

ScienceScope

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SOUTH AFRICA'S COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

CELEBRATING

70 Years

Ideas that work

Ideas
that work



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our future through science

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Cover page: CSIR researchers have successfully equipped a wave glider, pictured here off the Western Cape coast between Dassen and Robben Islands, with an acoustic echo sounder to better determine fish stock levels along the South African coastline. The technology will go a long way towards helping the Department of Agriculture, Forestry and Fisheries to regulate and allocate fishing quotas for more sustainable fishing practices. Wave gliders that carry sensors and solar panels and are able to convert wave energy into forward propulsion, can be steered via satellite and be at sea for several months at a time. The CSIR also uses wave gliders to monitor carbon dioxide level changes in the ocean to better predict the rate and potential effects of climate change.

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THE MAN BEHIND THE DIGITAL LASER

“Knowledge is power and by involving more people in science, we can advance our country and change the world.”

DR SANDILE NGCOBO

This CSIR scientist has been designing lasers for the past 10 years. As part of the team that developed the world's first digital laser, he helped make it possible, for the first time, to change the shape of a laser beam at the push of a button. He was also part of the team that designed a high-powered laser in rectangular symmetry, with the highest output power in the world.

**BRIGHT YOUNG SCIENTISTS BEHIND
IDEAS THAT WORK.**

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The CSIR's mandate commits us to conduct research and foster technological innovation and industrial and scientific development to improve the quality of life of South Africa's people. Over the years, our efforts have resulted – and continue to result – in many successful innovations and interventions. These efforts are a response to national priorities and are based on innovative ideas that can be practically applied to better the lives of citizens – *Ideas that work*.

IMPROVING SOUTH AFRICA THROUGH IDEAS THAT WORK

IN THE FIELD OF INFORMATION and communication technology, our researchers have developed a tool that will make possible the use of currently unused spectrum in television broadcasting frequencies to facilitate the cheaper delivery of high-speed broadband connectivity in underserved areas, especially in rural areas. This is a great example of using what we have to cater for what we need.

There are many other examples of ideas that work – such as a 3D underwater imaging system to help keep South Africa's ports, harbours and coastline safe, a technology that has the potential to be applied internationally. Or the clever use of laser technology to double the lifespan of the rolls used in steelmaking.

Some other CSIR-inspired ideas will go a long way to improving the health and welfare of our country and its people. These include changing the way hospital wards are designed in order to help limit the spread of TB, identifying crops that can be successfully grown and harvested on previously mined land, or coming up with green home-grown solutions for better, more effective water sanitation.

However, we have not always been bold enough in telling these stories. Recently, with encouragement from our stakeholders, we launched a media campaign to show South Africans what it is that we do, and to demonstrate that scientific and technological research can have a real and meaningful impact, that we truly are shaping “our future through science”. We wanted to show that our research is a response to national priorities and is based on innovative ideas that can be practically applied to better the lives of citizens – *Ideas that work*.

In this edition of *ScienceScope* we embrace the theme of *Ideas that work* by showcasing a wealth of ideas that are truly working to empower, sustain, protect and grow South Africa.

This publication is by no means an exhaustive list of all the solutions we have developed, but I trust that you will find yourself informed, enlightened, proud and amazed to read about these exciting projects and the various ways they are improving industry, contributing to prosperity and changing the lives of ordinary South Africans. They represent ideas that are shaping the future by making an impact today. *Ideas that work*.



Dr Sibusiso Sibisi,
CSIR CEO



PLAYING WITH DNA FOR A LIVING

“I have made it my mission to understand how our DNA contributes to disease – specifically diseases that concern Africa.”

DR JANINE SCHOLEFIELD

Stem cell research gives us valuable information about some of the continent's most threatening diseases, bringing us closer to finding preventions and cures. Janine, a geneticist at the CSIR, is making a significant contribution in this field. “The genes in our DNA don't just determine the colour of your eyes or your blood type. They also play a role in cell function and susceptibility to disease,” Janine explains. Her passion for genetics led her to work with non-embryonic stem cell technology in her lab. As she puts it, “It's such a valuable technique and could be used beautifully in combination with South Africa's diverse genetic population – to uncover clues about disease susceptibility relevant to our country.”

**BRIGHT YOUNG SCIENTISTS BEHIND
IDEAS THAT WORK.**

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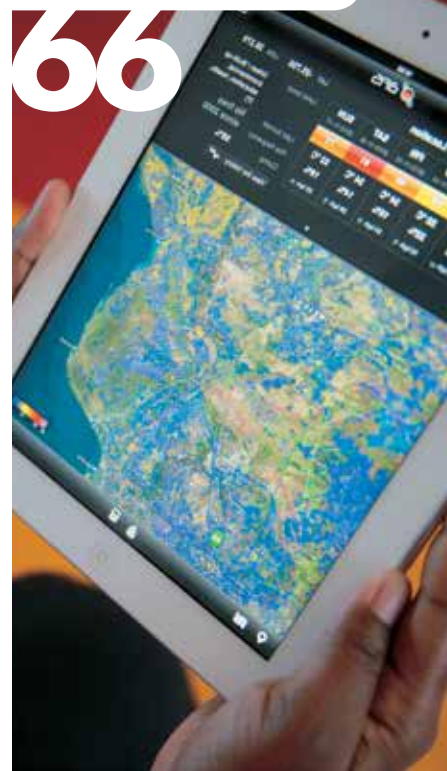
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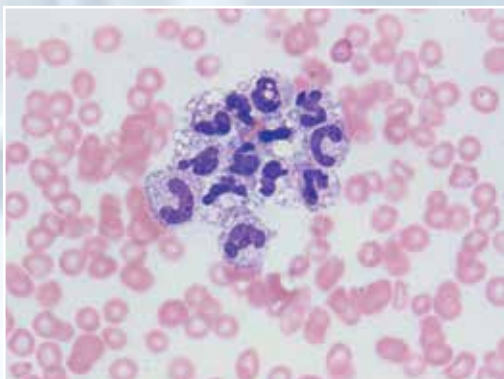


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WATER SANITATION SOLUTION

CSIR biologist Zandile Nxumalo holds a peripheral blood smear, normally used by specialist haematologists, to evaluate the cellular pathology of blood.

The CSIR has joined forces with the NHLS to develop technological solutions that are set to boost South Africa's capacity to train expert pathologists, deliver support services and perform quality control in laboratories across the country.



A digital view of a blood smear under a microscope.

CSIR COLLABORATES WITH NHLS TO IMPROVE PATHOLOGY SERVICES

Core challenges of modern pathology service delivery in South Africa include a scarcity of diagnostic skills and the inability to meet the high volume and complex disease burdens encountered in medical practice. The problem is most acute in remote areas, as the country's pathology specialists are mostly located in major cities. The CSIR has joined forces with the National Health Laboratory Service (NHLS) to develop digital pathology technology to help train experts remotely and to extend these services to all corners of South Africa.

SOUTH AFRICA IS CURRENTLY EXPERIENCING a shortage of expert pathologists. The NHLS provides laboratory and related public health services to over 80% of the population through a national network of laboratories. Every month its central laboratories receive thousands of blood samples from across the country. However, there is a shortage of trained diagnostic personnel to make correct diagnoses on often-complex cases and in such large volumes.

Training staff in this domain typically requires that the trainers – who are mostly based at central laboratories – and their students are positioned around multi-header microscopes to simultaneously view blood samples. This means that it is almost impossible to receive training to become an expert without spending a considerable number of hours at tertiary hospitals in central cities like Johannesburg and Pretoria.

“The CSIR has joined forces with the NHLS to develop technological solutions that are set to boost South Africa's capacity to train expert pathologists, deliver support services and perform quality control in laboratories across the country,” says Philip Marais, a development and implementation scientist at the CSIR.

Marais and his colleague, Zandile Nxumalo, a research biologist, were part of a CSIR-NHLS task team, led by Prof Johnny Mahlangu, head of the School of Pathology at the NHLS and the University of the Witwatersrand, who constructed the first version of a national digital pathology database containing 101 anonymous medical case studies.

For each of these case studies, an expert pathologist from the NHLS recorded the clinical features and full blood counts of the sample – developing a total of 1 214 digital images of blood samples with detailed annotations that identify specific abnormalities. Their work was peer-reviewed to ensure accuracy.

The assembly of these case studies into a database of digital images will facilitate the remote training of pathologists – from basic to specialist levels – based on the case study data. By having access to the digital database, students will not need to travel to central laboratories for training.

“We received positive feedback from both participants and facilitators after piloting the system during an annual morphology training course,” says Marais.

The database focuses on South Africa's unique disease burden, for example by depicting the effect of HIV and tuberculosis on the microscopic appearance of blood samples. With the support of this CSIR-developed technology, the NHLS aims to become a repository for haematology and morphology-related pathology information in Africa.

The initiative is set to increase the number of skilled staff to improve the number and accuracy of diagnoses. This will reduce the need for referrals and turnaround times for diagnoses and ultimately impact on the health of the people of South Africa and Africa by providing a higher standard of health care.

The CSIR team concluded the deployment of this digital pathology infrastructure to the NHLS's internal network, which went live in November 2014. The work is part of ongoing collaboration with the NHLS, which also includes the development of point-of-care diagnostic devices.

– Antoinette Oosthuizen

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CellLearn, digital pathology software technology developed by CSIR researchers.

CSIR and Stellenbosch University develop new software to improve childhood literacy in SA

In an effort to improve early childhood literacy in South Africa, the CSIR and Stellenbosch University have collaborated to develop an eBook on a touch-screen tablet, which is able to read out text using a digital voice.

IN 2011, CSIR ELECTRONIC ENGINEER specialising in human language technologies, Dr Febe de Wet and Stellenbosch University speech therapist and lecturer, Dr Daleen Klop, started exploring ways to use technology to improve early childhood literacy. Reading aloud to children is widely recognised as the single most important activity leading to language development. Among other benefits, reading aloud develops the children's ability to make connections between letters and sounds.

Unfortunately though, many South African pre-schoolers miss out on the luxury of having

The research team is now working on an isiXhosa version that will be piloted in the Eastern Cape during the second school term of 2015.

a parent or guardian read to them regularly. A single parent who works long hours may not have the time or energy. It is also possible that neither mom nor dad, nor granny nor aunty, knows how to read themselves.

To address this challenge, Klop and the CSIR's human language technologies research team are working on text-to-speech (TTS) software for South African languages. Klop's focus lies in emerging literacy, which applies to children who have just started, or will soon start school.

The idea they came up with, dubbed the EarlyLit project, uses a digital voice to read stories out loud from colourful, interactive and locally-produced eBooks on tablets.

Testing the concept, the research team produced an original Afrikaans tale about Thandi and her dog Jasper, with original

artwork and Afrikaans TTS audio.

The platform first introduces children to 'paging' through an eBook on a touch-screen tablet by means of static pictures of Thandi and Jasper, and accompanying text read out by the digital voice. "The kids caught on to using the tablet very quickly," says De Wet.

As part of the development, the children get to touch the main characters on the screen for an audio description of their activities, like Jasper rolling around on the grass or Thandi searching for a flower. More complex word-association



For a demonstration of the TTS software developed by the CSIR, visit www.qfrenzy.com.



A screen on the locally produced eBook. An isiXhosa version will be piloted this year.

exercises follow after that, all combining audio, text and images.

A pilot study with this prototype has been conducted to find out if the platform makes any difference to the development of reading and word-recognition skills. Forty-two children – from a community in the Western Cape where many parents work in the surrounding vineyards – took part in the study.

De Wet says the pilot study's preliminary results have been encouraging. "Although none of the children had any previous experience with computers or even cell phones, all of them quickly grasped the digital functions of the tablet and the interactive intervention programme. Comparisons between the pre-intervention

and post-intervention assessments showed that all the children learned new words as a result of the intervention. Furthermore, follow-up tests conducted eight weeks later, showed that they had retained the new vocabulary. Poor vocabulary is one of the main reasons for reading comprehension problems in young children. The study proved that this short-term intervention was successful in fostering vocabulary learning."

However, she says digital voice software does have some limitations, such as inappropriate intonations, an inability to personify characters, or occasional mispronunciations. But she asserts that the software would be much cheaper to produce than pre-recorded human narration.

Laurette Marais, appointed at the CSIR on a PhD studentship, combined the content provided by speech therapist Dr Daleen Klop of the Stellenbosch University and an Afrikaans text-to-speech system into an eBook.

It would also be much faster to produce in comparison with the time it takes to create proper studio recordings. The EarlyLit platform is completely local, which means accents are South African and content is culturally-relevant. No internet access would be needed to use it, and it is meant to enhance and complement printed literacy exercises that children can take home.

The research team is now working on an isiXhosa version that will be piloted in the Eastern Cape during the second school term of 2015.

The team also plans to extend the current software to include

features like word-level highlighting and an option for children to create their own stories from pictures, which could be read back to them using TTS.

"Our long-term goal is to support the Department of Basic Education's vision of improving literacy drastically from grade one to three," says De Wet. She hopes to bring publishers of educational material on board as well, in order to create a strong team of illustrators and story-writers to take the concept forward.



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A novel pilot plant in Limpopo has been commissioned in an initiative to produce green and black tea extract powder from the tea plant, *Camellia sinensis*, which grows on the 1077-hectare Tshivhase Tea Estate near Sibasa. The estate is situated in the foothills of the Soutpansberg Mountains in Limpopo, where rows of waist-high plants follow the natural contours of the estate.



EXTRACTING THE ESSENCE FROM TEA

The investigation into the production of botanical extracts is the outcome of the fruitful partnership between the Tshivhase Tea Estate, the Limpopo Department of Agriculture, the Department of Science and Technology and the CSIR.

The University of Venda is another important stakeholder. Professor Edward Nesamvuni has been a champion of the Tshivhase Tea Estate for a number of years, and has been instrumental in making the tea extract project possible. The university is expected to play a major role in research projects associated with the pilot extract facility in future.

Herbs Aplenty (Pty) Ltd and Vinco Steel (Pty) Ltd were the main technical partners responsible for the design, manufacturing and commissioning of the pilot plant.

Machine operator Tondani Mudau among tea bushes at the Tshivhase Tea Estate.

Tshivhase Botanical Extracts

The CSIR stepped up to partner on this project after the Limpopo Department of Agriculture commissioned a study to identify, investigate and pilot value-added products based on the tea crop. Bernadette Brown leads the CSIR team which combines experience and skills in enterprise creation with expert knowledge in botany and chemistry. She explains how this came about: "Tea extract is a high-value product used in cosmetics, beverages, pharmaceuticals and nutraceuticals. It therefore offers an additional value-added product to the black tea produced on the estate."

The CSIR's study required the planning and execution of a range of activities, including the pilot-scale production of tea extracts, to determine the viability of a future enterprise. A pre-feasibility study resulted in funding from Venteco (Pty) Ltd and the Department of Science and Technology for two subsequent phases.

Pilot plant in a container

Work on the pilot production facility started in 2012 and was completed in 2014. The facility incorporates a mix of local and international technologies. A feasibility study will be completed using data and information generated through the pilot production of extracts.

The pilot tea extract facility includes four main processing steps including tea brewing, filtration and concentration (through ultrafiltration and reverse osmosis technologies), and drying. It required studies to generate the required specifications and designs.



Tea extract in a powder trough.

Research revealed critical factors influencing design and the pilot facility was designed to fit within two modified containers.

In June 2014, the containerised pilot was delivered, installed and commissioned at Tshivhase Tea Estates. Run by trained operators, the routine production of tea extracts commenced in September 2014, together with an experimental programme designed to generate technical data and marketable products. Brown confirms: "Market interest and price are dependent on extract samples, and certificates of analysis."

She is proud of what the bigger team has achieved, "The technical and commercial know-how generated is valuable intellectual property that will provide a full-scale enterprise with a competitive edge in the market for tea extracts. Should a large-scale business be deemed viable, an enterprise creation phase is envisaged in some three to five years."



Toppies Topham, Manager: Tshivhase Tea Estate with a shoot plucked from a tea bush.

Did you know?

- Black tea is the term used to describe the familiar tea product sold commercially, which is processed using well-documented processes and yields a full-bodied amber brew. Green tea is a tea made from the same plant, but without an oxidation process.
- Tea harvesting is known as plucking; this twisting and pinching is done with both hands. Only fresh young shoots – "two and a bud" – are plucked from the mature tea bushes. After harvesting, the shoots are taken for processing.
- Popular commodities such as fruit and vegetables, green tea, black tea, red wine, coffee, chocolate, olives and extra virgin olive oil contain complex mixtures of polyphenols. Polyphenol is a term for the thousands of plant-based molecules that have antioxidant properties.



Plant operator James Bokosi.



Tea bags in the brewing tank.

The process of producing tea extract

The first part of the process is the extraction of tea. The tea leaves are put into large tea bags and brewed with hot water in a brew tank. In order to preserve the polyphenols, the temperature is carefully controlled using steam to heat the water.

"Polyphenols are the 'magic' ingredient," plant operator James Bokosi says. "The higher the polyphenols, the better the price that the extract is expected to command on the market."

The extract is then pumped into a filtration tank to remove microbes and residual plant matter (so-called insolubles).

The filtrate is put through a process of concentration by which excess water is removed. The result is a highly concentrated tea extract.

The final stage of the process involves a drip-feed of concentrate into a spray-drier where dry air is distributed. The resultant product – the extract – is gathered in a powder trough and carefully stored.

Producing the powder is, however, half the effort. Production protocols are meticulously followed and the pilot plant is maintained in pristine condition by adhering to a strict, prescribed regimen. The oversized tea bags are emptied of the 'brewed' tea shoots – now a heap of wet, limp leaves exuding a scent of cooked spinach – and washed in water.



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Fever-Tree has introduced a range of fragranced candles. www.fever-tree.co.za

African indigenous knowledge and science yield mosquito repellent

Studies by CSIR researchers and traditional healers on indigenous plants with mosquito repellent properties in the mid-1990s led to the discovery of a novel mosquito repellent. The essential oil of the indigenous plant, *Lippia javanica*, has more effective repellent properties than similar or comparable commercial products on the market.

A LICENSING AGREEMENT with Zollhaus International (Pty) Ltd has paved the way for marketing of mosquito repellent products, thereby realising the commercial benefit of the essential oil of *Lippia javanica*.

Mosquito control

As the most widespread and devastating of tropical diseases, malaria kills one African child every 30 seconds. Sufferers from chronic forms of malaria have diminished quality of life. Together with HIV and tuberculosis, malaria is a major public health challenge undermining development in the poorest countries of the world.

In South Africa, malaria is present in the three northern provinces bordering Mozambique and Swaziland, with seasonal transmission during October to April. Because of their nocturnal feeding habits, malaria transmission by the *Anopheles* mosquito occurs primarily between dusk and dawn.

Local populations have traditionally utilised *Lippia javanica* as a mosquito repellent. Cut branches are wiped on the skin and at the entrances to dwellings or burnt on an open fire at night.

CSIR researchers worked with traditional healers to identify the chemo type of the plant species with superior mosquito repellency properties. Dr Vinesh Maharaj, a former CSIR natural product

chemist, confirmed the outcome of this collaboration, "A benefit-sharing agreement between the CSIR and the owners of the traditional knowledge resulted in the first benefit payment to traditional healers during July 2012."

Coming up tops in efficacy

The efficacy (or effectiveness at producing a result) of the essential oil was evaluated at the South African Bureau of Standards (SABS) using olfactometer tests. An olfactometer is a device used to study insect behaviour in the presence of an olfactory stimulus.

Using a standard protocol with the yellow fever mosquito (yellow fever is an acute viral haemorrhagic disease), it was demonstrated that the CSIR-developed products are significantly more efficient at repelling and expelling mosquitoes when compared with the current products on the market.

Both repellency and expellency are important qualities. Repellency is the ability to prevent mosquitoes from entering an area; expellency is the ability to drive or force mosquitoes from an area.

Producing mosquito repellent candles

The essential step to realising the economic benefit of this discovery was the establishment of a community-based production process in Limpopo with funding from the Department of Science

and Technology. This followed the success of the trial plantation of the indigenous plant and the efficacy testing.

The production process starts with cultivation of the plant species on a 20 hectare cultivation site where the mosquito repellent crop is grown. The crop is harvested and distilled in an essential oil distillation factory on the site.

Workers at the factory of 650 m² in Giyani (Limpopo) have acquired the production technology and skills required to manufacture the mosquito repellent candles on-site. The factory contains equipment to formulate the active ingredients of the candles, and manufactures and packages up to 400 000 candles per year.

