CSIR C³

collaborate.create.commercialise.

CSIR C³ INNOVATION PROSPECTUS

An invitation to collaborate and commercialise

First edition - Published October 2023

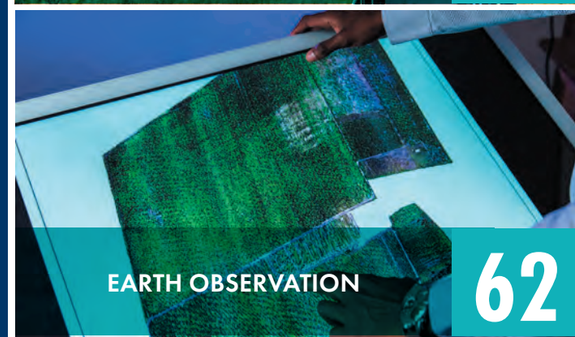
CSIR C³
collaborate.create.commercialise.

CONTACT ONE OF OUR COMMERCIALISATION MANAGERS

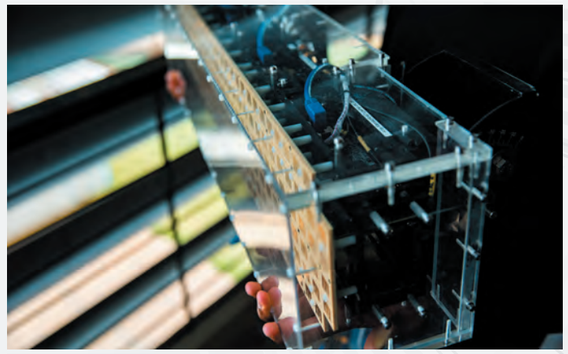
Innocent Siziba - *isiziba@csir.co.za*
Charmaine Twala - *ctwala@csir.co.za*
Minal Soni - *msoni1@csir.co.za*

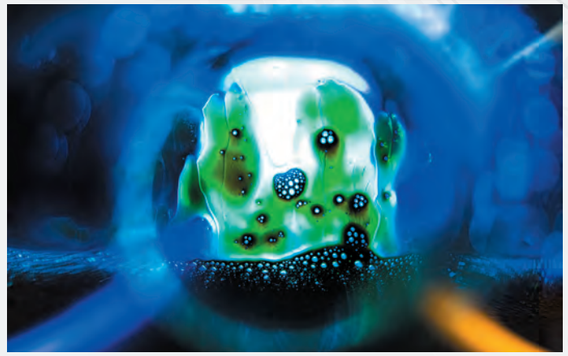
TABLE OF CONTENTS

OPPORTUNITY KNOCKING:
Technologies available for commercial uptake



AN INVITATION TO COLLABORATE AND COMMERCIALISE





Collaboration is a key CSIR value, and with the launch of CSIR C³, we are taking collaboration a step further. This innovation prospectus represents an unrivalled opportunity for collaboration in technology commercialisation. It is an invitation to tap into a collection of arguably some of South Africa's most exciting, novel technologies. Whether you aim to diversify your business, strengthen or complement your existing offerings, or venture into a new business, the CSIR has a range of technologies – some of which we are featuring in this prospectus – that has the potential to unlock the opportunities you've been looking for.

The technologies outlined in this prospectus have the potential to transform key sectors by teaming up with the right partners – entrepreneurs; established corporates; small, medium and micro enterprises (SMMEs); private equity; venture capitalists; specialised funds and government agencies.

This is where you come in. We invite you to join us in transforming these innovations into economic success stories. To work with us as we ensure technology maturation and market readiness. To jointly address market demands through innovations with economic potential. And for us to live up to our vision of becoming accelerators of socioeconomic prosperity in South Africa through leading innovation.

RAPID FIRE INTRODUCTIONS: THE CSIR AND CSIR C³

CSIR C³ is the technology commercialisation enterprise of the CSIR, South Africa.

CSIR C³
collaborate.create.commercialise.

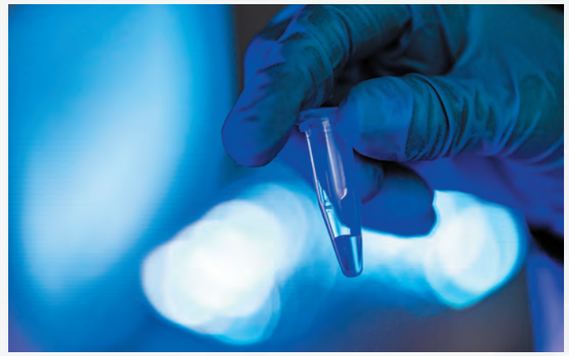
CSIR C³ (pronounced CSIR C-Cubed) is a stand-alone special-purpose technology commercialisation vehicle – set up by the CSIR – to commercialise and industrialise technologies and the intellectual property that the CSIR generates. The enterprise is a wholly owned CSIR company that holds, trades and commercialises CSIR-developed technology. It is a dedicated capability to commercialise CSIR technologies at pace and scale, acting as an accelerator to license and help incubate high-tech start-ups developed from CSIR intellectual property.

CSIR C³ is driven by specialists in business creation to nurture enterprises, build partnerships with current enterprises and stimulate investment to complement the technical capabilities of the CSIR.

CSIR C³ centres on collaboration, creation and commercialisation. Collaboratively, it innovates, creating cutting-edge technologies. It creates new enterprises and partnerships that add value to CSIR-developed technologies and progress them towards market utility. In commercialising the technologies through various business models and arrangements, this CSIR-owned company transforms the economy and society.

CSIR
Touching lives through innovation

CSIR – an entity of the Department of Science and Innovation – is a research and technology research organisation that researches, develops, localises and diffuses technologies to accelerate socioeconomic prosperity in South Africa. The organisation develops and protects its intellectual property.



THE CSIR: TOUCHING LIVES THROUGH INNOVATION

The CSIR's mandate is to undertake directed and multidisciplinary research, technology development and innovation that contributes to the improvement of the quality of life of South Africans. The organisation achieves this mandate in partnership with national and international research and technology institutions, parties in the public and private sectors and with civil society.

The CSIR's research, development and innovation contribute to industrial development and support a capable state. Intellectual property and know-how are the key outputs of the CSIR's endeavours, which it translates into products, processes and services.

The commercialisation of intellectual property and know-how is critical to the realisation of the CSIR mandate, and the CSIR's strategy places great emphasis on technology commercialisation through the creation of competitive enterprises or licensing to suitable existing companies to drive the growth of the South African economy. It is a critical step towards realising the CSIR's vision of being accelerators of South Africa's socio-economic transformation.

A strategy with greater impact as intent

In 2019, the CSIR adopted a new strategy to ensure that the organisation makes a greater impact in industry and consequently on the economy – in addition to our role of supporting a capable state. The strategy set out its intent to achieve maximum impact by focusing on the commercialisation of CSIR technologies and innovations for industrial development, as well as on technology and knowledge transfer that enable a capable state.

The organisation set out to leverage its strong science, engineering and technology (SET) capability base to drive innovation-led industrial development. Against the backdrop of the country's poor economic performance, and driven by global megatrends such as geopolitical uncertainties, economic recession, urbanisation, and supply chain disruptions, the CSIR voiced its strategic intent to rapidly advance to a situation in which its SET capabilities and industrial development endeavours become force multipliers that contribute to the competitiveness of South Africa's economy. The CSIR strategy has optimally positioned the organisation to make a significant contribution to industrial development, through contract research and development for industry and the commercialisation of the CSIR's intellectual property.

CSIR C³ is the next logical step in the organisation's strategic trajectory; it fulfils this intent by accelerating the pace and scale of commercialisation.

Impact track record

Throughout history, humans have looked for better ways to meet their daily needs. Over time, technological developments – innovative, new thinking and action – became the mainstay of inventions that improved individual livelihoods and societal well-being.

For close to 80 years, the CSIR has harnessed the collective expertise of its scientists and engineers to create innovative technological solutions that meet the needs of the country and its people. Examples of the impactful contributions that fuelled technological and social progress span decades and sectors.

From the famous tellurometer, the first microwave electronic distance measurement equipment that revolutionised land surveying worldwide and maintained the market lead for over 25 years, to a first-of-its-kind camera that visually displays defects on high-voltage electrical installations, such as powerlines, and which captured a sizeable portion of the world market in a highly specialised field.

