time, there was a worldwide shortage not just of Covid-19 vaccines, but also antibiotics, anaesthetics and many other active pharmaceutical ingredients,” she says.

Celecoxib, for instance, is not a finished drug product; it is an active ingredient that still needs to go to another factory to be put into a tablet, capsule or syrup form as a pain medication. While South Africa has an established industry in formulating and packaging drugs, most of the active ingredients are currently imported, despite making up a large portion of the cost of the final drug one buys at a pharmacy.

“What most people misunderstand is that while South Africa has fantastic multinational and local companies doing formulations, we need to secure our own active ingredient supply.”

Local manufacture is therefore the way to go, says Panayides, adding that local academia and basic research play a crucial role in establishing Africa’s pharmaceutical industry.

The Celecoxib success emanating from the University of Pretoria shows that the CSIR is well placed to catalyse the shift. “We’re building an open innovation facility and we’ve shown that we can work together and that this model actually works,” she says.

For Panayides, it’s about building an ecosystem of research and industry that supports wider access to medicines, especially in the public sector. “As the CSIR, we want to improve the quality of life of South Africans, so we would like to see the Department of Health having affordable access to drugs like Celecoxib. While it is not a life-or-death drug like an antibiotic, it will drastically improve quality of life for patients.”

Her team is currently in talks with local manufacturers to produce Celecoxib under licence from the CSIR and she invites other universities and pharmaceutical companies to partner with them for other avenues of research and product development.

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Benchtop continuous flow reactors and integrated analytical equipment at the CSIR's FuturePharma facility enables initial proof-of-concept process development. Once the drug ingredient production process is established here, it can be upscaled using the CSIR's large continuous flow facility.

# SOUTH AFRICA NOW MAKES CRITICAL MOLECULE FOR LAB-GROWN MEAT

*CSIR upscales growth factor production for local biotechnology firm*





Microbiologists grow bacteria at scale to produce and purify a commercial molecule.

**A** local biotechnology firm announced that it will produce a key molecule used internationally to grow meat products more sustainably. This follows the successful industrial scale-up of the molecule's production process in CSIR bioreactors, with funding from the Department of Science, Technology and Innovation and the Technology Innovation Agency.

Immobazyme, a South African start-up, originally approached the CSIR with a bacterial strain they had genetically modified to produce fibroblast growth factor 2 (FGF-2). This protein gives the signal to mammalian cells to multiply and proliferate, so it is essential for meat grown in a laboratory (commonly called lab-grown meat).

“Companies specialising in cell-cultivated meat take a cell from a cow or a fish or a chicken. They take it to the laboratory and then they make that one cell become many cells and eventually those many cells become a food product,” says Nick Enslin, Chief Commercial Officer and co-founder of Immobazyme.

Growth factors such as FGF-2 are added to guide and sustain the meat growth process, but these molecules have traditionally been very expensive to produce and are therefore costly for lab-grown meat companies.

Dr Veshara Ramdas, a biotechnology expert at the CSIR, says that when the Immobazyme team shared the potential value of FGF-2 for the global cultivated meat industry, her team saw an excellent business case to scale up their production process at the CSIR Biomanufacturing Industry Development Centre (BIDC).

“They brought the technology for us to look at development and scalability,” says Ramdas, adding that the CSIR's task was to develop a cost-effective and efficient process using precision microbiology and bioreactors.

First, microbiologists establish sterile and stable conditions and ensure that only Immobazyme's genetically modified *E. coli* is growing in the bacterial culture, as well as the protein of interest. The culture starts in a petri dish, grows further in a flask with ideal nutrients and is then transferred to large vessels known as bioreactors.

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Bioreactors are precisely controlled in terms of temperature, nutrients and other process parameters to ensure that the *E. coli* efficiently produces FGF-2 on a large scale.

“When we harvest the bioreactor, that whole broth then goes through a separation process,” says Ramdas. The liquid component is separated from the *E. coli* biomass.

Next, the FGF-2 protein must be cleanly extracted from the *E. coli* and purified. “Our product is based intracellularly, so we have to pop those cells open or break them open, in a process of mechanical disruption,” she says.

The broken *E. coli* cells are then removed from the mixture through centrifugation, a high-speed spinning process that forces heavy cell material to sink to the bottom of a container while the target protein remains in a clear liquid at the top.

“This clarified lysate goes through a purification process,” says Ramdas. The result is a pure protein powder of FGF-2 ready for cell culture in the lab-grown meat industry.

“For the first time in South Africa, we were able to demonstrate a process for this growth factor at a 50-litre bioreactor scale,” she says. “It is a huge achievement for the CSIR and this opens doors to other novel and unique technologies to localise, particularly fibroblast growth factors and others such as insulin growth factors.”

Enslin says the industrial insight gained through the collaboration with the CSIR is invaluable for its business going forward and the company also benefitted immensely from training provided by Ramdas and her fellow CSIR colleagues.

“The BIDC is an incredible facility; it is a world-class facility,” he says. “But I would almost say beyond the facility itself, the equipment and the machinery, there was this flow of ideas; it was a collaborative effort.”

He says the future holds larger-scale manufacturing for FGF-2, as well as other proteins and products they have in the pipeline. As a small firm, they will continue using the large facilities at the CSIR in Pretoria to bolster their own production.

“The fact that Immobazyme took a unique and new construct that they had developed and produced this FGF-2 in a cost-effective manner puts them in a competitive position compared to what is available internationally,” says Ramdas.

“At the end of the day, we got commercially viable product through this relationship, which is really cool to see,” says Enslin.



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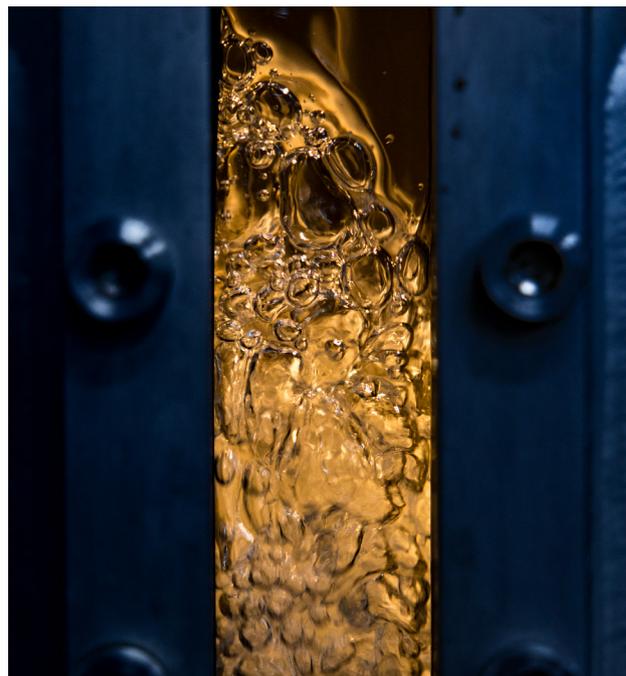
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The production process of FGF-2 was successfully upscaled using world-class bioreactor facilities at the CSIR. Bioreactors are precisely controlled in terms of temperature, nutrients and other parameters to ensure that the *E. coli* efficiently produces FGF-2 on a large scale.



**SCAN TO WATCH**

**▶ SOUTH AFRICA NOW MAKES CRITICAL MOLECULE FOR LAB-GROWN MEAT**

Immobazyme, a local biotechnology start-up, approached the CSIR with a bacterial strain they had genetically modified to produce a commercial protein called fibroblast growth factor 2 (FGF-2). This protein gives the signal to mammalian cells to multiply and proliferate, so it is essential for the laboratory-grown meat industry. The production process of FGF-2 was successfully upscaled at the CSIR with funding from the Department of Science, Technology and Innovation and the Technology Innovation Agency, under the Biomanufacturing Industry Development Programme.



Immobazyme, a local biotechnology start-up, approached the CSIR with a bacterial strain (left) they had genetically modified to produce a commercial protein called fibroblast growth factor 2 (FGF-2). This protein gives the signal to mammalian cells to multiply and proliferate, so it is essential for the lab-grown meat industry.

# NO SPOILERS: FROM FRESH PRODUCE TO NON-PERISHABLES

*Nutritional purees, desserts and soups year-round*





Several small local businesses will soon start manufacturing fruit and vegetable products at scale using a new food processing facility at the CSIR. The facility hosts a continuous-flow microwave food processing unit, which pulps and sterilises fruits and vegetables to make desserts, purees and soups that do not need to be refrigerated.

“This technology improves the shelf life, nutrition and food safety standards of various products made from fruit, vegetables or any fine powder-blended food,” says Phatheka Ndzotoyi, who heads up the agro-processing upscaling programme at the CSIR.

Her team set up the pilot facility at the CSIR in Pretoria and is now working with small business to develop new products and processes.

While this unit is the first of its kind in South Africa, Ndzotoyi says several factories in the United States of America are already producing product ranges using similar units at industrial scale following approval by America’s food safety regulatory body, the Food and Drug Administration.

“The CSIR microwave processing unit converts fresh fruits and vegetables into highly nutritious purees that can then be sterilised, allowing for storage of between 12 and 24 months without refrigeration,” she says. “We can thus process a continuous supply of raw materials that would otherwise have gone to waste as fresh products or have been discarded as surplus waste stock.”

This approach also gives consumers year-round access to nutritious fruits and vegetables that are not in season.

Ndzotoyi’s team secured R18.8 million in funding from the Department of Science, Technology and Innovation (DSTI) to establish the microwave processing facility. This funding also enabled her team to incubate three local start-ups looking to reduce food waste through innovation, namely Food Masters Africa, Manini Holding and Tanolemon.

Three more small enterprises specialising in orange-fleshed sweet potato products will soon be added to the fold: Kgarose Kgaros, Sibocali Foods and Success Foods. CSIR

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The CSIR agro-processing team in front of the new continuous-flow microwave food processing unit. This unit is the first of its kind in South Africa and supports product innovation for small business with support from the DSTI. From left: CSIR senior engineer Kersch Naidoo, senior process engineer Lucia Motsa, senior researcher and programme manager Phatheka Ndzotoyi and senior process engineer Trishen Reddy.

nutrition and food safety experts previously incubated these businesses to help them unlock the economic potential of this healthy root vegetable, which is often hampered by post-harvest losses and fragmented supply chains.

Since market analysis showed that more than 90% of consumers find orange-fleshed sweet potato products acceptable, processing to reduce waste and improve shelf life offers a solution.

Success Foods was able to develop an orange-fleshed sweet potato cooking flour, while Kgarose Kgaros produced their SweetPot Delight Porridge and Sibocali Foods created breakfast flakes that can be eaten with milk.

This initial product development phase was funded by the Technology Innovation Agency (TIA) and implemented by the Agricultural Research Council, the CSIR and the Southern Africa Network for Biosciences (SANBio).

“TIA has also been a partner in our microwave processing project since inception and would now like to use the new facility to help these orange-fleshed sweet potato enterprises upscale production for retail markets,” says Ndzotoyi.

Ndzotoyi says that while the pilot-scale microwave facility has already been successful, they have had feedback from industry that an industrial-scale facility able to process any fruit or vegetable would be beneficial for the sector.

The CSIR has thus applied for additional funding from the DSTI to build an industrial-scale microwave processing equipment at its campus in Pretoria.

Furthermore, they have managed to secure funding through the National Treasury to include a digital twin pilot for food innovations. This will allow the processing of all fruits and vegetables.

These upgrades will help address critical food safety challenges with on-site processing, while stimulating economic growth, decreasing food waste and loss and increasing food security.



New equipment at the CSIR, known as a continuous-flow microwave food processing unit, pulps fruits and vegetables to make desserts, purees or soups. From there, the products are packaged sterilely so that they do not need to be refrigerated. The unit enables nutritional products to be made year-round from raw materials such as fresh produce that would otherwise have spoiled or surplus food waste such as peels.



CSIR process engineer Lucia Motsa operates the CSIR microwave processing unit. Pureed fresh fruits and vegetables are processed, sterilised and packaged, allowing for storage of between 12 and 24 months without refrigeration.

“Our microwave processing unit does not compete with industry; on the contrary, it enables local production using the best modern technologies with the support of highly skilled food scientists and process engineers at the CSIR,” says Ndzotoyi.



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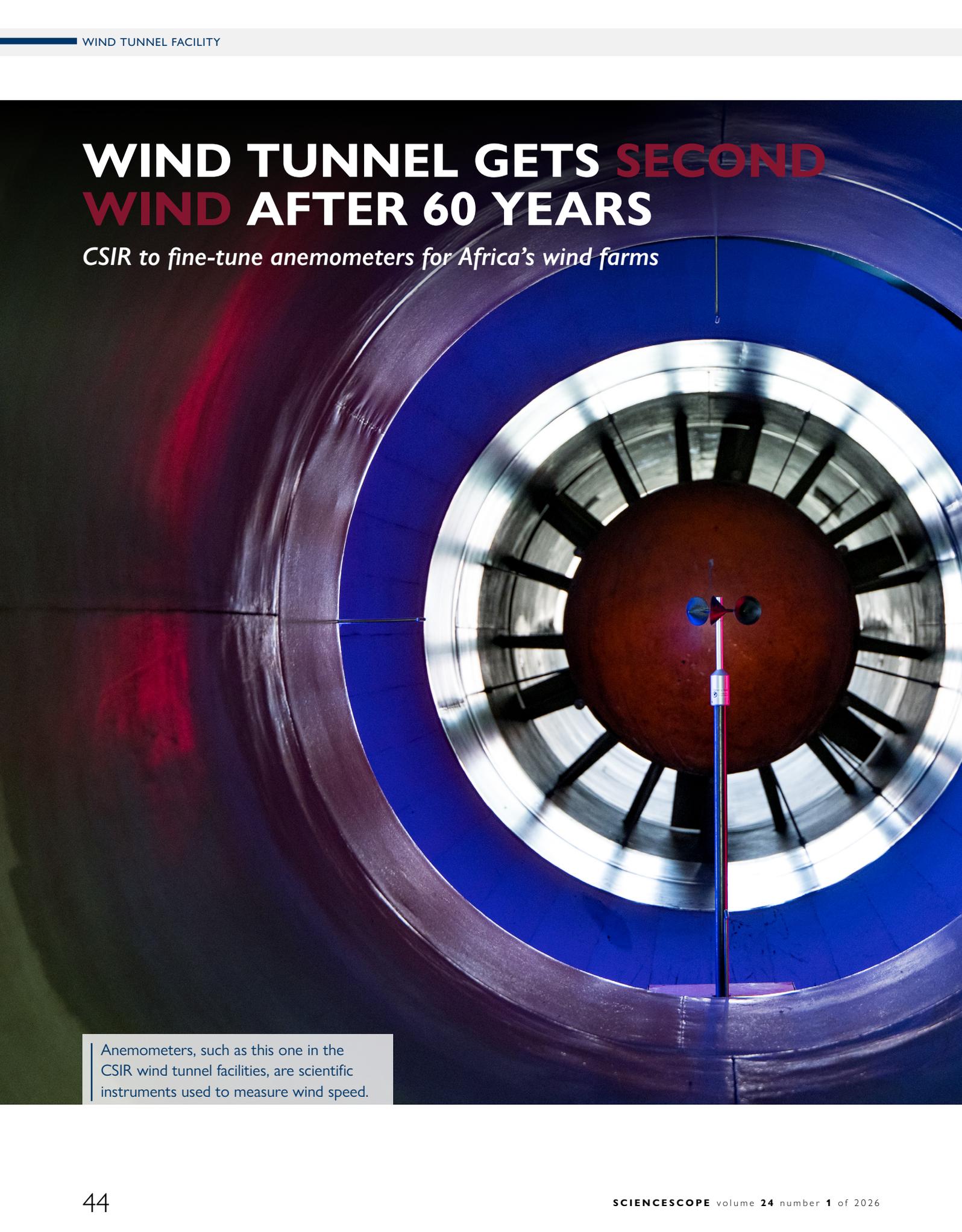
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# WIND TUNNEL GETS **SECOND** **WIND** AFTER 60 YEARS

*CSIR to fine-tune anemometers for Africa's wind farms*



Anemometers, such as this one in the CSIR wind tunnel facilities, are scientific instruments used to measure wind speed.



**B**y mid-2026, one of the CSIR's wind tunnels could become the first of its kind in the world accredited to calibrate anemometers, which measure wind speed. Industry experts say demand for affordable and local anemometer calibration in Africa is rising as offshore and onshore wind energy potential signal a boom in wind farm construction.

"Only nine laboratories around the globe are accredited to the international standard for anemometer calibration that wind farms need," says CSIR principal technologist Sarah Dikgale. She is leading the International Network of Wind Energy Measurement Institutes (MEASNET) accreditation process on behalf of the CSIR.

"Accredited laboratories are currently mostly in Europe and there are none in Africa or in the southern hemisphere," she says. "And yet, local wind farm installers need to calibrate the instrumentation used for site surveying and wind speed measurements to determine how much energy they can add to the grid."

The absence of local calibration facilities forces wind farm developers and researchers to send their instruments to Europe, resulting in costly delays and extended project downtimes.

Dikgale became aware of this problem through wind energy experts at the CSIR Energy Centre, who have been exploring ideal locations and solutions for wind energy generation along South Africa's coastline.

"We are looking at about 64 GW of potential between Saldana and Port Nolloth. Then there is also good potential around Cape Town, with around 6.4 GW," says CSIR energy expert Jan-Hendrik Grobler, citing the Offshore Wind Roadmap Study that was recently completed.

However, to realise this potential through wind farm construction, additional measurements of wind off the coast is needed. "Grobler's team is active in the wind energy research space that uses remote sensing LiDAR instruments, which require a calibrated anemometer for accurate measurements," says Dikgale.

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The CSIR has garnered support from the Department of Science, Technology and Innovation (DSTI) to upgrade the CSIR's two-meter open test section wind tunnel in Pretoria with a laser-based reference instrument used in anemometer calibration. The funding also enables the highly specialised process of MEASNET accreditation.

This open test section wind tunnel had been used primarily for aerodynamic testing since its construction in the 1960s. While wind anemometer testing was possible, the original instruments and protocols had become outdated and were undocumented.

Dikgale says the accreditation process should be completed by mid-2026. The move offers an entirely new avenue of testing at the CSIR's wind tunnels, which will support Africa's wind energy boom.

"This accreditation is not just about the CSIR and South Africa; the whole world is waiting for Africa to join the international community for anemometer calibrations," she says.

Importantly, all other MEASNET-accredited wind tunnels internationally have closed test sections for anemometer calibrations, whereas the CSIR could potentially offer calibration in open and closed test section wind tunnels.