The project provides employment for more than 20 people in rural communities.

To market

As its first step, the CSIR filed a South African patent on the use of extracts and chemical substances derived from the plant as mosquito repellents.

The CSIR negotiated commercial terms for a licence agreement with Zollhaus to formulate the patented extract into mosquito repellent/expellent products for distribution and sale to local and export markets. All royalties negotiated under the licence will be paid in full to the owners of traditional knowledge. Through this licence, the CSIR secured demand for

the oil produced by the local community and in the process helped generate economic activity for the local community. Based on its market findings, Zollhaus developed a range of fragranced candles that effectively repel mosquitoes. Additional SABS tests indicate that the improved product has fly-repellent properties.


Zollhaus has taken some additional steps to firm up marketing prospects. The registration of the mosquito-repellent candle in terms of Act 36 of 1947 allows the sales of candles to the public. Zollhaus also successfully negotiated sales with South African chains stores and the product is currently available under the brand name 'Fever-Tree' in more than 200 South African stores.

What lies at the heart of the success of South Africa's 'home-grown' mosquito repellent is a winning technology recipe in which several players at the CSIR fulfilled key roles: natural product chemists working with owners of traditional knowledge; enterprise creation experts giving guidance; and technology transfer experts who recognise the market potential of this product.

– Biffy van Rooyen



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A photograph of Isaac Mohlamme, a man with a shaved head and a light beard, wearing a grey blazer over a pink and white striped shirt. He is standing in a store aisle, reaching up with his right hand to touch a jar of 'FEVER' brand citronella candle on a shelf. The shelf is labeled 'CITRONELLA PRODUCTS' in large black letters. Below the candles are rows of clear glass mosquito lamps. The background shows more store shelves and bright overhead lighting.

Isaac Mohlamme, Business Development Manager at Zollhaus International (Pty) Ltd spends time in-store at a major retailer.

Facts about malaria

Malaria transmission is caused by the bite of a female *Anopheles* mosquito carrying the *Plasmodium falciparum* parasite.

Worldwide, mosquitoes transmit disease to more than 700 million people. Annually, it leads to more than 300 million acute illnesses and claims the lives of at least one million people.

Ninety percent of deaths due to malaria occur in Africa, with the majority of its victims children under the age of five.



The team behind the digital laser. From left are Dr Sandile Ngcobo, Liesl Burger, Prof Andrew Forbes and Dr Igor Litvin.

WORLD'S FIRST DIGITAL LASER UNVEILED

RESEARCHERS AT THE CSIR designed and developed a digital laser which offers a method of controlling and altering a laser beam's shape from within the unit. Traditionally, beams have to be altered as they leave the laser or via a costly refit to change the positioning of mirrors.

By replacing one of the mirrors with a liquid crystal display, researchers were able to alter the beam at will. The innovation is regarded as a milestone in laser technology and could spur future laser-related developments.

The laser will allow the scientists to digitally control laser beams and shape new ways of developing technology that will improve various aspects of everyday life such as faster broadband and medical advancements.

There are numerous potential uses for this technology from medicine to communications. This is a significant advancement from the traditional approach to laser beam control, which requires costly optics and realignment of the laser device for every beam change.

Since this is all done with pictures, the digital laser represents a paradigm shift for laser resonators. The dynamic control of laser modes could open up many future applications. The device represents a new way of thinking about laser technology, and CSIR researchers see it as a new platform on which future technologies may be built.



Dr Sandile Ngcobo's work on laser physics formed part of his PhD studies. The digital laser uses liquid crystal display technology to change the shape of a laser beam dynamically and instantly, a feat scientists have been working towards for a long time.





A sample of mammalian cells being prepared for multi-beam optical tweezing, sorting and analysis.

Optical tweezing potential further increased with multi-beam development

THE CSIR HAS MADE FURTHER ADVANCES in optical tweezing – the laser-based process of trapping microscopic particles and manipulating these for experiments in areas such as biomedicine and biotechnology. Researchers can now, for the first time, trap multiple particles by time-sharing the laser tweezing beam.

Researchers have in the past tweezed single mammalian cells and colloidal particles such as polymer and silica micro-beads. Now they intend to use the ability to tweeze multiple particles with a laser beam to develop point-of-care HIV diagnostic tools.

“To further hone skills in this area, CSIR researcher Fakazi Nhachissambe visited the University of Saarbrücken, Germany for a six-week training period under the tutelage of biophotonics expert Prof Karsten König in 2014. Nhachissambe is a Master’s student working with CSIR principal researcher Dr Patience Mthunzi in biophotonics research. Using automated multiple laser beams alongside different advanced microscopy techniques for tweezing purposes, Nhachissambe focuses on investigating potential medical and diagnostic applications of these technologies.

CSIR researchers intend using this tool in optical cell sorting for fractionation and separation of HIV positive from HIV negative cells. Ultimately it could result in optical microchips with applications in point-of-care HIV diagnostics.

About optical tweezing

The principle of optical tweezing is analogous to conventional tweezers, except here the trapping and control of the particle is purely with light and not with any mechanical device. Since these light-matter interactions occur at such a small (size) scale, optical tweezers hold massive potential for novel scientific developments and applications in the biomedical and the biotechnological research arenas.



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OVERCOMING BUFFERING

A technology that allows for video streaming in bandwidth-constrained environments

THE USUAL DIFFICULTY with streaming and viewing content on any device or computer is buffering, a particular type of disruption to the data stream. Buffering usually happens when the connection to the internet is slow or when the network is congested, meaning there is insufficient bandwidth at a given time to meet the demand.

The CSIR and its partners have put an end to this hindrance with the development of Adaptive Real-Time Streaming Technology (ARTIST). This technology allows viewers to watch live content on their mobile devices and computers from anywhere in the world without interruption to their video stream, even at very low connection speeds.

ARTIST has extended the concept of adaptive streaming to adapt faster and at very low rates, thus widening the access not only to urban areas, but also to rural areas. The technology is perfectly suited to the South African environment as it works in 3G and low-bandwidth environments like EDGE or GSM networks. Users are also able to use existing devices (Android smart phones and tablets) and existing mobile networks. It is rate-adaptive, meaning that the rate at which the video is streamed adapts according to the bandwidth available. Typically, its low bit rates range from 24 to 128kbps. The medium rates range from 64kbps to 200kbps.

– Ntombi Dyosop



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FINDING WAYS TO SHARE SPECTRUM AND BUILD NETWORKS IN UNDERSERVED AREAS

The CSIR has developed a tool to change the way spectrum frequency is managed and regulated. The tool will allow the use of unused spectrum in the television broadcasting frequencies, thereby helping to facilitate cheaper delivery of high-speed broadband connectivity in underserved areas.

WITH FREQUENCY SPECTRUM

in high demand, regulators globally are looking for ways to better manage this scarce resource. In Africa, the issue is not only about efficient spectrum usage, but also about building wireless broadband networks in underserved areas. The CSIR is leading efforts in these endeavours.

The electromagnetic spectrum is the range of all possible frequencies. It is the medium that allows for the provision of voice, data and television services over the wireless interface. It is a finite and often expensive resource.

The paradox of scarcity

While there seems to be a widespread shortage of usable spectrum, much of the needed spectrum is lying dormant or is currently under-used. Spectrum regulators, wireless service providers and governments are now working on finding ways to free up spectrum for the much-needed wireless broadband internet services.

The problem – which is acknowledged by spectrum regulators globally – lies with how spectrum has been managed. Spectrum management uses what is referred to as a static licensing regime, meaning that spectrum is licensed at a fixed price to a primary user. Often, the users – for one reason or the other –

cannot use the entire spectrum allocated to them, which has led to large tracks of licensed spectrum being under-utilised.

A new approach of managing spectrum is being mooted. This approach is called dynamic spectrum access. It proposes new techniques and tools of allocating and efficiently using radio spectrum resources.

Sharing spectrum

Spectrum sharing is an approach to dynamic spectrum access in which the available spectrum resource is used to accommodate either multiple user groups or to accommodate different types of uses. There are several techniques encompassed in spectrum sharing. These can be administrative; technical and market-based. Furthermore, spectrum can be shared in several dimensions, namely time, space and geography.

Spectrum sharing already exists in different forms; WiFi is one such example. Though spectrum sharing already exists, significant technical research and development is needed to free up more spectrum. Furthermore, progress needs to be made on associated regulatory issues.

A broader range of spectrum sharing and dynamic licensing technologies and solutions is being discussed by the

International Telecommunication Union, the European Union and the European Conference of Postal and Telecommunications Administrations forums. This will ultimately result in building affordable wireless broadband networks that can provide broadband internet services to consumers, businesses and government.

Managed sharing of spectrum

The biggest problem to overcome with spectrum sharing has been the issue of interference and signal collision. Until recently, it was not possible to check whether allocated broadcast frequencies are in use or not. Even if it were possible to identify broadcast frequencies not in use, no technology existed to allow for the unused broadcast frequencies to be repurposed for other forms of communication.

There are different methods and tools for managed sharing of spectrum. One of the most reliable techniques is the use of a geo-location spectrum database.

Geo-location spectrum databases allow efficient use and management of spectrum by assigning specific channels at specific locations to secondary users in such a way that the primary user of the band does not experience harmful interference.

Sharing CSIR expertise

The CSIR is one of the continent's leaders on the use of such databases to manage frequency. Researchers at the CSIR, led by Dr Fisseha Mekuria, have developed a novel tool for geo-location based dynamic spectrum allocation, covering all regions of South Africa.

Through a series of trials, the CSIR geo-location spectrum database has proven that it can identify frequency channels unused by TV broadcasters, at a particular location, and provide secondary broadband networks and internet service providers with regulatory information on signal strength and network coverage for a secondary user, so as not to interfere with primary users in the area. In this way secondary users can safely utilise unused spectrum for providing wireless broadband internet services.

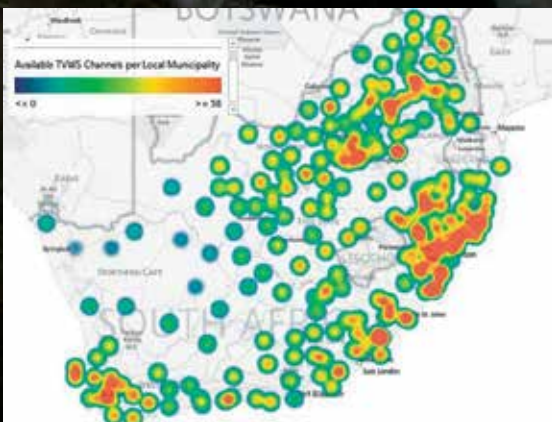
The CSIR has received requests from other countries on the continent, the most recent being Ghana, to aid them in designing such spectrum management tools. As in South Africa, other African countries are looking to accelerate wireless broadband connectivity to their underserved communities.



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CSIR researcher Litsietsi Montsi demonstrates useful aspects of the geo-location based dynamic spectrum allocation tool, developed by the CSIR. The Centre for High Performance Computing is hosting the database. Recent developments include a cloud-based spectrum service provision platform for flexible and scalable operation of the developed technology.

With the help of the CSIR, Ghana Technology University College is planning its own managed spectrum sharing trial. Using television white space networks as a test-bed, the trial is investigating the possibility of providing wireless broadband internet services through spectrum sharing.



This image shows an aggregate of white space spectrum availability for municipalities in South Africa. Recent developments include improved accuracy modelling of radio frequency propagation, in line with EU standards.

Loading sample fluid into the inlet channel of a paper-based microfluidic device.



The well-known pH test strips used in many chemical laboratories.



Viewing the test result on the reverse side of the paper-based diagnostic device, is CSIR researcher Klariska Moodley.

SENSORS WORTH MORE THAN THE PAPER THEY'RE PRINTED ON

If the famous litmus test for acidity could be regarded as the Nokia 3310 of paper-based sensors, then the advanced future paper-based sensors the CSIR is working on, will seem like smartphones in comparison. These sensors include fully functioning electronic circuits printed on a piece of paper, and a blood glucose level test that involves simply placing a drop of blood on a small square of treated paper. Future paper-based sensors will be cheap to manufacture, ideal for resource-scarce populations and will be able to help with some of the world's biggest environmental and health challenges. What makes paper-based sensors so attractive, is their simplicity. One application, a classroom chemistry demonstration kit, simply involves a piece of paper patterned with wax and a red cabbage being put in a blender.

RED LITMUS PAPER turns blue in an alkaline solution, and blue litmus paper turns red in an acid. It is a simple colour change on a piece of paper, but it reveals the pH of a solution.

The litmus test is often used as an introduction to chemistry in today's classrooms, but the technology has been around since the 1300s. In modern terms, one might even call it the first paper-based sensor ever to be invented. It was, and is, created by absorbing a mixture of lichen dyes onto filter paper.

"If we compare paper-based sensors to cell phones, the litmus test is like those early, brick-shaped objects that could do nothing besides connect a call," says Kevin Land, a microfluidics researcher at the CSIR. "Future paper-based sensors will be the equivalent of smart phones."

Picture, for example, an electronic circuit printed onto a piece of paper instead of onto a circuit board. Or a glucose test where a droplet of blood on a square of paper would be all that's needed to measure a person's blood sugar levels.

Or imagine an educational chemistry kit, where complex reactions can be demonstrated simply, using just a red cabbage, a folded paper cut-out and some every-day, easy-to-obtain liquids.

In what he calls a two-week 'sprint', Land and his colleagues dropped all their other projects to see how easy it would be to turn a piece of paper first into that educational tool, and later into advanced electronic and biological sensors that could be applied in areas like environmental monitoring or point-of-care medical diagnostics.

Such sensors would be cheaper to manufacture than current options, easier to transport, and they would be ideal for use in resource-poor settings.

They are also extremely scalable technologies. For example, in the case of an electronic circuit, a highly specialised printer can be used to apply fine metal tracks onto paper, or one can manually paint liquid metal onto a sheet using a small brush.

Even wafer-thin layers of transistors, diodes and batteries could be printed using advanced equipment, but it is just as easy to incorporate a regular, watch-sized battery and other 3D electronic components into a hand-painted circuit.

For the cabbage chemistry kit, wax is printed onto one side of a sheet of specialised paper (chromatography paper), leaving gaps where the liquids are to be applied, and channels where they are meant to flow within the paper.

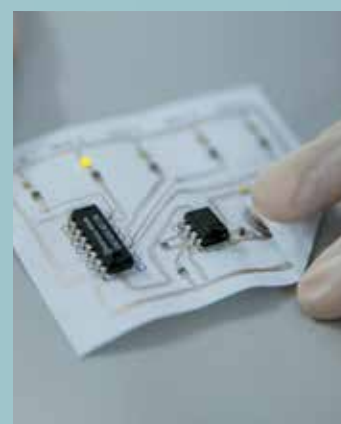
Next the sheet is placed onto a hot plate to melt the wax. This ensures that the wax absorbs into the paper right through to the other side, thus creating perfectly contained application spots and flow channels for liquids (wax is hydrophobic, meaning that it repels water-based solutions).

Land and his team used a straightforward protocol for using this kit in the classroom that involves popping a red cabbage into a blender to extract its purple juice, and then applying this juice to the wax-channelled paper, which has had common reagents like lemon juice and vinegar dried into it beforehand.

"This experiment produces the most brilliant and distinct colours," says Land emphatically, adding that it demonstrates chemical reactions at different pH levels.

The way forward will involve refining and then rolling out this classroom aid, and, depending on funding, investigating further options for advanced paper-based sensors that can be manufactured on a large scale and applied in the real world.

"The idea is that you could print almost any functional component straight onto a normal piece of paper," says Land. "From the wax for the fluid barriers, to biomaterials



Utilising standard electronic components to show timing circuits on paper.

like antibodies, to the chemistries required for detection, and even the electronics needed to display the result."

He adds that such paper-based sensors would comply perfectly with the World Health Organisation's ASSURED principle, which states that diagnostic tests should be **A**ffordable, **S**ensitive, **S**pecific, **U**ser-friendly, **R**apid and **R**obust, **E**quipment-free and **D**eliverable to end-users.

So, just like the litmus test, Land's envisioned paper technologies will not only be an easy way to teach students, but could help solve some of our biggest health and environmental challenges.



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The CSIR-developed power management device weighs less than 500 g and is just bigger than an average male soldier's hand. It has passed the MIL-STD-810F environmental tests, proving its durability for long-term field deployment.

CSIR develops a power management device to help soldiers reduce the weight of equipment

THE CSIR HAS DEVELOPED a power management device that helps soldiers to reduce the weight of equipment they carry during field deployments.

The new device has passed the MIL-STD-810F environmental tests, proving its durability for long-term field deployment.

The new device reduces the weight a soldier has to carry by reducing the need for many different chargers. With less weight to carry, soldiers are able to move faster and travel longer distances on foot, which contributes to a more agile defence force.

Each piece of electronic equipment that forms part of a soldier's dismounted kit has a custom battery pack and a charger, which leads to unnecessary duplication and added weight. The CSIR power management device can be charged from a number of sources, such as vehicle batteries

or by harvesting energy from the sun through a light, portable solar panel.

Intelligent cable identification technology ensures automatic source and load detection, to avoid a wrong connection which may lead to damaged batteries or overheating. This is particularly useful when the system is operated in complete darkness.

Any equipment used by a soldier on foot needs to be small, lightweight, efficient and robust. The CSIR device fully complies with these requirements. The user-interface is uncomplicated with an alphanumeric LCD display and five navigation buttons. It has two ports, clearly marked 'in' and 'out', instructing first-time users where to connect the energy source and where to connect equipment or batteries that are low on power. The display informs soldiers of power usage and remaining battery time, assisting them with optimal energy use management.



Fast fact Batteries contribute about 30% to the overall weight of a soldier's backpack, which also includes water, ammunition, weapons, navigation equipment, radios, food supplements and other equipment. These packs can weigh in excess of 80 kg.

The device utilises a rechargeable radio battery as the main energy storage item. Soldiers generally carry a radio with a battery pack and this battery pack is utilised optimally to power all their other

equipment. This also simplifies the logistical supply chain and reduces costs as only one type of battery is required for all the equipment.

The system was extensively tested in the CSIR's environmental testing laboratory. Testing involved exposing the device to temperature cycles varying between -21 degrees Celsius and 63 degrees Celsius. Its durability was put to strenuous altitude testing, as well as shock, vibration and water resistance testing.

Navigation systems and satellite phones, amongst others, are critical to mission success. By including the CSIR-developed device in a soldier's kit, they are able to charge batteries that power their equipment, despite having limited access to resources while on a mission.



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BOOSTING CONCENTRATION THROUGH BETTER NUTRITION

PROPER NUTRITION

IMPROVES HEALTH and provides people with the necessary nutrients to be more focused and productive, not only in the workplace, but also during the early school years. The CSIR has developed a vegetable-based nutritional drink, which is provided to learners in the Eastern Cape as part of a comprehensive education intervention programme to boost learning and improve the nutritional status of the learners in the province.

The Eastern Cape's Intsika Yethu municipality is one of the poorest in South Africa. Many children live in such poverty that their only meal of the day is the one provided by the Department of Basic Education's national schools nutrition programme. Researchers believe this lack of sufficient nutrients contributes to poor educational outcomes.

The nutrition challenge

A baseline study conducted by Vaal University Technology (VUT) showed poor iron status amongst children in five schools in the Cofimvaba district. In addition, chronic and acute malnutrition were mainly observed in the girls. The prevalence of underweight was 8,3%, acute malnutrition (wasting) 2.8% and stunting 5.6%. Only 2.3% of the boys suffered from chronic malnutrition (stunting) and no acute malnutrition was observed. Some 4.7% of the boys were overweight, which confirms the double nutrition challenge of over- and under-nutrition faced by the country, especially in children. "We developed a nutritional breakfast drink that provides micronutrients, in particular Vitamin A, iron and zinc, which have been shown to be lacking amongst South African children," says Tshidi Moroka,

manager of the CSIR's natural products and agro-processing research area.

"Vitamin A helps to improve vision, while sufficient iron can improve performance in school, and zinc improves the immune system as well as brain function."

Producing the drink

The CSIR transferred the production technology to the University of Fort Hare Agri-Park, which manufactures the drink and supplies it to the schools in three different flavours; chocolate, strawberry and vanilla. The nutritional drink contains vegetables such as sweet potato, carrot, beetroot and morogo, a highly nutritious indigenous vegetable similar to spinach. Other ingredients include sorghum, soya powder and milk and it is produced in a powdered premix format, which has to be mixed with clean water.