In addition to these innovations for industry, many remarkable CSIR technologies focused on supporting a capable state. The organisation developed a device that can monitor airborne transmission risk in public facilities; a comprehensive national oceans information management system that can track vessels along our coast, monitor flood hazards and detect harmful algal blooms, among others (www.ocims.gov.za); and a model to predict the results of an election to within 1% of the final result, with only 5% percent of the voting stations counted. Researchers also developed a text-to-speech product that can deliver synthetic voices in all 11 of South Africa's official languages (www.qfrency.com).

CSIR C³ will build on the CSIR's rich history of commercial successes – and learn from the failures – and is modelled on global best practice.

A PROUD INNOVATION TRACK RECORD

A selection of CSIR innovations since the organisation's establishment almost 80 years ago

1954

ELECTRONIC DISTANCE MEASUREMENT

Dr Trevor Lloyd Wadley invents the first microwave electronic distance measurement equipment, the **tellurometer**. The tellurometer revolutionised land surveying throughout the world. In 1956, a company, Tellurometer Ltd, was formed in Cape Town to exploit the invention and the first production model appeared in 1957. The company set up to manufacture the tellurometer maintained the market lead for this equipment for over 25 years.

ACCELERATED PAVEMENT TESTING

The **heavy vehicle simulator** is developed to accelerate the testing of road pavement materials by achieving the effect of 20 years of traffic on a road surface within three months. It earned South Africa more than R250 million in foreign revenue.

1965

1980s

LITHIUM-METAL-OXIDE ELECTRODE MATERIALS FOR BATTERIES

The CSIR contributes to **lithium-ion battery** research through the discovery of lithium-metal-oxide electrode materials with a spinel-type structure. Today, lithium-ion batteries power our smart phones, laptop computers, electric vehicles, smart grids and even our homes.

LIGAMENT REPAIR

The bollard – a medical device used in conjunction with a prosthetic ligament for the repair of cruciate ligaments in the knee – is invented based on research into **carbon-fibre surgical implants**. More than 60 000 of the locally manufactured devices are sold over three decades, the last sale being an order of 250 units in 2013.

1982

2000

BREATHABLE LAMINATED TEXTILES

The CSIR transfers and commercialises its **breathable laminated technology**. The technology is suitable for the manufacture of protective outerwear and garments for healthcare workers, providing protection against virus transfer. BreatheTex Corporation (Pty) Ltd, an SMME with a small CSIR shareholding, goes on to earn the Jürgen Schrempp Award for Excellence in 2002 at the South African Excellence Foundation Innovative Strategies for Competitiveness Conference.

2000

WATER-SOLUBLE POLYMER GEL TECHNOLOGY

The CSIR licenses its **water-soluble polymer gel technology**, which becomes the basis for Eyeslices, innovative cryogel eye treatment pads, which won numerous awards, including a Technology Top 100 Award in 2007.

ARMOURED VEHICLE FOR CASH-IN-TRANSIT INDUSTRY

A new **armoured multipurpose vehicle** offers better protection to safely transport cash for the cash-in-transit industry. It features improved mobility and better weight distribution, making it harder to overturn.

2002

2003

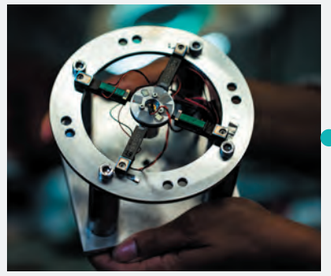
MOSQUITO REPELLENT CANDLE

The CSIR and owners of indigenous knowledge sign a benefit-sharing agreement that led to the development of a locally produced **mosquito repellent candle** using the oils of indigenous plants. Tests had shown that the essential oil of the indigenous plant, *Lippia javanica*, has more effective repellent properties than comparable products on the market. This led to the granting of a licence to formulate the patented extract into mosquito repellent products, such as candles.

ORBITAL IMPLANT

The Eyeborn orbital implant is launched at the annual international conference of the Ophthalmological Society of Southern Africa following years of research into bioceramics for medical applications. Eyeborn is a hydroxyapatite **orbital implant** used to replace the eyeball of a patient who has lost an eye. The first sale by the local distributor was to an ophthalmic surgeon from Zambia.

2004



2004

DOUBLING CAMERA IMAGE RESOLUTION

The CSIR patents a micro-scanning mechanism that enables the **image resolution** of a locally developed defence digital infra-red camera to **be doubled**, without the need to use a higher specification sensor.

2005

ADVANCED FIRE INFORMATION SYSTEM

The CSIR develops the **Advanced Fire Information System** (AFIS), which uses satellite data to detect fires in real time and automatically send warnings directly to users via cell phones and tablets. By 2012, AFIS was available as a mobile app. AFIS provides free wildfire information services to users around the globe, and value-added content for CSIR customers.

CAMERAS THAT DISPLAY CORONA DISCHARGE

A range of **cameras** that visually displays the **corona** discharge around defective, high-voltage electrical installations is licensed to UViRCO Technologies. The company captured some 50% of the world market and, in 2020, the powerline inspection system became the first ever to radiometrically quantify the ultraviolet light emitted from pylons.

2008

2009

ENCAPSULATION TECHNOLOGY FOR CASH-IN-TRANSIT HEISTS

A system that encapsulates the entire contents of an on-board vault in a solid block of **polyurethane foam** when a heist is detected, helps reduce cash-in-transit heists.

DIGITAL DOORWAY

The CSIR-developed **Digital Doorway**, a computer terminal equipped with educational games and applications, design functions and access to the Internet, is named one of the top 50 inventions in the world by *Time Magazine*.

2011

2012

EUCALYPTUS CLONE

A ***Eucalyptus* clone** developed by the CSIR and its collaborators is awarded the First Plant Breeders' Rights for *Eucalyptus* locally. New tree breeds that have better pulping properties help counter predicted shortfalls in the supply of wood.

2012

MOUTHPIECE AND NOSECLIP FOR SELF-CONTAINED-SELF RESCUERS

The CSIR licenses its patented rubber **mouthpiece**, used in self-contained self-rescue breathing apparatus, to Afrox. These rescuers supply mine workers with oxygen during emergencies such as fires or explosions underground. Earlier, the CSIR also redesigned a nose clip that was distributed globally, with over half a million units sold worldwide.

ULTRASONIC SYSTEM TO MONITOR RAILWAY LINES

In collaboration with Armscor's Institute for Maritime Technology, the CSIR co-develops an **ultrasonic system** that monitors heavy-freight **railway lines for breaks**, remotely and in real time. Transnet Freight Rail installs the world-first system on its 860 km-long Sishen-Saldanha iron ore line and the system wins the top award in the technical category at the annual Armscor CEO Awards.

2013

2014

MICROSPHERE TECHNOLOGY

The CSIR licenses its patented **microsphere technology** to CSIR spin-out company ReSyn Biosciences (Pty) Ltd. Microspheres are tiny beads onto which molecules can attach. MagReSyn® microspheres maximise the surface area for molecules to bind on. They bind targets very specifically and have helped to boost drug development, diagnostics and industrial processes.

DEPLOYING SMALL VESSELS FROM MOVING SHIPS

The South African Navy successfully demonstrates the operational viability of a CSIR-designed **davit system** to deploy a small vessel from a moving ship during, for example, **anti-piracy operations**. The system compensates for dynamic deck loading, as well as wave movement through a hydraulic wave-compensating system, which matches the movement of the waves to the movement of the boat being deployed.

2014

2015

ECO-FRIENDLY BIOLOGICAL PRODUCTS

OptimusBio, a CSIR spin-out company, introduces a range of eco-friendly biological products for sanitation, water treatment, aquaculture and agriculture to the market. The company manufactures **biological products** that contain active beneficial bacteria. The CSIR had been developing *Bacillus*-containing products for several years.

2015

DETECTING FETUSES AT RISK OF STILLBIRTH

Clinical trials of a simple, cost-effective Doppler **ultrasound device**, called the Umbiflow, starts in Tshwane in Gauteng. The device can determine, at the primary point-of-care, whether a **fetus** that is deemed small for gestational age **is healthy or potentially sick**. The device uses ultrasound to measure blood flow in the umbilical artery of a third trimester fetus to assess placental sufficiency or insufficiency. The trial shows a 50% reduction in stillbirths in the community.