"If we get this accreditation, we then have an opportunity to put together the newly recognised international standard for open test section wind tunnel calibrations and these conditions more closely resemble the real-world environment."

The CSIR's suite of wind tunnels are the largest and most sophisticated in Africa, operated by a team of highly skilled engineers.

"We are excited about the benefits in terms of technologies and how this could develop the country, create employment and harness our vast offshore and onshore wind resources," says Grobler, referring to the growing wind energy sector in general.

He says the new calibration facility will also support the Wind Atlas for South Africa, a publicly accessible wind energy resource map that the CSIR maintains in partnership with the [South African National Energy Development Institute \(SANEDI\)](#).



A panoramic view of the CSIR's open test section two-meter wind tunnel. The CSIR has garnered support from the DSTI to upgrade this wind tunnel's reference instrument to calibrate anemometers. The funding also enables the highly specialised process of obtaining international accreditation. The tunnel had been used primarily for aerodynamic testing since its construction in the 1960s.



CSIR researchers say demand for affordable and local anemometer calibration in Africa is rising as offshore and onshore wind energy potential signal a boom in wind farm construction.



“From our perspective as energy researchers, we are all passionate about energy and we really see that wind has potential for South Africa,” he says.

Grobler and Dikgale’s efforts form part of the [South African Renewable Energy Master Plan](#), launched by the government in 2025 to localise renewable energy manufacturing and accelerate the just energy transition. The plan is being implemented by SANEDI, through DSTI entities such as the CSIR.



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CSIR mechanical engineering technician Kgaugelo Mabeko (left) and principal technologist Sarah Dikgale prepare an anemometer for calibration in the two-meter open-air wind tunnel in Pretoria. The CSIR’s suite of wind tunnels are the largest and most sophisticated in Africa, operated by a team of highly skilled engineers. Dikgale’s team is obtaining international accreditation for wind anemometer calibration at the CSIR’s wind tunnels to support Africa’s wind energy boom.

# STRONG METAL PARTS HOT OFF THE PRESS

*CSIR Hot Isostatic Press Facility to boost local manufacturing*





The CSIR unveiled its state-of-the-art Hot Isostatic Press (HIP) Facility in Pretoria in 2025. This cutting-edge facility is set to revitalise local manufacturing by developing high-performance metal components for industries such as aerospace, medical, energy, railway and mining.

“We assist industries to develop their own process for hot isostatic pressing. We do this by identifying the parameters suitable for production of a particular component and we do research based on that,” says Maurice Maliage, a senior CSIR engineer.

As part of its mandate to modernise and rejuvenate local manufacturing, the CSIR's HIP facility is equipped with the latest technology to enhance the strength and durability of metal parts. The HIP process involves the densification of metal powders through elevated heat and pressure, transforming them into solid, high-performance components, even components with highly complex geometries.

This process minimises the need for welding or machining, significantly reducing material costs for local manufacturers.

The facility is therefore designed to support local companies in advancing their products by developing strong and durable metal components. It was established through the National Equipment Programme with funding from the Department of Science, Technology and Innovation.

Dion Greyling from Metallurgical and Manufacturing Services, an early client of the facility and a local metallurgical company, highlighted the significance of the HIP process: “We're very excited about the reintroduction of the HIP in South Africa, because this is the only HIP available for development and for possible commercial advancements.”

The CSIR's team of experts conducts rigorous tests before and after the HIP process, using metrology equipment and X-rays to ensure that the parts are free from pores and potential weak spots or defects.

*(continued overleaf)*

“We start by taking the part into the X-ray machine where we check for defects,” says Maliage. “From there we measure the dimensions of the part that is going to be pressed, and then we press at a certain temperature and pressure as requested by the client.”

After pressing, the part is again checked for pores or defects, and the dimensions are rechecked to ensure there are no distortions on the components or the material.

Greyling emphasised the impact of the HIP facility on the industry: “The actual mechanical properties that we’ve tested of the HIP product exceeds the powder manufacturer’s best results ever. It’s phenomenal that we can revitalise the industry.”

Where hot isostatic pressing is determined to be a cost-effective and efficient solution, the CSIR facility can strengthen metal parts on an ongoing basis right here in South Africa, supported by the latest material science research and development.

CSIR CEO Dr Thulani Dlamini describes the HIP facility as a significant step forward for the manufacturing sector. “For eight decades, we have been true to our mandate of fostering industrial development through science and technology,” he says. “We will continue to seek out opportunities to employ advanced capabilities that strengthen not only our innovation landscape but the robustness of industry and national competitiveness.”

The CSIR invites local inventors and component producers to engage its experts on joint technology development collaborations to build and modernise South Africa’s manufacturing sector.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/manufacturing/materials-and-manufacturing>

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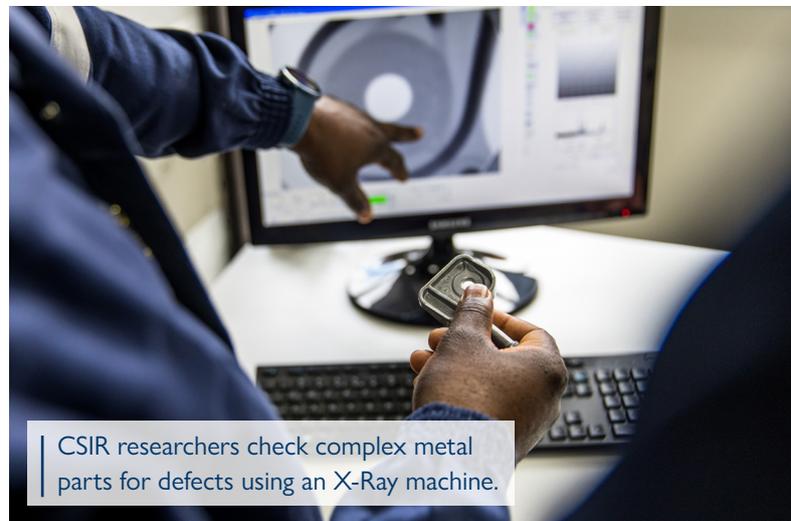
Maurice Maliage, a senior CSIR engineer, prepares the Hot Isostatic Press at the CSIR in Pretoria.



**SCAN TO WATCH**

## **HOT OFF THE PRESS: HIGH-PERFORMANCE METAL PARTS FOR THE SOUTH AFRICAN INDUSTRY**

CSIR engineers and researchers are helping local companies develop strong and durable metal components for industries as diverse as aerospace, medical, energy, railway and mining. Our hot isostatic press (HIP) removes pores and weaknesses from metal alloys, and can turn metal powders into solid, high-performance components with even the most complex of geometries. Where hot isostatic pressing is determined to be a cost-effective and efficient solution, the CSIR facility can strengthen metal parts on an ongoing basis right here in South Africa, supported by the latest material science research and development.



CSIR researchers check complex metal parts for defects using an X-Ray machine.

316L stainless-steel powder, a high-quality material used for 3D printing, produced at the CSIR.

# ULTRASONIC ATOMISER SHOWS ITS METTLE

*Titanium and stainless-steel powder for 3D printing produced at the CSIR*

**A**dvanced manufacturing experts at the CSIR have produced 10 kg of titanium powder to be used in the three-dimensional (3D) printing of aerospace and biomedical applications using its ultrasonic atomiser. This follows a batch of 8 kg of 316L stainless steel powder, which was the first material produced following the acquisition of the new ultrasonic atomiser facility.

In additive manufacturing, 3D printing can be achieved through a technique called powder bed fusion, where an object is constructed layer by layer using a heat source to fuse powder particles together.

The ultrasonic atomiser machine produces high-quality powders that have the required particle size, flowability and density needed in additive manufacturing, specifically for powder bed fusion techniques. Currently, South Africa depends on imports to access powders of this quality.

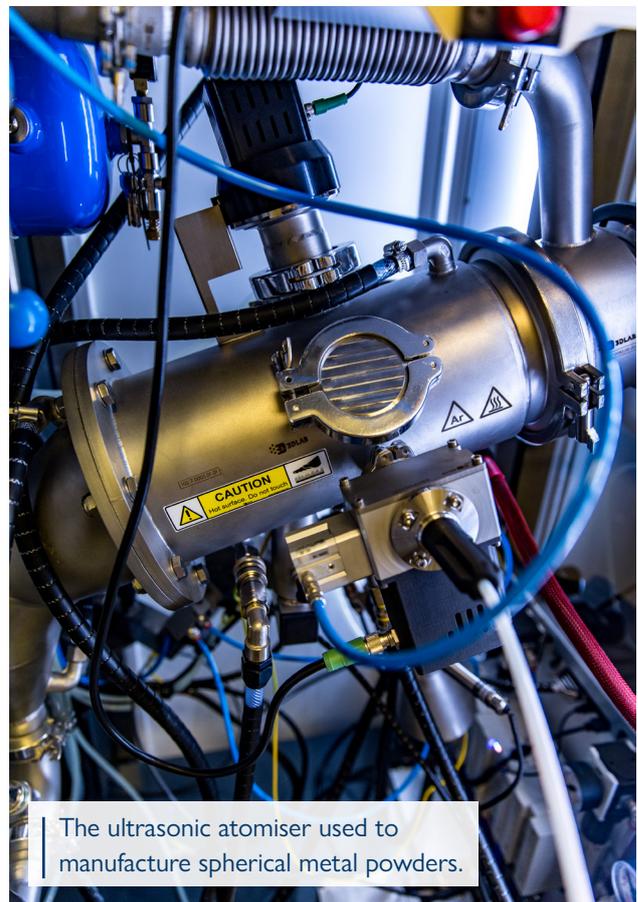
CSIR principal researcher Dr Ntombi Mathe says: "Our aim has been to create a sustainable local supply of high-quality stainless-steel powder, which currently has significant demand in the additive manufacturing space. Utilising our capabilities and expertise, we believe we can contribute to the establishment of locally produced powder to grow the advanced manufacturing industry. We are excited about the potential this holds for driving industrial growth and localisation."

The group has used the local atomised powder to 3D print prototype tools valuable for industrial use. The prototypes were manufactured using Hyrax, which was designed and manufactured by a local company called [Aditiv Solutions](#).

Mathe says: "By manufacturing our own metal powders and developing printers, we are fostering an ecosystem

where innovation breeds economic empowerment – advancing technology, supporting local businesses and creating job opportunities. This approach leads to a cycle of positive economic growth and development."

The ultrasonic atomiser machine was co-funded by the National Research Foundation, an entity of the Department of Science, Technology and Innovation.



The ultrasonic atomiser used to manufacture spherical metal powders.

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# WE'RE BUILDING A ROBUST 3D PRINTER FOR METAL PARTS

*Perfect for the factory floor, Metalix precision-prints complex designs fast*

**A**fter successfully 3D printing intricate, lightweight titanium parts like drone frames, gearboxes and throttle grips for the aerospace industry, the CSIR is now building a compact new machine that can print spare parts for mining, energy and various other sectors.

The machine, dubbed Metalix, is a CSIR design built by local manufacturers and suppliers.

CSIR engineers expect the Metalix pilot plant to be operational by mid-2026, ready to 3D print complex designs of steel, aluminium, nickel and other materials. Local manufacturers will have the option of using the CSIR's pilot plant for research, design, optimisation and contract manufacturing or installing their own Metalix machine on their factory floors.

Shaik Hoosain, a leading CSIR engineer, says Metalix is a new industrialised incarnation of the CSIR's Aeroswift printer, which fuses titanium powder layer by layer into aerospace components. Researchers demonstrated several successful builds with Aeroswift, including a drone frame, gearbox and throttle grip.

"Aeroswift is still one of the largest and fastest metal 3D printers in the world, designed and built here at the CSIR with government backing and in collaboration with local aerospace company Aerosud," says Hoosain.

What began in 2011 as an experiment in local additive manufacturing (commonly known as 3D printing), Aeroswift soon revealed demand for a more practical factory-floor machine to print complex metal parts beyond aerospace and beyond titanium. And so Metalix was born: a robust, compact 3D printer that can manufacture intricate steel, aluminium, nickel and other metal parts up to a size of 600 mm by 600 mm by 700 mm.

"The main advantage of additive manufacturing is that you've got design freedom," says Hoosain. "It's not here to replace conventional manufacturing processes; it has its niche applications where designs are complex and parts have intricate features."

He says manufacturers of valves, pump spares and other consumables serving the mine industry, as well as power, oil and gas sectors, can use Metalix to prototype and test designs quickly and affordably.



The CSIR's Aeroswift machine (right) 3D prints intricate, lightweight titanium parts like drone frames (left) and a leading edge cover (middle) for the aerospace industry. Learnings from the Aeroswift project over the last 15 years inspired a new robust factory-floor 3D printer for complex or custom steel, iron, aluminium and nickel parts.

“It saves quite a bit of time and costs compared to conventional processes or even engaging overseas suppliers, because you can design and print straight away, test the prototype and then iterate locally as required,” he says. “It also prints faster than conventional 3D metal printers because of the high-power laser we’ve incorporated, which heats and fuses the material much more quickly.”

In addition, unlike conventional machining from a billet, additive manufacturing does not waste any metal powder. “It is a green process in that you can recycle and reuse the powder,” says Hoosain.

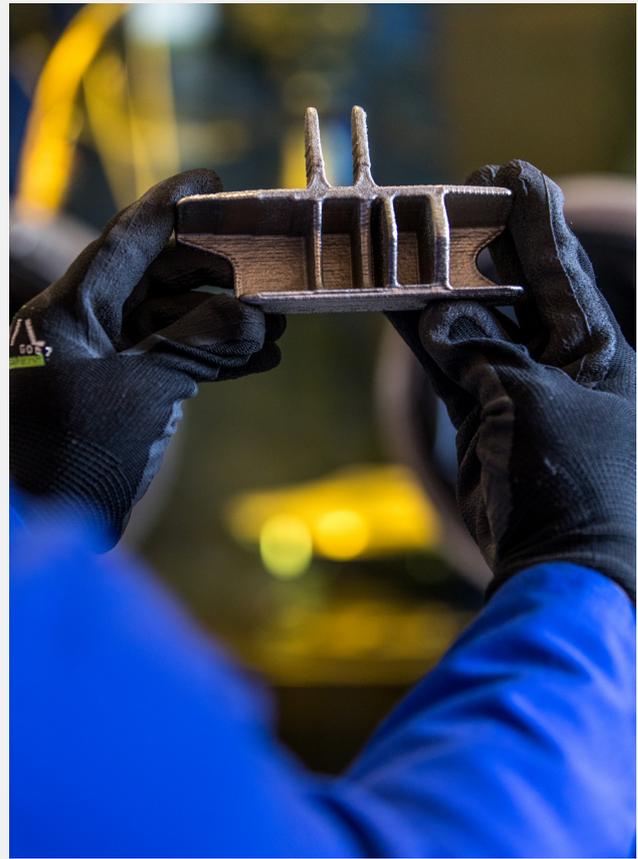
The CSIR also offers desktop design and simulation support to industry, whether companies have existing designs that need to be optimised before printing or are starting from scratch with a custom or once-off part.

“We do a lot of simulation work to de-risk every build and ensure a high rate of success,” he says.

Furthermore, the CSIR is home to an ultrasonic atomiser, which uses soundwaves to turn molten metal wires and rods into metal powders required for 3D printing. Researchers have already successfully created a high purity batch of stainless-steel powder (page 53), with plans to eventually supply a range of metal powders for Metalix.

Hoosain says that all subsystems for the CSIR’s Metalix pilot plant were manufactured by local suppliers and are currently being assembled at the CSIR in Pretoria. Once the plant opens its doors, factories will also be able to order their own machines from the CSIR, knowing that full installation and maintenance support is available from local suppliers through the CSIR.

This new, proudly South African machine can print larger parts than international competitors and it can print a wide variety of materials using different types of metal powders.



A 3D printed part at the CSIR’s advanced manufacturing facility. The CSIR is now assembling the first Metalix pilot plant, which is expected to start 3D printing complex steel, iron, aluminium and nickel designs by mid-2026. The machine was designed by the CSIR and consists of several subsystems manufactured by local companies.

The CSIR’s Metalix, Aeroswift, ultrasonic atomiser and other additive manufacturing facilities underpin the national drive to revive local manufacturing and are supported by the Department of Science, Technology and Innovation.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/manufacturing/laser-technologies/metal-additive-manufacturing>

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All underground miners in South Africa carry self-contained self-rescuers to provide oxygen in emergencies. By law, these devices must be tested at the CSIR to ensure every batch conforms to the highest safety standards so that lives may be saved. Upon arrival at the CSIR self-contained self-rescuer laboratory, the devices are fitted to breathing simulator machines for testing.

# NEW HUMANOID MACHINE CERTIFIES EMERGENCY BREATHING DEVICES FOR MINERS

*Building on over 90 years of zero-harm mining innovation, this machine is the latest addition to the CSIR's Cottesloe labs in Johannesburg.*

**A**ll underground miners in South Africa carry self-contained self-rescuers to provide oxygen in emergencies. By law, these devices must be tested at the CSIR to ensure every batch conforms to the highest safety standards, so that lives may be saved.

"These are rescue devices that miners carry underground," says Peter Rowlands, the business manager of local firm Afrox's self-rescue division. "They carry them 100% of the time that they're on shifts. They are carried on their belts, and they are intended to provide them with oxygen in the event of an emergency when they can't breathe."

To test whether the device will provide enough oxygen, stay cool, be easy to breathe from and last long enough for the wearer to get to a place of safety, Afrox submits samples from every new batch to the CSIR.

"The CSIR's self-contained self-rescuer lab in Cottesloe is the only one in the country, and likely in the SADC region," says CSIR senior engineer Michael Sehlabana.

Upon arrival at the lab, the devices are fitted to a humanoid breathing simulator for testing. While the latest machine to be added to the lab has a human head form, these machines are humanoid in the sense that they mimic a human's breathing almost precisely.

"If you put your hand in front of its mouth or outlet pipe, you can feel the breath," says Riaan Bergh, a mechanical engineer and testing expert at the CSIR. "What makes it special is that it exhales at the same temperature, humidity

and rate as a human, and when it inhales, it measures how difficult or easy breathing is."

The machine's artificial lungs also dose the out-breath with carbon dioxide (CO<sub>2</sub>) from a cylinder. This is to test whether the self-rescuer device binds CO<sub>2</sub>, to maintain easy breathing of oxygen for its human wearer – an important aspect considering that the device creates a closed or isolated system, meaning that no oxygen can enter and no CO<sub>2</sub> can escape into the surrounding air.

"We simulate the breathing of a human being and then we monitor the oxygen and carbon dioxide levels," explains Sehlabana. "We also monitor the temperature that is generated throughout the test, and we look at the breathing resistance, which is the difficulty of breathing from such a device."