In order to measure the impact of the drink, VUT will conduct a study to look at biochemical measurements and anthropometrics at the end of 2015. The results will show how the intake of the drink affects the levels of the three micro nutrients. So far the feedback from the school principals is that the breakfast drink has improved school attendance. "Nutrition is important for learning outcomes, as hungry children find it hard to concentrate in class," says Moroka. The project is funded by the Department of Science and Technology and forms part of a broader educational intervention also supported by the Department of Basic Education.

– Antoinette Oosthuizen



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The nutritional drink is produced in a powdered premix format, which has to be mixed with water.



A *eucalyptus* flower is covered with a pollination bag after controlled pollination.



Eucalyptus flower.



The hybrid *Eucalyptus* planted during trials (above) and field trials (right).



A NEW *EUCALYPTUS* BREED FOR BETTER WOOD PULP

In South Africa the demand for wood for various products significantly outstrips supply. Studies have shown that the current shortfall in the supply of wood is expected to continue over the next 30 years. To address this need, researchers developed two novel *Eucalyptus* hybrids with improved pulping properties.

IMPROVEMENTS IN VOLUME, basic wood density and pulp yield have the biggest impact on the profitability of pulp production. As part of Project Pulp, the CSIR, in partnership with the Department of Science and Technology and NCT Forestry, has developed a commercial and a pre-commercial hybrid *Eucalyptus* clone.

"The main purpose of the clones was to provide the pulping industry with a better quality of wood," says Karen Eatwell, a researcher at the CSIR specialising in tree improvement.

A pre-commercial clone is one that has performed well under experimental conditions and that should be tested over a period of two to three years at separate sites to establish its potential for commercialisation. A commercial clone is one that has performed well during the commercial testing and is therefore recommended for use by NCT Forestry.

Eatwell says one of the CSIR clones passed its pre-commercial and commercial testing and the hybrid clones have, for the last two years, successfully been

marketed through established and licensed forestry nurseries to forestry growers throughout South Africa.

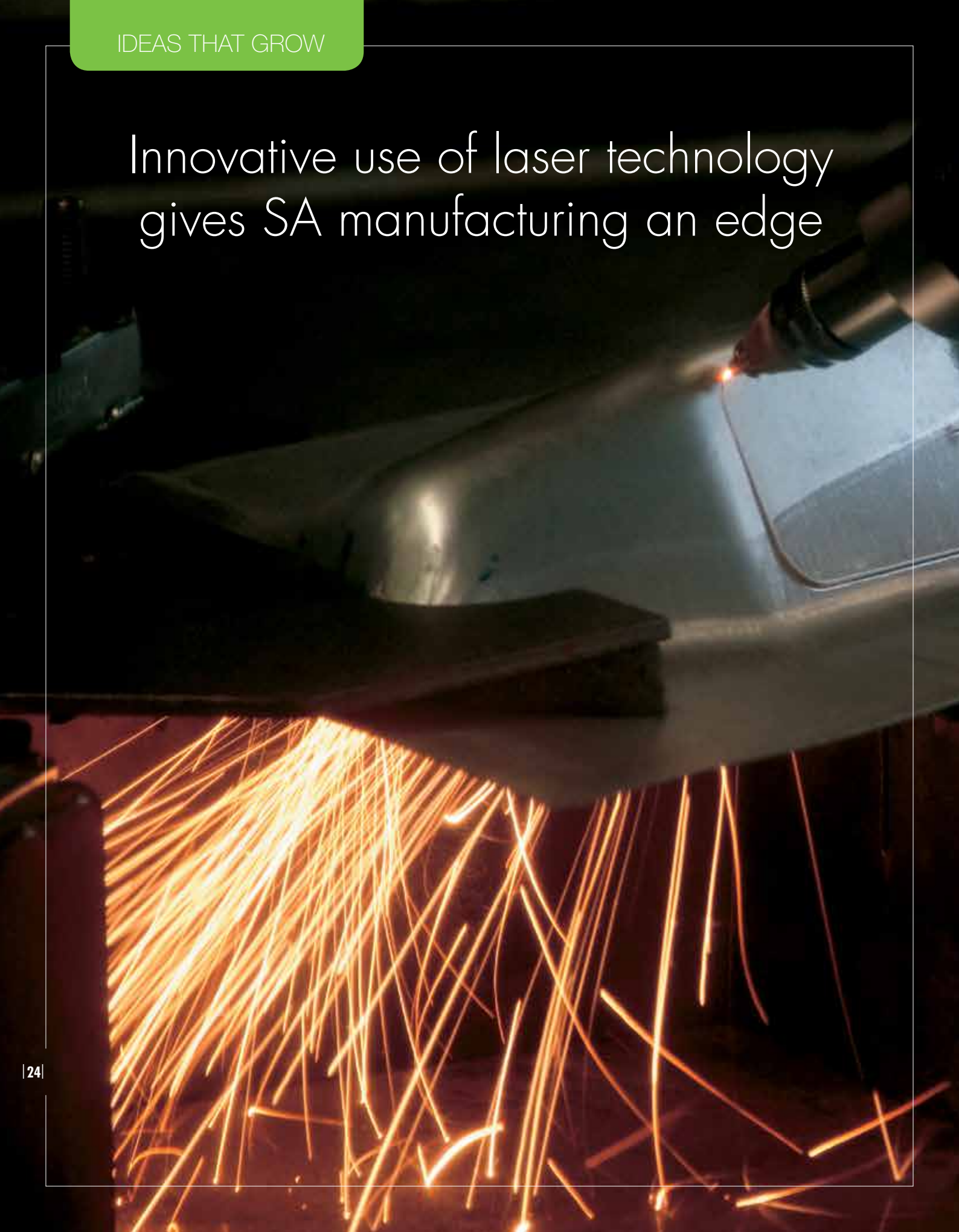
Plant Breeders' Rights – which prohibits anyone else from reproducing the clone – were awarded to *Eucalyptus* clone CSIRGxN2107 which displayed superior performance in various field trials. "This was the first Plant Breeders' Rights for *Eucalyptus* to be issued in South Africa," says Eatwell.


– Reyhana Mahomed



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Innovative use of laser technology gives SA manufacturing an edge





Laser 3D cutting of automotive components.

The CSIR, through its laser engineering services, helps to save the South African industry millions of Rands by increasing productivity and reducing direct and indirect maintenance costs by eliminating the need for expensive imported replacement components and excessive downtime.

“LASER CLADDING TECHNOLOGY enables us to save the South African manufacturing industry millions of Rands on a yearly basis,” says the CSIR’s Hansie Pretorius. “For instance, laser cladding offers a cost-effective alternative to repair rather than replace high value components such as turbine rotors in the power generation industry.

We use laser cladding to repair journal areas – part of the shaft that makes contact with the bearing – on these high value components. Previously they were either scrapped or exported to Europe for repair at enormous cost, not to mention the downtime incurred. “We can use laser cladding for refurbishment of turbine blades and compressor blades, and the repair of aircraft gear boxes, cylinder heads, shafts and tooling,” he says.

Similarly, the CSIR provides a service to the automotive industry and suppliers to the automotive industry through which the global competitiveness of this sector is enhanced by means of access to state-of-the-art laser technology. Local suppliers of car body parts benefit from the CSIR’s 3D cutting technology which enables cost-effective production of sample parts for quotation purposes and setting up of assembly lines.

To date, the CSIR’s laser-enabled manufacturing group has done laser cutting, hardening, engraving and welding work for companies such as Mercedes Benz, VW/Audi, Ford, Nissan, Toyota and Maserati. Work was also done for Denel on the Rooivalk Attack Helicopter; Tupperware, and for various tooling manufacturers.

“One of our biggest clients in laser hardening is Bell Equipment,” says Pretorius. “For Bell, we do selective hardening on specific areas on stub axles.” Pretorius is proud to say that the group’s work can also be seen in the new VW Polo line, where they did laser hardening on the styling lines of a bonnet press tool in order to increase the service life of the tool.

The successes of the group bear testament to the CSIR’s continued commitment to enable and support the global competitiveness of local industry through research, development and innovation.



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LASER-BASED INNOVATION CONTRIBUTES TO COMPETITIVENESS IN STEELMAKING

The CSIR, in collaboration with ArcelorMittal, has developed a laser-based process to drastically increase the service life of foot rolls used in steelmaking.

PRODUCTION COST PLAYS A MAJOR role in determining the cost of any product or commodity. Both the direct and indirect costs associated with the maintenance of production equipment impact on the cost of

production. Continuous casting machines play a pivotal role in steel production. It is in these machines that the molten metal is cast, resulting in solid slabs from which the myriad of steel products will be manufactured

down the line. For the industry to remain competitive, production losses because of a malfunction or even scheduled maintenance of continuous casting machines should be kept to an absolute minimum.



CSIR metallurgist Corney van Rooyen monitors the concast roll cladding process (left). The service life of foot rolls such as those shown above can be increased by up to 300 percent with the use of laser technology.

The most vulnerable components in a continuous casting machine are the foot rolls. These rolls are positioned just under the mould in the continuous casting machine and are used to contain the solidifying slab. These rolls operate under extreme service conditions which include high temperature corrosion and oxidation, abrasive wear and cyclic thermal loads caused by the rolling contact with the solidifying slab and the cooling water that is sprayed onto the opposite side of the roll. The combination of these conditions is known to pose a serious threat to the surface condition of metals in general and foot rolls are no exception. The surface degradation of these foot rolls determine the scheduled maintenance intervals for continuous casting machines. Any intervention which could result in a substantial increase in the surface life of foot rolls will be beneficial to the cost of steel production.

The service life of a foot roll is determined by the extent to which the material from which it is manufactured can resist the wear mechanisms that are triggered by the operating conditions that it is exposed to. The ability of a material to resist wear is determined by its chemical composition in combination with its microstructure. The microstructure in turn is determined by a combination

of the chemical composition and the thermo-mechanical history of the material.

Traditionally the wear resistance of foot rolls is improved by a martensitic stainless steel overlay which is applied by means of an arc welding process. The service life of these rolls is limited by sensitisation of the stainless steel as a result of carbon pick-up from the roll material during welding. This is because the high heat input associated with arc welding causes excessive dilution of the overlay material by the carbon-containing roll material as well as a microstructure which contains ferrite in addition to the martensite. The carbon depletes the chromium from the ferrite in the matrix which reduces its corrosion resistance along the ferrite-martensite interfaces. Corrosion along ferrite-martensite interfaces will eventually result in the disintegration of the material and compromise the integrity of the surface.

The CSIR in collaboration with ArcelorMittal devised an innovative process through which the low heat input and excellent control of a high-power laser is combined with an overlay material with a novel chemical composition to produce a weld overlay which increases the service life of foot rolls by between 200 and 300 percent. The low heat input provided by the laser-

based process eliminates carbon pick-up through much-reduced dilution, while the chemical composition in combination with a rapid solidification produces a fully martensitic microstructure which contains no ferrite.

The enhanced performance of the laser-welded foot rolls was verified during field trials which started in 2010 at the ArcelorMittal plant in Vanderbijlpark. ArcelorMittal started using laser-welded foot rolls in 2012 and continues to do so.

The laser-based process has been licenced to FW Gartner, an American-based multinational surface engineering company for international distribution. Höganäs AB has been contracted to manufacture the CSIR-developed welding consumable under a royalty agreement. The research that laid the foundation of this successful invention was published in the prestigious *Welding in the World* which is the mouthpiece of the International Institute of Welding. Corney van Rooyen was also honoured by the Southern African Institute of Welding with the Harvey Shacklock Gold Medal for his research.

Steel is one of the most widely used materials today. It is encountered in practically every aspect of modern society, including transportation, construction, mining, agriculture and consumer goods. Every year some 1.3 billion tons of steel is produced globally.



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TITANIUM METAL PRODUCTION AND CASTING TECHNOLOGIES FOR INDUSTRY

The CSIR is developing a suite of complementary technologies to help South Africa add value to its vast resources of titanium. Key to this is a novel process for producing primary titanium metal. A small-scale titanium pilot plant has been established to focus on up-scaling the production of titanium metal powder.



THE TITANIUM PILOT PLANT is a step towards a commercial scale plant that will be able to produce titanium powder at a lower cost than present imports and alternative processes, making this light metal an economically viable option on which many downstream manufacturing industries can be based and sustained.

South Africa has vast reserves of titanium-bearing minerals and is the second largest producer of mineral concentrate in the world. Apart from concentrating the mineral to produce titanium slag and pig iron, little further value is added to the mineral before exporting it. It is believed that there is significant potential to add value and create much-needed employment if titanium metal is extracted from the mineral concentrate and a new downstream industry is created to manufacture titanium metal components and products.

The pilot plant uses a novel and patented process that is internationally competitive. The DST has been a key

stakeholder in this initiative and has allocated more than R100 million for the development of this technology.

One of the other complementary technologies developed by the CSIR is an investment casting process for titanium. Very few companies in the world can produce titanium castings using an investment casting process. The CSIR developed a process for South Africa's industry to use and is not only refining this process, but also optimising every step in the process so that the technology, equipment and everything needed for the process, can be successfully transferred to industry.

"I believe that the investment casting of titanium represents a wonderful opportunity for the local manufacturing industry," says Pierre Rossouw, CSIR principal technologist charged with developing the CSIR's titanium investment casting process. "The industry will have access to locally produced materials and techniques that previously had to be imported at a very high premium."



Cost-effective semi-solid metal casting technology suitable for various industries

Research has shown that with the use of a novel rheo-high pressure die casting (R-HPDC) technology developed by the CSIR for the casting of semi-solid metal alloys, high-quality metal components can consistently be produced at a low cost.

THE CASTING OF SEMI-SOLID METAL ALLOYS

was first developed at the Massachusetts Institute of Technology (MIT) in the early 1970s. The challenge for the CSIR's researchers and engineers was to develop a technique that consistently produced high-quality products that could be used in cost-sensitive niche markets, such as the automotive industry.

Following research conducted at the University of KwaZulu-Natal in the mid-1990s, the CSIR developed and patented a novel semi-solid metal rheocasting system in 2002 for the preparation of semi-solid slurries from the liquid state.

Two technologies can produce metal slurries at a temperature at which semi-solid casting can take place, namely thixocasting and rheocasting. Thixocasting is a two-step process. Special feedstock material is purchased at a much higher cost and reheated to the semi-solid state (highly capital and energy intensive) before forming into a final component. With rheocasting, in

contrast, the molten metal is cooled and cast into a solid shape in one step.

The biggest advantage of the rheocasting process is that the slurry can be made on demand and 'in house'. The chemical composition of the cast metal can also be modified and tailored to meet the quality and property specifications of the components. This allows scrap and other used metals to be directly re-melted for subsequent rheocasting, which contributes to lower production costs.

The rheo-high pressure die casting (R-HPDC) technology developed by the CSIR is both flexible and capable of processing just about any alloy or metal with a melting temperature below 1 000 °C.

The technology can be used to develop components for a number of end-users, from the aerospace industry to prosthetics. Discussions about the suitability of the technology are underway with bicycle manufacturers.



An automotive component (brake calliper) produced in aluminium alloy A356 with the CSIR rheo-high pressure die casting process.



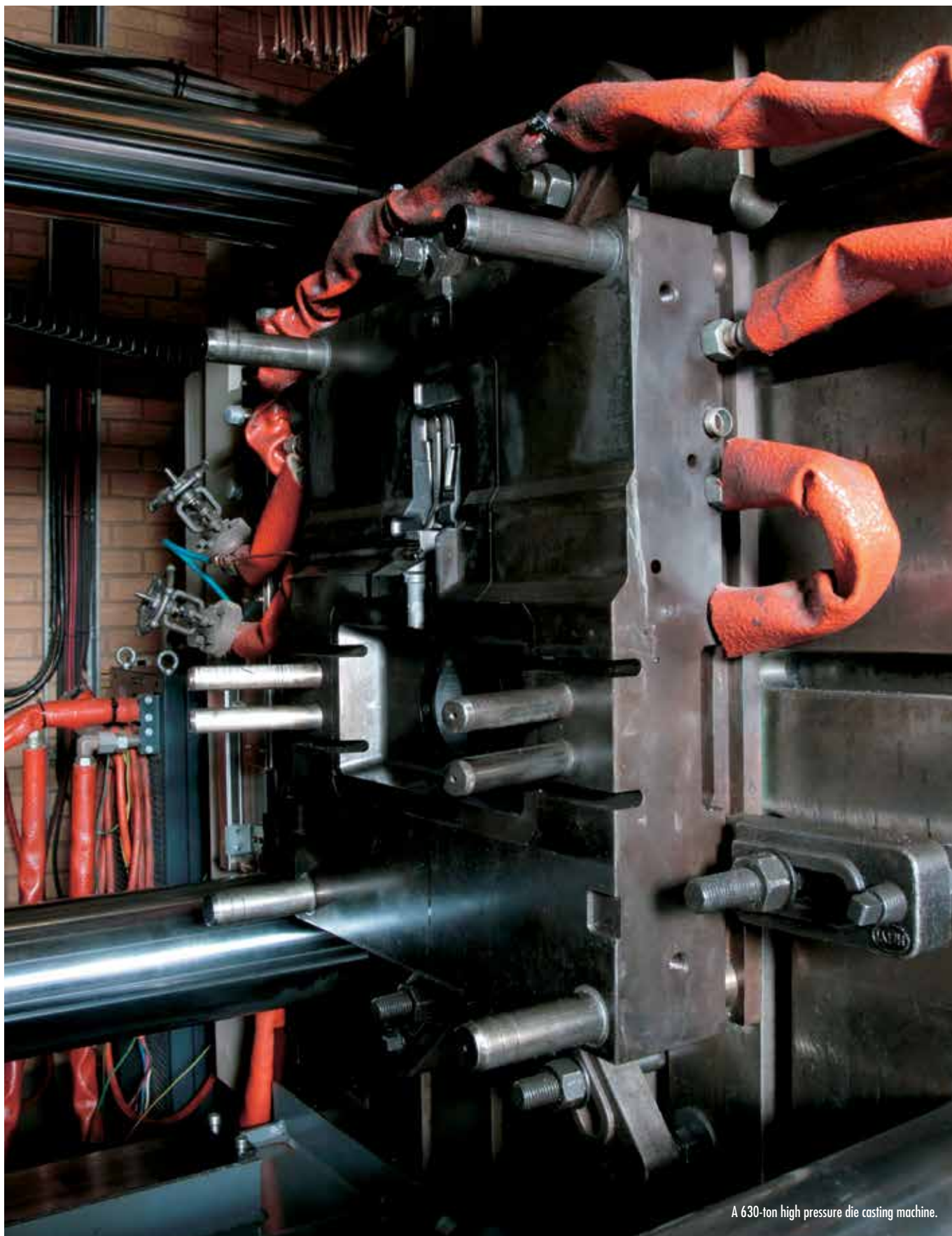
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The integrated induction and forced air cooling coil is at the heart of the CSIR Rheocasting System used in the organisation's rheo-high pressure die casting process.

Further reading: Curle UA, Möller H, Govender G. R-HPDC in South Africa. *Solid State Phenomena* 192-193 (2013) 3-15.



A 630-ton high pressure die casting machine.

30 years of prosthetic relief offered by the bollard



The CSIR-developed bollard, used in the repair of knee ligaments.

The bollard – a medical device used in conjunction with a prosthetic ligament for the repair of cruciate ligaments in the knee – was developed by the CSIR in 1982 and more than 60 000 devices have been sold over the past three decades, the last sale being an order of 250 units in 2013.

THE CSIR-INVENTED and developed implantable expanding rivet is made of carbon fibre reinforced polysulfone (a family of thermoplastics). It resulted from the CSIR's investment in research on biomaterials with a focus on developing composite materials that were biomedically more compatible than the metals used for surgical implants at the time, without compromising strength.

In 1984, the bollard received the Chairman's Award for Excellence from the SABS Design Institute (at that time called the Shell Design Awards). It was also the first carbon fibre reinforced composite implant to be approved by the US Food and Drug Administration for human surgery.

Sales of the device started in 1984, via the CSIR's technology commercialisation company, Technifin. In 1989, co-inventor Peter Mundell left the CSIR and set up Fibretek Developments CC to manufacture the bollard. Fibretek later became a private company (Fibretek Developments (Pty) Ltd). It was one of the first South African medical device manufacturing companies to develop export markets for its products.