GREEN COMPONENTS FOR AIRCRAFT

The CSIR and commercial airliner Airbus are granted joint patents in 2016 and 2017 on the development of non-load-bearing interior **aircraft panels** using the **natural fibre, flax**. The team combined woven flax fabric with phenolic resin (a synthetic polymer) to replace glass fibre composites. The CSIR also developed and patented an environmentally friendly, flame-retardant treatment to comply with the aerospace industry's fire, smoke and toxicity requirements.

2016

2016

BREATH-ANALYSING GLUCOMETER

A South African patent is granted for a CSIR-developed **breath-analysing glucometer** to replace invasive finger-prick glucometers for monitoring diabetes. The device detects acetone, a by-product in the breath of a person with very high blood sugar levels through the use of a micro-nanochip. In 2019, clinical trials were undertaken in collaboration with the University of Pretoria, followed by an application for registration with the South African Health Products Regulatory Authority in 2020.

SMART SPECTRUM MANAGEMENT

The Independent Communications Authority of South Africa gazettes a regulatory framework for commercial use of television whitespaces (TVWS). This was made possible by the CSIR's development of a **smart spectrum management** tool, the outcome of research into dynamic spectrum management. TVWS technology uses the gaps, known as white spaces, between terrestrial television broadcasts to deliver affordable broadband networks. The innovation won a National Science and Technology Forum award in 2020.

2018

2019

ENCAPSULATION TECHNOLOGY

The CSIR licenses its patented **encapsulation technology for probiotics** in which the active ingredient is enclosed to provide a barrier against moisture, high temperatures and gastric fluids. The technology is based on the combination of two novel ideas, namely the encapsulation of the probiotic in a pH-responsive interpolymer complex and an encapsulation process occurring in an anaerobic supercritical carbon dioxide environment.

2019

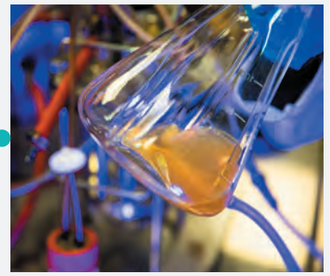
ENHANCED CREW ESCAPE SYSTEM

The CSIR and Armscor develop a new prototype system that **enhances** originally fitted **crew escape systems** in submarines of the South African Navy. The safety of submariners depends on their rapid and safe escape from a stricken submarine on the seabed. The submarine tower escape safety system was the outcome of a project initiated by the South African Navy in conjunction with Armscor, the Institute of Maritime Technology and the CSIR.

ENZYME MANUFACTURING TECHNOLOGY

The CSIR licenses its **manufacturing technologies** for the local production of DNA ligase and DNA polymerase **enzymes** to CapeBio Pty Ltd. The molecular biology enzyme reagents had been isolated from South Africa's indigenous biodiversity using metagenomics techniques. Biotechnology research and development activities rely heavily on the use of proteins and enzymes as reagents. This work laid the foundation for what would become the first locally developed PCR (polymerase chain reaction) test kit and reagents to test Covid-19 in 2021.

2019



2019

PLANT-BASED VETERINARY VACCINES

The CSIR, in collaboration with the University of Pretoria, successfully produces highly efficacious candidate **veterinary vaccines** for influenza in *Nicotiana benthamiana* (tobacco) plants. The CSIR, in collaboration with its research associates at the University of Cape Town and Onderstepoort Biological Products, had also filed a patent during 2017 for its proprietary vaccine candidates against African horse sickness and the Bluetongue virus, and published the work in acclaimed international journals.

EASY-TO-USE VENTILATOR

The CSIR helps alleviate the impact of the Covid-19 pandemic by developing a novel, easy-to-use **ventilator** system. The ventilator uses standard, hospital-grade oxygen supply, and features easy-to-use, on-device flow gauges to adjust the fraction of oxygen-enriched air in steps of 10% oxygenation. Several collaborators assist in the design, manufacturing and distribution of the ventilator, which had been evaluated by the South African Health Products Regulatory Authority.

2020

BIOCIDES

A CSIR formulation of **biocides** for Biodx (Pty) Ltd is registered as the only type two and four biocides from Africa in the European Union. These types of biocides refer to products used as **surface disinfection for food contact** and general surface disinfection, respectively. The two products have been tested against Covid-19 and have a kill rate of 99.987% within seconds of application. The commercial partner sells ton quantities of the products to different local and international markets.

2021

2021

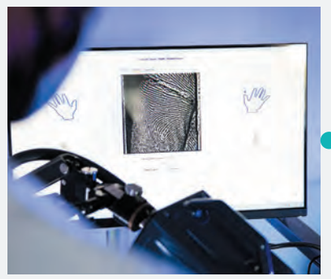
LOW-COST WASTEWATER TREATMENT SOLUTION

CSIR-developed technology based on a specific consortium of microalgae that removes excess nutrients (nitrates and phosphates) from domestic wastewater is implemented at the University of Malawi Wastewater Treatment Works. Earlier, the technology had been implemented at the Motetema and Brandwacht Wastewater Treatments Works in South Africa. The technology assists local municipalities to improve domestic wastewater effluent quality.

CONVERTING DIGITAL TEXT TO SYNTHETIC SPEECH

The CSIR signs a licence agreement with Holding BV, a global voice specialist, for a first-of-its-kind software product that converts digital text into synthetic speech, in all 11 official South African languages. Since 2002, CSIR researchers have been developing capabilities to work with resource-scarce languages and adapt state-of-the-art text-to-speech techniques for the South African context. The technology helps government and businesses to overcome language barriers and reach a wider audience.

2021

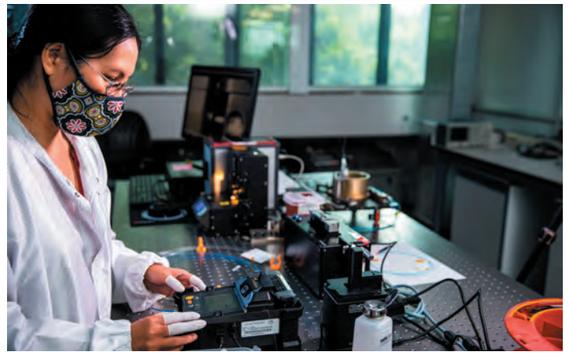


2022

FINGERPRINT SYSTEM

A CSIR-developed fingerprint system is tested at the Bronkhorstspruit Forensic Mortuary in Gauteng, as a means of acquiring fingerprints of corpses. The system uses optical coherence tomography, a non-invasive imaging system that uses light waves to capture micrometre-resolution images.

THE CSIR: TOUCHING LIVES THROUGH INNOVATION



Impact enablers: World-class infrastructure and human capital

The CSIR is at the forefront of innovation thanks to its unique resources and capabilities. The organisation boasts teams of top-tier researchers, engineers and technologists with exceptional depth of expertise across various fields. These individuals rely on state-of-the-art facilities and processes that enable the CSIR to turn visionary ideas into tangible realities.

Infrastructure: Powerful enabler of research translation

Infrastructure renewal and development is a CSIR strategic objective. For the CSIR to undertake research and development, it needs modern cutting-edge facilities and scientific infrastructure. The infrastructure base encompasses laboratories, pilot plants, prototyping facilities, industry development facilities and instrumentation for testing, evaluation, design and technology experimentation. This infrastructure provides a sound foothold from which to collaboratively develop, customise, diffuse and implement technologies that spur competitiveness among high-impact industries and support South Africa's re-industrialisation endeavours.

The CSIR is continuously investing in infrastructure that enables it to translate its research and development outputs, and those of its partners in the National System of Innovation, into products and services that strengthen South Africa's industries and enable its state.

Some of the large infrastructure investments in recent years resulted in world-class facilities that include a photonics prototyping facility to help grow the country's photonics industry; a biorefinery industry development facility to help ensure that maximum value is extracted from biomass waste; a biomanufacturing industry development centre to stimulate the growth of the biomanufacturing industry; a biodegradation testing facility to assist the local plastics industry with the verification of products that are being promoted as biodegradable; a learning factory to demonstrate and develop skills in fourth industrial revolution technologies; high-performance computing infrastructure; an indoor energy storage testbed to support local players in the battery value chain; and a supercritical carbon dioxide encapsulation facility.

These industry-like facilities will be enhanced – and new ones added – to provide the technology support to enhance the market entry of products and their continuous improvement in the incubation and acceleration phases.