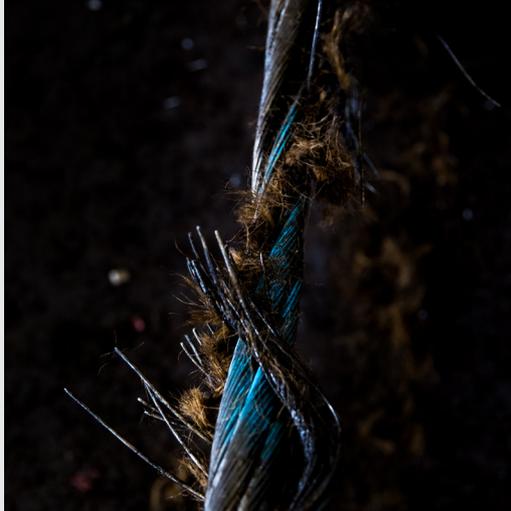
The team also checks the duration of oxygen supply from the device and compiles all the data into a report sent directly to the mine where the device will be used.

Sehlabana says that the testing is therefore an independent safety confirmation that miners, mine officials and authorities rely on.

"These CSIR laboratories are one of their kind – they are unique because regulators, in this case the Department of Mineral and Petroleum Resources, rely on our results," he says.

"We are pretty much joined at the hip," adds Rowlands, referring to the extent and quality of testing Afrox

*(continued overleaf)*



## ROPE TESTING LABORATORY

The CSIR rope testing laboratory provides a critical service for the mining industry: testing of steel winder ropes used to lift or lower people and goods underground, ensuring they can safely withstand massive forces.

requires from the CSIR. “We’ve got facilities to do the testing ourselves, but we really need to have that independent testing that the industry seeks from us.”

Sehlabana says the Cottesloe labs also provide two other critical services for the mining industry, namely testing of steel winder ropes used to lift or lower people and goods underground, and mechanical testing of mining supports, safety hooks and many other mechanical products that need structural testing.

“The mechanical lab opened its doors in 1935, so we have really been driving mining innovation for over 90 years,” he says, adding that there is no other facility in South Africa that can test self-rescuers; none that can test the steel winder ropes to the forces of 15 mega Newtons; and none that can test lifting tackle or electrical conductors that are 25 m long.

“The CSIR also continues to invest in the Cottesloe facilities, including a new visitors reception for clients who deliver test items or who want to witness the tests, and we invite power distribution line contractors, civil construction companies and heavy lifting and machine moving contractors in particular to come and explore our mechanical testing lab’s offerings,” says Bergh.

He adds that besides Afrox, other major self-rescuer manufacturers like DEZEGA and Dräger rely on the CSIR’s self-contained self-rescuer testing laboratory, while

rope suppliers of brands like Haggie, Bridon, Kiswire, Verope, Teufelberger-Redaelli and WireCo are long-term partners of the rope testing laboratory.

“This facility is very important to the South African economy because the work that is done here has an influence on how policies are developed, how zero harm is achieved in the mining industry and how manufacturers do their research and development,” says Sehlabana.

Another CSIR facility that promotes safety in the mining industry is the Kloppersbos fire and explosion testing and training facility located north of Pretoria. It offers competency-based training in mine emergency response, explosibility characterisation of coal dust and various industrial dusts, large-scale explosion suppression testing, fire testing of conveyor belts and batteries and coal dust explosion safety awareness training.

 More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/mining/mine-testing-and-training-services>

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**SCAN TO WATCH**

## MINES AND MANUFACTURERS RELY ON CSIR TESTING FOR SAFE, QUALITY PRODUCTS

The CSIR ensures that products in the mining industry and beyond are safe and of high quality. Our rope testing lab, self-contained self-rescuer lab, and our mechanical testing lab are national assets in terms of the facilities and expertise we have available to support South African businesses. For over 80 years, mines, manufacturers and users have relied on our technical expertise and testing facilities to adhere to legally mandated regulations and international standards, and for research and development.



### MECHANICAL TESTING LABORATORY

The CSIR mechanical testing labs have been driving mining innovation for over 90 years. It provides mechanical testing of mining supports, safety hooks and many other mechanical products that need tensile and compressive testing.

### FIRE EXPLOSION TESTING AND TRAINING FACILITY

The CSIR fire explosion testing and training undertakes tests for the evaluation of underground explosion suppression systems, as well as dust suppression systems. It is used for demonstrating large-scale coal dust or methane explosions during training sessions for underground workers.



CSIR robotics engineers are working on a reconfigurable, low-cost and rugged prototype mobility device called Buddy4Life, which will assist children, adults and caregivers affected by cerebral palsy. The team opted for a manual reconfiguration system in the prototype that is very simple, robust and doesn't require tools: a caregiver simply adjusts Buddy4Life's side supports by loosening and tightening built-in screws. From left: Zubair Suddoo, Willis de Ronde, Ruth Stubbs, Dr Sunveer Matadin and John Giani.



# CEREBRAL PALSY BUDDY4LIFE MOBILITY DEVICE

*Low-cost and rugged, it grows as you grow*

**C**SIR robotics engineers are working on a reconfigurable, low-cost and rugged prototype mobility device called Buddy4Life, which will assist children, adults and caregivers affected by cerebral palsy.

The device is one of several projects underway at the CSIR Centre for Robotics and Future Production, which develops bespoke robotics, wearables and automation systems for diverse applications across e-mobility, defence, space, manufacturing and health.

Dr Sunveer Matadin, a lead robotics researcher at the facility, says the Buddy4Life mobility device is destined for local manufacture. It will help reduce preventable deformities caused by improper seating, and will make seating adjustments easier for carers.

He explains that mobility aids are lifelines for families of children living with cerebral palsy. Unfortunately, assistive devices currently on the market are often unaffordable, with families needing to purchase larger ones as children grow.

“The size of these expensive existing devices is fixed, so children outgrow them and may develop deformities if they cannot get access to a larger, appropriately sized wheelchair at the next stage of life,” he says.

In addition, existing mobility devices can only provide support to toddlers from about age two, and not from infancy. “This is a major cause of deformity because by the time a child is fitted for a mobility

device, their muscles may have already developed imbalances or grown at different rates compared to their skeleton,” says Matadin.

The CSIR Buddy4Life is novel in that even a baby can be seated in it, and it can then be adjusted for size as the child grows. “There is nothing like this in the local market – it is designed to last a lifetime, supporting children from infancy through adulthood.”

The concept was inspired by a heartfelt plea in 2024 from community health worker and disability consultant Ruth Stubbs. She works with The Paige Project, a non-profit organisation that supports individuals and families affected by cerebral palsy.

“Early intervention is critical. If we don't intervene, deformities start setting in – you start getting scoliosis, which is the curvature of the spine; you start getting kyphosis; you get obliquity of the hips, of the pelvis. And these cause additional secondary complications to the existing diagnosis,” says Stubbs.

Matadin's team invited Stubbs to advise them on how an ideal mobility device would function to support children with CP as they grow, and they surprised her with a prototype on 26 November 2025. It features easy-to-adjust trunk supports, a footrest, a tray table, brakes and more.

“All the ideas and all the discussions that have happened over the last few months; there isn't one thing that hasn't been included,” said Stubbs in response to the surprise reveal. “It's like a magic wand!”

*(continued overleaf)*

Matadin says the current prototype is an outcome of phase one of the project, which is intended to provide relief in severely resource-constrained communities. It has been specifically designed to be easy to manufacture locally and incorporates light-weight, low-cost, but hardy materials.

“This is about helping children and adults with cerebral palsy as well as their families, but it is also about enabling small businesses to generate income by making this product locally,” says Matadin.

In phase two of the project, the CSIR’s robotics experts will integrate smart features, pneumatics and artificial intelligence, which will all help reduce frequent specialist callouts to help carers correctly seat children.

“The positive there is that the information can be sent to a central office where a specialist like Ruth, for example, could remotely direct even a non-expert to adjust the device,” he says.

Matadin stresses that a simple, robust design remains his team’s priority.

“Designing such a simple product to solve a complex problem really put our engineering and robotics know-how to the test,” says Matadin, explaining that it is relatively easy to make something functional with fancy mechanics and robotics, but designing a lightweight, simple-to-use, and easy-to-manufacture device with all the required degrees of freedom is far more difficult.

“So, this work is not out of place amid the work we do in space robotics, wearables like exoskeletons, and human-in-the-loop automation,” says Matadin.

The team opted for a manual reconfiguration system in the prototype that is very simple, robust and does not require tools: a caregiver adjusts Buddy4Life’s side supports by loosening and tightening built-in screws.

“This design is going to make it a lot easier for a caregiver to make the necessary adjustments,” says Stubbs. “What’s so amazing about it is that it grows and expands with the child, so it’s economical, it’s affordable, it’s practical, and

it speaks to seating that the family can get involved in and understand.”

Matadin’s team envisions that the two phases of the CSIR Buddy4Life project will help create an ecosystem that not only supports children who need it most in rural areas but can be scaled to benefit both resource-constrained and affluent communities worldwide.

“This is not only for poor communities, because if you have a standardised platform like this, even the richest of the rich will still benefit,” says Matadin.

Stubbs and Matadin say they will now work together to trial the prototype Buddy4Life in the field to inform further design improvements and to see how the device will address challenges carers face with existing mobility devices.

Stubbs explains: “If you put a child in and the child sits, is the footrest going to hold a spasm? Is the centre of gravity in place? Is it comfortable? Is there good head control? Is there good trunk control? Are they then able to bring their hands up onto the table and be interactive? Can they start self-feeding? How easy is it going to be for mom or a caregiver to transport it through the streets? Is it going to fit into a shack? Is it going to fit into an RDP house?”

On behalf of the CSIR team, Matadin invites non-profits, corporate social investment programmes, government and industry to support the technology development, manufacturing and distribution of the device as partners in the Buddy4Life project.

As with other technologies developed at the CSIR, the design will eventually be licensed to local manufacturers.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/manufacturing/robotics-and-smart-manufacturing>

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**SCAN TO WATCH**

## CEREBRAL PALSY BUDDY4LIFE MOBILITY DEVICE GROWS AS YOU GROW

CSIR robotics engineers announced they are working on a reconfigurable, low-cost and rugged prototype mobility device called Buddy4Life, which will assist children, adults and caregivers affected by cerebral palsy. The device is intended to help reduce preventable deformities caused by improper seating. In phase two of the project, the CSIR's robotics experts will also integrate smart features, pneumatics and artificial intelligence, which will help reduce frequent specialist callouts currently needed to help carers correctly seat children. As with other technologies developed at the CSIR, the design will eventually be licensed to local manufacturers.

The CSIR Centre for Robotics and Future Production also houses the CSIR Learning Factory, which provides a hands-on environment to develop industry-relevant skills – particularly in 4IR technologies – by combining theoretical learning and real-world application and demonstration. These factories are modular and customisable to suit specific sectors such as mining, automotive or aerospace.





# C-GULL RADAR SYSTEM TO FLY OVER FARMS, DAMS AND RAILWAYS

*New drone-mounted technology  
passes calibration testing in CSIR  
anechoic chamber*



CSIR engineer Hebert Tema demonstrates how the C-Gull's phased-array antenna focuses energy during testing in the CSIR's anechoic chamber. The array can be seen here as an ordered set of small golden rectangles. Instead of physically moving an antenna, this technology allows C-Gull to steer its radar beam electronically by precisely controlling the radio wave properties of many small antenna elements.

**C**SIR researchers developed a compact, specialised radar system that can be mounted on a drone to monitor farms, tailings dams, power lines, railways, mine walls and other critical infrastructure day or night, in any weather. The system, dubbed C-Gull, brings a powerful tool – previously limited to satellites and government use – closer to everyday civilian applications.

“If you are a farmer or a mining company, you do not want a satellite image only once a month,” explains Willie Nel, a leading radar expert at the CSIR. “By the time you see a problem, the damage has already been done.”

For decades, synthetic aperture radar (SAR) has largely been the domain of governments and defence agencies. These systems are expensive, power-hungry and complex to operate. What makes C-Gull different is not just its small size, but its intent: to make radar sensing practical, affordable and easy to use by business owners and local authorities responsible for service delivery.

“At scientific conferences, you will find that most of the papers are not about military applications, but are more focused on environmental and Earth observation applications such as monitoring earthquakes, disaster management and safety, such as monitoring dams. And also precision agriculture to monitor crops,” says Dr Ciara Blaauw, a principal engineer at the CSIR. “There are thousands of things people can do with SAR.”

Unlike optical cameras, radar does not rely on sunlight. It can “see” through clouds, smoke and rain, detecting subtle changes in the landscape over time.

SAR works by transmitting radio waves towards the Earth and measuring the signals that bounce back. The C-Gull works in the C-band of the radio frequency spectrum (5.5 GHz), hence the “C” in its name.

It is also the smallest member of a family of SAR systems developed at the CSIR, named after seabirds to reflect their different roles. The larger C-Hawk is designed for medium-altitude aircraft and the C-Eagle for high-altitude

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A 360-degree view of the C-Gull SAR system mounted on specialised equipment within the CSIR anechoic chamber. Researchers fine-tuned the radar system's precision beam using this large conical room where special materials absorb radio frequency reflections. The facility allows researchers to measure exactly what energy goes where and then to optimise it for real-world conditions.

unmanned aerial vehicles (UAVs), while the C-Gull focuses squarely on low-altitude, lightweight drones and local monitoring.

Nel and Blaauw are part of the team that designed, built and tested the C-Gull SAR system at the CSIR's facilities in Pretoria. They fine-tuned the radar system's precision electronic beamforming in a specialised testing facility called an anechoic chamber.

"This room is designed to absorb radio signals so that they do not reflect off the walls, floor or roof of the room, creating a very "quiet" environment for radio waves," says Katlego Mosito, the lead system engineer on the project.

This allows engineers to accurately test and adjust the direction and focus of the radar beam used by the SAR system.

"This facility allows us to measure exactly what energy goes where and then to optimise it so that when you use it in the real world, it performs as promised," Mosito adds. "We have also confirmed that the system works outdoors, using a rail facility installed on the roof of a building on the CSIR campus to emulate real-world conditions."

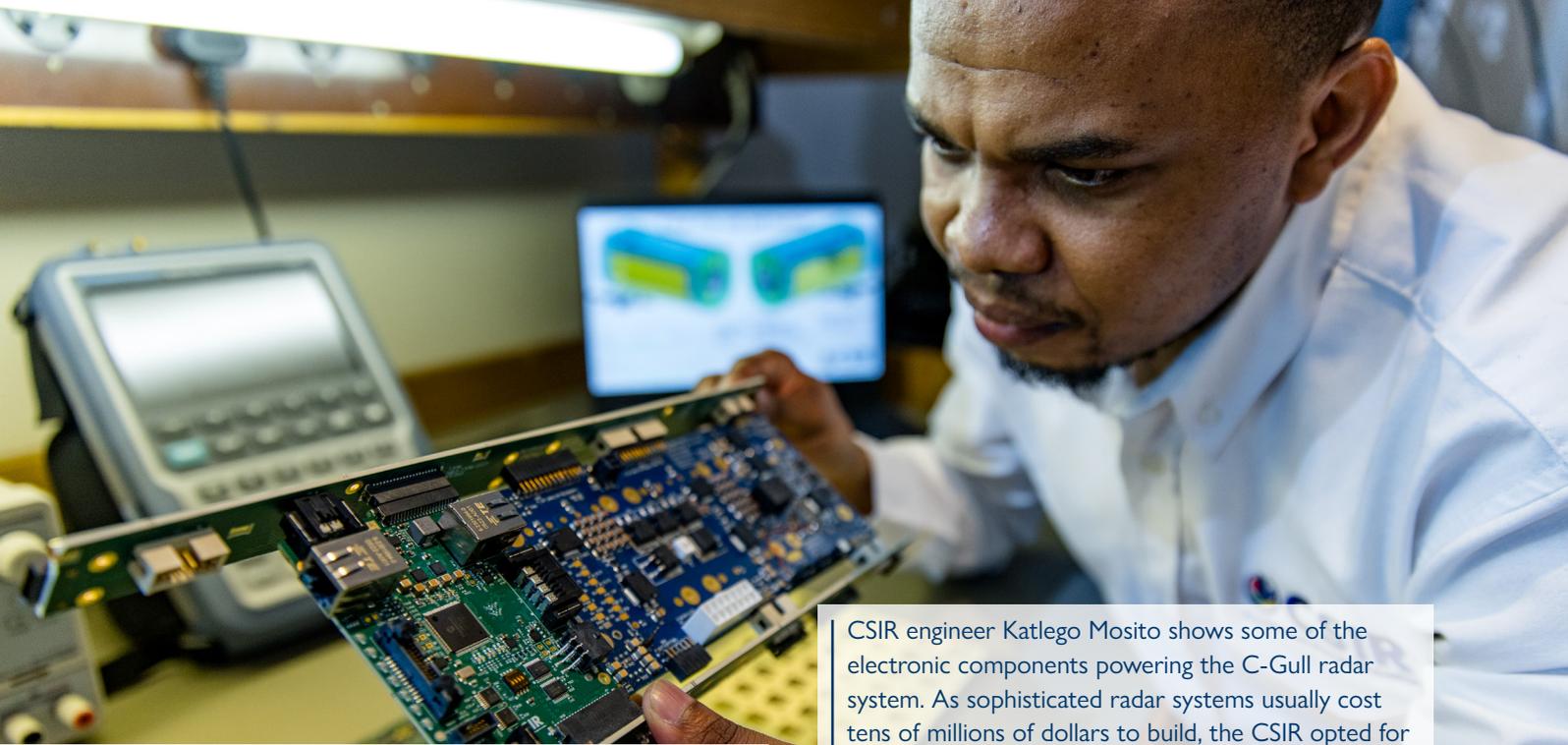
The research team has now moved on to real-world flight tests, with the C-Gull prototype mounted on drones or UAVs. A first demonstration flight took place in February 2026 at the CSIR in Pretoria, where the system was installed on a rotary-wing drone, imaging towards the N1 highway and the CSIR.

"These trials are crucial for system performance demonstration, as well as optimisation. For example, it ensures that the software is tweaked to correctly process radar data from a moving platform into geo-located, focused SAR images," says Mosito.

Nel says that a small SAR system on a UAV can be flown repeatedly over the same area, collecting consistent data to build a time-series view of change in the area.

This is invaluable for security and infrastructure monitoring: a rail corridor prone to theft can be flown daily; a tailings dam can be checked for water seepage or movements in the dam wall immediately after heavy rains and a farm can be assessed even during prolonged cloud cover.