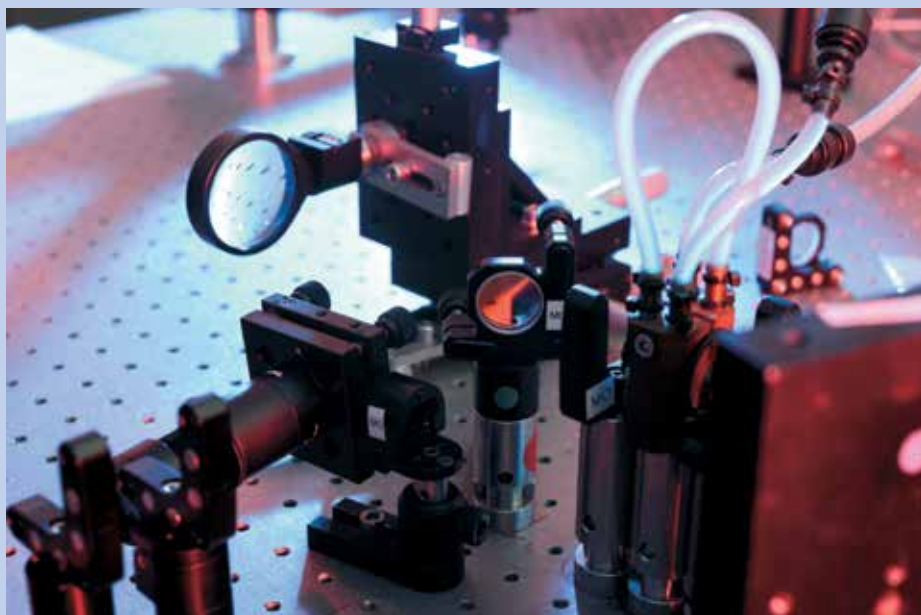
"Very few companies, if any, can sustain themselves from income based on a single product, but Fibretek was fortunate to have had sufficient sales in the early years to be able to invest in the development and commercialisation of other products, such as the Optoscan Visual Field Scanner and the Cape Town Stereotactic Pointer," concludes Mundell.



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International optics producer takes up CSIR laser technology

Cassidian Optronics, formerly Carl Zeiss Optronics, adopted a CSIR-developed concept to customise its range of lasers. CSIR scientists demonstrated that a minor modification to a standard industrial laser system (the addition of two novel mirrors) increases the efficiency of the system by a factor of ten. The technology has significant potential and forms the basis of a new Technology Innovation Agency commercialisation project.



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A RELIABLE PROCESS TO PRODUCE a key reagent that is used to predict the shelf-life of beer is increasingly used by local and international breweries.

The reagent, α -phenyl-*N*-tert-butyl nitron (PBN), is used in combination with an analytical technique called electron paramagnetic resonance spin trapping. The application of this assay is used to measure the resistance of beer to free-radical oxidation. Typically, all brewed beverages contain a certain amount of naturally occurring antioxidants that protect their quality. Beverages with increased levels of natural antioxidants are resistant to the oxidation process for longer periods and thus the beverages are stable for increased periods.

By predicting the shelf-life of the beverage, the beverage producer can determine the product's useful retail life within the commercial environment, leading to improved logistical planning and profits. The robust PBN process developed yields a high-quality product which has been taken up by the brewing industry.

CSIR process chemist, Dr Greg Gordon, started working with a team on the technology in 1998 and developed a market-ready product by 2002. Thereafter the market was developed and expanded to include supply to local and international breweries. The technology was then licensed to Chemical Process Technologies (Pty) Ltd and the PBN business has subsequently grown under their stewardship.



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Brewing industry
uses innovation
to predict the
shelf-life of beer

Studies pinpoint crops that can be grown on previously mined land



Forest trees were part of the trial to ascertain what plants could be cultivated on previously mined land.



The study site in Richards Bay.

With the right fertilisers, crops like peanuts, Bambara nuts, rosemary, tea tree, mango and certain *Eucalyptus* clones can be successfully grown on the characteristic sloping dunes near Richards Bay after mining of the land. The CSIR, contracted by Richards Bay Minerals (RBM), recently completed assessing the feasibility of using previously mined land for agricultural purposes.

THE STUDY, the Richards Bay Minerals Alternative Land Use Project, was aimed at developing sustainable agricultural land use options for the land the company is leasing from communities for mining.

The crops assessed for feasibility included forestry species, legumes, vegetables, fruit trees, herbs and pasture grasses. The trials also assessed the capacity of the crops to continue land rehabilitation through soil improvement.

The conditions on the sloping dunes which characterise the mined land are different depending on the direction they face and position relative to the top and bottom of the dune. This, as well as the effects of the sea breeze and irrigation on the growth of crops and trees was also considered during the trials. The growth of trees was tested on four sites: sea-facing sites, inland-facing sites, steep slopes and flat surfaces. The growth and yield of crops and fruit and nut trees were assessed on flat surfaces at the top and at the bottom of the dunes.

The yield of each crop was assessed against a determined benchmark yield of the crop as informed by the KwaZulu-Natal Department of Agriculture. A crop was deemed to be technically viable if its yield consistently equalled or exceeded

the benchmark level for three years. The crops found to be technically viable were peanuts, bambara nuts, cowpea, napier fodder, Rhodes grass, rosemary, tea tree and mango. On all sites assessed, six *Eucalyptus* clones were found to survive well, yield high volumes of high quality wood and to be resistant to a common pest. The clones were recommended for planting on the previously mined dunes.

The trials entailed the periodic monitoring of soil. Soil samples were collected before annual crops were planted and two weeks after the harvest of each crop to measure soil properties including exchangeable acidity, total cations and magnesium. The consistent low nutrient levels in these soils indicated that successful crop production on the mined sand dunes could only be achieved with the use of appropriate fertilisers. However, it must be noted that the results represented only four years of cropping and changes in soil properties take a longer time to manifest.

– Reyhana Mahomed



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Rosemary plants growing successfully on previously mined land.



Assessment of the crops was done at regular intervals.



Cultivation of rosemary plants.



Freshly harvested peanuts.

PROJECTING FUTURE CLIMATE CHANGE OVER AFRICA

The African continent is likely to experience a wide range of impacts from future climate change, with large parts of subtropical Africa projected to become generally drier and significantly warmer during the 21st century. This may threaten the sustainability of agriculture and livestock farming, biodiversity and water security. It is likely to alter energy demand and increase the prevalence of natural disasters such as flooding, droughts and fires. The CSIR helps find workable ideas that aid us in understanding and planning for what may be the greatest problem ever faced by humanity.

THE CONCENTRATION OF carbon dioxide (CO₂) in the earth's atmosphere has increased by about 40% since the industrial revolution and is the main cause of global warming and climate change. CO₂ concentrations are continuing to rise, mainly driven by human activities, and in particular the burning of fossil fuels for energy.

Increased greenhouse gas concentrations have already caused global temperatures to rise and climate experts are warning that further global warming may take place

at an accelerated rate. A concerted international effort is needed to mitigate the magnitude of the change, but countries will also need to consider adaptation measures at a regional level to prepare for changes that are inevitable.

Twice the risk

This is particularly challenging in southern Africa, a region faced with economic and developmental challenges and where temperatures over some regions will rise at about twice the global rate of temperature increase.

A field of maize destroyed by hailstones from an afternoon thunder-shower in the Umzimkulwana Valley in the Drakensberg. Extreme weather events such as thunder and hail storms are predicted to increase as a result of climate change in Southern Africa.





Increased temperature as a result of climate change will make cattle vulnerable to heat stress, which may impact their feed intake and fertility. Nguni cattle are indigenous to Southern Africa and may be more resilient in such conditions.



Dr Francois Engelbrecht leads climate studies, modelling and environmental health research at the CSIR.

Dr Francois Engelbrecht – who leads climate studies, modelling and environmental health research at the CSIR – says that South Africa is particularly vulnerable to climate change. “Even if global efforts to curb CO₂ emissions successfully limit temperature increases during the 21st century to 2°C relative to pre-industrial times as climate scientists hope, southern Africa could see an increase of up to 4°C over the interior regions.”

Research

Global climate models have become the main tool to project future climate change. However, their projections are of too coarse horizontal resolution to develop climate change projections at a regional or municipal scale.

The CSIR's climate modellers, supported by the Centre for High Performance Computing, are therefore developing downscaled climate projections, which are being used widely to project the local impact of climate change on South Africa and Africa.

Impact on agriculture

In agriculture, research has shown that a 4°C temperature increase can significantly reduce maize harvests over southern and East Africa. “In a worst-case scenario where global climate mitigation fails, temperature increases of 6 to 8°C are plausible over parts of Africa. International

crop modelling studies show that no current maize varieties can withstand such drastic temperature increases, and failure of the maize crop in southern and East Africa may reach drastic proportions under such a scenario,” says Engelbrecht.

Researchers from the University of Pretoria have also used the CSIR's models to project the future of potato farming in South Africa. They have found that the increase in CO₂ levels might boost potato harvests, but this benefit will be lost if there is not enough water for irrigation due to projected decreases in rainfall.

Tomato farmers in the north-eastern parts of South Africa are reporting that it has already become too hot to grow tomatoes in mid-summer in parts of Limpopo. They are foreseeing a shift of tomato production, at least to some extent, to farms in cooler Gauteng where winter frost is likely to occur less frequently under climate change.

According to the CSIR's Dr Emma Archer-Van Garderen – who has studied the impact of climate change on cattle farming – future increased temperatures can cause heat stress which can influence feed intake, fertility, weight gain and mortality. Different breeds have different heat thresholds and farmers might have to look at more resilient, locally adapted breeds to maintain production.

Biodiversity

Climate change could also induce bush encroachment as plant species differ in their capacity to benefit from CO₂. This in turn could have a negative impact on the natural habitat of large herbivores that survive in the grasslands and savannah regions of South Africa. Warmer and drier temperatures will also impact on many other aspects of the country's biodiversity. Fynbos – which evolved over thousands of years in moderate temperatures and wet winters – may not be able to thrive under drier winters that are also significantly warmer, while small bird species are highly vulnerable to extreme heat conditions.

Industry

CSIR research on the climate future of Africa is also starting to find increasing impact in industry, says Engelbrecht. Eskom currently uses the CSIR's downscaled climate models to inform its adaptation strategies in terms of the effects of high-impact climate events on Eskom infrastructure and household demand for energy.

CSIR researchers project that Africa may experience more extreme weather events under climate change, such as intense thunderstorms, large-scale flooding, heat waves and drought. An increase in tropical storms and cyclones that reach land are also projected for the northern parts of neighbouring Mozambique.

Many sectors, including the insurance industry, are likely to be increasingly affected by the costs associated with high-impact climate events.

Informing policy

CSIR research on climate change also informs national policy-making. Recently, the CSIR climate change projections formed an integral part of the Long-Term Adaptation Scenario Project of the Department of Environmental Affairs (DEA) and related CSIR research informs the position of the DEA on aspects of the climate negotiations of the United Nations Framework Convention on Climate Change (UNFCCC).

Climate change projections are continuously being refined and extended. Engelbrecht points out that, going forward, the CSIR's climate change researchers will contribute to international climate change projection initiatives, such as the Coordinated Regional Downscaling Experiment and Coupled Model Inter-comparison Project Phase 6 of the World Climate Research Programme. CSIR researchers will also study the implications of the UNFCCC climate negotiations to inform suitable adaptation and mitigation strategies for Africa.



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SEA-FARING GLIDER EQUIPPED FOR MORE ACCURATE FISH STOCK SURVEYS

CSIR researchers successfully equipped a wave glider with an acoustic echo sounder to determine fish stock levels along the South African coastline.





Unmanned marine vehicle fitted with an active sonar system on deployment between Dassen and Robben Islands.

UNSUSTAINABLE FISHING

is a big threat to ocean ecosystems. It destroys the physical environment of marine life and distorts the entire food chain in the oceans. According to the World Wildlife Fund, more than 80% of the world's fish stocks have been pushed to (or beyond) their biological limits and are in need of strict management to restore them.

The Department of Agriculture, Forestry and Fisheries has the responsibility to determine the available fish stock levels in South Africa's Exclusive Economic Zone (EEZ) to regulate and allocate fishing quotas. The EEZ is a seazone prescribed by the United Nations over which a state has special rights in terms of the exploration and use of marine resources.

Currently, scientists from the department conduct these surveys by following a predetermined route along the coastline. Once the on-board underwater sonar detects species that resemble fish, a net is drawn to capture a sample of the species. Using the data gathered from the sonar images and fish samples, fishing quotas are established.

Janet Coetzee, a scientist from the department, says, "Currently we only do two surveys a year. If we can have something out there more often to provide information on fish migration patterns, it will be of great use."

In an effort to assist the department, the CSIR used its expertise in oceanography and research in the southern oceans, combined with its experience in developing technology for specialist maritime applications, to develop a solution which will allow the department to perform more surveys per year while saving costs.

The first successful field experiments took place in March 2014 and since then research and development has improved the unit to the extent that it can potentially be continuously deployed for months at a time. The wave glider can store high-resolution data onboard, while sending compressed data back to research centres for immediate processing.

"This means that the department will have continuous access to current data, allowing them to focus their trawling where needed and spend less time at sea. Having current data will improve their understanding of fish behaviour and migration

patterns," says Hannes Zietsman, a CSIR senior engineer and maritime defence expert.

Technology building blocks

The technology components comprise a sonar system to detect fish, and a data-capturing unit installed on an unmanned marine vehicle that serves as the sensor platform. The integration of these technology components was supported by industry partner, Sea Technology Services. Zietsman worked with Sea Technology Services to design, develop, and integrate a power supply unit that powers the sonar and data-capturing unit. The vehicle relies on wave propulsion to glide forward, making it possible for the vessel to be deployed for long periods. The data-capturing and control unit is housed in a payload compartment made available by Liquid Robotics.

First field deployment

During a field test experiment in March 2014, the system – measuring just under 3 m in length – was deployed for a sea trial of two days. Travelling at an average speed of 2.4 km/h, the vessel covered 121 km between Robben and Dassen Islands. The signal received from the echo sounder proved stable and the research team successfully

detected schools of fish. The improved glider was deployed in March 2015 to assess its performance over longer periods.

Coetzee says: "We are excited to continue the work. Future tests will look at the glider's performance in rough seas, strong currents, and its ability to cross a vast area in Agulhas Bay in a set time frame. The possibility of deploying multiple gliders (referred to as swarm robotics), fitted with cameras and other devices, will enable us to identify the specific fish species, which will greatly advance the effectiveness of our surveys. The work will ultimately reduce the number of ships that have to be out at sea, saving the department's already strained resources."

The technology offers potential for broader applications such as maritime domain awareness, commercial fishing, ocean carbon and climate observation and oceanographic research.

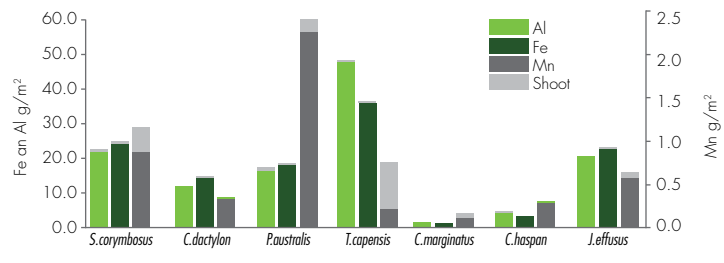
– Lésa van Rooyen



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Scientists identify indigenous vegetation to help rehabilitate metal-polluted Olifants River

CSIR experts in water chemistry and botany have found that certain indigenous vegetation are able to rehabilitate rivers polluted with metals such as iron, aluminium and manganese. Seven common and pollution-tolerant plant species prevalent on the banks of the Upper Olifants River were found to bioaccumulate these metals in areas where rivers are affected by mining and industry.



Mineral uptake in the selected species.

SOUTH AFRICA is a mineral-rich country with a history of unsustainable mining practices that have resulted in polluted rivers, thereby affecting the quality of water reaching communities.

“We looked at sites in the Upper Olifants River which were severely impacted by acid mine drainage and industrialisation and found that the water chemistry did not correspond to the suspected severity of the anthropogenic input,” says CSIR researcher, Dr Jessica Chamier. The water quality (especially metal concentrations), were lower in areas with vegetation and functioning ecosystems adjacent to the river.

“We looked at how much metal had accumulated in the plants as well as in the soil surrounding the plants and compared that between the different plants,” explains Chamier. It was established that particular plant species have the ability to better tolerate and remediate certain metals associated with acid mine drainage. This could be established through

either extraction from the soil or water into the plant, called phytoextraction, or by simply stabilising the metals in the soil close to the plant’s root system, which is called phytostabilisation.

The uptake of metals in plants delays and reduces metal transport downstream, which results in improved water quality reaching the communities who rely on water from the river for their livelihoods. The pollution-tolerant species investigated were *Cyperus haspan*, *Schoenoplectus corymbosus*, *Typha capensis*, *Phragmites australis*, *Cynodon dactylon*, *Cyperus marginatus* and *Juncus effusus*. Many of these species were previously found to take up various heavy metals.

For a holistic account of the ability of the selected species to bioremediate the river, five study areas were demarcated and selected for sampling and time series mapping. This entailed the collection of fresh shoot and root material; soil samples; biomass data; and species samples.

Analysis of the samples indicated that, given the varying degrees

of human impact and pollution, the nature of the plants and the natural geology, the metal concentrations of plant materials varied significantly between specimens and sites.

While root concentrations of aluminium and iron always exceeded shoot concentrations, these metals are almost exclusively trapped in the roots of all species. “It would help if the metals were only taken up in the shoots,” says Chamier, “that way we would have been able to just mow the plants instead of uprooting the whole plant.”

Based on bioconcentration factors and root to shoot translocation of the metals, *Typha capensis*, *Schoenoplectus corymbosus*, and *Juncus effusus* were found to show the greatest potential to bioaccumulate and phytostabilise aluminium and iron. Plant accumulation of manganese differed to that of iron and aluminium. *Typha capensis* and *Schoenoplectus corymbosus* showed the greatest potential to accumulate manganese in the shoots. However, given the significant biomass of *Phragmites*

australis, this plant showed the highest potential to accumulate and stabilise the largest concentration of metals per m² of vegetated area. *Phragmites australis*, known as the common reed, occurs in disturbed to pristine wet areas including tidal and non-tidal wetlands, brackish and fresh-water marshes, river edges, shores of lakes and ponds, roadsides, and ditches. It prefers full sun and can tolerate fresh to mesohaline salinities.

The study found that, while none of the species could be classified as hyperaccumulators of aluminium, iron or manganese – in other words, plants capable of growing in soils with very high concentrations of metals – *Typha capensis*, *Schoenoplectus corymbosus*, *Phragmites australis* and *Juncus effusus* have accumulation and high phytostabilisation potential.

– Reyhana Mahomed



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Health effects of the metals prevalent in the Olifants River

ALUMINIUM – Consumption of this metal has been found to have links to neurological effects and dementia in patients already suffering from renal failure. Aluminium consumption is also linked to obesity.

IRON – Excessive consumption of iron has a number of health effects, including, but not limited to, weakness, lethargy, arthritis, impaired memory, cancer, diabetes and impotence.

MANGANESE – The consumption of manganese has links to hallucinations, forgetfulness and nerve damage, Parkinson’s disease, lung embolism and bronchitis, impotence, weak muscles, headaches and insomnia.

GREEN, HOME-GROWN SOLUTIONS FOR WATER SANITATION

A range of water treatment products under the name of Optimus Bio is making its mark in the local market for waste water treatment, aquaculture and agriculture.



OPTIMUS BIO
GREENER TOGETHER

OPTIMUS BIO, a company started from within the CSIR, will soon be spun out of the organisation. Its product range is locally developed and manufactured using indigenous bacteria and providing high-quality, truly environmentally friendly solutions.

"Our products are biotechnology-based solutions developed from the CSIR's proprietary *Bacillus* database and production technology," says Dr Raj Lalloo, a chief scientist at the CSIR who is driving the technology development of Optimus Bio's products. He will also be heading up the company. "These products have been developed and manufactured locally, with indigenous biologicals, and are providing employment in the biotechnology industry."

The green technology sphere in which Optimus Bio competes is aimed at ensuring food, health and water security solutions that are environmentally sustainable. One product includes special bacteria used in aquaculture that improve fish production and minimise negative environmental impact. Another improves the quality of life for those in rural areas by remediating neglected pit latrines or maintaining the bio-activity in currently used latrines or septic tank systems. There are also products that assist with sustainable agro industries by providing biological methods of pest control and plant growth. Lastly, Optimus Bio has a product range that contributes towards the broader responsibilities brought by urban effluent load in the form of biological products for sewage treatment plants and domestic eco-friendly detergents.