The human factor: The fundamental driver of innovation and impact

The CSIR is first and foremost people-centred. It is committed to building its talent ecosystem and investing in the development of its staff. The organisation has some 1 550 staff members who make up the science, engineering and technology (SET) base, of whom some 20% have PhDs and another 30% have Master's degrees. Diversity is high on its agenda, with close to 40% of this SET base comprising women and 70% black South Africans.

This investment in the men and women who apply their specialist knowledge in pursuit of innovative research and development, has kept the organisation at the forefront of global developments in science and technology and the ability to continuously contribute to the generation of new knowledge and technological innovation.

The CSIR has strengthened its capabilities to commercialise technology by building specialised capabilities in business development and commercialisation to complement and support the dedicated capabilities in CSIR C³.

THE CSIR: TOUCHING LIVES THROUGH INNOVATION

CSIR focus areas

The CSIR focuses on nine technology sector clusters and supporting initiatives. This focus has resulted – and continues to result – in many impactful innovations and technologies with benefits for these diverse, but complementary, sectors. While technologies and innovations available for commercial uptake will almost exclusively have been developed for these sectors, they often become valuable in other sectors.

Advanced Agriculture and Food

Improve production through precision agriculture; add value and reduce waste through advanced (agro) processing

Future Production: Chemicals

Strengthen local pharmaceutical, chemical and other industries through advanced product, process and materials development

NextGen Health

Strengthen South Africa's health security by locally developing vaccines, biologics and precision-medicine-based treatment

Future Production: Manufacturing

Enhance manufacturing industry competitiveness through digital transformation and 4IR technologies

Future Production: Mining

Support the growth and revitalisation of the mining industry

Defence and Security

Build resilient defence and security capabilities in support of national security imperatives

Smart Places

Enable smarter natural resource use, environmental sustainability and smart infrastructure

Smart Mobility

Enable South Africa to have an efficient, effective, integrated, safe and competitive transport and logistics sector

NextGen Enterprises and Institutions

Enable digital transformation in government, public institutions and industry

CSIR C³: COLLABORATE. CREATE. COMMERCIALISE.

CSIR C³ on a page

VISION

The vision of CSIR C³ is to catalyse the re-industrialisation of South Africa by establishing new technology-based industries.

MISSION

CSIR C³ transforms innovations into economic success by investing in high-end technologies, identifying the right entrepreneurs and matching them to technologies, funding and markets – thereby creating a strong portfolio of high-value technology companies.

THE CSIR AND CSIR C³: TWO MUTUALLY REINFORCING INSTITUTIONS

CSIR
Touching lives through innovation

- Sole shareholder of CSIR C³
- Maintains evergreen pipeline of intellectual property
- Provides infrastructure and technical backing

IP generation

CSIR Intellectual Property	Technology maturity assessment	Partner (entrepreneur/ corporate) identification and onboarding	Identification and onboarding of suitable investors	Deal structuring and closure	Technology de-risking/ business model development	Monitoring and evaluation (performance/ compliance) and reporting

Seamless business creation

CSIR C³
collaborate.create.commercialise.

- Transacts on behalf of the CSIR (technology de-risking through to market entry)
- Selects the most appropriate business model to commercialise technology
- Incubates and accelerates technology to market

CSIR C³: COLLABORATE. CREATE. COMMERCIALISE.

The CSIR has set up an enterprise to commercialise its intellectual property at a pace and scale in keeping with its industrial development strategy and its vision to accelerate socioeconomic prosperity through leading innovation. The enterprise is called CSIR C³ (pronounced CSIR C-Cubed) and is a stand-alone technology commercialisation vehicle.

The CSIR C³ logo

The three-dimensional design is cube-like or can be interpreted as three diamonds held together by the letter "C".

The three-dimensional design captures the multifaceted nature of the CSIR's contribution and impact.

"CSIR" is part of the name, as the enterprise is wholly owned by the CSIR.

The graphic device is cubed shaped and solid – yet not locked – with a clear core to capture openness to collaboration.

CSIR C³

collaborate.create.commercialise.

Two colours are used in the design – the same blue used in the CSIR logo, indicating the close link with the CSIR's brand values, and a turquoise accent that adds a more energetic hue to capture greater assertiveness and agility as is required in the competitive commercial milieu.

The cube has three visible sides, which represent the tri-focus of collaboration, creation and commercialisation. The three sides also depict the three critical success factors for commercialisation of intellectual property, namely a solid intellectual property base, entrepreneurial capacity and capital investment.

The CSIR C³ brand story

The CSIR C³ brand has its origin in the three core values of collaboration, creation and commercialisation.

Our roots are firmly anchored in the mandate of our parent organisation, the CSIR, to undertake research, technology development and innovation that contribute to the improvement of the quality of life of South Africans. We give wings to the intellectual property generated by the collective genius of the CSIR.

We create new enterprises and partnerships that add value to CSIR-developed technologies. With our partners, we mature and commercialise these technologies – getting them to the markets that need and want them. Collaboratively, we transform our economy and society.

Mandated to trade in all CSIR intellectual property

CSIR C³ has a mandate to house and trade in all CSIR intellectual property. The company transacts on behalf of the CSIR. It undertakes technology de-risking activities, decides on licensing models, identifies entrepreneurs, sets up enterprises, provides market information, secures financing and structures deals.

Close ties: CSIR and CSIR C³ roles

An evergreen intellectual property pipeline

The CSIR's knowledge assets are vast and include patents, know-how, technology packages, trade secrets, technology demonstrators and designs. This will ensure that CSIR C³, as the CSIR's technology commercialisation enterprise, will be able to maintain an evergreen pipeline of intellectual property. The CSIR will retain intellectual property ownership, availing rights of exploitation under specified terms to startups and established businesses. In assessing the intellectual property prioritised for commercialisation, relative market attractiveness (market size, growth rates, competition) and competitiveness (technology differentiation and potential market share) are considered.

In addition to maintaining an evergreen pipeline of assets for commercialisation, the CSIR's role extends to securing seed funding, access to relevant infrastructure such as pilot facilities, incubating start-ups and maintaining relevant multidisciplinary skill sets.

The CSIR C³ portfolio

The CSIR has developed many technologies and products that are ready to be de-risked, scaled up and taken to the market. Some of these technologies require funding to take the final step towards commercialisation, while others are ready to be taken up by the market.

Many considerations are at play when including technologies and innovations in the CSIR C³ portfolio, including demonstrated (and potential) socioeconomic impact and potential financial returns.

Raising seed funding to support priority technologies

The CSIR has raised initial seed funding to support priority technologies to demonstrate its commitment to the commercialisation of its technologies and to ensure that these technologies become attractive to the market. The organisation continues its engagements with investment houses to raise further seed funding.

Role summary: The CSIR and CSIR C³

The CSIR generates intellectual property. CSIR C³ seamlessly builds business from CSIR intellectual property.

CAPABILITIES

CSIR C³ brings together **CSIR intellectual property, capital and entrepreneurs**

CSIR C³ has **incubator/ accelerator activities**

CSIR C³ **raises funding** to provide pre-seed/ seed funding **to de-risk technologies,** including incubation and acceleration, and **takes intellectual property to market with partners**

Although autonomous, CSIR C³ will maintain strong technology and innovation ties with the CSIR, as well as with the technologies and intellectual property it wishes to commercialise. CSIR C³ will be actively backed by a strong suite of multidisciplinary capabilities.

CSIR C³: COLLABORATE. CREATE. COMMERCIALISE.

Choose to do business with CSIR C³

CSIR C³ optimally brings together intellectual property, funding and entrepreneurs.

The company matches technologies and financing options and commercialises technologies through all available options, including licensing, equity investments and independent spinouts.

For the entrepreneur, SMME or established corporate

CSIR C³ has high-value assets. We understand technology development, users and that the market is dynamic. For this reason, CSIR C³ provides platforms that enable co-development with industry; invests in capabilities such as rapid prototyping to shorten the innovation lifecycle and produces minimum viable products rapidly; and leverages existing and new relationships to co-create and co-innovate with industry.