The SAR system relies on an advanced antenna technology known as a phased array. Instead of physically moving the



CSIR engineer Katlego Mosito shows some of the electronic components powering the C-Gull radar system. As sophisticated radar systems usually cost tens of millions of dollars to build, the CSIR opted for affordable yet powerful commercial electronics, such as those used in cell phones, to reduce building costs by a factor of 100. The result is a system that delivers high-quality radar data while remaining economically viable for civilian use.



antenna to scan the radar beam, this technology allows C-Gull to steer its radar beam electronically by precisely controlling the radio wave properties of many small antenna elements.

“The radar can focus energy where it is needed, in the same way one would focus the beam of a torch rather than letting light scatter in all directions,” says Nel. “Radio waves behave like water waves, so we can use the analogy of dropping water into a pond: if you drop one drop, you see a circle; if you drop two at the same time, the waves interfere,” he explains. “But, by carefully timing many such drops, energy can be directed precisely; they add up in one direction and subtract everywhere else.”

One of the big barriers to using radar has always been how specialised it is. Evans Magaoga, lead software engineer on the project, says they worked hard to make the system easier to operate. “This way users do not need to be radar experts to get value from it.”

In practice, this means selecting an area on a map and choosing a flight path using software. “The system then handles the complex radar parameters behind the scenes,” says Magaoga.

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Such a sophisticated radar system would usually cost tens of millions of dollars to build, says Nel, but they have found a workaround using commercially available electronics.

“Cell phone components have become incredibly powerful and affordable, so we realised we could use those to build a SAR system for literally a hundredth of the price,” he says.

This meant the team had to rethink everything from radio-frequency connectors to processing hardware. In many cases, expensive defence-grade components were replaced with carefully designed circuit boards and commercial computing platforms, without compromising performance.

The result is a system that delivers high-quality radar data while remaining economically viable for civilian use.

With growing challenges like aging infrastructure, climate-driven extreme weather and the need to manage land and resources more sustainably, the C-Gull offers South Africans a way to detect problems earlier, respond faster and reduce risk.

“This is about changing who has access to and gets to use radar,” says Nel. “If we can make SAR useful to farmers, engineers and municipalities, then we have really succeeded.”

This team of radar researchers is already working with small UAV businesses and C<sup>3</sup>, the CSIR’s technology commercialisation vehicle, in preparation to move the C-Gull to market.

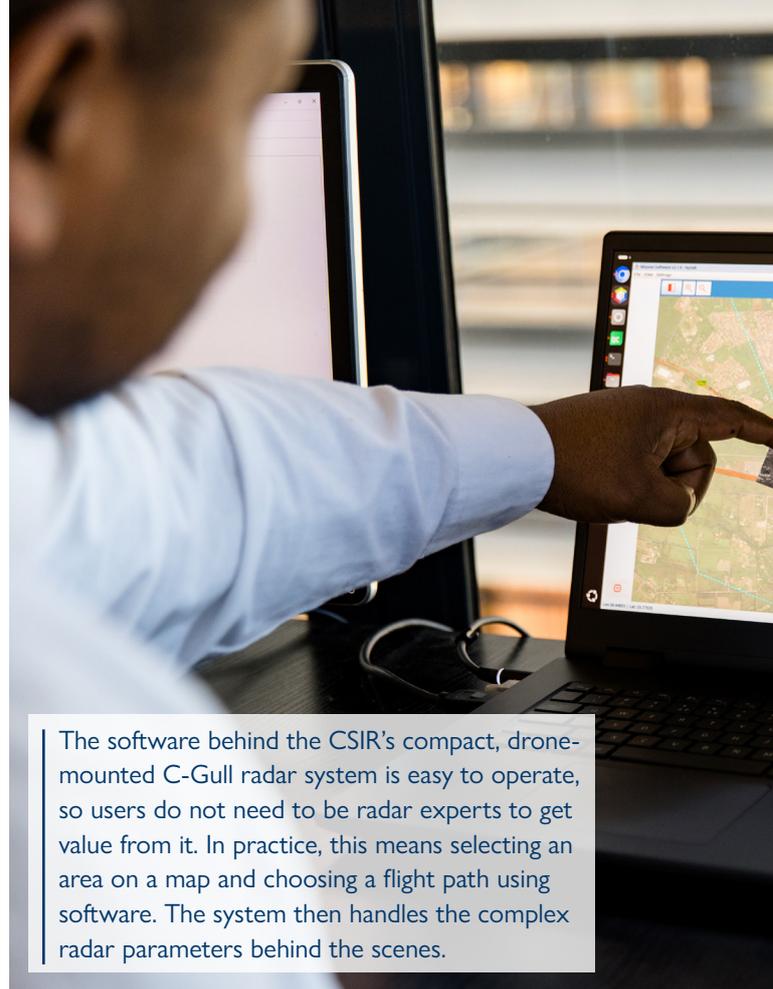


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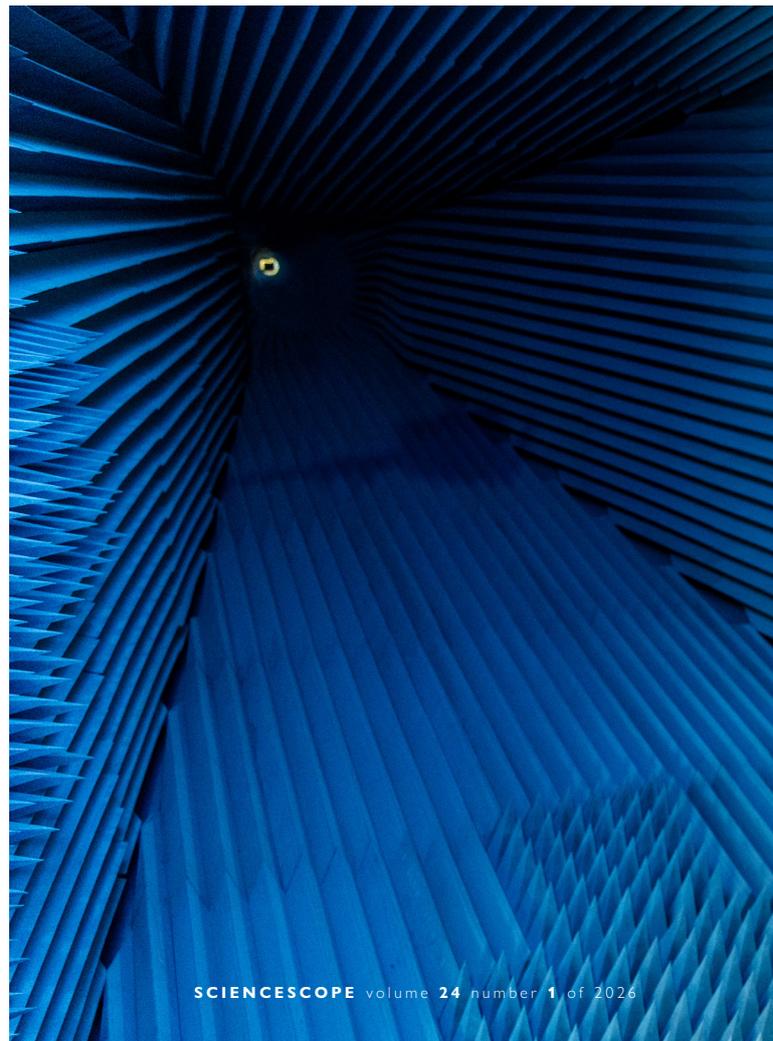
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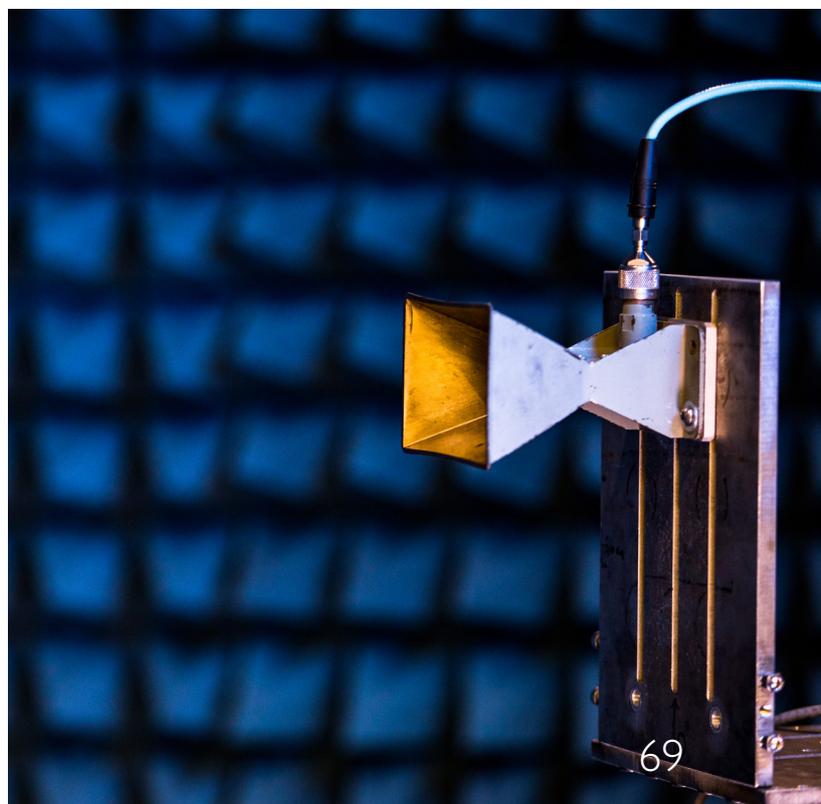
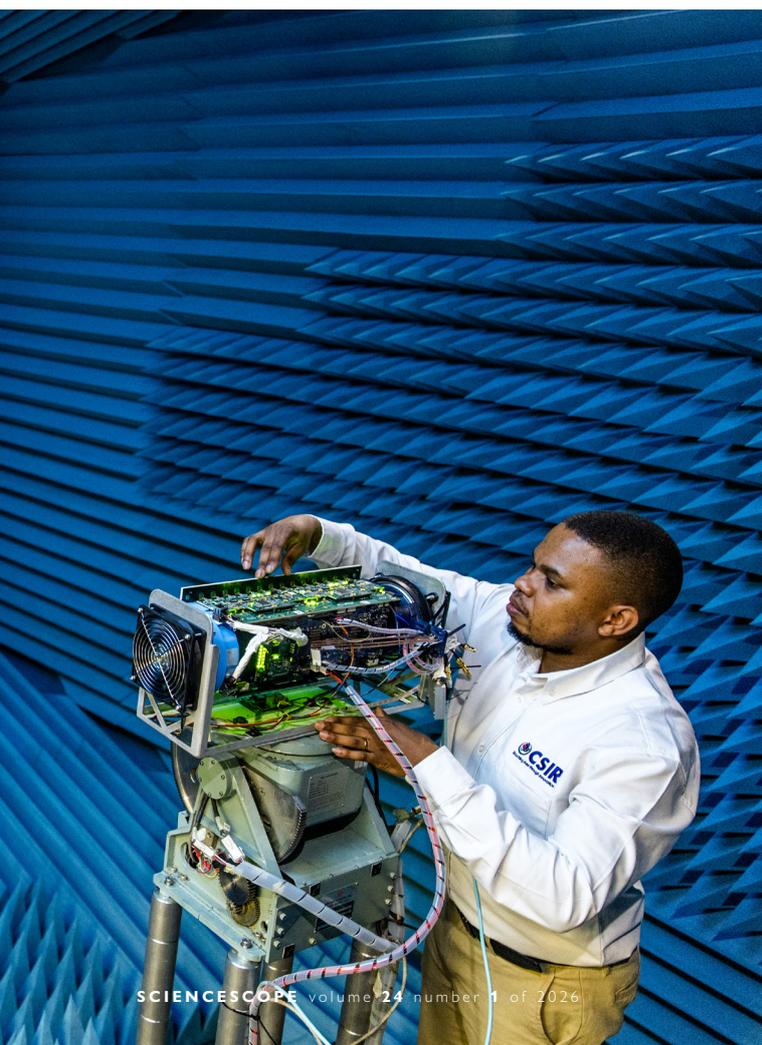
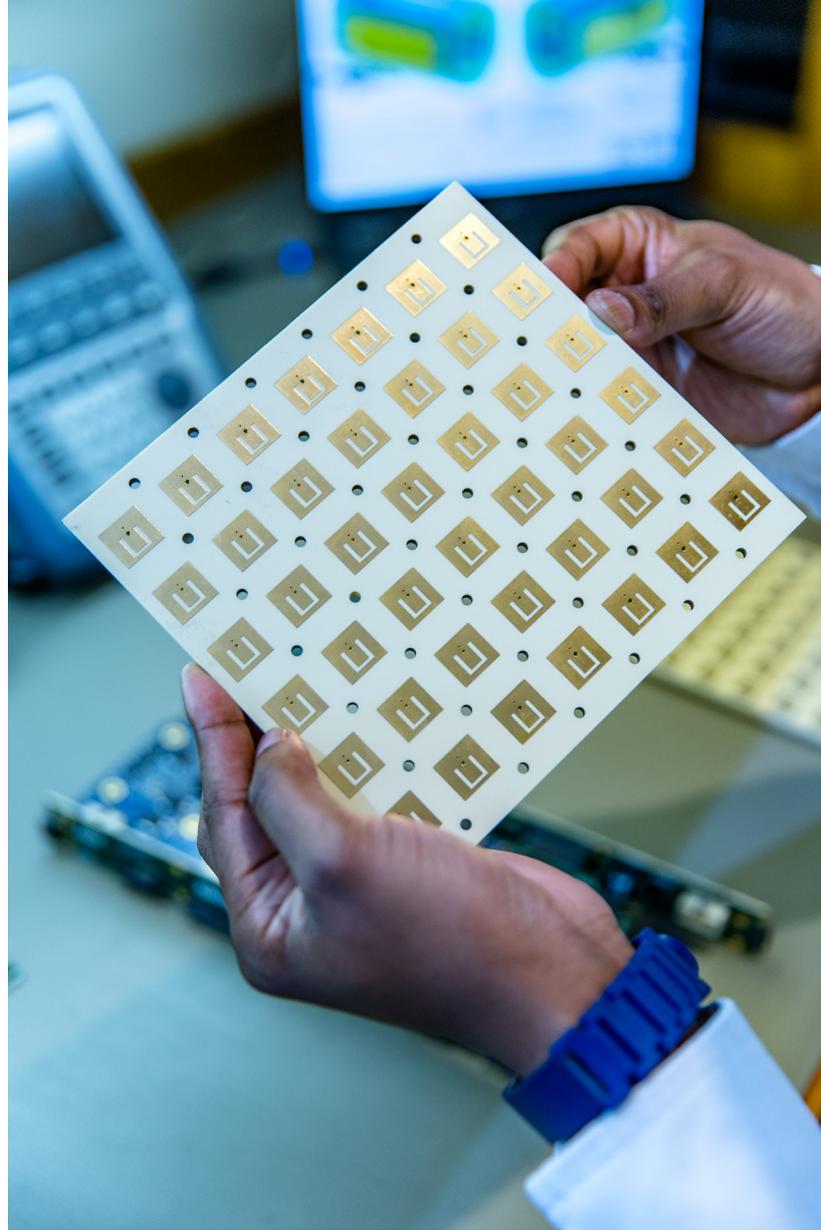
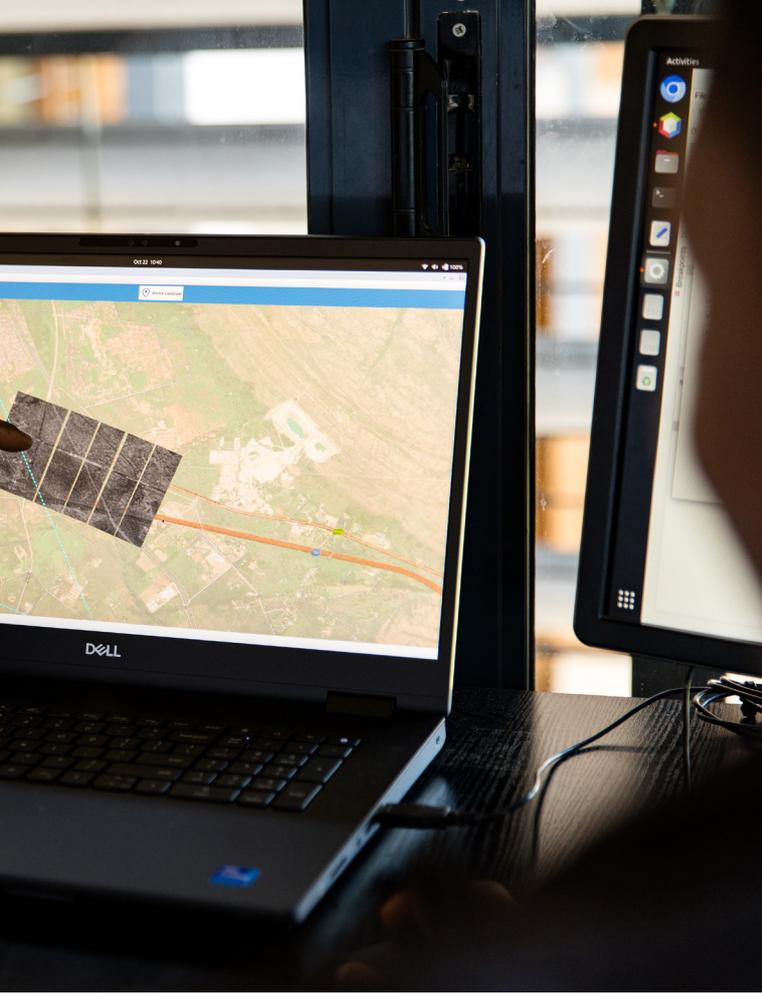
>> **Willie Nel**

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The software behind the CSIR’s compact, drone-mounted C-Gull radar system is easy to operate, so users do not need to be radar experts to get value from it. In practice, this means selecting an area on a map and choosing a flight path using software. The system then handles the complex radar parameters behind the scenes.







## SINK AND SYNC: UNDERWATER WI-FI TO TRANSMIT SONAR IMAGES ALMOST INSTANTLY

*How we are creating near real-time “eyes and ears” from ocean depths*

**C** SIR researchers say underwater drones will soon be able to broadcast high-resolution sonar images of ocean pipelines, hidden underwater mines, subsea cables and even mineral prospects to the surface faster than ever before. They are fine-tuning two critical technologies that make this possible at the CSIR’s underwater testing facility in Pretoria, following a recent sea trial in Simon’s Town.