Lalloo says: "South Africa is facing a water shortage crisis. Inadequate sanitation and water treatment are major contributors to this situation. Both government and the private sector are seeking environmentally sustainable solutions to address this problem. Relevant biomanufacturing products can support social and economic growth and job creation whilst assisting with better service delivery."



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From left, CSIR researcher Ghaneshree Moodley and interns Makungu Hlungwani, Monono Mobanga, Lendewe Maphalla and Buhle Ngomane at work in the organisation's microbiology quality assurance laboratories.





Dr Raj Laloo, a chief researcher at the CSIR, is the driving force behind the technology and green products being developed for waste water treatment, aquaculture and agriculture.



The quest for renewable materials that are lightweight, strong and durable

Global efforts to reduce energy consumption and to protect the environment are challenged by an increasing need for consumer products and the rising cost of fuel to transport both goods and people. Many industries are considering alternative technologies to replace petroleum-based plastic products with 'green' materials and CSIR experts are contributing towards such innovations.

PLASTICS ARE MADE OF CHEMICALS derived from petroleum and have replaced many natural materials such as wood, leather, metals and ceramics in components in household and commercial products. The world's petroleum resource is however regarded as finite, because fossil fuel forms relatively slowly in nature and cannot be replaced at the rate at which it is extracted to meet with the current global consumption. Therefore, in due course, a demand for petroleum is expected to surpass supply.

This has led to renewed interest in 'green' energy-efficient products from naturally renewable bio-based resources. The CSIR, with support from the Department of Science and Technology, established a Biocomposites Centre of Competence, which coordinates the efforts of engineers and scientists from science councils, tertiary education institution and industry who are dedicated to the development of innovative methods to create new bio-based materials which can be produced from renewable resources, including wild plants and post-harvest agricultural wastes. Some of the work undertaken is featured in this article.

Aircraft panels using flax

"In work done with Airbus, we developed a natural fibre-reinforced sandwich panel for non-load-bearing aircraft interior structures by combining woven flax fabric with phenolic resin (a synthetic polymer) to replace the currently used glass fibre composites," says CSIR materials scientist Dr Maya John.

However, fibre-reinforced composites can pose a serious health hazard in the event of fire through the release of toxic gases, vapours and small particles which people can inhale. To address this, CSIR researcher Steve Chapple developed and patented an environmentally friendly, flame-retardant treatment to comply with the aerospace industry's fire, smoke and toxicity requirements. This treatment was applied to the fabric before making the composite for improved fire resistance.

The aircraft panel meets the strength and weight specifications and the group is in the last stage of developing laminates. It has been delivered to Airbus for further tests and a joint patent has also been filed for the product and the manufacturing technique.



Dr Sudhakar Muniyasamy, a CSIR chemical scientist, explains how researchers are using combinations of poly(lactic acid) (a bioplastic) and natural fibres derived from maize stalks to develop biodegradable materials which will replace non-biodegradable commercial polymers used to make crates like the one shown.

Crates using maize stalks

Other work includes the use of post-harvest agricultural waste for the construction of 'green' crates to replace commercially available polypropylene crates which are not bio-degradable.

According to CSIR chemical scientist, Dr Sudhakar Muniyasamy, researchers are using combinations of poly(lactic acid) (a bioplastic) and natural fibres derived from maize stalks to develop biodegradable material which could be used for green packaging. "The challenge is to improve the brittleness of poly(lactic acid) by reengineering its chemical structure using eco-friendly additives and plasticisers to develop materials that are non-toxic to the environment," he says.



Bioplastic developed using a CSIR-patented process.

A new plastic-like material from sugar cane and other crop waste

Researchers are developing new materials through furfuryl alcohol polymerisation. Asanda Mtibe is a PhD student at the CSIR involved in the synthesis of polyfurfuryl alcohol from furfural alcohol. This is obtained from the reduction of furfural, which is a renewable chemical produced from agricultural residues such as sugar cane waste products, corn and wheat. The CSIR patented a process for preparing polyfurfuryl alcohol products in 2012.

From this, a strong black plastic-like material is developed, which could eventually have applications in the automotive, aerospace and building industries.

"The product is highly water-resistant, hard and rigid. We would like to reinforce the product with natural material and have already prepared cellulose nanofibres from maize stalk that are ready to be incorporated into new biopolymers," says Mtibe.



Sugar cane bagasse.

Automotive parts using hemp and flax

It is believed that the use of natural fibres in the production of automotive components can make vehicles 30% lighter, while the production is expected to consume a fifth of the energy required for traditional glass fibres.

The CSIR is working with large vehicle manufacturers to develop door panels and rear parcel trays from biocomposites in an effort to replace synthetic materials/imported fibre products with locally sourced natural fibres such as kenaf.

The technical challenge is that these items need to achieve an adequate service life and have equal or superior physical and mechanical properties.

Below: Motor vehicle rear parcel tray made from biocomposites.



Sustainable building material from kenaf, flax

CSIR researchers are combining natural fibres, such as flax and kenaf, with epoxy to optimise a moulding process to create corrugated roofing panels.

"The ultimate goal is to also develop a soya- or vegetable oil-based bioresin to replace the epoxy so that the roofing panel is entirely biodegradable at the end of its life cycle," says materials engineer Osei Ofosu.

The final product will need to have ultraviolet stabilisers to protect it against sunlight, be treated with flame-retardants and must have the ability to withstand humid conditions.

"Another advantage of natural fibre-reinforced components is that it does not conduct heat well, which means it allows for better temperature control in buildings," Ofosu says.

The research has progressed to a stage where researchers are doing tests on panels made from flax, kenaf and agave fibres.

The use of plants that thrive in arid and semi-arid areas or that can be locally grown and harvested, such as the Agave plant, also has the potential to stimulate local rural economies by creating jobs for subsistence farmers and entrepreneurs.

Aviation and automobile industry

The rising fuel cost has forced aviation and automotive industries to develop light-weight components that increase the energy efficiency of vehicles and aircraft. For many years, the interior panels of aeroplanes and cars have been constructed from synthetic, petroleum-based materials. CSIR materials engineers and chemical experts are researching the use of natural fibre-based composites to replace these.



Natural fibre-reinforced sandwich panels for non-load-bearing applications with smaller samples which have undergone fire testing.



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HEAVY VEHICLE SIMULATOR: an idea adopted around the world

The heavy vehicle simulator (HVS) is a CSIR-developed testing facility for roads. It is a success story with global impact and one that has had a major impact on the design, construction and maintenance of roads locally and abroad for more than 40 years.

ROADS ARE THE LIFEBLOOD of an economy; at a cost of between R15 million and R8 million for a kilometre of highway with a relatively short lifespan of 20 to 40 years, a country's roads infrastructure has to be scientifically constructed and maintained to maximise cost-effectiveness.

The HVS is a high-tech accelerated road-testing field lab with unique

instruments that measure and analyse the engineering performance of road structures and material layers to test whether a specific road will have an acceptable lifespan. These results are invaluable in taking corrective action in road design and selecting the best construction materials and methods when planning the construction of long stretches of new roads.

Testing ultra-thin concrete for high-volume roads

The CSIR-developed HVS has been used locally to test ultra-thin concrete technology for application in high-volume roads in South Africa. This followed a research project initiated by The South African National Roads Agency Limited (SANRAL) with the CSIR, the University of Pretoria and the

Cement and Concrete Institute. The original road design was imported from Denmark and adapted for local conditions. According to the CSIR's Louw du Plessis, an international expert in accelerated pavement (road) testing, "the ultra-thin, high-performance concrete is heavily reinforced – up to seven times more steel is used than ordinary continuously reinforced concrete.

Impressive impact

The HVS:

- enables the improvement of road design and construction practices;
- provides a high-tech field lab for accelerated road-testing;
- simulates damage caused by traffic over 20 years in three months; and
- has been exported to a number of countries, with 17 units active worldwide.

Although the thickness of the concrete is only between 50 and 75mm, it has very high compressive and bending strengths, which makes it suitable for heavy loads on high volume roads."

SANRAL has implemented the technology for high-volume roads on a few pilot projects with success. A section of the N12 near the Gillooly's interchange in Gauteng and a section of the N1 between the Klip River Toll Plaza and the Huguenot Tunnel are examples of successful implementation. The technology is also well suited for job creation as a big portion of the construction process is done by hand. Studies have shown that the labour content is approximately 350% higher than conventional road construction methods using mechanical machinery.

Over the next few years, CSIR research using the HVS will be aligned with the Gauteng Provincial Department of Roads and Transport strategy to cost-effectively and efficiently rehabilitate and upgrade Gauteng's road network – one where more than 70% of the roads have reached the end of their design lifespans. Attention will be given specifically to public transport routes, freight corridors and the upgrading of unpaved roads.

It is foreseen that the local and international HVS programmes will continue to thrive, with other countries and research groups likely to order HVS machines.



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HVS technology licensing

The HVS technology platform was licensed to Dynatest, a private company in the USA. Dynatest markets and manufactures the machines and also maintains the 18 machines already in operation. The CSIR receives a royalty for HVS sales from Dynatest.



The HVS Mk IV owned by the Gauteng Department of Roads and Transport in operation in the field, testing ultra thin concrete test sections.



Road cracking failures caused by accelerated testing of the HVS.



High volumes of traffic, especially heavy vehicles, have a detrimental effect on roads. This is specifically true for roads that have been built inappropriately. The CSIR heavy vehicle simulator facilitates accelerated road testing.



The CSIR-developed wave compensating hydraulic davit system enables deployment of smaller vessels from a moving ship.

A technology intervention that helps the SA Navy apprehend pirates

Incidents of piracy on the east and the west coasts of Africa in recent years resulted in shipping companies reconsidering the Cape sea route. South Africa needed to act to ensure that such incidences did not escalate, as it would have dire consequences for trade.

IN STEPPING UP the fight against acts of piracy on the trade routes around the Cape, the South African Navy realised that their existing anti-piracy deployment capabilities needed to be expanded. In order for South Africa's four multi-purpose naval ships (frigates) to be effectively used to apprehend pirates, a smaller boat carrying a reaction force needs to be dispatched from the frigate. During a piracy

incident, every second counts, which means that the boats must be rapidly deployed, while the frigate is on the move.

The CSIR's maritime security group already had experience in the field of controlled surface deployment of boats from moving ships. A removable davit system – a small crane typically used on a ship to suspend or lower a lifeboat – could be the solution. The CSIR developed a davit system

for the frigates that was extensively tested along the Cape Peninsula. Tests were performed with a range of boats used by the Maritime Reaction Squadron and other operational forces.

Deploying a small vessel from a moving ship is a risky activity – the waves directly next to the moving ship can be very rough and the smaller vessel is at risk of capsizing or being smashed into the larger vessel.

The CSIR's davit system compensates for the wave movement through a hydraulic wave-compensating system, which matches the movement of the waves to the movement of the boat being deployed. The davit system ensures that forces are evenly distributed along the deck. The base also houses the drive system, with local and remote controls, stored energy for a full deployment and recovery



What is a davit system?

A davit system is a crane-like device, typically one of a pair that is fitted to a ship's deck. It is used for the launch and recovery of smaller vessels carried by the mother ship.

operation, as well as the logistic support equipment needed for the boat.

Niël Goslett, a mechanical engineer from the CSIR maritime security research group, says, "Ships are normally designed with davit systems as part of the equipment with all the relevant load factors designed into the hull structures. In this case, the system had to be developed to have the minimum impact on an already-designed hull structure in an area not intended for boat work. The CSIR managed not only to meet the structural challenge, but also to come up with a very innovative, removable davit system that can be fitted, as well as positioned according to the SA Navy's operational needs."

The complete system fits onto an ISO-container footprint, mounted and adapted on the

ship's deck. The davit system can accommodate boats of various hull-shapes, weighing up to five tons. Two of these davit systems are typically fitted to the ship, with another two boats housed in the ship's boat bay on CSIR-developed cradle systems. The boats, as well as the crew, can be lowered and retrieved safely by the davit system, with the hosting ship underway, saving valuable time and enabling forces to respond to piracy threats faster.

From workshop to operational success

While sea trials were underway, South Africa – through the SA Navy – was called upon to prepare for anti-piracy operations. The Navy requested the use of the newly developed davit system to use it in their combat exercise. With the

pilot model hoisting system installed, the Navy successfully demonstrated the operational viability of the system during this exercise.

Apart from successfully supporting integrated Naval operations on the east coast of Africa to counter piracy, the capability has also allowed the Navy to conduct extended operations on the west coast of Africa. This ensures that the South African National Defence Force meets its mandated responsibilities with regard to the Southern African Development Community.

More systems were subsequently developed to outfit Navy frigates, as well as the supply vessel, SAS Drakensberg.

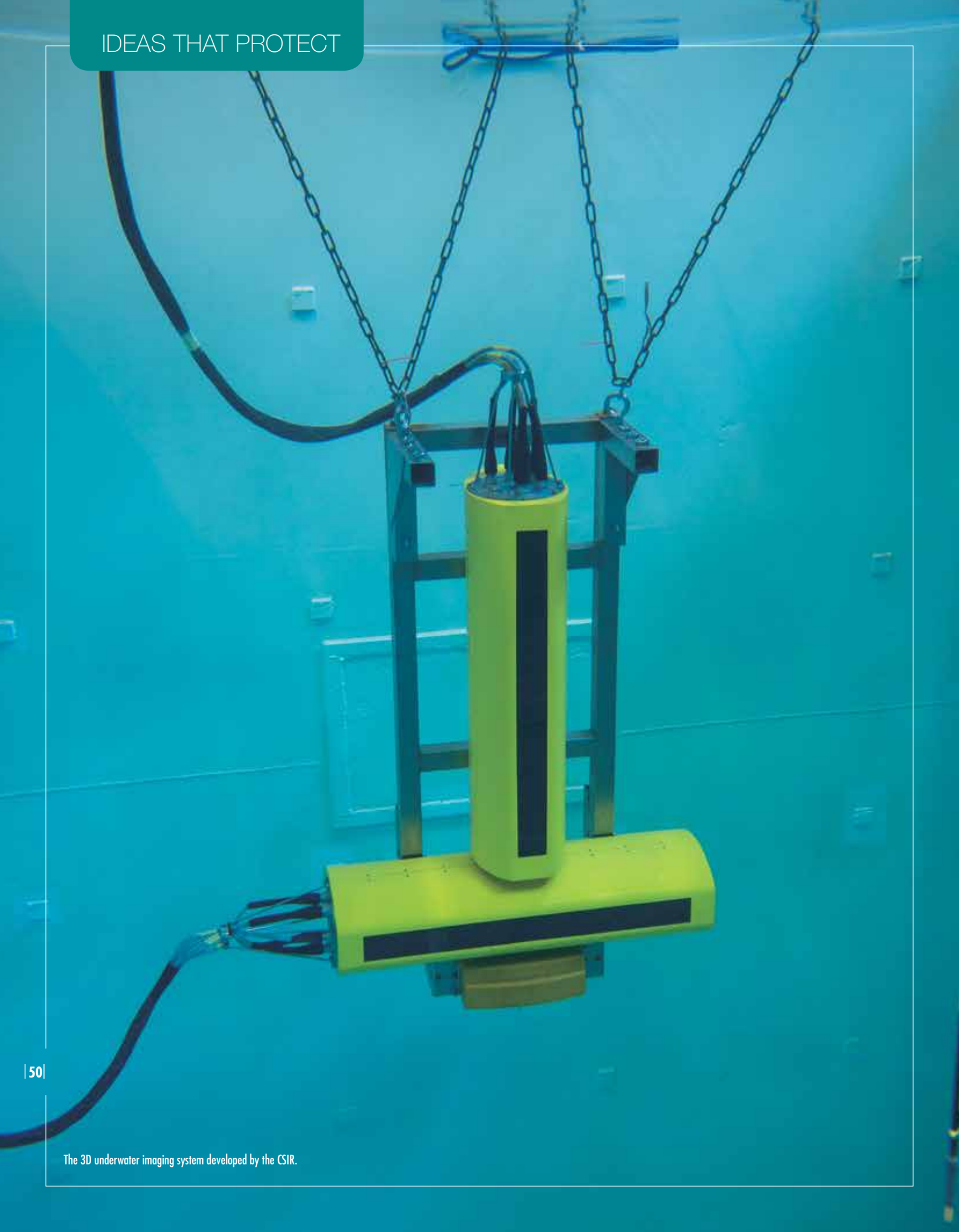
– Lésa van Rooyen

An idea that works for the SA Navy

The davit system allows the SA Navy to host fast surface vessels on the already-designed hull structure of South African-owned frigates in an area not intended for boat work. This enhances the vessel's capability to include search and seizure, interdiction, insertion and recovery over beaches, as well as search and rescue.



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PROTECTING SHIPPING CORRIDORS WITH 3D IMAGING

Keeping shipping corridors around South African ports, harbours and the coastline safe from threats is an economic imperative because approximately 90% of goods enter the country by ship. These threats include piracy – which has now reached the coastline of neighbouring states – poaching and the smuggling of illegal cargo underneath the hulls of ships.

CSIR RESEARCHERS HAVE DEVELOPED the world's first low element count three-dimensional (3D) underwater imaging system. A sea-going prototype was tested in the Simon's Town Harbour in February 2015. The system produced images, simultaneously in 2D and 3D with fine resolution.

According to Kiri Nicolaides, who leads the ultrasonic research group at the CSIR, conventional imaging technology would require more than 4 000 separate sets of sensors to produce a 3D underwater image.

"Our team developed a system which produces the same image using only 96 sensors (32 transmitters and 64 receivers), making it much more cost-effective. The system can detect (locate) objects underwater in two dimensional (2D) planar mode (radar type display) and classify (recognise features) objects in 3D imaging mode.

"It has been shown to produce world-first images with detailed features not previously achieved with so few sensors. In the naval environment such features can support faster decisions in response to potential threats."

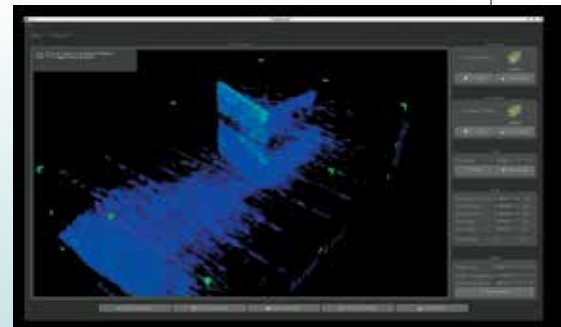
Nicolaides says naval ships on peace-keeping missions often need to cross uncharted shallow waters. "The 3D sonar technology described above can also do route surveying (forward looking sonar), in order to become familiar with the operating environment by taking images of the sea bottom and eventually recognising potential underwater threats. The technology can also assist in surveillance of sea life such as schools of fish for research and monitoring. It also has application in the mining industry."

The development of the 3D system builds on the CSIR's experience gained over several years in the field of piezo-composite sensor materials and unique signal processing techniques and electronics.

The South African Navy, Armscor and the CSIR were the main funders and contributors to the development of this technology.



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A 3D sonar image shows what a mooring block looks like underwater in the Simon's Town Harbour in the Western Cape.



Researchers lowering a sea-going prototype of the CSIR's 3D underwater imaging system during tests.



A sea-going prototype of the CSIR's 3D underwater imaging system being tested in the Simon's Town Harbour in the Western Cape.



MAKING COASTAL ENGINEERING WORK



A scaled physical model study for Transnet National Port Authority on the rehabilitation of Dolos breakwaters in Richards Bay. These mega structures have been constantly pounded by waves over the past 40 years.

At the CSIR coastal and hydraulics laboratory, researchers build scaled physical models of ports and structures to simulate the effect that elements such as wind and water will have on real ports and harbours. Kishan Tulsi, a civil engineer at this national research facility, has worked on projects such as the massive Doha harbour in Qatar, the Port Hedland Harbour in Australia and local projects such as the Ngqura port in Port Elizabeth and the Durban access channel widening and presently, breakwater investigations in Richards Bay.



Gregory Davids and Kishan Tulsi, right, discussing the construction plan of a physical model.

FOR TULSI, taking a conceptual design from a small scaled physical model and applying it to reality to produce a huge, durable structure that positively affects people's daily lives, is what *Ideas that work* is all about.