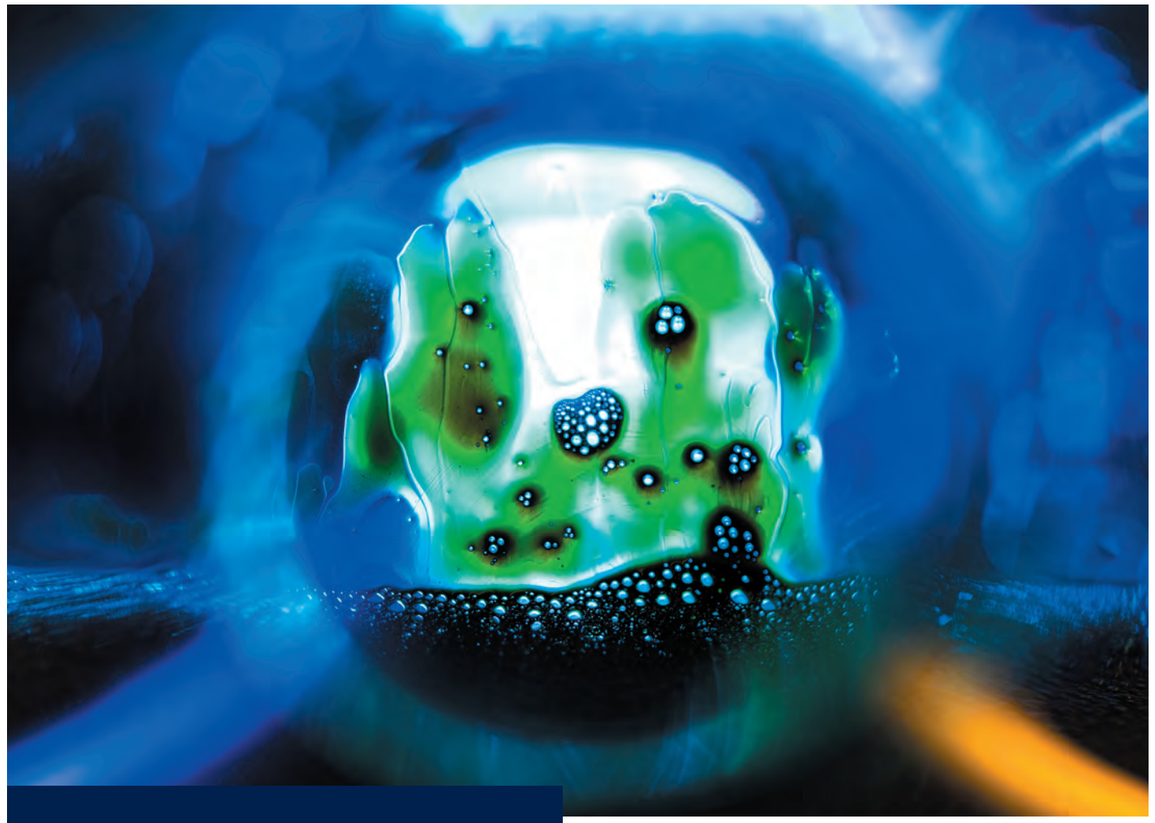
For investors

As an investor (equity partner, specialised fund) you can invest in CSIR C³ and in the start-ups that it creates. You will get return on your investments depending on the business model and investment terms agreed to, including taking up equity in the startups.

For innovators

Assistance with taking your ideas to market. CSIR C³ can also assist you with intellectual property support, workspaces, prototyping laboratories, market sample production and sector-specific infrastructure.

OPPORTUNITY KNOCKING: TECHNOLOGIES AVAILABLE FOR COMMERCIAL UPTAKE THROUGH CSIR C³



RESPONDING TO AN INSATIABLE MARKET DEMAND FOR LACTIC ACID

A local biomanufacturing process for the production of lactic acid

Addressing a problem and fulfilling a market demand

Disruptive bio-based innovation: Ending the reliance on an imported platform chemical

Bio-based production is widely viewed as a central manufacturing element of the next bioeconomy. Currently in South Africa, there is not a significant emphasis on the manufacture of bio-based platform chemicals. However, the country has become Africa's largest consumer of green chemicals, such as bio-lactic acid. This creates a unique opportunity for local technology development that moves away from petroleum-based chemicals and supplies a local market that is currently reliant on internationally supplied green chemicals.

Lactic acid is an organic acid that is generally recognised as safe and is widely used in the food, pharmaceutical, cosmetics and industrial sectors. This bio-based platform chemical is currently imported to meet the South African demand. Consequently, local production would eliminate the country's reliance on international supply and help stabilise the cost of this raw material, mitigating the impact of currency fluctuations.

More importantly, the lactic acid bio-manufacturing process relies on the bioconversion of a sugar feedstock. Consequently, the development of a domestic lactic acid production technology could be a game-changer for the South African sugar industry. This would align with its diversification strategy aimed at introducing new products, aside from sugar, to establish additional revenue streams.

The technology on offer

A biomanufacturing process for lactic acid from sugar by-product

The CSIR has established a bioconversion platform that focuses on alternate pathways for chemical production. The platform is geared towards local production and replacing imports of bio-based platform chemicals, including lactic acid. This shift will have a direct impact on the bioeconomy. The current bioprocess enables the bioconversion of industrial feedstocks or by-products, such as sugarcane molasses or sugarcane juice, to produce lactic acid by an indigenous microorganism. The technology has evolved from the proof-of-concept stage to achieve a technology readiness level (TRL) of 6. This optimised bioprocess, conducted at a 30 L scale, demonstrates a conversion rate of over 85% for the sugar feedstock into the final product, with titres exceeding 100g/L during the upstream process. Additionally, multiple downstream processing methods have been developed and optimised resulting in a purified product ranging from 75% to 92%, making it highly suitable for diverse applications across the industrial, food and cosmetic sectors.

Value proposition and competitive advantage

An all-local recipe: Local raw materials, microbe and biomanufacturing genius

The bespoke bioprocess is exceptionally localised, utilising readily available raw materials and indigenous microorganisms to generate local advantages. It aligns seamlessly with government's priorities, encompassing local manufacturing, job creation, social enrichment, environmental preservation and import replacement. The adoption of this technology will safeguard the local industry dependent on this raw material from the pricing fluctuations caused by currency shifts, while also creating avenues for global market competition.

The lactic acid produced is cost competitive and meets various industrial sector purity requirements, benefiting the local food, pharmaceutical, cosmetics and industrial sectors. South African retailers and product manufacturers can now compete internationally by using local bio-based products.

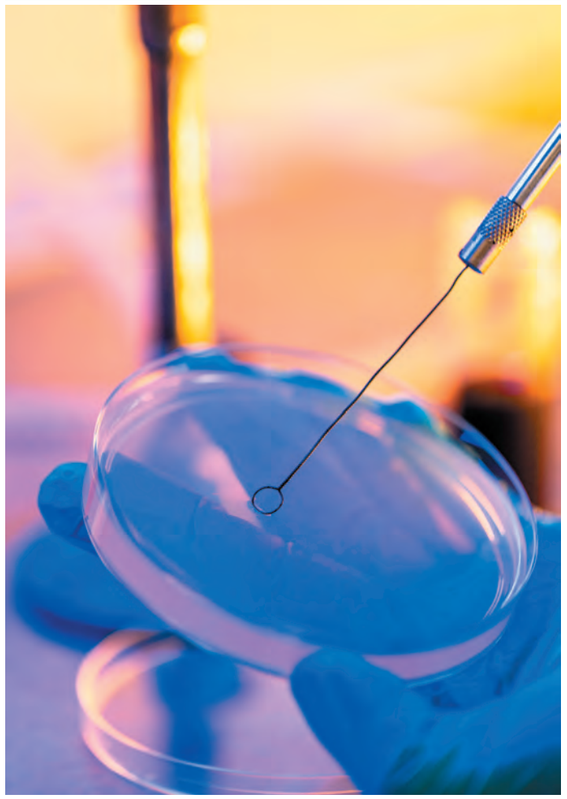
In the longer term, the technology heralds the beginning of an alternate chemical production industry in Africa. It offers a prospect for diversifying the South African sugar industry. Additionally, the chemical conversion of lactic acid into bioplastic will unlock new opportunities within the biopolymer industry, ultimately reducing its reliance on imported raw materials.

Market opportunity

A rising lactic acid demand on the back of a bioplastic surge

Globally, the production of bio-based chemicals and polymers has already reached an annual estimate of 50 million tons, generating revenue exceeding USD5.4 trillion. This global market is dominated by bio-based platform chemicals (building blocks), bio-based (green) solvents and biofuels. These products are manufactured directly from biomass, either through chemical or enzymatic processes, or by converting biomass using microorganisms during fermentation.