"One technology is called synthetic aperture sonar (SAS) and the other is, in simple terms, underwater Wi-Fi using sound waves," says Kiri Nicolaidis, a lead researcher in sensor systems at the CSIR.

Mounted together on an unmanned underwater vehicle, the two complementary systems will solve a double problem that has limited underwater exploration thus far: poor-quality sonar images of ocean and dam floors taken at a distance and the need to wait for the vehicle to surface to retrieve and process image data into useful maps and high-quality visuals.

The CSIR team is solving the first problem around imaging with specialised signal and image processing algorithms, as well as novel transducers (an electrical component that acts as an underwater antenna to transmit and receive sound waves).

Compared to traditional transducers, these locally developed, wide-bandwidth components give the CSIR's

SAS systems four times more bandwidth to send and receive underwater acoustic waves. More bandwidth means higher data rates with fewer errors, which translates into higher-resolution images.

By arranging a large set of these tiny transducers in an array and using the movement of an underwater vehicle, researchers can synthetically create a much larger "virtual" aperture for sonar imaging. This increases the resolution of images, regardless of whether the target is nearby or far away.

"SAS is like the high definition television version of sonar," says Josiah Jideani, a senior engineer in the CSIR's ultrasonics research group. "SAS shines when you're looking for very small targets or objects that conventional types of sonar won't be able to detect."

In the oil and gas industry, for example, SAS can be used for underwater pipeline inspections to check for small leaks or damage. It can also be used for mineral

*(continued overleaf)*

prospecting, geological surveys, marine archaeology, buried underwater mine detection and undersea internet cable monitoring.

The sonar system can be mounted on autonomous underwater vehicles (AUVs) or on a towed underwater platform (a towfish, pulled behind a small boat). The challenge, however, is maintaining a stable speed and straight trajectory, both of which are essential for synthetic aperture processing. Light boats and surface waves introduce motion that must be corrected algorithmically - this is what Jideani's team is currently working on, in addition to imaging and autofocusing algorithms.

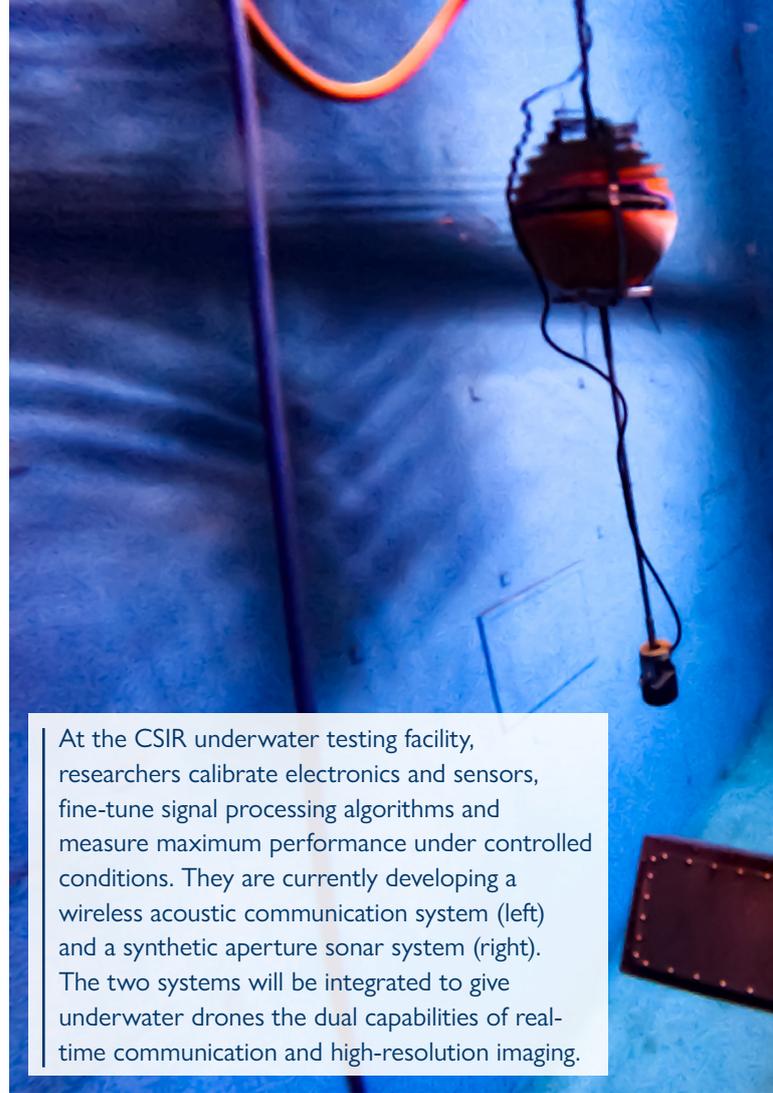
At the CSIR underwater testing facility, the sonar team calibrate the underwater transducers and electronics, fine-tunes signal processing algorithms and evaluates performance under controlled conditions.

"We take the sensors and load them into the tank," says Jideani. "There, we've got a mechanised gantry that we can control electrically to move along a straight line. As the gantry moves, the sonar pings and receives echoes and we then process that file to generate an image of whatever is on the floor of the tank."

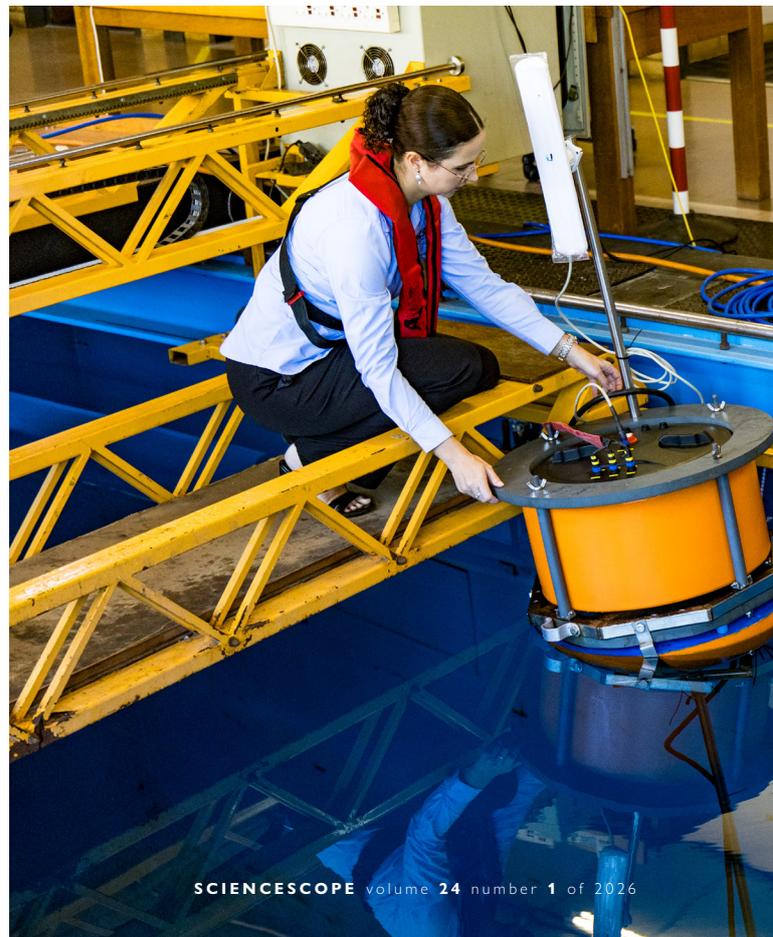
The team also performs ocean and dam tests that introduce uncontrollable variables such as waves, currents, speed changes and platform instability. Data collected during field tests are brought back to the facility, where the team adjusts the algorithms to compensate for real-world conditions. This iterative cycle between controlled testing and field deployment is central to the technology development process.

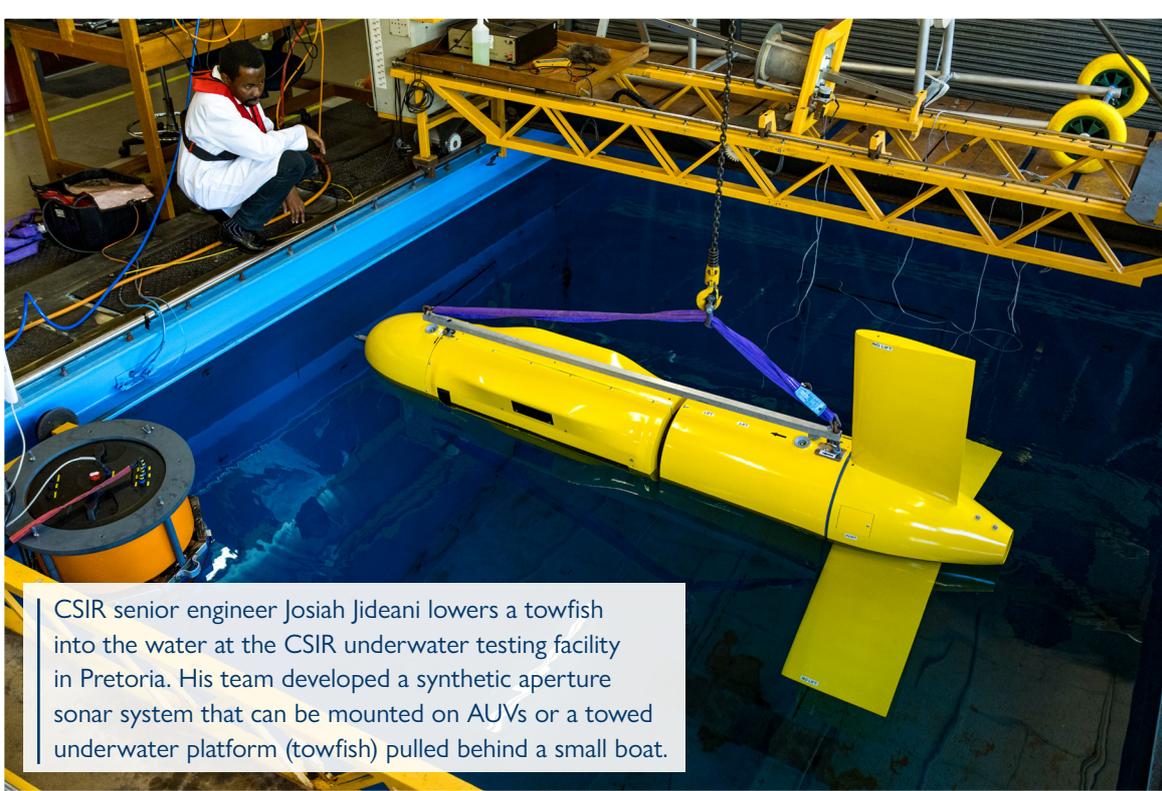
In parallel, researchers are tackling the second problem: how to get information back to the surface while a system is still submerged.

"Currently, operators have to wait for an underwater drone (AUVs) to complete its mission and surface again to download the data," says CSIR senior engineer Elna Niemann. "Seeing snapshots during the mission would provide a lot of savings in terms of time, resources and money."

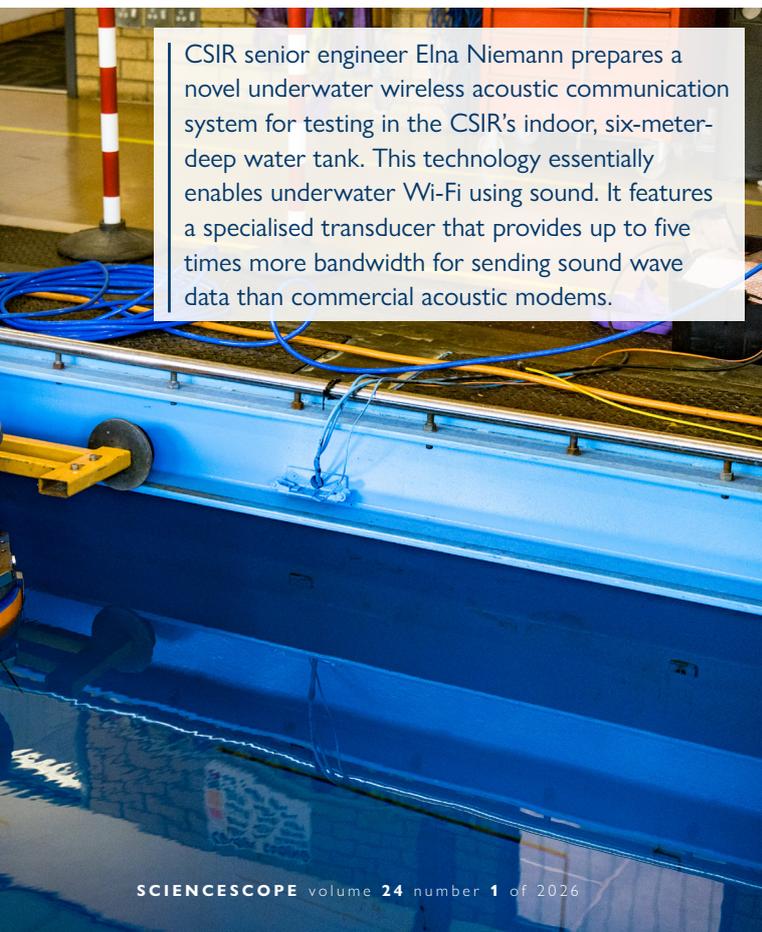


At the CSIR underwater testing facility, researchers calibrate electronics and sensors, fine-tune signal processing algorithms and measure maximum performance under controlled conditions. They are currently developing a wireless acoustic communication system (left) and a synthetic aperture sonar system (right). The two systems will be integrated to give underwater drones the dual capabilities of real-time communication and high-resolution imaging.





CSIR senior engineer Josiah Jideani lowers a towfish into the water at the CSIR underwater testing facility in Pretoria. His team developed a synthetic aperture sonar system that can be mounted on AUVs or a towed underwater platform (towfish) pulled behind a small boat.



CSIR senior engineer Elna Niemann prepares a novel underwater wireless acoustic communication system for testing in the CSIR's indoor, six-meter-deep water tank. This technology essentially enables underwater Wi-Fi using sound. It features a specialised transducer that provides up to five times more bandwidth for sending sound wave data than commercial acoustic modems.

She explains that radio waves used for high-speed communication above water typically don't travel well underwater. "You can't just submerge a wireless modem underwater and get the same kind of performance you would on land."

However, she says, sound waves travel very well underwater.

Her team is developing an underwater wireless acoustic communication system or Broadband Underwater Data Communication. This is, in essence, underwater Wi-Fi using sound.

Again, the novelty lies in a specialised ultra-wide bandwidth transducer that provides up to five times more bandwidth for sending sound wave data than commercial acoustic modems.

"We can offer internet-like speeds compared to the commercial offering, which is more in line with telegraph speeds," she says.

Niemann says the team first tested the algorithms and physics behind the system at the indoor facility at the CSIR in Pretoria. "The underwater testing facility is where it all begins; if it's not working here, it won't work anywhere else."

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CSIR researchers headed to Simon's Town early in 2026 for a sea trial of the synthetic aperture sonar and underwater Wi-Fi technologies they are currently developing. Ocean conditions introduce uncontrollable variables such as waves, currents, speed changes and platform instability. Data collected during field tests are brought back to the CSIR's underwater testing facility for further fine-tuning. This iterative cycle between controlled testing and field deployment is central to the technology development process.

“Our underwater facility was established over 40 years ago,” says Nicolaides. “It has played a big role in the development of underwater sonar technology at the CSIR and in the broader sonar technology ecosystem in the country.”

He adds that the facility allows researchers to validate technologies to international standards.

Nicolaides, Jideani, Niemann and the rest of the sensors research team headed to Simon's Town early in 2026 for a sea trial of the SAS and the underwater Wi-Fi prototype.

“While we tested the synthetic aperture sonar at sea, we were also able to test the broadband underwater data communication project in the harbour,” Niemann says. “We were able to achieve very high data throughput, with very good results.”

She says the team will be integrating the two systems, to bring real-time communication and high-resolution imaging together in a single offering for underwater drones.

“Our goal is to provide both the eyes and ears of what the drone is doing underwater,” says Niemann.

The CSIR extends its gratitude for ongoing support for this research to Armscor, the South African Navy and the Department of Defence, especially the Defence Materiel Division and the Directorate Technology Development.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/manufacturing/sensor-systems>

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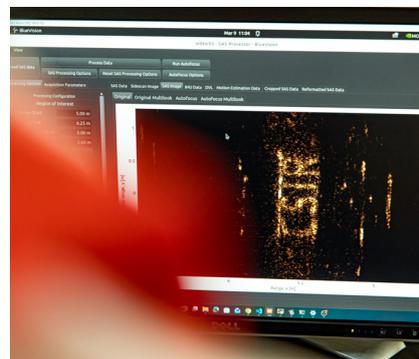
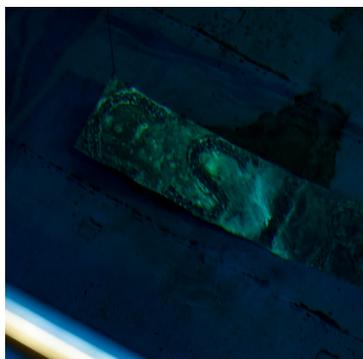


**SCAN TO WATCH**

## SINK AND SYNC: UNDERWATER WI-FI TO TRANSMIT SONAR IMAGES ALMOST INSTANTLY

Underwater drones will soon be able to broadcast high-resolution sonar images of ocean pipelines, hidden underwater mines, subsea cables and even mineral prospects to the surface faster than ever before. #TeamCSIR is fine-tuning two critical technologies that make this possible at the CSIR's underwater testing facility in Pretoria, following a recent sea trial in Simon's Town.

The CSIR extends its gratitude for ongoing support for this research to Armscor, the South African Navy and the Department of Defence, especially the Defence Materiel Division and the Directorate Technology Development.



At the CSIR underwater testing facility, a mechanised gantry (1) moves a submerged synthetic aperture sonar system along a straight line through the water to image a metal board on the floor of the tank (2). The word “CSIR” is spelled out on the board using glass marbles, which serve as small topographical protrusions (3) to be imaged. As the gantry moves, the sonar pings and receives echoes through the water and researchers then process the data to generate an image of the board's features (4). In the real world, synthetic aperture sonar can be used for underwater pipeline inspections, mineral prospecting, geological surveys, marine archaeology, buried mine detection and undersea internet cable monitoring.



Light emissions can be used to confirm the presence of multiple contaminants in a single sample. An inductively coupled plasma optical emission spectrometer and an inductively coupled plasma mass spectrometer are key instruments used to test for elements like antimony, arsenic, cadmium, lead and selenium.