"It's really exciting to watch your model design become a mega structure that is pounded by waves from day one, and to have created something able to successfully withstand the elements," he says.

When one considers that around 90% of South Africa's trade passes through its ports, not to mention the human lives dependent on their safety, one realises the responsibility that Tulsi's job entails. "One of the toughest parts of my job is predicting conditions far into the future. Imagine trying to predict more than a century into the future," he says. For many of us, making sure that our projects deliver so far into the future is not a consideration, but for Tulsi, it is a daily concern.

Approximately half the world's population lives in coastal regions, yet coastlines are continuously being battered by surging seas, eroding property and infrastructure that people build their livelihood around.

"We cannot prevent a coastal storm from occurring, but with the research that we do at the CSIR we help reduce the havoc caused by storms. We develop systems to defend and protect South African coastal communities. Examples of the work we've done recently include coastal erosion protection in KwaZulu-Natal, and

building scaled models to test the safety of designs for recreational purposes, like the eThekweni tidal pool and small craft harbours around South Africa," says Tulsi.

"The most rewarding part of my job is seeing people enjoying themselves on the beach, knowing that I have contributed to their happiness and safety," he says. "That's what I like about the CSIR," he adds. "It gives people like me the opportunity to change things for the better."

The CSIR has also made it possible for Tulsi to connect with some of the greatest minds in the field, including engineers who were involved in the development of the dolos in the 1960s. The dolos is a South African-invented geometric concrete

shape, used in great numbers to protect harbour walls. This innovation was a great achievement in South African engineering, which is why working with engineers from the dolos generation was such a privilege. "These brilliant engineers were my mentors and helped fuel my passion," Tulsi says.

When asked what advice he would give to the younger generation, Tulsi says, "Develop your sense of awareness and take a genuine interest in the world around you. Understand how things work and never disregard the impact that humans can have on the natural environment."



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Scaled physical model study of a ship at berth at an iron ore jetty. The ship motions, forces on mooring lines and the force of the ship on the jetty fenders are being determined while the waves impact on the ship.

SHAKING PLANES: FLUTTER EXCITATION SYSTEM TO TEST AIRCRAFT INTEGRITY

For more than 30 years, CSIR expertise and ongoing research in aircraft flutter clearance have ensured that military aircraft and those of the aeronautical industry are fit for flight.

FLUTTER is a dangerous dynamic instability that all aircraft can encounter. It is driven by mass and stiffness distribution in the aircraft structure, combined with aerodynamic characteristics.

The CSIR developed novel flutter excitation systems to test and evaluate aeroelastic stability. "The purpose of a flutter exciter is to impart vibration into a structure. It literally 'shakes' the aircraft during in-flight testing

to test its aeroelastic stability," explains Dr Louw van Zyl, an aeronautics researcher at the CSIR.

"A flutter exciter is installed on the flight test aircraft, providing a consistent energy input over a wide frequency range to excite all the natural frequencies of the aircraft structure. We use accelerometers to measure the vibrations and from the response we can determine the flutter

margin of the airframe at a given flight condition," he says.

In case of flutter, the oscillations of the aircraft would grow exponentially until the structure fails, or until the aircraft speed is reduced to below the flutter speed. Aerodynamic loads are proportional to the square of the flight speed; therefore speed has a significant influence on aeroelastic stability. Adding or removing weight from the aircraft wing



(e.g. when adding weaponry) affects the mass distribution, as well as the aerodynamic loads and will also affect the aeroelastic stability of the aircraft, that is, whether and how quickly structural vibrations will stop.

Virtually all new aircraft as well as military aircraft with new store configurations – such as added weapons, tanks or bombs – undergo rigorous flutter analysis and testing. The CSIR provides services in all three phases of the flutter clearance process, namely ground vibration testing and modal analysis, flutter prediction and flutter flight testing.

Although atmospheric turbulence and control impulses can be used to excite the aircraft structure, a flutter excitation system improves the signal-to-noise ratio of the accelerometer responses and is more repeatable while covering a wider frequency range.

“The flutter exciter used by the CSIR is based on a rotating annular wing concept. Because it is an aerodynamic exciter, it produces a larger excitation force at low frequency compared to inertial types. By rotating, it also provides a larger excitation force at high frequency compared to oscillating vanes or control surfaces.

“The frequency range and duration of the excitation provided by the system is programmable.

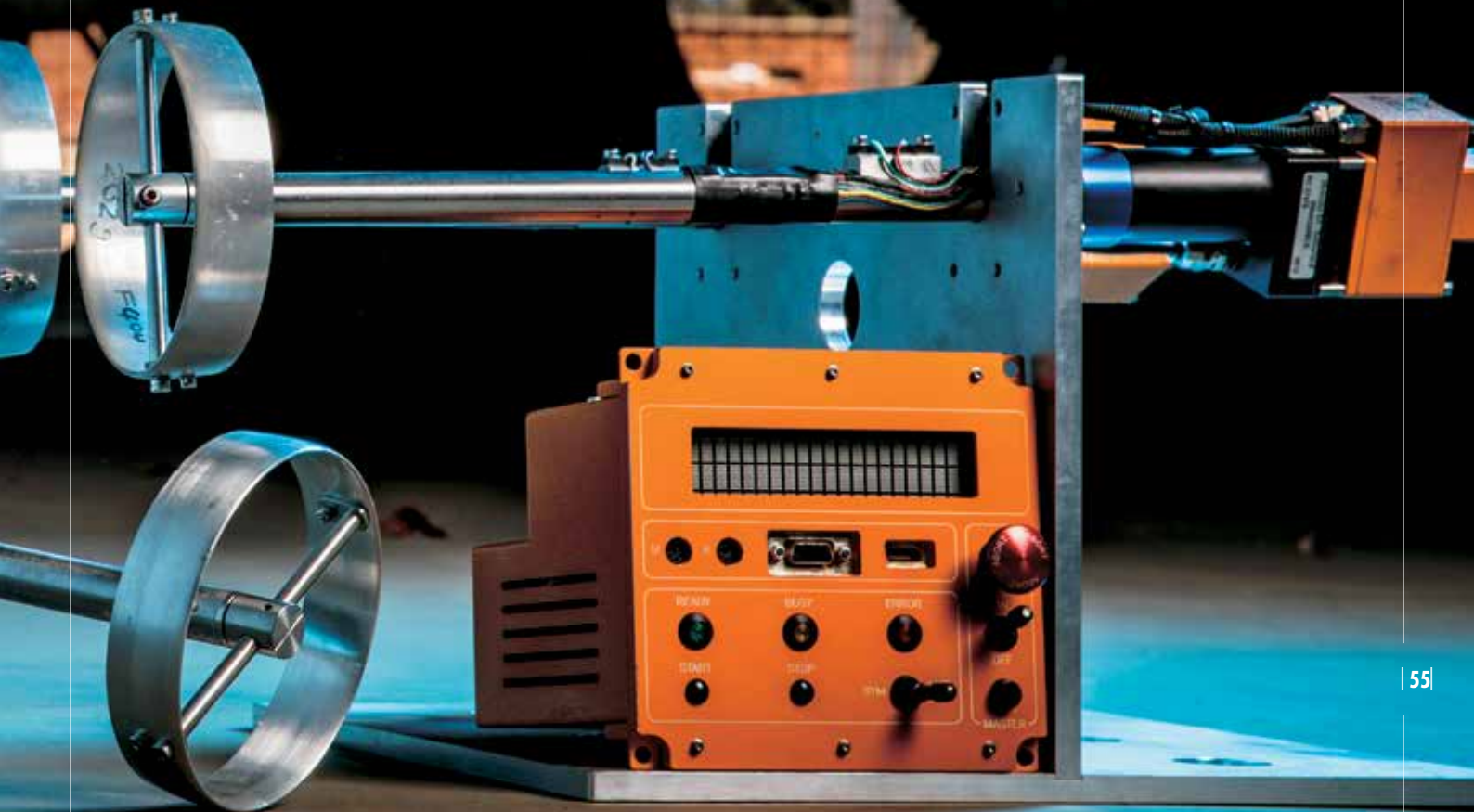
The magnitude of the excitation force is controlled by the size of the annular wing and the angle of incidence, which is ground adjustable. It can be used both on light civilian aircraft and high-speed military aircraft,” explains Van Zyl. “The exciter is sufficiently compact to fit into a store and thus does not influence the flutter characteristics of the store configuration being cleared.”

– Nicole de Kock

A flutter excitation system, carried by the flight test aircraft, allows for energy input into the aircraft structure to excite its natural frequencies. During flutter flight testing, these structural vibrations are measured by accelerometers and the responses are used to determine if flutter onset is likely or not.



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A screenshot of the CSIR-developed manual fingerprint feature extraction software which aids in the development and testing of algorithms that are implemented in the functions of the CSIR fingerprint software development kit.



CSIR software developer Ebrahim Saith demonstrates some of the features of the CSIR-developed fingerprint analysis software.



Right: The team of CSIR software developers who developed the fingerprint analysis software, namely Ebrahim Saith, Tshegofatso Thejane, Leandra Webb and Dick Mathekgga.



CSIR fingerprint analysis software licensed to industry player

The CSIR developed a fingerprint software development kit which comprises a collection of functions for performing various fingerprint image processing operations.

A LICENSING AGREEMENT was signed with iPulse Systems, a South African company specialising in the design and manufacture of biometric hardware and integrated software solutions. With this licensed technology, iPulse now has the ability to design and build a uniquely South African product that can be specifically customised for the continent. This is particularly necessary in the mining industry, for instance, where the labour force has specific issues relating to their fingerprints.

iPulse secured a royalty bearing non-exclusive know-how licence to commercially exploit the CSIR-developed fingerprint processing software in Sub-Saharan Africa. The majority of the algorithms incorporated in the fingerprint software development kit were developed at the CSIR.

Compared to similar products on the market, the CSIR's software development kit gives users access to certain fingerprint features and is also suitable for use as a research tool. It will empower fingerprint identification system developers to make customisations currently not possible with existing offerings, which will distinguish their products from those of competitors. It can also be used to decrease the identification search time.

The agreement forms part of the CSIR's strategy to provide strategic independence to South African high-tech enterprises, by reducing their dependence on foreign technology solutions suppliers. The development of the technology is a result from the investment by the Department of Science and Technology into the development of biometric competency in the country.



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AN IDEA THAT PROTECTS AGAINST ANTI-PERSONNEL MINES



The surrogate lower leg device is used to characterise the effectiveness of mine-resistant boots used in humanitarian de-mining operations. Antipersonnel mines remain a significant scourge in countries with a history of conflict causing much trauma to citizens of these nations.



The Frangible Surrogate Lower Limb is a research tool developed by the CSIR to research the impact of antipersonnel mines on lower limbs. Many similar devices exist but the CSIR lower limb is unique in that shock wave velocities and their attenuation through the lower limb can be estimated.

The CSIR has developed a ruggedised shoe that protects the wearer's feet against the effects of an anti-personnel mine explosion. The 'mine boot' attenuates the initial shock wave and the subsequent blast event within its sole. This reduces the risk of complete loss of limbs.

THE MINE BOOT is the result of research by blast and mine clearing experts to investigate and quantify the injury mechanisms resulting from the detonation of anti-personnel blast mines. The protective ability lies in the materials used to manufacture the sole of the shoe.

The purpose of the boot is to prevent amputation in the event of small anti-personnel mine detonations as well as to mitigate tissue and bone damage during larger anti-personnel mine detonations. Saving as much of the leg as possible does not only mean faster rehabilitation but also makes it easier to fit and use a prosthetic limb.

The product is available either as a full boot – or as a boot with separate, strap-on sole that be applied or removed as needed when entering mine fields.

The technology behind the boot is unique and has been patented. The boot has reached the development phase and licensing options with industry partners are being considered.

As part of the research process, the CSIR also developed a surrogate lower left leg which approximates an actual human leg in terms of geometry and the properties of materials and substances used to construct it. The leg is used in destructive testing in order to assess the degree of tissue and bone damage sustained, as well as to estimate the potential levels of amputation. Different from other, similar products, this surrogate leg is fitted with a unique sensor system capable of measuring the shock or stress wave progression through the leg in microseconds.

Specialised facilities for testing, evaluation and measurement of ballistics and explosives

The CSIR performs a range of testing, evaluation and measurement services in support of mobility and personnel safety for landwards forces. This includes the engineering testing and validation of armoured vehicles to evaluate its response to landmines and improvised explosive devices. Sophisticated sensors and high-speed photographic facilities are part of the test laboratory and site. Interventions are designed for existing vehicles or other personnel protective devices in support of the military and peacekeeping forces deployed in combat zones in Africa.



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The protective ability of the Mine Boot results from the particular materials used in the sole.



A landmine.



Anthropomorphic test devices – better known as crash test dummies – are installed in a human drop test rig which was designed by the CSIR. Various impact sensors installed in the dummies, as well as high-speed cameras, are used to collect data during tests to evaluate potential injury due to impact caused by an explosive.

The landmine has been branded as the ultimate indiscriminate killer, impacting on the lives of many in the estimated 78 mine-affected countries throughout the world. Despite campaigns and treaties to ban the use of landmines, mines are still produced and laid in some countries. In 1999, the Ottawa Convention – also known as the Mine Ban Treaty – became effective with member countries entering into a legal undertaking to not use, produce or acquire mines as well as to clear mined areas and assist communities in contaminated areas with information and support.

National Recordal System:

Safeguarding the future of indigenous knowledge through ICT

South Africa has a wealth of informal, but invaluable and useful knowledge residing in its communities. Until recently, this wealth of knowledge had not been formally recorded. Now the country is ready to actively record, preserve, legally protect and promote indigenous knowledge. This is made possible by the completion of an information system designed to serve as the repository of all indigenous knowledge.

THE NATIONAL INDIGENOUS KNOWLEDGE MANAGEMENT SYSTEM (NIKMAS) was developed by the CSIR in close collaboration with the National Indigenous Knowledge Systems Office (NIKSO) of the Department of Science and Technology (DST).

The system is used to manage prior art declaration (a legal term that describes information available to the public, but that has not been formally attributed to owners). Importantly, it also supports the development of new intellectual property through the knowledge collected. The system forms part of an overarching initiative, called the National Recordal System, to formalise indigenous know-how.

The National Recordal System initiative supports communities, guilds and other indigenous

knowledge holders to record their know-how with a view to creating opportunities that might be of benefit to communities. Benefits may include community recognition, identity, sustainable livelihoods, economic value and improved quality of life.

In addition, the National Recordal System initiative aims to bring fragmented databases together through a portal to enhance the National System of Innovation. Innovative and new technologies were introduced to help capture indigenous knowledge that has for centuries been transferred from one generation to another in oral format. Such indigenous knowledge is now being collected in multimedia formats without losing significant contextual information.

– *Bandile Sikwane*



Below: As part of the recording, preservation and protection of indigenous knowledge, extensive records are collected such as the identification and harvesting of plants, the preparation method, application, storage and shelf life. The knowledge is documented in verbal and visual formats through multimedia and stored in a structured repository.





Pictured in her pharmacy during recording for the purpose of preserving indigenous knowledge, is Ms Grace Masuku of the Bagatla Ba Kgafela community in the North West province. She is an educator, conservationist and environmentalist who serves in the Bagatla Ba Kgafela Traditional Authority.



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Dr Therese Stark, a plant biotechnologist, prepares an agrobacterium solution for infusion into the leaves of the tobacco plant in a CSIR plant growth room.

PLANT-BASED TECHNOLOGY AGAINST RABIES



Rabies deaths in humans worldwide have declined during the last few decades, yet this deadly animal-borne viral disease still kills thousands of people in poor regions, especially those burdened with uncontrolled stray dog populations. These poor communities are also least able to access expensive life-saving treatment after being bitten by a rabid animal.

CSIR RESEARCHERS HAVE genetically engineered the micromachinery of a leafy tobacco plant to produce a significantly cheaper rabies antidote, called Rabivir™. This product could in future significantly increase access to this type of preventative medicine.

Internationally researchers have been looking at the development of plant-based technology to develop more affordable medicine for a range of global health threats, most recently Ebola.

In South Africa, rabies is endemic in dogs and wildlife species, such as jackals and mongooses. Mere scratches on the skin may lead to the virus infecting the central nervous system and brain. Once symptoms start, death is mostly inevitable, which is why the CSIR wanted to develop technology that could improve access to post-exposure prophylaxis.

Current treatment involves vaccination as well as the administration of human anti-rabies immunoglobulin (RIG), antibodies that are normally injected directly into the wound. RIG provides immediate protection, but is expensive as it is produced from the serum of immunised people, while the vaccine takes more than a week to become effective.

Rabivir™ is an alternative to the RIG-component of this post-exposure prophylaxis regime, but at a fraction of the cost (R300 versus R3 000 for a treatment course).

CSIR researchers collaborated with international partners and programmed *Nicotiana benthamiana* plants, a close relative of commercial tobacco plants, to produce rabies antibodies. Plant-based systems,

such as this one, have the ability to produce large quantities of protein in a short period of time, which lends itself to rapid response during pandemics when preventative treatment is urgently needed.

One of these international partners is Kentucky BioProcessing in the US, a global leader in the expression, extraction and purification of proteins from plants. CSIR scientists also worked closely with the World Health Organisation and MAPP Biopharmaceutical.

Rabivir™ now needs to be tested against rabies strains that are endemic in target markets. GreenPharm, the proposed spin-off company of this research, is also seeking funds to complete pre-clinical trials to test safety for humans. Once safety is confirmed, clinical trials to test

efficacy on humans need to be done before the product can go to market.

According to Dr Ereck Chakauya, a CSIR scientist involved in the development of Rabivir™, plant-based expression systems are fast, inexpensive and scalable. "They are gaining momentum as bona fide sources of functional biopharmaceuticals. They have been proven as suitable technology for the production of effective vaccines for rapid responses against pandemic outbreaks," he says.

– Antoinette Oosthuizen



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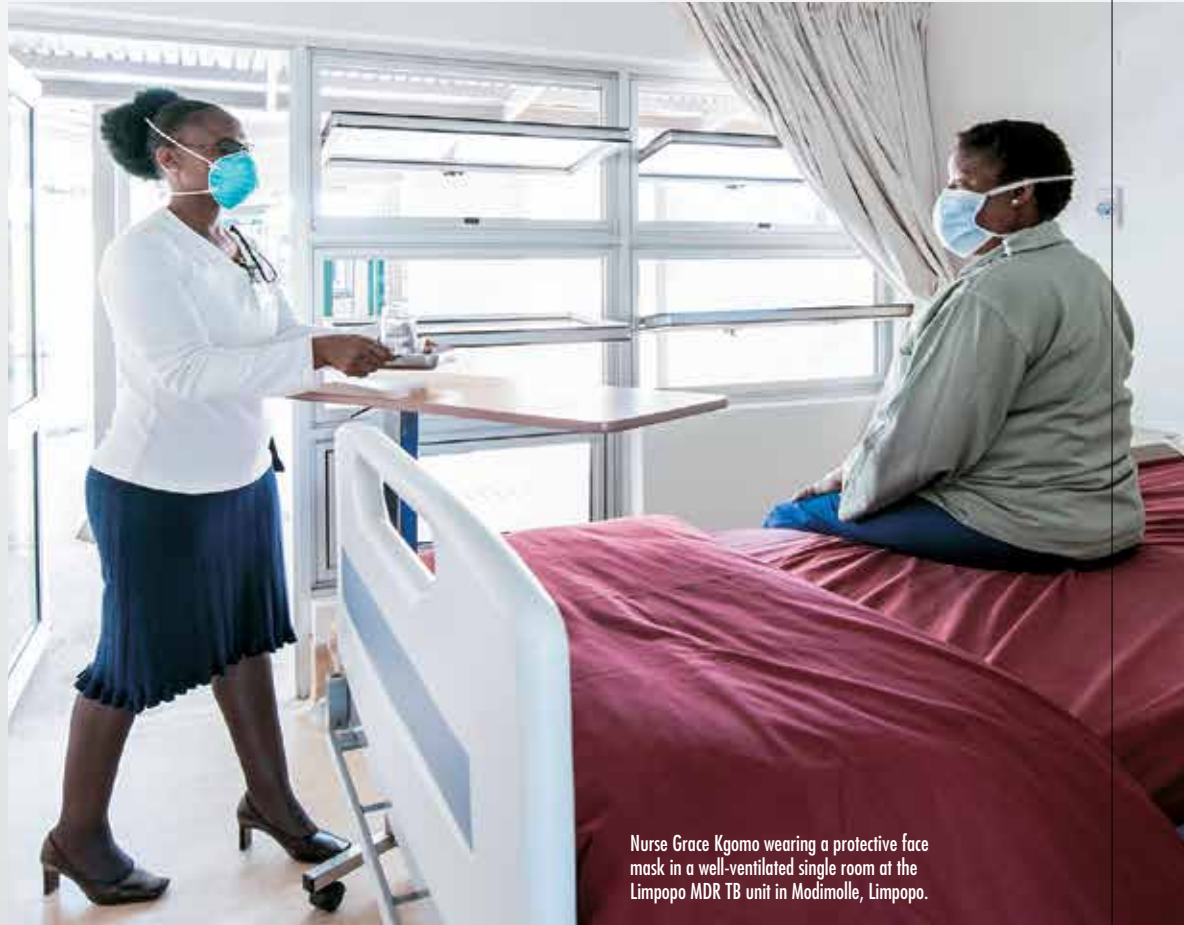
A microcentrifuge tube containing an extract from the tobacco leaves is being placed in a microcentrifuge that will spin at a high resolution to collect plant debris and insoluble material at the bottom, as seen on the right. The solution contains the protein that the researchers are studying.