Sugarcane molasses is utilised as a media component for the production of lactic acid.



Streaking of the indigenous microorganism that is crucial in the upstream process of lactic acid.

The global market for lactic acid alone reached USD3.1 billion in 2022 and is expected to grow at a compound annual growth rate of 8% to USD5.8 billion by 2028. However, lactic acid is available in various grades, depending on its purity and intended application. The use of lactic acid across multiple sectors, including pharmaceuticals and the food and beverages industry, is expected to increase demand. Furthermore, one of the most significant areas of global interest in lactic acid lies in bioplastics, a sector that has experienced remarkable growth over the past decade as the market for sustainably sourced plastics has shifted dramatically toward renewable materials.

In South Africa, the market size for imported lactic acid, primarily targeted for use in the industrial and food sectors, amounts to approximately R105 million annually. However, a key driving force for the adoption of this platform chemical is its conversion into bioplastics for use in the bioplastic industry, which currently represents a USD9 billion annual global market.

Business opportunity

Become a lactic acid producer to supply the food, pharmaceutical and other industrial markets

The technology is available to a local licensee through CSIR C³, offering opportunities as a standalone business or for integration into established commercial industries, including the local sugar industry. Additionally, there is potential for joint ventures with small-scale sugarcane farmers and independent millers. International licensing and commercialisation avenues are also available.

The CSIR is committed to facilitating ongoing enhancements and the development of new technologies through research and development partnerships.

Investment and return on investment

Invest to capitalise on an established market need and a burgeoning new need

An investment of R20 million over a two-year period is required to facilitate the technology's scale-up, conduct pre-commercial feasibility assessments for integration into existing industries and support business development. Subsequently, there will be a three-year plan for establishing and commissioning a manufacturing plant, projected to cost approximately R60 million.

The anticipated revenue from replacing imports in the local South African lactic acid market is estimated to range from R105 million to R120 million annually. Entry into the global market sector for bioplastics – at a conservative 2% market share – is valued at approximately USD116 million to USD125 million annually.

A team of bioprocessing experts

The research and development efforts are led by a CSIR chief researcher, who has over 25 years of experience in the biotechnology sector, nationally and internationally. The CSIR team of bioprocessing experts brings a wealth of knowledge in scaling up technologies for commercialisation and providing support to industry, as well as small, medium and micro enterprises.

The team will also leverage and integrate existing capabilities in chemistry, polymer processing and bioplastics, and will use existing infrastructure at CSIR facilities, such as the Biorefinery Industry Development Facility, Biomanufacturing Industry Development Centre and Nanomaterials Industry Development Facility. These CSIR-established centres serve as hubs for technology development and market-facing facilities, accelerating the translation and commercialisation of innovative technologies.

The CSIR has strong capabilities in synthetic chemistry and bioprocess engineering. To expedite commercial implementation, additional expertise will be recruited and developed in areas such as process engineering, microbial engineering, metabolic modelling, as well as polymerisation and polymer formulation.

Aseptic sampling during the fermentation processes.

ENQUIRIES:

>> Charmaine Twala
ctwala@csir.co.za

A CSIR technical assistant overseeing the scaling up of the lactic acid technology.

LACTIC ACID APPLICATIONS

Yoghurt

Sourdough

Beauty products

Application of three different CSIR 'green' cement blends for plastering, binding mortar and stock bricks.

GIVING THE MARKET A COMPETITIVELY PRICED, SUSTAINABLE CEMENT ALTERNATIVE

Technology to affordably produce 'green' cement

Addressing a problem and responding to market demand

Finding an affordable alternative to cement, a carbon dioxide culprit

Globally, the cement industry faces mounting pressure to address the issue of carbon dioxide (CO_2) emission and seek solutions for its mitigation. Cement production is a significant emitter, releasing as much as 1 000 kg of CO_2 for every ton of cement manufactured, thus accounting for approximately 5–7% of the world's anthropogenic CO_2 emissions.

One approach to mitigate these emissions involves the increased use of supplementary cementitious materials such as fly ash, slag and silica fume, to partially substitute Ordinary Portland Cement (hereinafter referred to as ordinary cement) clinker. However, a notable challenge arises due to the geographical limitations of these materials. Fly ash, for example, is predominantly found in Mpumalanga, while slags and silica fume are primarily available at smelters located in Gauteng and North West. Consequently, there is a critical need to identify alternative cementitious materials that are abundantly accessible, capable of meeting demand, and competitively priced.

The technology on offer

Processes, equipment and mix formulations to produce competitively priced metakaolin-based cement

The CSIR has developed a cost-effective process for beneficiating South Africa's extensive reserves of kaolinitic clays to produce metakaolin (calcined clay) through the use of vertical shaft kiln technology. The CSIR has protected its intellectual property concerning optimised processes, production equipment, mix formulations, as well as specialised applications and products.

Kaolinitic clay deposits, used in metakaolin production, are abundant and ubiquitously available across at least six of the country's provinces, including the Eastern Cape, Gauteng, Limpopo, North West, KwaZulu-Natal, Mpumalanga and the Western Cape. This widespread availability of kaolinitic clays renders metakaolin an accessible and viable choice for cement production.

Metakaolin-based cement blends offer several advantages, including significantly reduced carbon footprints, cost-effectiveness, enhanced durability, greater strength and improved reliability of strength, often featuring faster setting times compared to most available cement products. Remarkably, metakaolin-based cement blends can be produced at a mere 45–50% of the cost of ordinary cement with a similar strength rating. Metakaolin can replace up to 70% of ordinary cement, resulting in the elimination of up to 40% of CO_2 emissions while maintaining cement quality. Furthermore, the application process for metakaolin-based cement blends mirrors that of ordinary cement, ensuring a seamless transition to this more sustainable and cost-efficient option.

Despite its potential as a cement extender or supplementary cementitious material, metakaolin has struggled to gain market traction due to its high market price. Conventionally, metakaolin is manufactured on an industrial scale using processes such as rotary kilns, flash calciners and multiple hearth furnaces. These methods entail substantial capacity demands, substantial capital investments and intricate operational procedures.

The core of cost-effective metakaolin production for green, affordable metakaolin/cement blends revolves around the design and operation of the vertical shaft kiln. The use of a vertical shaft kiln for metakaolin production represents an innovative approach.

Value proposition and competitive advantage

Simple, low capital expenditure, close-to-market green cement production

The production of metakaolin from South Africa's huge reserves of kaolinitic clays located near user markets, holds immense market potential. The employment of vertical shaft kiln technology for calcination consumes significantly less fuel compared to ordinary cement production methods. This not only reduces production costs but also plays a pivotal role in reducing environmental impact.

Consequently, metakaolin-based cement blends, which are not only greener but also more economical and high-performing than ordinary cement, can be introduced to the market at exceptionally competitive prices.

Furthermore, a mini-cement business model will be adopted. It offers several advantages, including reduced capital expenditure (capex) and simplified plant operations. This model creates opportunities for emerging broad-based black economic empowerment entrepreneurs to venture into the cement industry by establishing mini plants. By setting up the mini plants in proximity to abundant sources of kaolinitic clays and target markets, transportation costs are minimised, ensuring that metakaolin-based cement blends can be delivered to the market at highly competitive prices.

Key characteristics and advantages of this technology in contrast to traditional cement production include:

- Adherence to current cement specifications;
- A substantial reduction in carbon emissions by 30%–40%;
- A notable decrease in energy consumption by at least 40%;
- Access to ample and easily obtainable resource materials;
- Lower capex, simple manufacturing processes and reduced production expenses;
- Compatible with existing ordinary cement technology;
- Suitability for small to medium-sized enterprises; and
- Enhanced performance and durability.

Historically, the African cement industry was primarily dominated by large multinational corporations. However, a shift occurred at the beginning of the 21st century with the entry of new players into the market. This influx of fresh competition, combined with expanded production capacities from the newcomers and existing industry players led to intensely competitive markets. With lower prices per ton of cement, lower margins followed. Today, newcomers to the South African market are still operating, market shares have stabilised and cement prices have started to increase.

Given the proportionally small volumes that CSIR C³ licensees will produce, the impact on market prices will be negligible. The upward price increase over the next few years will therefore be to the licensees' advantage.