# CHEMICAL SIGNALS IN THE SEDIMENT

## *CSIR scientists trace pollution in South Africa's waters*

**P**ollution often develops gradually. Long before it causes obvious or large-scale environmental damage, it leaves subtle chemical fingerprints in rivers, groundwater, estuaries and coastal sediments. Detecting these early warning signs – often present at concentration levels below the detection limits of most laboratories – requires specialised instruments and scientific expertise.

The CSIR's [environmental chemistry laboratory](#) in Stellenbosch, one of South Africa's few advanced environmental chemistry laboratories, is doing exactly that: tracking the chemical signals of human activity in water systems.

The laboratory analyses a wide range of environmental samples, from drinking water and wastewater to freshwater, groundwater and seawater and even sediments, plant material and biological tissues. These analyses help scientists and decision-makers understand how pollutants move through catchments and coastal ecosystems, and more importantly, when and what management actions need to be taken to avoid environmental and human health consequences.

“Human activities such as municipal wastewater discharge, mining and industrial processes all leave chemical traces in the environment,” explains laboratory manager Sebastian Brown. “Our role is to measure those traces accurately so that authorities can understand what is happening in the water system.”

“Many municipalities discharge treated wastewater through pipelines known as outfalls, which release effluent into rivers or the ocean. These discharges must be monitored to ensure they do not harm surrounding ecosystems,” says Brown.

The CSIR assists municipalities by measuring nutrients such as ammonia, nitrate, nitrite and phosphate, as well as trace metals and organic compounds. These measurements are used to assess whether wastewater treatment systems are performing effectively and whether discharges comply with environmental standards.

The CSIR has worked nationally with the Department of Environmental Affairs and regionally in the West Indian Ocean with the United National Environment Programme to establish water quality guidelines. When problems occur, such as unexplained pollution in a river or the sea, the laboratory's analyses can help identify likely sources and guide corrective actions.

South Africa's long mining history means that trace metals remain an important environmental concern. One example is mercury, which can enter rivers and coastal waters through mining waste, industrial activities or acid mine drainage. Once in the environment, mercury can accumulate in sediments and living organisms, posing risks to ecosystems and human health.

To strengthen national monitoring capacity, the CSIR laboratory has invested in specialised instruments such as a direct mercury analyser and an inductively coupled plasma mass spectrometer. These systems allow scientists to detect extremely low concentrations of mercury and other metals in environmental samples. With this capability, [CSIR researchers have also joined global efforts to standardise mercury testing](#) to protect environmental and human health.

The laboratory's work extends beyond rivers and wastewater systems. It also supports environmental monitoring in South Africa's ports. Sediments in ports must be dredged to maintain safe depths for shipping. Before dredged material can be safely disposed of, scientists must determine whether it contains harmful contaminants. The CSIR analyses port sediments for trace

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CSIR analysts like Francois Jansen measure the oxygen required to chemically break down organic and inorganic matter in water. This chemical oxygen demand test is crucial for evaluating water quality and understanding the impact of industrial effluent and wastewater on the environment.

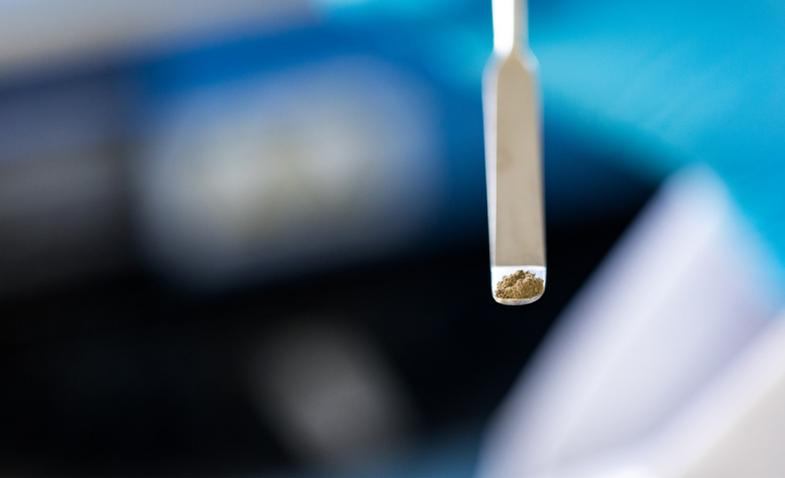
metals and other pollutants, helping the Transnet National Ports Authority ensure that maintenance dredging is conducted in an environmentally responsible way.

Behind every water sample analysed in the laboratory lies an important decision, whether it relates to wastewater treatment, pollution control or environmental permits.

“Our analysts focus on producing reliable, defensible data,” says Brown. “Decision-makers rely on that information when they need to manage pollution risks or improve treatment systems.”

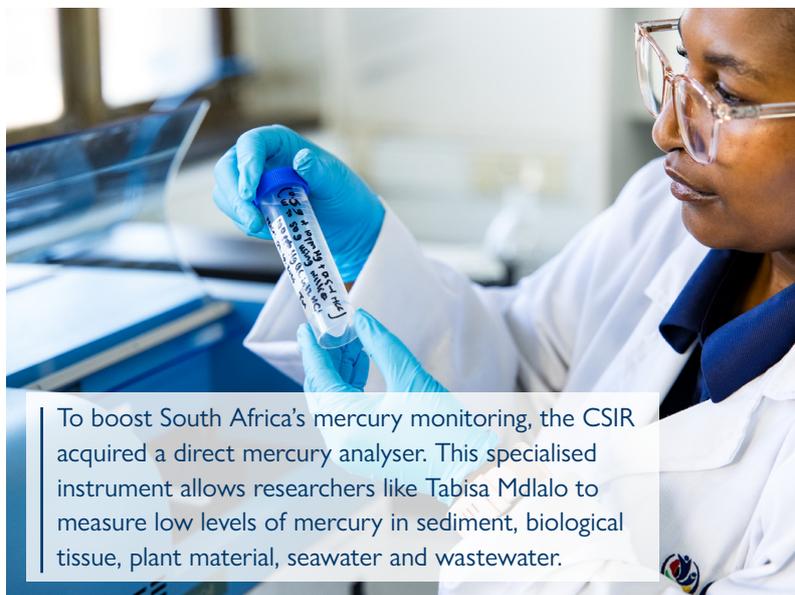
The laboratory also supports innovative research projects within the CSIR, including trials of nature-based wastewater treatment systems that use algae to remove nutrients from water through a process known as phycoremediation.





Much of the laboratory's work takes place behind the scenes, with analysts working meticulously to ensure accuracy at low detection limits and to maintain standards demanded by national accreditation systems and international interlaboratory calibration exercises, but its impact reaches far beyond the laboratory benches and instruments.

By combining advanced analytical technology with rigorous scientific methods, the CSIR's environmental chemistry laboratory helps municipalities, regulators and industry understand how human activities affect South Africa's water systems and how those impacts can be reduced.



To boost South Africa's mercury monitoring, the CSIR acquired a direct mercury analyser. This specialised instrument allows researchers like Tabisa Mdlalo to measure low levels of mercury in sediment, biological tissue, plant material, seawater and wastewater.



CSIR experts like Nafisah Jacobs measure low levels of nutrients such as ammonia, nitrite, nitrate, phosphate and silicate in seawater, drinking water, wastewater and industrial effluent. They use what scientists call automated colorimetric methods, which are high-throughput, computerised tests in which a specific colour change confirms the presence of a nutrient.

In a country where water is precious and vulnerable, these chemical insights help protect not only rivers, catchments and coastlines, but also the people and communities who depend on them.

The CSIR invites other government entities and industry to work with researchers at its environmental chemistry laboratory to survey the impact of human and industrial activities on South Africa's water systems.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/natural-environment/sustainable-ecosystems/coastal-systems-and-earth-observation>

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# SA-EGYPT POWER UP ON AFRICAN SOLAR ELECTRICITY PRODUCTS

*The CSIR and Egypt's Helwan University partner on local solar panel and inverter quality testing*

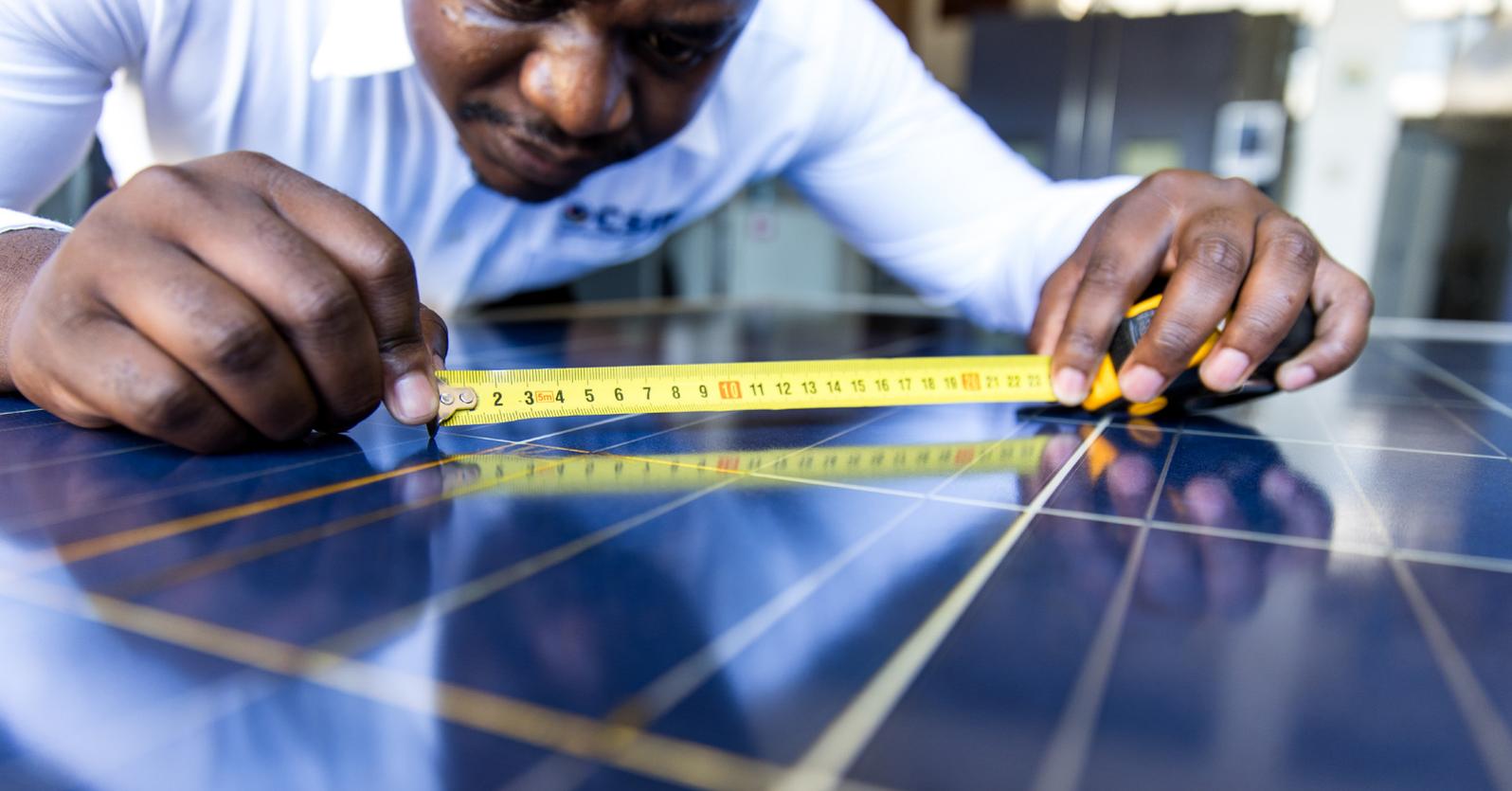
From the south to the north, contractors and customers on the continent expect solar photovoltaic (PV) modules, or solar panels, to perform for 25 to 30 years on rooftops and farms. Indeed, there are both legal and financial consequences for everyone involved if Africa's booming solar PV installations were to prove unsafe, unreliable or short-lived.

In response to this rising demand for quality local products, the CSIR has allied with Egypt's Helwan University to help African manufacturers improve solar panel system reliability. The partnership will help reduce the reliance on imports as businesses and governments expand Africa's solar energy footprint.

"The CSIR is strong on the PV module side, and the Egyptians are very good in the inverter space, so we are bringing the two capabilities together," says Dr Kittessa Roro, a lead researcher at the CSIR Energy Research Centre.

The South African work packages, which are jointly funded by the CSIR and South Africa's Technology Innovation Agency, will thus help manufacturers benchmark locally

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made solar PV modules for quality and reliability, as well as improve performance.

CSIR senior researcher Manjunath Basappa Ayanna says the CSIR is home to the only facility in southern Africa to offer the full suite of internationally recognised solar PV module quality and performance tests.

“The CSIR’s [Solar PV Quality and Reliability Laboratory](#) is an ISO 17025 accredited facility offering test services to plant owners, project developers, as well as engineering, construction, operation and maintenance companies since 2021,” he says.

Technicians at the lab begin with a visual inspection to look for cracks, broken glass, moisture damage or any signs of damage due to mishandling of the solar PV panel during transportation, which could impact the installation or performance.

Next comes the power output measurement, where the panel is exposed to a burst of bright, artificial “sun” to ensure it matches the manufacturer’s labelled specifications. “We have a pulsating lamp that flashes for less than a second, and then we can determine all the electrical parameters from there – your power, voltage and current,” says laboratory technologist Hlaluku Wisani Mkasi.

Ayanna explains that these power measurements are essential for quality assurance and stress testing, as they set performance baselines, verify compliance, detect power loss from stress and ensure reliability as per international standards.

From there, the panel is placed in a dark room, powered up and then photographed using an electroluminescence camera that captures infrared light emitted by individual cells. The result looks much like an X-ray image, revealing cracks and defects hidden from the naked eye, as well as dead zones where no electricity is being produced. This method detects approximately 90% of defects that could affect performance.

The panel is then submerged in a water tank for an electrical safety test.

“Solar panels are generally designed to be safe to conduct routine maintenance, like manual cleaning, without switching off the system. However, if there’s a power leakage, wiping the panels can create an electrical path to your body that may result in a serious electrical shock,” explains Mkasi. Power leakages lead to maintenance safety risks, he says, but they also lower the panel’s performance, which risks investments made in a new solar PV system development.



After the non-destructive tests, Mkasi's team exposes the panel to accelerated ageing and stress testing in accordance with the international gold standard, IEC 61215.

For example, technicians use a special machine to check if the panel can withstand intense vibrations, simulating possible damage due to transportation, installation, handling and strong winds during operation. It also determines resistance to static pressures or loads such as snow.

The panel is also baked for 1 000 hours (42 days) at a temperature of 85°C and at 85% humidity to simulate decades of harsh African weather conditions. If the panel loses more than 5% of its rated power, it fails.

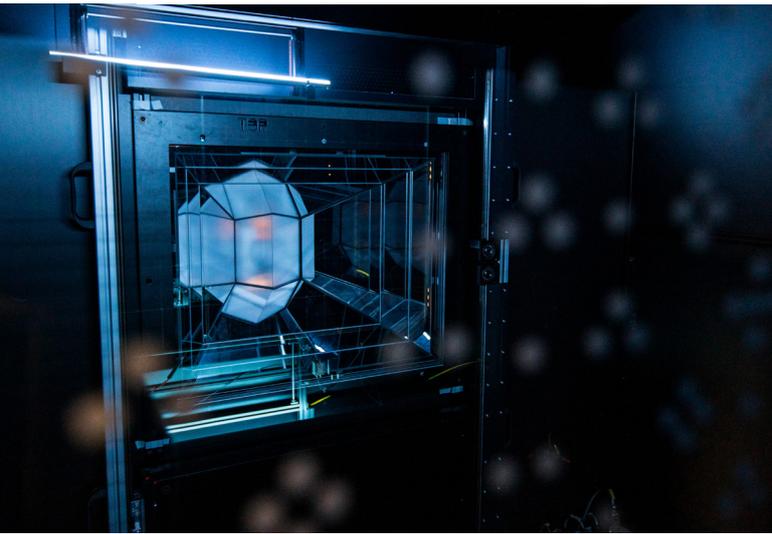
Mkasi says the CSIR team has seen a wide range of problems over the years, both in the laboratory and in the



Solar PV modules submitted for safety testing at the CSIR are submerged in a water tank and exposed to high voltage to check for current leakages. Current leakages lead to maintenance safety risks, but it also lowers the PV modules' performance, which risks investments made into a new solar development.

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To measure power output, a solar PV module is exposed to a burst of bright, artificial “sun” in an environment-controlled dark chamber. “We have a pulsating lamp that flashes for less than a second, and then we can determine all the electrical parameters from there – your power, voltage and current,” says laboratory technologist Hlaluku Wisani Mkasi.



field: panels that only produce 30% of their claimed power output (known technically as rated nameplate power), others with cracked cells, and some with dangerous electrical faults.

Regardless of whether panel samples pass or fail the tests on offer at the CSIR, his team issues a comprehensive technical report. Importantly, these reports can be used in court proceedings, such as when project developers face liability claims when solar panels fail or underperform.

Reliability testing is not only about preventing sub-standard products from flooding the market, says Mkasi, but also about protecting long-term system performance, reducing technical and financial risk and giving investors confidence in large-scale solar projects.

Ayanna adds that the partnership with Egypt’s experts on inverter reliability testing will expand confidence in African solar system products even further across the continent.

Helwan University has established a national inverter reliability and standards testing platform in Egypt, and its experts have developed the hardware and software for a prototype three-phase inverter.

“Helwan University *has developed a new platform for the first time in Egypt* to perform the necessary standard tests of the well-known IEC and IEEE standards on a PV three-

phase inverter system adopted in the residential sector,” says Ayanna. “The inverter test platform is intended to reduce performance and safety risks and to demonstrate long-term quality and reliability.”

According to the agreement signed between the university and the CSIR, Egypt also brings a broad ecosystem of industrial, regulatory and business support organisations to the partnership, which will help accelerate market adoption and uptake of new local products.