Limiting the spread of tuberculosis by changing the way hospital wards are designed

Tuberculosis (TB) is a major health problem in South Africa. The CSIR, by re-designing the layout of hospitals and their ventilation systems, is helping to reduce the transmission of TB in hospitals. These innovative and effective solutions are now part of the standard guidelines for health care infrastructure in South Africa.



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Nurse Grace Kgomo wearing a protective face mask in a well-ventilated single room at the Limpopo MDR TB unit in Modimolle, Limpopo.



The spacing of seats and large open spaces at the outpatient unit of the Limpopo MDR TB unit in Modimolle, Limpopo, are supported by the CSIR guidelines for infection control in hospitals.



Face masks that protect health workers.



Areas for sputum collection are demarcated, have signage and allow optimal air flow.

The Limpopo MDR TB unit in Modimolle, Limpopo



Single rooms for patients are fitted with multiple windows that can open and a specially designed roof, among other features, to maximise the movement of air.



The seats for a waiting area in a quad are only partly covered by a roof structure to allow for good airflow.



Patients are encouraged to spend time outdoors and many aesthetically pleasing open spaces with seating form part of the complex's design.

TUBERCULOSIS (TB) is one of the leading causes of mortality in South Africa and the emergence of extremely drug-resistant strains is a risk to both patients and staff in public health care facilities. CSIR experts have formulated recommendations to the national Department of Health for the design of health care facilities, such as clinics and hospitals where TB patients, some of whom may be infectious, initially seek healthcare. They also provided technical advice on the construction of long-term accommodation, which are needed to admit drug-resistant TB patients, sometimes for months at a time.

South Africa, according to the World Health Organization, has one of the highest TB burdens in the world. TB is the most common opportunistic infection for HIV-positive patients, making active treatment and the prevention of cross-infection high priorities, especially since the emergence of extremely drug-resistant TB strains.

The decentralisation policy of TB treatment away from institutionalised care to a community-based system will result in TB patients visiting state clinics and hospitals, raising the need for effective infection control practices. Some patients, who are acutely ill with multidrug-resistant TB or extremely drug-resistant TB, might also need long-term accommodation in TB facilities where staff and other patients need to be protected from cross-infection.

The CSIR is home to specialists in the field of building design, engineering and best practice for TB infection control. They are currently assessing health care facilities across South Africa with a focus on airborne infection control, and are also training architects, engineers and clinical professionals with the support of the United States Centers for Disease Control and Prevention and the University of Pretoria.

The spread of TB

TB is spread from person to person through the air by droplet nuclei (very small particles 15 to 30 times smaller than a grain of sand). These are produced when a person who has an active TB infection, coughs, sneezes or has to produce sputum samples for TB tests. The droplet nuclei potentially contain highly infectious bacteria, which are so small that indoor air currents can keep them airborne for hours, depending on the ventilation conditions. The bacteria can then be inhaled to replicate in the lungs.

Once infected, those with compromised immune systems are more susceptible to the disease. TB treatment normally requires taking medicine for six months and for those with resistant TB strains, up to two years.

Assessing facilities

It is crucial that infectious TB patients in public health clinics are managed in a dignified and confidential manner while reducing the risk to others.

"A typical clinic assessment of a facility would include an evaluation of the ventilation conditions of the waiting areas, the fast-track capacity to quickly identify and refer an infectious TB patient, as well as evaluating the hospital programme to prioritise and reduce unnecessary travel through a facility," says Jako Nice, a CSIR research architect.

Long-term accommodation

In an earlier project funded by The Global Fund, the national Department of Health approached the CSIR to research and facilitate the design of new long-term accommodation units for more than 400 TB patients at nine centres across the country. The project included the upgrading of existing buildings, where solutions were constrained by the existing structures, as well as the construction of new units where the experts had the freedom to introduce new infection control solutions in their designs.

The team of architects, engineers and health planners proposed various solutions. Where appropriate, they recommended the use of natural ventilation and environmentally sustainable design solutions. These designs were tested at the CSIR's building performance laboratory, primarily through the use of computational fluid dynamics modelling. CFD modelling involves the use of applied mathematics, physics and computational software to visualise the flow of air, gas or fluid through space.

Using CFD software, researchers built a virtual model of facilities to simulate, visualise and analyse the ventilation performance of the design proposals. The key findings were that the ventilation efficiency depends on a building's geometric design, the climate of the region, indoor temperature, the type of windows, indoor airflow, as well as occupancy of the space.

The aim was to ensure that there is sufficient movement of air through the buildings to effectively mix the air to reduce the concentration of the infectious droplet nuclei while providing sufficient thermal comfort levels for patients.

This work by the CSIR contributed to the development of health care infrastructure norms and standard guidelines, which were published in the Government Gazette in 2014 and will support future health care capital works projects. — *Antoinette Oosthuizen*

IDEAS THAT SAVE

The CSIR's Advanced Fire Information System means that prevention of large-scale destruction caused by wildfires can be set into motion faster than ever before, saving lives, property and infrastructure.

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ONE FIRE DISASTER TOO MANY:

How the Advanced Fire Information System became an idea that saves

THE ANCIENT GREEKS told the story of a bird called a Phoenix. This mythical bird was destroyed by fire, but rose again from the ashes, stronger and more beautiful than before. In the same way, the story of the Advanced Fire Information System (AFIS) starts with a tragic fire and something great that resulted from it.

In 2001, a terrible fire broke out in the Kruger National Park destroying 45 000 hectares and killing 23 people. Immediately after hearing the news, Philip Frost, a young geographer at the time, started mapping out the fire with satellite data, showing where it started and how it spread. Frost started thinking about the lives that could be saved if the right people had access to this information as soon as the fire broke out. Thus, the idea of AFIS was sparked, literally from a disastrous fire.

AFIS has subsequently grown into a globally used, easily accessible system that provides accurate and immediate fire information and automatically sends fire warnings directly to users via cell phones and tablets.

"I'm really proud of what we've achieved," says Frost, "to think that people as far away as Silicon Valley in California are using AFIS is mind-blowing. AFIS has really grown to be at the forefront of this kind of technology, worldwide," he says.

Frost will tell you, though, that AFIS was not an overnight success. It took years of trying to convince people, that this technology could make an impact. "There were some people, however, who stood by me all the way and really believed in the idea. If people like Renier Balt, who worked at the CSIR at the time, didn't give me a break and said, 'Let's make it happen', AFIS wouldn't be here today." He believes that partnerships are often key to the success of a project. "Great collaborations can get you far."

With the help of colleagues such as Lee Annamalai, AFIS has become a world-leading, comprehensive fire information system. "As AFIS grows, we get more young and brilliant people on board, keeping us invigorated and stimulated to move forward."

The AFIS team constantly applies new developments in technology to the system, something they have done from the beginning of the project. As Frost puts it, "When we started AFIS, we were using satellite data to which the public previously had no access. Few had put satellite technology into a useable system before – it wasn't like it is now with everybody having access to satellite information through Google Maps. People were wary of technology; we had to break some real barriers of perception."

"The next step is incorporating user-generated information to make the AFIS picture more complete than ever before. Through the AFIS mobile application, users are able to take a geotagged photo of a fire and upload it into the system. We also plan in future to include tweets on fire events, and for fire managers to relay stories of their experiences," he says.

"*Ideas that work*, after all, is all about pushing the barriers of innovation so that a bigger impact can be made; AFIS is an idea that works to save lives. It's as simple and practical as that," Frost says.

Frost fully believes in how young and upcoming South African scientists can positively impact the future. "Don't ever think this is just South Africa," he says. "We have everything we need to become great, right here. Start thinking out of the box and look for new and innovative ways to do things. If you believe in what you're doing, you can make almost anything happen."



This image from the Advance Fire Information Service shows fire detections for 2015 over the western and southern Cape.



An alert sent out to volunteer fire fighters in Cape Town by a user of the AFIS mobile app.



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PORTABLE LANDING LIGHT SYSTEM FINDS USE IN PEACEKEEPING AND CIVILIAN CONTEXTS

THE CSIR HAS DESIGNED and developed a portable landing light system. The system is lightweight and can be carried as part of a paratrooper's kit. It can be rapidly set up to either mark a drop zone for paratroopers or to lay out a landing strip for aircraft. The lights are remote-controlled and can be switched on and off either by operators on the ground or by the pilot from as far away as 10 km.

The lights are most often used by paratroopers in peacekeeping operations when they are dropped in areas where there is no landing strip. When the aircraft approaches, the lights are switched on, and then switched off immediately once it has landed safely. The lights can be set in visible light or infrared mode. When infrared enabled, the lights can only be detected by night vision equipment.

Initially required to assist defence force personnel in areas without sufficient air transport infrastructure, the system has also found civilian application with mining companies both in South Africa and further on the continent.

The system consists of twelve lights, each fitted with a transmitter/receiver. An operator's remote control is effective at a distance of up to 600 m. A pilot is able to control the landing lights from as far as 10 km away. Once the landing light closest to the remote control is switched on or off, it subsequently effects the light closest to it within a distance of up to 200 m. With six lights on either side, a landing strip of 1 000 m and longer can be marked out. This means a plane of the size of a Hercules transport aircraft can be guided with this system.



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Mobile laser-based solution for the refurbishment of large industrial components

The CSIR has developed a strong competence in laser-based refurbishment, based on laser cladding technology. This technology is now available on the factory floor, thanks to CSIR engineers who designed and constructed a mobile laser welding system that can be used on-site. This ability is especially valuable for the refurbishment of large and high-value components with faster response times and significant cost savings to industry.

THE CSIR DEVELOPED a mobile laser-based refurbishment system in a bid to provide a faster and therefore cheaper service to industry. This technology uses a high-power industrial laser. The power source for this type of laser is generally housed in a built-for-purpose facility. However, the worn components are often so large (the size of an entire warehouse) that it can only be transported to the facility for refurbishment with considerable time and effort. Repairing the components on location saves industry the time and money it would have cost to transport it to a refurbishment facility. It also saves on the down-time of their factory through the loss of a functional component.

With laser cladding technology, a high-power industrial laser generates a small puddle of molten metal (a weld pool) on the surface of a metal. New material in the form of a metal powder is injected into this weld pool. When the laser beam and powder injection system is traversed across the work piece, the metal surface and newly deposited layer solidify, creating a new layer of material. This new layer is metallurgically bonded to the base material, ensuring excellent adhesion of the new layer to the original metal surface.

CSIR engineers focussed their laser-cladding research and development on stainless steel applications. It is in these adaptations and the mobile system development where significant new knowledge and applications were generated.

"The mobile system can be used to repair high-value components on-site," says CSIR laser welding engineer Corney van Rooyen.

"With the mobile system, the laser source is coupled to a mobile robotic delivery arm that handles the beam delivery and powder-feeding systems. We can fit the entire system on the back of a truck and transport it to wherever the service is needed."

As part of the industrial test and evaluation phase of the project, the team repaired high-value turbine rotors used in the power generation and petro-chemical industries at MAN Diesel and Turbo, a Johannesburg-based turbine engineering firm. Single components in these industries can cost up to R25 million. Laser cladding offers repair processes that can be significantly lower than the replacement cost of the original component, without reducing (or negatively impacting) the original technical specifications of the component.

"The impact is huge, since the costs incurred due to loss of production caused by long turn-around times if a new component had to be sourced, can be significant compared to the refurbishment of the component," says van Rooyen.

Laser cladding is a relatively new technology applied in South Africa. The CSIR has built up a sound knowledge base and van Rooyen believes that its application will grow beyond the current niche of high value components.

René Hefti, PrimeServ Service Manager at MAN Diesel & Turbo, says, "Laser cladding technology, especially the mobile system as developed by the CSIR, will open up more opportunities for the local manufacturing market."



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A SYSTEM TO MONITOR LARGE-AREA SURFACE DEFORMATION



Deformation monitoring for improved asset risk management.



Pro-active monitoring of potentially dangerous health and safety conditions.

The CSIR has developed a robust system to rapidly detect deformation of land surfaces. This is particularly useful in mined areas, where early detection of deformation is key.

IN SOUTH AFRICA, large areas are affected by surface deformation associated with underground mining or natural geological processes. The consequences of surface deformation events are frequently severe, leading not only to damage to infrastructure and the environment, but also threatening the health and safety of humans.

Deformation hazard assessment is becoming critical in an age where populations are increasing in dynamic environmental settings. The appropriate response to a hazardous event will depend on our ability to understand the nature of the hazard in question and, ideally, to derive early-warning indicators using appropriate technology.

Traditionally monitoring

The monitoring of surface deformation has traditionally been achieved using field surveying techniques such as spirit-levelling and GPS surveys. Particular concerns associated with traditional approaches relate to the risk associated with sending survey personnel into potentially unstable areas. Furthermore, field-based measurements can only take place once the existence of surface deformation becomes evident through observation by some other means, such as rainwater ponding on agricultural fields or detection of infrastructural damage. Additionally, the field-based techniques provide point-based measurements meaning that the full extent of deforming areas is frequently poorly understood. The field-based techniques are also labour intensive and time-consuming, often requiring inaccessible areas to be covered by foot. Since the environment is highly

dynamic and continuously changing, monitoring would require frequent revisits, making field-based observations virtually impossible to implement in practical terms.

In the mining environment in particular, proving the stability of undermined areas is important for post-mining rehabilitation and would require continuous monitoring for an indefinite time into the future. The inadequacy of field-based surveying techniques and its failure to provide early warning capability suggests that a service to remotely detect and monitor surface subsidence over large areas would be desirable.

Integrated earth observation products from satellite observations

The CSIR has developed a large-area surface deformation monitoring system that uses data captured by earth-orbiting synthetic aperture radar satellites. Synthetic aperture radar (SAR) sensors measure the phase (time delay) and amplitude of microwave signals returned from the earth surface. The phase of the signal is directly related to the travel distance between the satellite and the surface. Any surface deformation between image acquisitions would result in an increase or decrease in the travel distance causing an offset in phase. The interference pattern between two images captured at different times can then be calculated. This is called radar interferometry. Advanced image processing techniques can then be applied to isolate the phase contributions resulting from surface deformations. This is called differential interferometry.

These techniques provide the ability to map centimetre to millimetre scale surface

deformation and to monitor the spatial evolution of deforming areas over time. It provides a comprehensive overview of deformation detected over large areas (up to 150 km by 150 km in extent).

Information superiority

The satellite data can be collected in all weather conditions, irrespective of cloud cover, thereby ensuring a reliable, monthly deformation measurement service. The deformation measurements are provided on a web-accessible platform with tools for the visualisation of the change in deforming areas over time. The outputs of the satellite-based subsidence monitoring system are geared towards overcoming the limitations of current surface deformation monitoring programmes by providing deformation maps over large areas at risk of undergoing surface deformation. Early detection of deforming areas means that dangerous health and safety situations can be mitigated.

The large-area and remote-monitoring capability provided by the deformation monitoring service provide a low-cost deformation information system that will inform users of deformation events through electronic notifications and reporting tools. It essentially provides a robust system for the rapid detection and long-term monitoring of surface deformation over wide areas, effectively overcoming the limitations of traditional monitoring techniques.

– Dr Jeanine Engelbrecht



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The CSIR-developed monitoring system for large-area surface deformation.

CSIR DEVELOPS AND DESIGNS TECHNOLOGY TO DETECT SEDIMENTATION IN SLURRY PIPELINES

The CSIR has designed and developed a detection device to detect sedimentation of solids during slurry transportation to tailings dams. The technology prevents blockages and also enables the optimisation of pumping conditions to reduce water and energy consumption.

MINES GENERATE LARGE VOLUMES of waste. In South Africa, annually, some 150 million tons of gold and platinum tailings are pumped in slurry form into tailings dams. Solid wastes may be generated in any phase of the mining cycle.

The most significant waste-generating mining activities occur during the operational phases, which require the movement of large amounts of rock waste and metallurgical tailings. Tailings are the materials left over after the process of separating the valuables from the uneconomic material of an ore.

The tailings are then disposed of through slurry transportation from the metallurgical plant to the tailings dam, using water. However, mines often experience blocked or choked pipes during this operation, which results in downtime and associated costs. To prevent blockages, pipelines are often operated with additional water and at higher than necessary flow velocities. This practice leads to the wasting of

valuable resources, as the process is not controlled and therefore not optimised.

The CSIR-developed technology focuses on addressing the industry need to eliminate pipe blockages in slurry pipelines and similar applications by detecting settlement in pipes and to send such information – in real time – to operators to take corrective action.

Sedimentation: The common denominator in slurry transportation

Project leader and CSIR senior researcher Dr Hartmut Ilgner says when talking about sedimentation, people should think about the mounds of mine sand at tailings dams in and around Johannesburg. “Those heaps of fine sand are processed from mined ore which is milled to make it very fine to extract the gold, using chemicals. What remains is very fine sand which is pumped as waste to tailings dams and which become dry over the years.

Ilgner says the characteristic of mined ore varies and if mines do not pump fast enough through the pipelines, the sand settles down and causes sedimentation.

“First to settle will be the bigger and heavier particles that will need more agitation by the liquid to remain in suspension. Else they start to settle at the bottom of the pipeline and form a sediment which might grow and eventually block the pipeline.”

The sedimentation, according to Ilgner, could be attributed to a couple of things, such as mines not milling fine enough or the occasional presence of heavier materials which can cause sedimentation and blockages.

“These are some of the things we want to prevent,” he says. “The pumping of tailings with variable settling characteristics is a world-wide metallurgical problem.”

In addition to the detection of sedimentation, the technology also has the potential to assist mines in saving water and energy. This can

THE TECHNOLOGY



The instrument provides the state of flow in the pipeline either as

- 1 no sedimentation;
- 2 sedimentation detected (and issues a warning);



Non-invasive, clamp-on sensing head at the bottom of a tailings pipeline.

The project was undertaken by a consortium comprising the CSIR, Stoner (Pty) Ltd and Paterson & Cooke Consulting Engineers (Pty) Ltd. The development was funded by the Technology Innovation Agency during a four-year period.

An exclusive license agreement was reached in July 2014 between the CSIR and Paterson & Cooke Consulting Engineers, with Settec (Pty) Ltd as the commercial vehicle through which the intellectual property will be exploited.

be achieved by using the online instrumentation to pump safely at higher slurry concentration and lower velocities while transporting the same dry tonnage of solids.

Without this technology, mines cannot anticipate the occurrence of sedimentation and cannot adapt their management of the system accordingly. "If operators just increased the pumping speed and water volume it would result in increased velocity, abrasion in the pipeline and energy wastage," notes Ilgner. "Our technology will assist in saving energy and

water by aiding in optimising the process of pumping material from the mines to the tailings dams.

Ilgner says the CSIR is targeting gold, iron ore and platinum mines locally and internationally, as well as companies that deal with solids that can be pumped.

Versatility and ease of installation demonstrated

The technology was presented at the 19th International Conference on Hydrotransport on the Handling of Solids in

Pipelines held at the Colorado School of Mines, USA. After that, it was successfully trialled at the Saskatchewan Research Council's Pipe Flow Technology Centre in Saskatoon, Canada.

The tests proved the versatility and ease of installation of the non-invasive clamp-on heads of the sedimentation detection technology, which can be fitted to any pipe diameter.

Ilgner has his eyes on the Canadian oil sands industry, where the variability of the mined materials is of concern for the reliable operation of the pipelines, which have formidable pipe diameters in excess of 800 mm.