Market opportunity

A price-based cement purchase decision with a low-carbon benefit

Every year, approximately four billion tons of cement is produced worldwide, with Africa accounting for 5.1% of the global cement produced. This is projected to grow at a compound annual growth rate (CAGR) of 5.9% by 2029, driven by urbanisation and infrastructural development.

Currently, the South African cement sector produces around 13 million tons of cement annually, with a capacity to produce over 20 million tons per year. The market is projected to grow at a CAGR of 2.5% between 2023 and 2028, reaching a value of around 15.5 million tons. However, due to the influx of low-priced cement imports from China and Vietnam, the industry operates below its full capacity. Consumers have been basing their cement purchasing decisions primarily on price, resulting in an increased demand for cheaper imported blended cements. The CSIR-developed metakaolin-based cement blends can be produced and sold at competitive prices, comparable to imported cement rates – creating jobs and reducing carbon emissions.

Business opportunity

Maximising on mini-cement businesses

A mini-cement business model will be adopted. Prospective non-exclusive licensees can license the technology via CSIR C³.

CSIR C³ will also sell a proprietary CSIR-designed and custom-made vertical shaft kiln to primary licensed producers of metakaolin. Primary and secondary licensees will be licensed to blend the metakaolin with ordinary cement (CEM 1) and other additives to produce metakaolin cement blends of desired performance specifications. The primary licensees are those that will be licensed to produce metakaolin and metakaolin-cement blends, while the secondary licensees are those that will be licensed to

blend procured metakaolin and other materials to produce the metakaolin-cement blends.

CSIR researchers with extensive expertise in cement research and product development will assist the primary licensees in setting up plants nationwide for a designated fee. The licensees will distribute the metakaolin-based cement blends to end-users and intermediaries such as retailers, cement blenders, precast producers and specialty cement companies.

A similar mini-cement model is commercially successful in India, the world's second largest producer of cement, behind China.

Investment and return on investment

Invest in a mini-cement business model for South Africa and the rest of Africa

An estimated R10 million is required to meet operating costs associated with pilot production of green cements in collaboration with a pre-selected third-party with future commercial interest. CSIR C³ may host/incubate several potential licensees at the green cement piloting facility prior to the setting up of a licensee production facility.

An estimated R70 million is required for capital expenditure to set up a 100-ton-per-day green cement plant. Typically, at a discount rate of 10%, for a 100-ton-per-day plant, the net present value exceeds R10 million; the internal rate of return exceeds 20% and the pay-back period is less than five years.

Milestones and timelines

The CSIR is establishing a pilot plant for scaling up operations, which will serve to mitigate risks, conduct market testing and trial collaborations, and scale production to reach an annual output of 18 000 tons of metakaolin cement blends. In year two, CSIR C³ may host potential licensees at the green cement piloting facility prior to the establishment of licensee production facilities. By year three, small, medium and micro enterprises may be licensed to produce the CSIR-developed cement blends at their own facilities.

A team of multidisciplinary experts

The research and development efforts are supported by a team of researchers and engineers with extensive expertise in various fields, including ceramic engineering, materials science and technology, chemical engineering, civil engineering, mechanical engineering, process engineering, manufacturing and production management.

ENQUIRIES:

>> Minal Soni
msoni1@csir.co.za

Top: CSIR researchers at an experimental site where the technology was tested. Left: A concrete roofing tile industrially manufactured from a CSIR-developed cement blend. Above: A sample of the CSIR 'green' cement blend. Right: Stock bricks made using CSIR 'green' cement blends and different aggregates.

SINGULAR TECHNOLOGY PLATFORM FOR 3D PRINTER DEVELOPMENT AND ON-DEMAND PARTS PRODUCTION

A high-speed, high-power metal additive manufacturing platform

Addressing a problem and responding to market demand

Wastage and waiting: The challenges that haunt a secure supply of spare parts

Additive manufacturing technology is impacting the global economy, not only from a design or manufacturing process, but also from a wider societal and macro-economic perspective. Notably, it plays a pivotal role in fostering environmental sustainability by reducing carbon footprints and facilitates greater production flexibility aligning with circular economy principles in manufacturing. Numerous countries have invested in this domain as a national strategy to boost the development of an ecosystem that fosters technology adoption to drive competitiveness and sustainability.

Within the mining sector, there is a growing demand for additive manufactured parts. This surge is driven by disruptions in supply chains, a heightened focus on environmental sustainability to reduce carbon footprints and significant advantages offered by on-demand spare parts production, notably in terms of minimising downtime.

The CSIR has over a decade of experience designing printers and printing large parts. The latest development is a three-dimensional (3D) metal printer capable of producing large, diverse and high-volume parts. Part and process development, as well as qualification services, can be sourced from the CSIR. Furthermore, the presence of local maintenance and repair support forms key elements of the value proposition.

The technology on offer

Advanced 3D printing technology for printer and component manufacture

The CSIR has been developing large metal 3D printers since 2011. The CSIR, through its Parliamentary Grant, and the Department of Science and Innovation (DSI) have invested in the Aeroswift technology platform, as well as the development of associated technologies and processes.

On the strength of these learning and technology advances, the CSIR and DSI are currently developing a pre-industrial metal 3D printer, which uses a high-power laser to melt metal powder, offering a competitive, large-build platform, allowing the manufacturing of large-sized or large numbers of final-use parts. Already, this machine serves as a foundation for multiple successful projects within the CSIR, encompassing the development of subsystems, feedstock, technologies, processes, applications, parts and product initiatives distributed throughout the organisation.

The machine is designed to process reactive and non-reactive materials, boasting an impressive large build volume of 600 x 600 x 700 mm. It is equipped to produce parts efficiently, thanks to its high consolidation rate, driven by a powerful laser source.

Value proposition and competitive advantage

Faster, stronger and more versatile, on-demand parts production

The machine has twice the speed per laser system, a larger build platform, and comes at a more cost-effective price point compared to international competitors. This translates into the capability to produce a wide range of large parts or batches of parts at a highly competitive price.

Printing large parts carries risks such as thermal distortions and quality deficiencies. The Aeroswift family of machines leverages local expertise at the CSIR, built on a decade of experience in designing and printing large parts, as well as in process development and qualification. The availability of local support, maintenance and repair services is a key value proposition.

While the machine meets the basic requirements for machines with large build platforms, it is also designed as a platform for ongoing innovation. Subsequent versions of the machine will incorporate innovations in new subsystems.

Through dedicated CSIR research and development programmes focused on critical subsystems, we provide a sustainable and lasting competitive advantage. These key subsystems will also be localised to facilitate rapid support, repairs, upgrades and seamless integration within the broader manufacturing value chain.

Market opportunity

A surge for on-demand parts production to avoid downtimes

The demand for additive manufactured parts is currently experiencing an upsurge, driven by disruptions in supply chains, an increased focus on environmental sustainability and the inherent advantages of reduced downtime and shorter lead times achievable through on-demand spare parts manufacturing.

A light aircraft throttle grip printed in titanium alloy. 3D printing has found its way into several industries including power supply, defence, mining, automotive and aeronautics.

Nested build layout of a throttle grip, also from titanium alloy. A range of materials and techniques are researched and tested.

The market for advanced parts exhibits significant potential, yet it is still in the process of development. This gives rise to a classic "chicken and egg" scenario in which the demonstration of functional machines and market validation serve as important avenues to enter the market and stimulate demand. A targeted group of potential end users and partners who are interested and actively engaged in further development, eagerly anticipating the availability of these machines, has been identified.

A comprehensive study on parts-on-demand revealed substantial cost savings, potentially amounting to tens of millions of dollars annually, achievable through the utilisation of metal 3D printers.

In a significant partnership within the mining sector, the CSIR collaborates with a major player as a lead user of the machine. This marks the development of a machine ecosystem tailored and continuously improved to cater specifically to the needs of the mining sector.

The mining sector is actively working towards enhancing its corporate social responsibility by fostering a positive impact within the communities where it operates. The intention is to establish certified local on-demand production centres in these communities, which will not only manufacture parts but will serve as catalysts for businesses. This initiative will result in the creation of new jobs, skill development and the expansion of original equipment manufacturer services that directly support mining operations.

While mining will be the initial primary market, other markets will also be serviced due to the inherent flexibility of advanced manufacturing technology. Beyond mining, critical parts will also be produced for industries such as the energy generation, aerospace and automotive sectors.