Roro, Ayanna and Mkasi say that better local solar system products and quality regulations are good for manufacturers, good for customers, good for the environment and good for energy security all over Africa.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/natural-environment/energy/energy-supply-and-demand>

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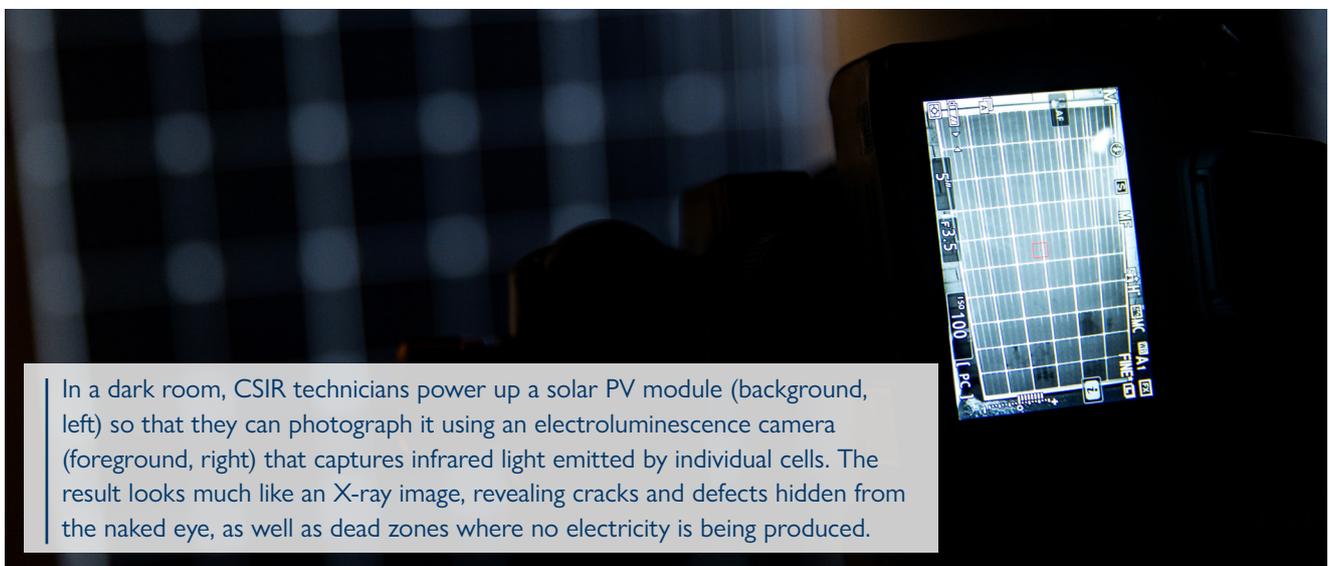
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**SCAN TO WATCH**

## THE CSIR PV MODULE QUALITY AND RELIABILITY LAB

The laboratory operates according to international standards to fully characterise PV modules, provoke real-world failures in sub-standard modules through accelerated stress tests, and quantify the impact on performance and safety. The accelerated stresses highlight issues that can impact the long-term performance of PV modules in a matter of weeks rather than years. The test results are used to inform procurement decisions and define contract requirements with suppliers. The capability includes an indoor sun simulator for electrical performance tests across a range of temperature and irradiance levels, a thermal cycling chamber to test the quality of the interconnections, a damp heat chamber to test the quality of the lamination, a mechanical load tester to check the strength of the module and high-voltage safety equipment to check the insulation properties under wet and dry conditions.



In a dark room, CSIR technicians power up a solar PV module (background, left) so that they can photograph it using an electroluminescence camera (foreground, right) that captures infrared light emitted by individual cells. The result looks much like an X-ray image, revealing cracks and defects hidden from the naked eye, as well as dead zones where no electricity is being produced.

# FULLY FLAT: HOW TO DISCHARGE OLD BACK-UP BATTERIES FOR RECYCLING

*Safely recover valuable materials from used lithium-ion cells*

**R**esearchers at the CSIR's Energy Storage Testbed, a battery testing facility, developed a practical recycling protocol with South Africa's national mineral research organisation, Mintek. The protocol ensures lithium-ion batteries are inert before they are dismantled for materials recovery.

CSIR engineer Renesh Thakoordeen says Mintek approached his team to address the growing problem of what to do with back-up batteries when they reach end of life. Lithium-ion and other types of batteries are made of



Mintek approached the CSIR to address the growing problem of what to do with back-up batteries when they reach end of life. Researchers at the CSIR Energy Storage Testbed, a battery testing facility, developed a protocol to discharge lithium-ion batteries completely before they are dismantled for materials recovery.

valuable materials and minerals that should be recovered and reused, rather than piling up in landfills leaching toxic chemicals into the environment.

“The idea is to recycle these batteries and reclaim some of the material that is within the battery itself,” he says. But getting to those materials safely is not straightforward and there is a misconception that a flat battery is a safe battery.

“You need to open up the battery and there is still quite a bit of energy in the battery even when it is flat, so you have to de-risk the battery.”

Part of the challenge is that voltage can rebound after discharge. “Every time you bring it down, it just goes back up again,” he says. “It is almost like squeezing a sponge: as soon as you stop squeezing it, it goes back to its normal shape.”

A safe protocol to discharge these batteries completely had not yet been developed in South Africa, so Thakoordeen's team devised one using the CSIR's programmable battery-testing equipment, capable of controlled charge and discharge.

He explains that flat batteries are volatile: during discharge there is a risk that the voltage could suddenly increase, leading to a rapid rise in temperature and a risk of combustion. They therefore carefully monitored the batteries during the controlled discharge process using a thermal camera and thermocouples (sensors that measure temperature differences between two metal wires).

“We can see on a very small scale if the temperature is starting to increase rapidly and can act before an incident occurs,” he says.

In simple terms, the protocol focuses on taking a battery that appears discharged and ensuring it is truly safe to handle before any dismantling step takes place.

This, he says, is clearly not work for amateurs. “I would 100% not do this at my house; no one should ever open up a battery even when it is flat,” he warns.

The protocol was specifically developed for old lithium iron phosphate batteries supplied by Mintek, but it should hold true for other battery chemistries too.

“These are commercial and residential batteries that pose a real risk as a huge waste stream in future,” he says, explaining that they are now commonly installed in homes, businesses and public facilities to manage power interruptions or to switch to solar power. “Such batteries must be disposed of properly; they cannot just be thrown into the bin.”

Thakoordeen says policies and guidelines are needed for proper disposal to avoid environmental harm. “If we do not, we are going to have a massive issue with these batteries filling up landfills. This may cause fires or toxic chemicals may seep into the ground, poisoning water supplies.”

But battery recycling is about more than physical safety and environmental protection. It is ultimately also about resources, since batteries contain materials that could be recovered and returned to the economy.

“You can recover the lithium, copper, aluminium and obviously the steel and plastics around that,” says Thakoordeen.

By developing such local protocols, standards and guidelines, the CSIR battery testing facility is a key infrastructure supporting South Africa’s fast-growing battery economy. It also builds local capability and trust across the battery value chain through skills development and independent testing of residential, commercial and utility-scale batteries.

Thakoordeen says developing the safe battery discharge protocol with Mintek required CSIR chemists, engineers,



Thermal imaging shows how the temperature rises after one hour (top) and three hours (above) in an old back-up battery as it is discharged in a controlled environment at the CSIR’s Energy Storage Testbed. A rapid rise in temperature means there is a risk of combustion, so CSIR researchers say that before dismantling a battery for recycling, it should be fully discharged using a new protocol developed in partnership with Mintek.

security staff and health and safety officers to be on high alert and the result is a standard procedure that they are looking at patenting.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/natural-environment/energy/energy-storage-testbed>

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# SCIENTISTS ON THE SCENE AS ROAD DEATHS CLIMB

*High-tech vehicles, road standards and better driving schools urged*

**B**ystanders and motorists rely on driver assistance technology, road restraint systems and other safety features to reduce harm in case of a crash, but the road death toll is already climbing in 2026. CSIR researchers say the problem can be tackled scientifically from all angles.

As schools re-opened for the 2026 academic year, South Africans awoke to devastating news: 14 learners were killed after a scholar transport vehicle they were travelling in crashed into an oncoming truck in Vanderbijlpark, Gauteng. The driver of the scholar transport vehicle had tried to overtake multiple other vehicles by moving into the oncoming lane.

CSIR transport safety scientist Khangwelo Muronga says harm from crashes like these could be minimised by fitting public transport vehicles with an Advanced Driver Assistance Systems (ADAS), and by strengthening the rigour of driving licence testing and professional driver permit processes. Investing in more forgiving road designs that help guide driver behaviour and reduce the risk of collisions would also be valuable.

But any intervention should be scientifically tested and validated to ensure that standards are met and that products work within South Africa's unique road conditions and driver behaviours.

Muronga leads a team of researchers at the CSIR Transport Safety Laboratory, which shares independent,



The CSIR Transport Safety Laboratory features a driving simulator (left) and a test vehicle (right), which help researchers design real-world experiments to test driver assistance technologies, road restraints, weather conditions and the impact of accidents on passengers, drivers and bystanders. Real-world data, in turn, feeds back into simulations, which can be used to design better driving regulations, technologies, manufacturing standards and driver training programmes, and to recreate accident scenes for legal or insurance claims.

scientific findings with authorities like the South African National Roads Agency (SANRAL) and the Road Traffic Management Corporation (RTMC), as well as the Automobile Association of South Africa.

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“Our goal at the CSIR Transport Safety Lab is to do something about the stats reported every year,” says Muronga, in reference to the annual death toll from road crashes. In 2025, South Africa recorded over 11 000 road fatalities, resulting from just under 10 000 crashes.

“We can reduce those numbers, and it helps to look scientifically at what really causes these fatalities.”

In a 2024 study, the University of KwaZulu-Natal and local company Accident Specialists brought the CSIR on board to see how well South Africa’s standard road restraint systems protect bystanders, especially children, during a crash.

“We had a child-sized crash test dummy sitting inside the vehicle, and we had some adult and child dummies standing next to the road restraint,” he says, adding that South African pedestrians often sit on guardrails on the side of the road.

“We wanted to see what happens to the child in the car in the event of an impact, and whether the crash would be fatal for pedestrians. We also checked if the airbags in the vehicle would deploy or fail, and whether the barriers themselves are safe or would contribute to injuries.”

They found that the barriers worked well only when manufactured strictly according to the standard. “There is a very thin line between a barrier being effective and not;

it’s not something that allows for any margin of error,” says Muronga.

While formal recommendations have not yet been made to SANRAL or the RTMC, the CSIR is engaged in ongoing work with these entities to implement performance-based road restraint systems in South Africa.

In another area of research, Muronga’s team was again invited by the University of KwaZulu-Natal and Accident Specialists to look at how well seatbelts and automatic braking systems perform in existing vehicles or vehicles that will soon enter the market. For lower speed tests, the team used inflatable animal models to simulate unexpected wildlife crossing the road, such as during a safari at the Kruger National Park. These tests replicate real-world driving conditions and assess whether the vehicle’s ADAS detects the obstacle and applies the brakes in time.

Muronga says that for these and other tests, he has been particularly impressed by the performance of vehicles from Chinese manufacturers.

In general, the CSIR’s research recommendations are shared formally with authorities, as well as informally with manufacturers and other stakeholders through platforms like the Southern African Transport Conference.

Muronga adds that the CSIR is helping to strengthen the evidence base needed to ensure that cars sold in South Africa comply with safety standards.

But even if vehicles and roads are as safe as scientifically possible, human error remains a critical factor. This is true, for example, for the 22-year-old now facing charges of reckless and negligent driving for his role in the fatal Vanderbijlpark scholar transport accident.

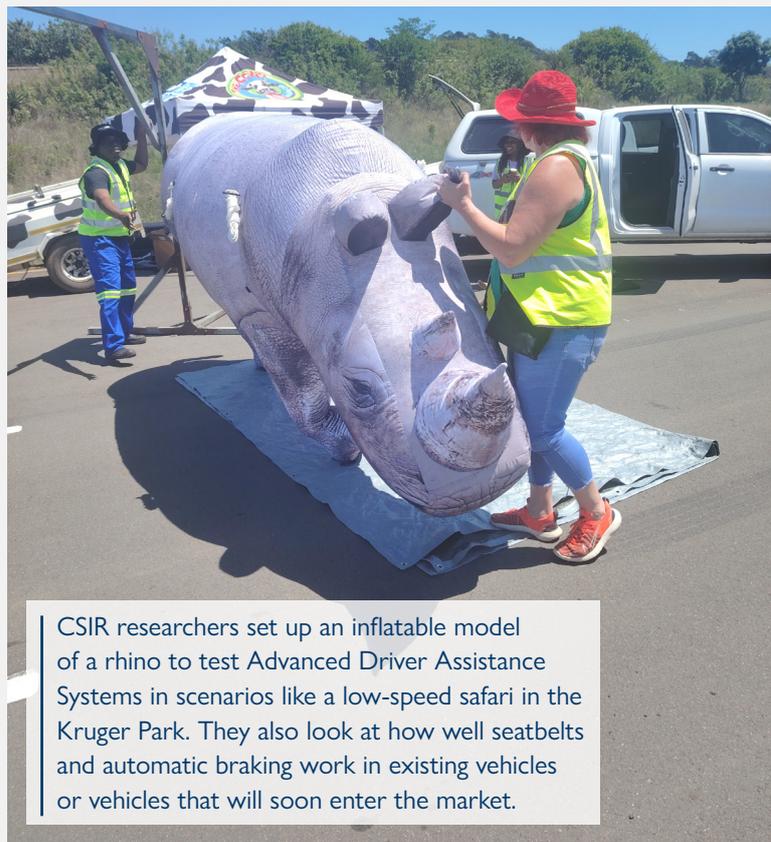
“We have also been testing novice versus experienced drivers, and we are looking at how South Africa’s driving schools are teaching people to drive,” says Muronga.

His team is using insights from the driving simulator and test vehicle to better understand gaps in driver training

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A crash test dummy is placed in a passenger seat for testing, while others are set up along a road barrier to mimic pedestrian behaviour. The University of KwaZulu-Natal and Accident Specialists brought the CSIR on board to see how well South Africa's standard road barriers protect bystanders and passengers. The restraint systems contained the vehicle at the speed of impact as per the standard specification.



CSIR researchers set up an inflatable model of a rhino to test Advanced Driver Assistance Systems in scenarios like a low-speed safari in the Kruger Park. They also look at how well seatbelts and automatic braking work in existing vehicles or vehicles that will soon enter the market.

and the standards of driving schools. “We want to advise on the kind of training driving schools should be doing beyond just the current K53 exam.”

Broadly, he says, South Africa needs transport safety solutions that are research-based and aligned with road safety standards issued by the World Health Organization, and which comply with the United Nations Decade of Action.

He also invites authorities and vehicle manufacturers to expand collaborations with the CSIR to help bring down South Africa’s road death toll. “The CSIR Transport Safety

Laboratory is a state-of-the-art facility that supports national efforts to reduce road fatalities and improve transport infrastructure through scientific research, data-driven solutions and advanced technologies.”



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/mobility-and-logistics/transport-safety>

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### CSIR TRANSPORT SAFETY LABORATORY

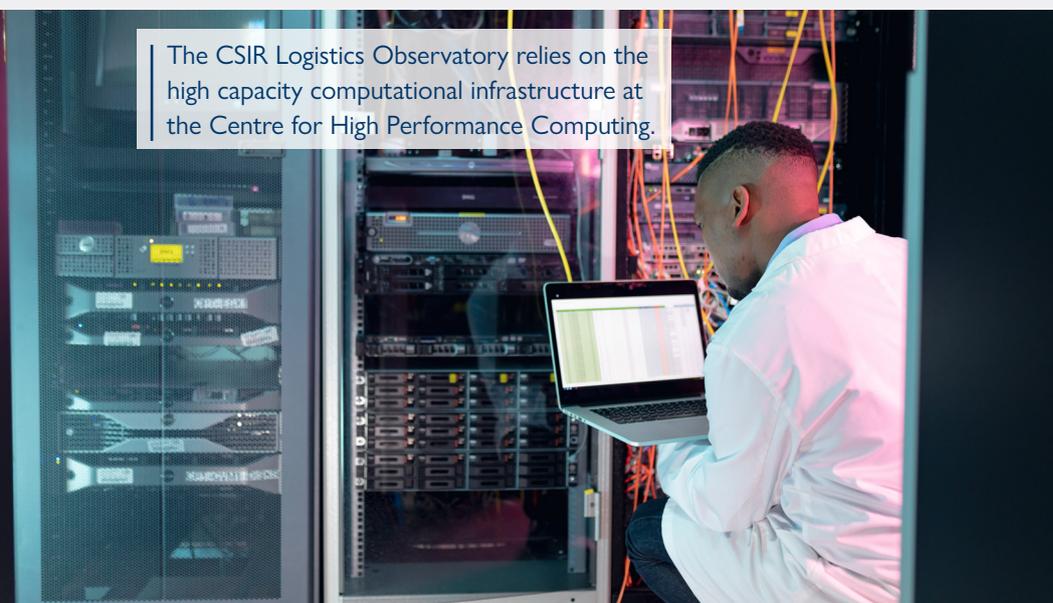
The CSIR Transport Safety Laboratory is a state-of-the-art facility that is part of the country’s efforts to reduce road fatalities and improve transport infrastructure through scientific research, data-driven solutions and advanced technologies.

# COMING SOON: A BIG DATA PORTAL TO PUT SA FREIGHT BACK ON THE RAILS

*It's a go for cargo with new CSIR Logistics Observatory*

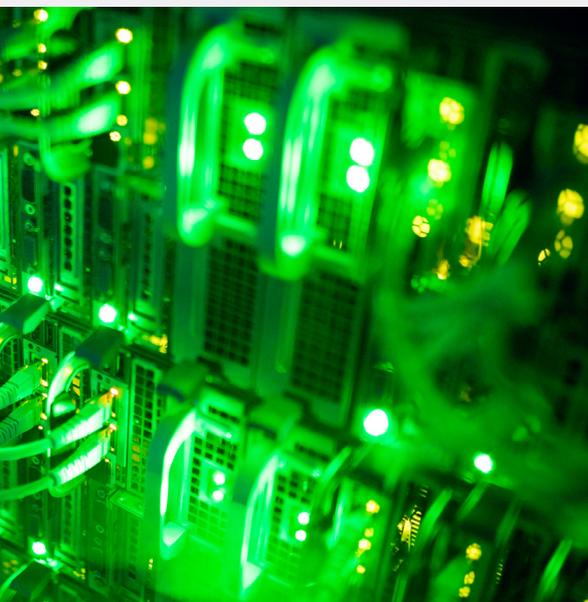


Transport and logistics make up about 10% of South Africa's Gross Domestic Product, so big data and digitisation projects like the CSIR Logistics Observatory are key to supporting decision-making in the sector. Organisations like the South African Association of Freight Forwarders have welcomed the tool as an independent means to explore and address concerning patterns in air, sea, road and rail freight.



The CSIR Logistics Observatory relies on the high capacity computational infrastructure at the Centre for High Performance Computing.