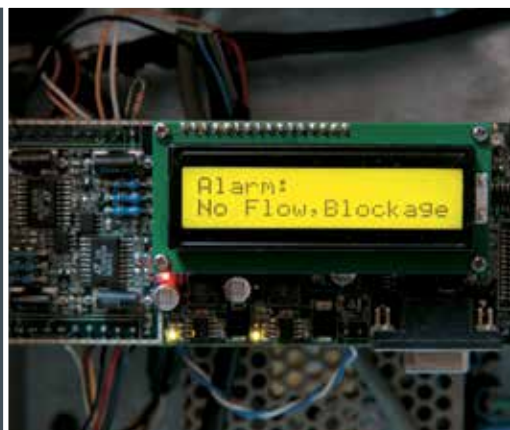
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or as

3 no flow, pipe blockages
(and sounds an alarm)

The detection device uses a sensor that detects the onset of solids deposition at the pipeline bottom to identify dead zones. The unit is portable and can be used as an inspection tool for trouble shooting.

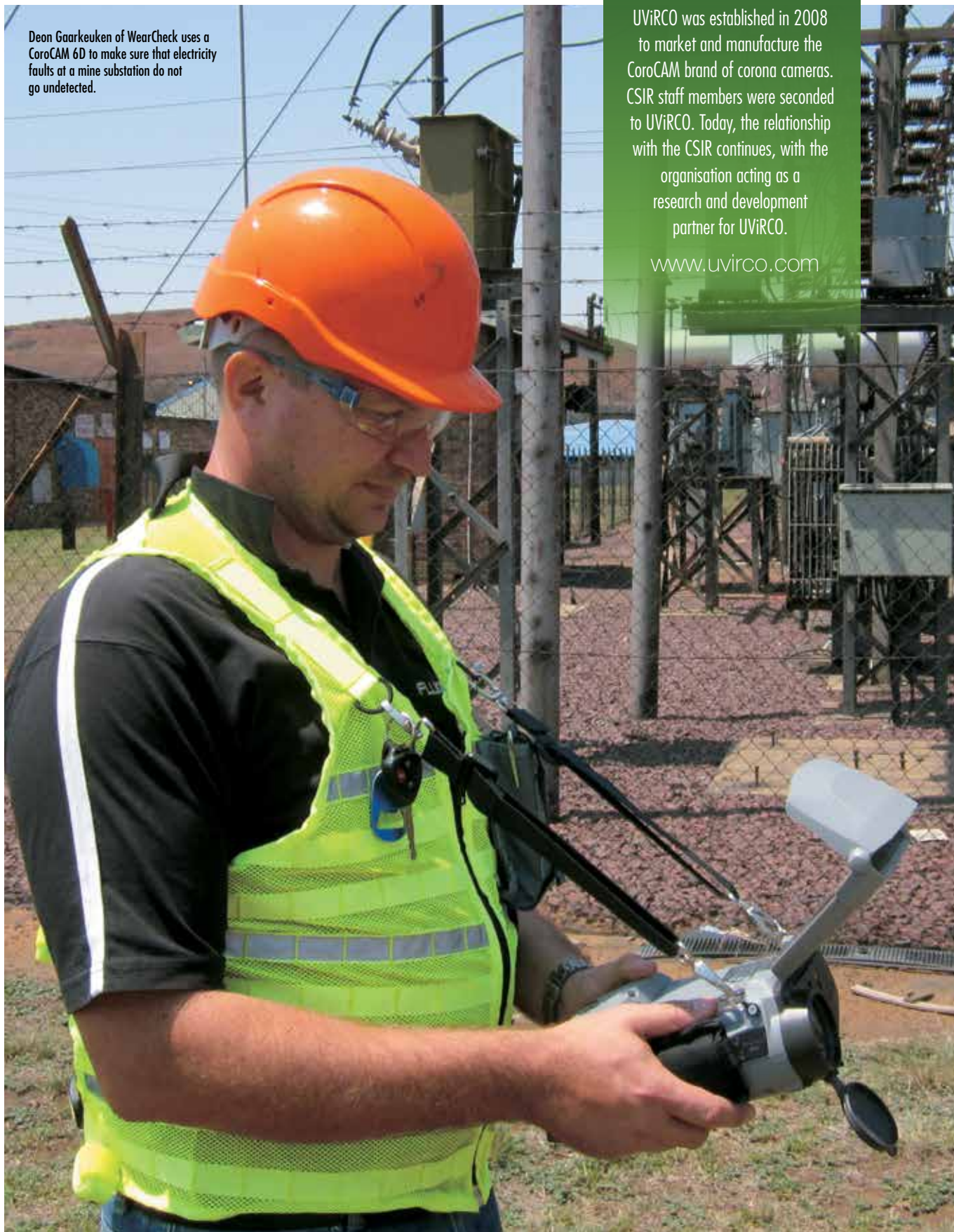


Deon Gaarkeuken of WearCheck uses a CoroCAM 6D to make sure that electricity faults at a mine substation do not go undetected.

About UViRCO

UViRCO was established in 2008 to market and manufacture the CoroCAM brand of corona cameras. CSIR staff members were seconded to UViRCO. Today, the relationship with the CSIR continues, with the organisation acting as a research and development partner for UViRCO.

www.uvirco.com



COROCAM: BEHIND THE LENS OF AN IDEA THAT WORKS

As electricity consumption around the world increases, power utilities are experiencing more and more pressure to manage their available power supplies more efficiently. Preventative maintenance can reduce blackouts and power loss on high voltage equipment. This means identifying electricity faults before too much electricity is lost. These electricity leaks, however, are invisible to the naked eye. This is where CoroCAM comes in.

COROCAM literally makes the invisible visible by capturing invisible electricity leaks on camera. This means that power lines can be repaired before blackouts ensue. CoroCAM is a single, compact device that can detect and visualise ultraviolet discharges.

CoroCAM, developed in 1992, was the first of its kind anywhere in the world, making CoroCAM the original corona camera. For over 18 years, CoroCAM technology, developed by the CSIR in collaboration with Eskom and licensed to UVIRCO Technologies, has been a market leader in the field of ultraviolet detection and imaging cameras. To date, seven models have been manufactured, each pushing the boundaries of existing technology, with the CoroCAM 504 being the most popular.

One of the brilliant minds behind CoroCAM is Roel Stolper, a principal researcher at the CSIR who has built a distinguished career in the field of electro-optical engineering.

"It all started with a simple phone call from an Eskom engineer doing his PhD on polymeric insulators," says Stolper.

"He asked whether I would be able to develop a camera technology that makes high voltage corona discharges visible to the human eye."

This was the beginning of a breakthrough. "I started to examine the spectral radiance of corona discharges with the help of a spectra-photometer," Stolper says. "By understanding the corona physics process, I started to design and develop the required optics, filters, a detector and electronic signal processing circuitry with an embodiment housing all these components."

The first corona detection camera could only record at night – but what was really needed was a camera that could detect corona in daylight. This led to the development of the solar blind corona imaging camera.

Following this, Stolper and his team added an infrared camera to record the thermal gradients on electrical equipment, which led to the development of the multi-spectral camera, the MultiCAM.

By combining the ultraviolet, visible and infrared imagery, users are given a comprehensive picture of the state of a high-voltage installation. At this stage, UVIRCO Technologies (a CSIR spin-out) was established and the CoroCAM product range licensed to it. CoroCAM became a significant commercial success.

At the CSIR, the team developed a technology which enables a high voltage engineer to measure the corona radiation in absolute units, which allows the user to determine the rate at which the corona is damaging the high-voltage installation.

The most recent stage in the CoroCAM journey has been the cooperative development of a fully radiometric ultraviolet-infrared camera to replace the MultiCAM.

Stolper says that CoroCAM would not have been the successful product it is today, if it hadn't been for great teamwork.

The impact of CoroCAM is felt at home and abroad – and for Stolper, this is what *Ideas that Work* is all about. As Stolper puts it, "we have established technologies and products that earn foreign revenue for the country, creating wealth and employment in SA through export of hi-tech products."

"Besides the fact that CoroCAM is used by engineers and electricians worldwide – from China to the United States – CoroCAM's real impact is in the employment that it has created locally."

Jaco Hart of the CSIR testing CoroCAM 8 mock-up ergonomics.



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UMBiflow

Innovative Umbiflow device used to determine fetus health set for trial commencement

CSIR RESEARCHERS HAVE DEVELOPED a simple, yet effective Doppler ultrasound device, called the Umbiflow, that can determine, at the primary point-of-care, whether a fetus that is deemed small for gestational age (SGA) is healthy or potentially sick. The device uses ultrasound to measure blood flow in the umbilical artery of a third trimester fetus as a means of assessing placental sufficiency or insufficiency. Using Umbiflow will help healthcare practitioners to assess quickly and easily whether it is indeed necessary to refer a pregnant woman with an SGA fetus to a specialist – thereby saving the costs of unnecessary referrals.

In 2013 a field trial was conducted in the Western Cape to measure the operational effectiveness and economic impact of the device and to assess whether its use in a primary health care setting has the potential to reduce the unnecessary referral of pregnant women for specialist care. Now, a full clinical trial is set to be conducted in Mamelodi, Pretoria. After conclusion of the trial, the CSIR will be looking to partner with NGOs and potential licensees that will be able to assist with the marketing, distribution and sales of Umbiflow devices

www.umbiflow.com.

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From left at the Society for Lab Automation and Screening Conference in Washington DC in the United States are Dr Adam Hill of Novartis, Dr Olga Berejnia and Brian Kozlowski of Merck, Dr Isak Gerber and Dr Justin Jordaan of ReSyn Biosciences, Dr Mary Jo Wildey of Merck and Dr Jonathan O'Connell of Forma Therapeutics.



CSIR biotech spin-off wins prestigious product award for microspheres

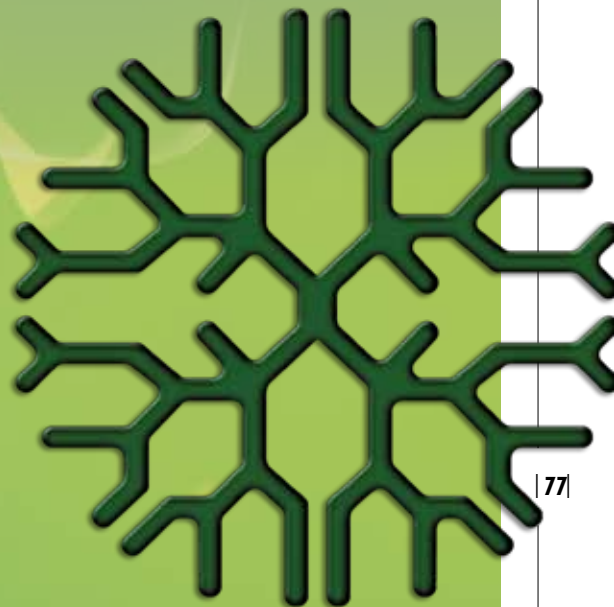
RESYN BIOSCIENCES, a biotechnology spin-off company from the CSIR, won a prestigious new product award at the Society for Lab Automation and Screening (SLAS) conference held in Washington, DC, in the United States of America for its range of innovative MagReSyn® microsphere products. These unique microspheres are helping scientists find disease mechanisms faster to identify causes of disease.

Microspheres are tiny beads onto which molecules can attach. MagReSyn® microspheres are unique in that they resemble a ball of wool rather than a solid sphere – maximising surface area for molecules to bind on. They can also bind targets very specifically and have already helped to boost drug development, diagnostics and industrial processes.

The new product award is given to companies that design unique and novel technologies based on the potential impact these products are likely to have. MagReSyn® products were developed by ReSyn Biosciences CEO, Dr Justin Jordaan, and his team at the CSIR.

Jordaan said the MagReSyn® products data demonstrated product quality and utility and that ReSyn Biosciences was selected out of a total of 296 life sciences companies who participated in the SLAS 2015 exhibition – 61 of which submitted products for consideration of a new product award designation.

For more info visit www.resynbio.com.





The SMS forecast provides current and predicted measurements for ocean current strength and direction, wave height and direction as well as wind speed and direction for the whole of False Bay.

Louis Teichardt, a local commercial fisherman from Kalk Bay in the bigger False Bay on the Western Cape south coast, receives a forecast message from the CSIR's experimental SMS coastal early-warning system.

INNOVATIVE SMS COASTAL EARLY-WARNING SYSTEM

proving popular among False Bay fishermen

A simple idea to use existing environmental and oceanographic numerical models and data to create an early-warning system that could help prevent drownings along the Western Cape coast, has developed into a comprehensive tool that is already proving popular and useful among False Bay fishermen.

AN SMS COASTAL EARLY-WARNING SYSTEM that combines climate, weather as well as ocean current and wave data sets to create detailed nine-hour short-term forecasts, provides fishermen on small fishing vessels with accurate information relating to current strength and direction, wave height and frequency, as well as wind speed and direction.

"We wanted to see how we could use existing technology to empower local communities by warning them of approaching rough sea conditions to help prevent drownings along the coast," says Dr Christo Rautenbach, a senior CSIR researcher. "We decided to focus on creating an early-warning system for small commercial fishing vessels that are particularly vulnerable to sudden worsening sea conditions."

False Bay was chosen as a pilot site for the system because it has a thriving commercial fishing community.

The CSIR has created a mathematical, numerical model that uses satellite and model data from the US National Centers for Environmental Prediction (NCEP) as boundary conditions and incorporates CSIR spatial varying wind forecasts and existing CSIR oceanographic models in order to create an accurate, holistic spatial

wave and flow climate model for the entire False Bay area.

"The model that we built takes most abiotic environmental, weather and oceanographic data into account and is therefore quite comprehensive and has so far proven to be reasonably reliable," says Rautenbach.

"We get new information on wave, current and wind measurements every three hours. Therefore every three hours the model can provide us with a new nine-hour forecast for ocean and wind conditions in False Bay."

A pilot study is currently underway to test the accuracy of the system and to make the necessary calibrations to the model.

The CSIR met with members of the Department of Agriculture, Forestry and Fisheries and local fishermen from False Bay, where fishermen were briefed and trained on how to use the system and provide helpful feedback.

"The system is very easy to use. The fishermen simply send an SMS code to a specific number and within seconds they receive an SMS reply with the latest prediction for False Bay's current strength and direction, wave heights and direction and wind conditions, as well as what the forecast will be for the next nine hours," says Rautenbach.

"We have interns who phone the fishermen every day to ask a set of

questions to determine how accurate the predictions were compared to the actual experience out on the ocean, to ask whether the fishermen are noticing any patterns of over- or under-prediction and to ask whether the data was useful.

"Because the system provides them with accurate information on the strength and direction of sea currents at the surface as well as at the bottom of the bay, the fishermen have begun to use the text message to better plan their fishing practices. For this reason, the SMS system is proving quite popular."

The SMS format was chosen because it creates a simple, affordable and quick communication system – and because fishermen don't often take smartphones or tablets out on the ocean.

"In time, we want to create an app that uses the same data to provide recreational swimmers and surfers, as well as members of the public, with more accurate coastal forecasts."

– Fanie van Rooyen



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MAKING HISTORY IN DIGITAL HOLOGRAPHY



"If I see a great opportunity – an advancement in science that can change the way we live – I grab it with both hands and give it everything I've got." **DR ANGELA DUDLEY**

Angela is a CSIR scientist who makes the seemingly impossible, possible, with ground-breaking advancements in the field of digital holography. Unlike conventional holography, which involves creating a hologram by illuminating an object with a laser beam, digital holography means that researchers do not need the laser beam to create a hologram. If the hologram can be mathematically calculated, it can be implemented digitally on a liquid crystal display. Progress in digital holography will lead to advancements in secure and efficient quantum communication. "Being able to transfer information securely is essential for military applications and even everyday internet banking," Angela says.

**BRIGHT YOUNG SCIENTISTS BEHIND
IDEAS THAT WORK.**

www.csirideasthatwork.co.za



science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

IDENTITY IS IN THE EYE OF THE BEHOLDER

“Dare to be different, but at the same time,
stay true to yourself.” GUGULETHU MABUZA-HOCQUET

These are very appropriate words indeed from the woman who has committed her research to identity protection. The way Gugu sees it, your identity is all you really have – and the answer to protecting it, lies in iris biometrics.

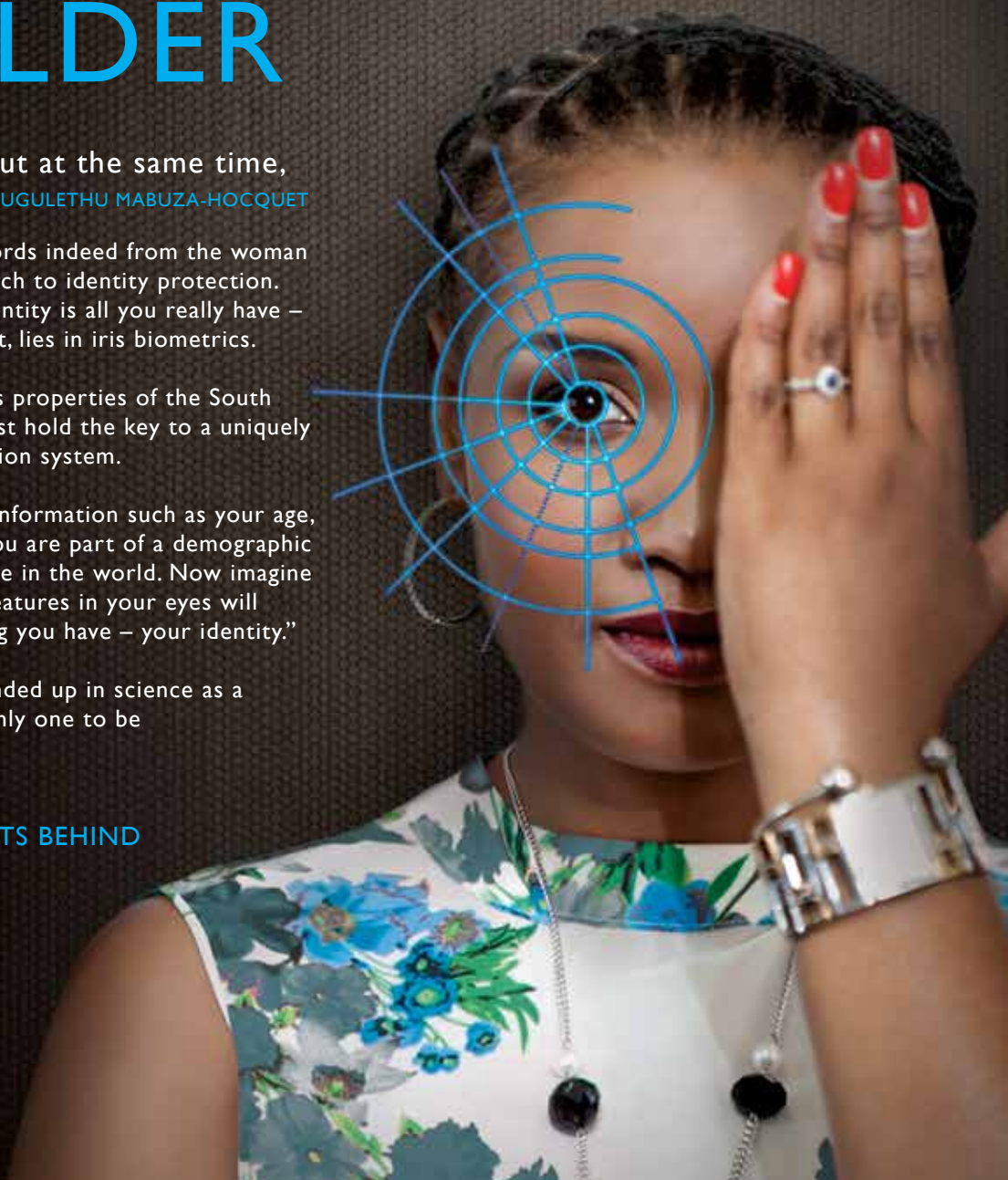
She is exploring the unique iris properties of the South African population that may just hold the key to a uniquely South African security encryption system.

“Your iris does not only hold information such as your age, gender and race, it also says you are part of a demographic mix that is not found elsewhere in the world. Now imagine a future where those unique features in your eyes will protect the most valuable thing you have – your identity.”

Gugu describes the way she ended up in science as a “beautiful accident”. It’s certainly one to be thankful for.

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