**W**hether by rail, road, sea or air, freight forwarders need reliable, detailed information to get ore, produce, timber and other goods from A to B, come rain or shine.

Such information will be accessible through the [CSIR Logistics Observatory](#), a new data-driven digital tool. Through visuals, maps, toggles and charts, it helps the freight industry, researchers, policymakers and other logistics role players understand what is going on with our transport networks.

Suppose a flash flood cuts off access to a bridge on a major trucking route, or strong winds at Cape Town's port interrupt the loading of shipping containers onto export vessels. What if our road network's main arteries miss a new industrial development, or if a natural disaster, disease outbreak or political situation creates a gap in the supply chain?

These daily operational, strategic and tactical challenges are what the CSIR Logistics Observatory has been designed for: it will keep expanding its capabilities to inform decisions to pivot from problems to streamlined supply chains.

"We can make updates in real time as we get access to more information," says Anieke Swanepoel, a CSIR engineer involved in building and maintaining the observatory.

She says the platform replaces the annual *State of Logistics* report that the CSIR had published in previous years, essentially becoming a live repository for high-quality research, publications and reports. It also enables data sharing and validation among researchers and industry stakeholders.

Users will be able to zoom in on bridges, airports, railways and targeted infrastructure developments, as well as service delivery metrics, import and export data, specific commodities, climate threats, freight demand dynamics and operational data like congestion or safety incidents.

"It's user-friendly and interactive, so the user can decide what elements they want to see on our geospatial maps so that it better suits their needs," says Swanepoel.

Dr Mathetha Mokonyama, who heads up the CSIR's mobility and logistics research, says the observatory is powered by the CSIR-hosted Centre for High Performance Computing (CHPC). The CHPC is a key national cyber-

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infrastructure facility, and is supported by the Department of Science, Technology and Innovation (DSTI).

“The CHPC is critical and ideal for this platform – the simulation models that we’re building are going to be reliant on high-capacity computational infrastructure,” he says.

Mokonyama says transport and logistics make up about 10% of South Africa’s Gross Domestic Product, so big data and digitisation projects like these are key to supporting decision-making in the sector. “If we leave things to chance and we just operate on autopilot, then we are not going to grow the economy as well and as fast as we should.”

The South African Association of Freight Forwarders (SAAFF) has welcomed the CSIR Logistics Observatory as an independent tool to explore and address any concerning patterns in air, sea, road and rail freight. They are actively contributing industry data to the platform.

“Once you have a tool that can dissect the data, you can do what-if scenarios,” says SAAFF CEO, Dr Juanita Maree. “You can then influence policy,” she says, emphasising that both the public and private sectors ultimately want policies that support seamless and steady supply chains.

She says the platform will help foster sustainability and trustworthiness in the logistics sector, for the ultimate



Computing experts and servers at the CSIR-managed Centre for High Performance Computing (CHPC) form the backbone of data-driven tools like the new CSIR Logistics Observatory. The CHPC is a key national cyber-infrastructure facility, and is supported by the Department of Science, Technology and Innovation.



**SCAN TO WATCH**

## FREIGHT FORWARDERS WELCOME CSIR LOGISTICS OBSERVATORY

Whether by rail, road, sea or air, freight forwarders need reliable, detailed information to get ore, produce, timber and other goods from A to B, come rain or shine. Such information is now accessible through the CSIR Logistics Observatory, a new data-driven digital tool. Through visuals, maps, toggles and charts, it helps the freight industry, researchers, policymakers and other logistics role players understand what is going on with our transport network.

benefit of customers in South Africa, Africa and beyond. The CSIR invites industry bodies and donors to further fund the integration of specialised data or applications, such as for agriculture or port logistics.

Swanepoel says her team is also open to exploring data sharing and collaborations with universities and other organisations across the continent. “Our primary aim is to support unbiased national decision-making, but we welcome support from the transport and logistics community to maintain and expand the CSIR Logistics Observatory,” she says.

 More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/mobility-and-logistics/logistics-and-supply-chains>

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Through visuals, maps, toggles and charts, the CSIR Logistics Observatory will help the freight industry, researchers, policymakers and other logistics role players understand what is going on with our transport network. Users can zoom in on bridges, airports, railways and targeted infrastructure developments, as well as service delivery metrics, import and export data, specific commodities, climate threats, freight demand dynamics and operational data like congestion or safety incidents.



# MOSSEL BAY WASTEWATER TURNS GREEN, NATURALLY

*10 000-fold reduction in E. coli with algae-based water treatment*



Dr Luyanda Ndlela inspects an algae culture at the CSIR's microbiology laboratory in Stellenbosch.

**O**n the outskirts of Mossel Bay, a series of wastewater ponds are quietly doing important work. Water that enters the system as untreated effluent leaves cleaner, safer and suitable for reuse, thanks to a nature-based solution that begins in the laboratory.

At the CSIR's microbiology laboratories in Stellenbosch, researchers are cultivating algae to help municipalities respond to growing pressures such as ageing wastewater infrastructure, climate change impacts and urbanisation.

The work is part of a long-running CSIR project that uses microalgae to improve water quality in a low-energy, low-cost way while delivering tangible environmental and social benefits. The project is funded locally by the Department of Science, Technology and Innovation, through a [European Biodiversity Partnership programme](#).

"The algae are naturally occurring biomass, so we are using nature to heal itself," explains the lead CSIR researcher on the project, Dr Luyanda Ndlela.

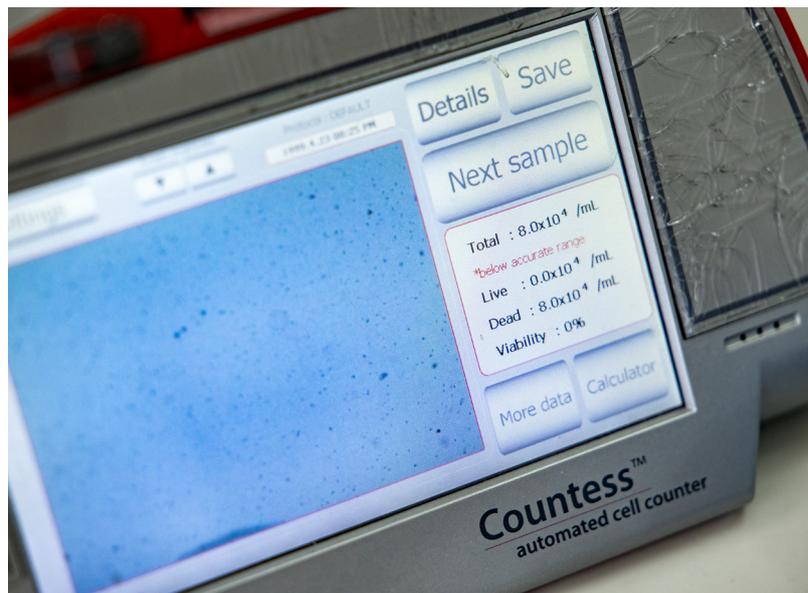
Inside the Stellenbosch laboratories, algae are grown, monitored and prepared before being transported to Mossel Bay, where municipal teams continue cultivating them at scale. The laboratory work is essential: it ensures that the right strains are healthy, stable and able to perform once they are introduced into real-world wastewater systems.

"What happens in the lab is basically that we have these naturally occurring algal isolates that we then create a co-culture with," Ndlela explains. "This means we grow two different species of the same genus, *Chlorella*, together."

Researchers then use laboratory techniques like spectrophotometry, chlorophyll extraction and cell counts to track algal growth and health with precision.

"Visually, you can see them becoming greener as they grow, but for scientific purposes we measure chlorophyll as an indirect measure of algal mass," says Ndlela. "That tells us that they are actually growing and growing well."

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Researchers use laboratory techniques such as spectrophotometry, chlorophyll extraction and cell counts to track algal growth and health with precision in the CSIR microbiology laboratories in Stellenbosch. The higher the colour intensity of green chlorophyll and the more cells they observe, the healthier and plentiful the algal biomass.

The cultures are upscaled using a CSIR-patented medium that optimises growth and nutrient uptake. Once they reach the right concentration, they are transported to Mossel Bay as a pure co-culture, accompanied by training manuals that guide municipal staff on how to continue the process on site.

“The municipality then builds up the culture in bioreactors using light and a bit of nutrients,” says Ndlela.

From there, the algae are released into a series of wastewater ponds, where they begin to do what they do naturally: grow, out-compete harmful organisms like *E. coli* bacteria and absorb unwanted nutrients from sewage. “By outcompeting other indicator pathogens and dominating the ecosystem, they take up the nutrients,” Ndlela explains.

In Mossel Bay, the system works across seven ponds, with water moving through the treatment process over a period of about 10 days. As the algae dominate each pond in sequence, researchers monitor changes in conductivity, pH, chemical oxygen demand and microbial load.

“We had some *E. coli* issues and with this project it has basically reduced the *E. coli* in the groundwater,”

says Gershwin Kock, assistant manager of wastewater treatment at Mossel Bay Municipality.

“We’ve seen a reduction of up to 90% of nitrates and phosphates and a 10 000-fold reduction in pathogens such as *E. coli*,” says Ndlela.

These improvements matter not only for regulatory compliance, but for the wider environment and local economy. In Mossel Bay, treated water does not flow directly into a river; instead, it impacts groundwater that is abstracted downstream for agricultural use.

“This technology has improved the groundwater and the farmers are happier about the type of effluent they’re getting for agricultural purposes,” says Kock.

The success of the project in Mossel Bay is closely tied to the strength of the partnership between the CSIR and the municipality. Over nearly a decade, the municipality has consistently maintained the system, followed technical guidance and stayed engaged with the research team.

This consistency has allowed CSIR scientists to move beyond short-term pilots and study how the technology performs over time in real environmental conditions.

“You can do a lot in the lab, but it is only once the system is out in the environment that you really understand how it functions,” Ndlela explains. “This relationship has enabled us to keep refining and improving the technology.”

Beyond improving water quality, the algae-based system has also contributed to ecological recovery. As nutrient levels and pathogen loads decrease, other organisms begin to return.

“You start seeing things like water fleas, tadpoles and insects in the final ponds,” says Ndlela. “Those are very sensitive indicators and you would not find them in highly contaminated water.”

While the results are encouraging, Ndlela is careful to emphasise that the work is ongoing.

“This is very much a work in progress,” she says. “We don’t have all of the answers, but we know enough now to say that it is functional, consistent and capable of supporting wastewater treatment.”

One concern often raised about algae-based systems is whether the algae themselves could become a problem once released. Ndlela says this is a misconception.

“These algae are naturally occurring,” she explains. “They’re applied in a controlled system, and they’re already part



Researchers monitor Mossel Bay wastewater treatment ponds where a special combination of *Chlorella* algae has been introduced to clear contaminants. They check for changes in conductivity, pH, chemical oxygen demand and microbial load. The treatment results in a reduction of up to 90% of nitrates and phosphates, and a 10 000-fold reduction in pathogens such as *E. coli*, thereby delivering clean groundwater for nearby agricultural use.

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Once the algae co-cultures have reached the right volume and concentration at the CSIR microbiology laboratories in Stellenbosch, they are transported to Mossel Bay. There, training manuals guide municipal staff to build up the culture in bioreactors using sunlight and a CSIR-patented nutrient mix. From there, the algae are released into a series of wastewater ponds, where they begin to do what they do naturally: grow, outcompete harmful organisms like *E. coli* bacteria and absorb unwanted nutrients from sewage.

of natural aquatic ecosystems when conditions allow. We're not introducing anything alien or invasive to the environment."

Looking ahead, the CSIR is exploring how the algal biomass itself could be harvested and repurposed for feed, bio-packaging or biofuels, contributing to a circular economy.

"At the final treatment pond, we want to extract all of that biomass to close the loop by using it for other things," says Ndlela, cautioning that careful risk assessment and ongoing research is still needed since the algae have been exposed to sewage.

Nevertheless, the Mossel Bay project is building momentum for wider adoption of nature-based solutions, within other municipalities and in industry.

By linking laboratory science in Stellenbosch with practical, on-the-ground implementation in Mossel Bay, the project demonstrates how research infrastructure, long-term partnerships and ecological thinking can come together

to address some of South Africa's most pressing water challenges.

As Ndlela puts it, improved water quality does more than meet technical standards. "It fulfils the mandate of improving people's lives through science and it brings an awareness of what nature can provide when we work with it, rather than against it," she says.

"This approach was easy for us to implement because it's less operational and requires no electricals or mechanical input; it's just manpower and it's light work," says Kock. "Nature-based solutions are the way forward and there is definitely a place for them in a more advanced world of wastewater treatment."

The CSIR invites municipalities and industry to explore and partner on nature-based water treatment solutions.



More information about our research, facilities and services: <https://www.csir.co.za/what-we-do/natural-environment/water>



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## WE GROW ALGAE FOR NATURE-BASED MUNICIPAL WATER TREATMENT

Wastewater ponds in Mossel Bay use a special algae treatment developed by the CSIR to improve water quality in a low-energy, low-cost way, while delivering tangible environmental and social benefits. The treatment results in a reduction of up to 90% of nitrates and phosphates and a 10 000-fold reduction in pathogens such as *E. coli*, thereby delivering clean groundwater for nearby agricultural use. The CSIR invites municipalities and industry to explore and partner on nature-based water treatment solutions. The project is funded locally by the Department of Science, Technology and Innovation, through a European Biodiversity Partnership programme.



Researchers check the diversity of organisms in water collected from a Mossel Bay wastewater pond following treatment with algae. The algae reduce nutrient levels and pathogen loads, allowing organisms like water fleas, tadpoles and insects to return. Such organisms are sensitive indicators of ecosystem health as they do not thrive in highly contaminated water.

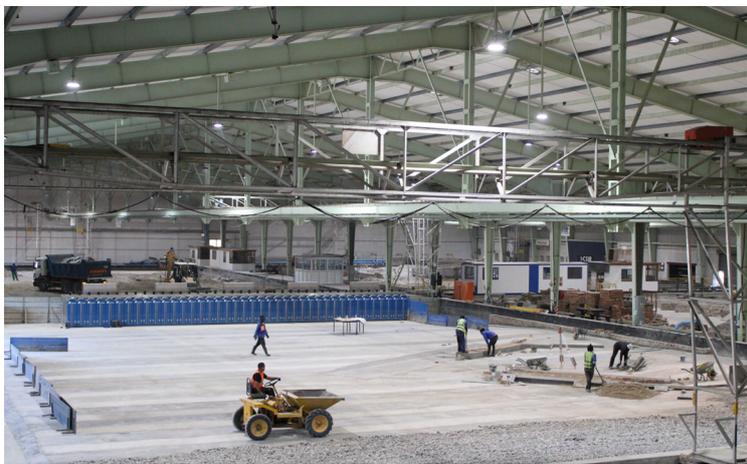
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| The CSIR Coastal and Hydraulics Laboratory



A 3D replica of the main breakwater at the Port of Mossel Bay, is under construction at the CSIR Coastal and Port Hydraulic Laboratory in Stellenbosch (top). The study will inform decisions on the rehabilitation and extension of the port's main breakwater (above).

# PORT OF MOSSEL BAY BREAKWATER SCALED WITH ARMOUR PROTECTION

*Small-scale planning with big impact*

Some 370 km from Mossel Bay, a replica of its port and surrounding seabed is being constructed at the CSIR Coastal and Hydraulics Laboratory in Stellenbosch. The Transnet National Port Authority (TNPA) has called on coastal engineers at the CSIR to conduct physical model studies to validate the proposed rehabilitation options for the existing rubble mound breakwater at the Port of Mossel Bay, as well as assessing the stability of a potential breakwater extension.

The project entails rehabilitating approximately 300 m of the existing 500 m breakwater, as well as adding a possible 200 m extension north of the main breakwater. These modifications will improve port operations by strengthening safety, efficiency and supporting long-term economic viability. The armour layer at the Port of Mossel Bay is made up of various-sized Dolos, which are interlocking concrete units that were invented on home soil. As is the case with many other breakwaters, this layer of protection has become compromised as continuous wave action and severe storms have caused visible deterioration.

To test the specifications of the proposed breakwater repairs at the Port of Mossel Bay, the CSIR is conducting two-dimensional (2D) and three-dimensional (3D) physical modelling tests. The 2D study is nearing completion, while works on the 3D model is in process. Once completed, the 3D model setup will include the port and marine infrastructure in its entirety, allowing a full investigation of interventions to prevent further deterioration of the port's main breakwater. The breakwater repair is essential for continued port functionality and the findings of these studies will eventually be included in the final design.

The 3D study is, in many cases, considered to be a continuation of the 2D study, with each study focusing on different aspects of the design. The 2D study is ideal for testing breakwater cross-sectional designs, as it allows for quicker turnaround times at more affordable rates. The CSIR glass panel flume is a popular option among clients, since it also allows the test setup to be viewed from the side, including interactions between the different components. For the Mossel Bay study, a total of four different design cross sections have so far been tested and testing of additional designs may still be considered.

The 3D model, on the other hand, covers the more complex 3D features of the design and therefore provides valuable insight into how the incident waves interact with the breakwater and nearby marine infrastructure, including inside the port basin. 3D model setups are more time-consuming and therefore more costly to run, but they replicate the real-world hydrodynamic interactions between the different design structures, which is essential in selecting the most optimum design solution. "Construction of the 3D model is in full swing and we

plan to complete it soon," says CSIR engineer and project manager Lukhanyo Somlota.

Breakwaters often face increased damage from continuous wave attack and extreme storm events. Damage trends have recently been exacerbated by climate change and rising sea levels. Rehabilitating a breakwater helps restore its structural integrity, ensuring continued protection of harbours and coastlines from high-energy waves and counteracting deterioration.

Rubble mound breakwaters are made up of different layers comprising of different materials. The armour layer is the outer protection and the first layer of defence against structural failure. "CSIR technicians and engineers conduct regular monitoring at the Port of Mossel Bay's breakwater, where they gather field data to assess the extent of the damage to the various structural components," Somlota says.

"Currently, we are in the final stages of constructing the seabed bathymetry, which will be followed by setting up the existing port basin, quays and rubble mound structures. All wave conditions are calibrated with the existing structures in place to accurately replicate wave-structure interactions. Once all wave conditions have been calibrated, all structures will be touched up to make sure that they are replicated as per the design. "At this stage, the model is ready for testing," Somlota says.

Achieving high reliability and accuracy is essential for a complex and high-impact project of this nature. As an essential infrastructure, the breakwater creates sheltered water areas that assist the port's operational efficiency as a specialised hub for general cargo, local oil and gas, fishing and petroleum industries and maritime services at its smallest port.



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