Moreover, in an effort to expand the machine's market reach, initiatives like the Collaborative Programme in Additive Manufacturing by the DSI are dedicated to developing the metal additive manufacturing process chain. This commitment aims to facilitate the broader adoption of additive manufacturing across various component markets.

A competitor analysis has revealed that the new Aeroswift pre-production machine is highly attractive thanks to its large build platforms and is at the forefront of the market, with limited competition.

Additionally, there are significant advantages to being a pioneer in offering high-quality, large 3D-manufactured parts to the global mining industry from a commercial standpoint.

Business opportunity

Technology development partnership and 3D parts printing services to industry

Income will be generated through both the sale of machines and the provision of 3D printed parts as a service to industry. The revenue models and strategies will remain adaptable, subject to continuous refinement, aligning with the dynamics of supply and demand within local and international market segments. Feedback from end users and industry partners will be instrumental in shaping these approaches.

The CSIR remains committed to fostering the adoption of additive manufacturing in the industry. This commitment includes ongoing manufacturing demonstrations of market-ready advanced manufacturing

From the intricate to the heavy: An unmanned aerial vehicle frame benefits from the flexibility of 3D printing (above). A leading-edge turbine blade cover (50 cm in length) for an aircraft engine (below).

parts. Simultaneously, the organisation aims to create opportunities for capable machine-building industrialisation partners to produce and deploy machines, generating revenue through appropriate fees and royalties facilitated by CSIR C³. This project also seeks to actively participate in shaping the emerging industry, with initiatives such as incubating industrial partners to enable the development of the hardware value chain for machine building.

The CSIR will engage with stakeholders, including industry representatives, to establish suitable large 3D-printing facilities. This effort will commence with facilities located in proximity to mining operations. This includes the related traditional manufacturing systems, heat treatment facilities, large infrastructure, equipment and process flows.

Investment and return on investment

Invest to capitalise on the quest for on-demand parts

The programme requires a R60 million investment over two years, a significant portion of which has already been secured through funding from the DSI for the pre-commercial machine development phase. The CSIR seeks to de-risk and accelerate the completion of the initial pre-commercial machine and to secure significant private equity investment.

To achieve these goals, a total of R30 million is required to mitigate risks and accelerate the development of the inaugural machine. With this allocation, R10 million is designated for key machine componentry, with an additional R20 million allocated to the placement of a machine with an industry partner. This funding will further advance market development and enhance efforts towards successful commercialisation.

Milestones and timelines

Pre-commercialisation efforts, which encompass commissioning, testing and refining the first pre-production machine, are expected to take a year. The subsequent phase involves commissioning a pre-production machine at an industry partner's site and demonstrating progress within a full-scale production environment, set to occur in the second year. During this period, capital will be raised to enable the establishment of multiple local original equipment manufacturers and printer farms within South Africa. These entities will serve a wide range of industries, commencing with the mining sector.

A team of experts in photonics and laser technology

The CSIR Photonics Centre team has a proven track record that spans numerous years, encompassing expertise in various domains. These domains include laser metal melting, electronics, high-power lasers and laser delivery, automation, machine control, mechanical engineering, as well as machine design and construction.

ENQUIRIES:
>> Innocent Siziba
isiziba@csir.co.za

Formulated biodegradable polymer pellets.

FORMULATIONS FOR BIODEGRADABLE PLASTICS FOR A GREENER FUTURE

Biodegradable plastic formulations tailored for use in packaging, agriculture and medical device casing

Addressing a problem and responding to market demand

Conventional plastic: Pollution pest

The current patterns of production and consumption of conventional plastics are unsustainable. Conventional plastics are non-biodegradable, leading to visible pollution in soil, marine environments and the air when discarded, landfilled or burnt.

Products that are practically non-recyclable, such as plastic mulch films used in agriculture, often end up being disposed of in the environment or break down into microplastics, causing ecological issues with frequently underestimated consequences.

To address the pollution problem, there is a growing demand for biodegradable alternatives for specific product lines. These alternatives must meet performance requirements, making it essential to tailor the properties of biodegradable polymers.

The CSIR specialises in modification processes and a range of formulations designed to address specific needs. These include biodegradable mulch films suitable for crops with varying lifecycles and rigid formulations suitable for biomedical device casings.

The technology on offer

Biodegradable polymer plastic formulations

CSIR C³ offers a range of modification processes and biodegradable polymer plastics formulations for commercial uptake. These formulations are tailored for flexible and rigid applications in packaging, agriculture and medical device casing. The formulations contain up to 40 wt% locally derived natural materials, undergo complete composting, converting into carbon dioxide, water and biomass without any release of toxic residues. They are well-suitable for instances where the end-of-life scenario supports biodegradation or composting, such as in the case of biodegradable mulch films.

Value proposition and competitive advantage

Biodegradable plastics at up to a third cheaper than commercial counterparts

While several commercial biodegradable polymers are two to four times more expensive than conventional polymers, the CSIR-developed biodegradable plastics have been formulated to achieve cost reductions by up to 30%. Unlike imported neat or formulated equivalents, our solution is customised to address specific needs.

In contrast to imported equivalents, the CSIR uses up to 40 wt% locally sourced material to unlock functionalities that would otherwise remain inaccessible. The approach allows for customised formulations, for instance, controlled biodegradability rates and biodegradable mulch films for short-, medium- and long-term crops.

Market opportunity

A growing sustainability awareness that could flourish with lower production cost

In South Africa, as with the rest of Africa, the biodegradable plastics market is currently almost non-existent but is expected to grow significantly. Currently, it is characterised by low-volume imports of finished products, formulated intermediates and virgin pellets for specific applications. Globally, bioplastics constitute just 1% of the annual production of polymers, with the capacity for bioplastics projected to rise significantly from an estimated 2.2 million tons in 2022 to an estimated 6.3 million tons in 2027, growing at a compound annual growth rate exceeding 20%.

The global market is valued at approximately USD4.8 billion. With market segments, biodegradable polymers are finding niche applications in agriculture, medical and packaging industries. Production capacity is expanding and companies are opting for mergers, acquisitions or geographic expansions to gain a competitive edge.

South Africa does not produce any major biopolymers. Therefore, forming downstream beneficiation partnerships such as joint ventures with industry leaders could yield mutual benefits. Elsewhere, drivers for the shift towards biodegradable plastics include favourable policies, consumer preferences for environmentally friendly products, uniform labelling and major brands adopting more sustainable practices. In South Africa, there is an increasing awareness of sustainability among a niche market segment, although scaling is hampered by high costs. Demand-side policy interventions could help drive biodegradable plastics consumption. Nevertheless, the current flexible and rigid packaging, as well as agriculture markets are valued at over R38 billion. It is estimated that approximately 5% of this market could transition to biodegradables in 10 years, amounting to a market size of approximately 54 290 tons.

Prototype CSIR biodegradable mulch film produced at industrial partner premises.

Business opportunity

Producing and selling formulated pellets to biodegradable plastic product manufacturers

Licensees of the technology will be able to manufacture, market and sell formulated and compounded pellets to converters. These converters, in turn, will produce final products such as composting bags, agricultural mulch films, diapers or plant clips for distribution to end-users. The compounding business's primary revenue stream will be derived from the sale of these biopolymer pellets, while CSIR C³ will receive royalties based on these sales. To ensure a consistent supply of base biopolymers, such as polybutylene adipate-co-terephthalate, the business may want to partner, through a joint venture, with major producers.

Investment and return on investment

Invest to capitalise on the rise of biodegradable plastic

An estimated R40 million is required to establish a compounding business that will cater to the addressable market. This budget includes R10 million allocated for pre-commercialisation activities to de-risk the process. The payback period for this investment is five years, with a net present value of R54 million, calculated at an 18% discount rate, with an internal return rate of 30% over a 10-year analysis period.

Milestones and timelines

Pre-commercialisation activities are expected to take a year; the manufacturing facility will be set up during the second year and full-scale production will commence in the third year.

A team of experts in biodegradable plastics

The technical team is highly experienced in the formulation, processing and characterisation of biodegradable plastics. Apart from expert knowledge on biodegradable plastics, the core team has multi-disciplinary skills that facilitate the successful achievement of project goals.

ENQUIRIES:
>> **Charmaine Twala**
ctwala@csir.co.za

A SOLUTION FOR PORTS AROUND THE WORLD: FORECASTING THE MOTION OF MOORED SHIPS

A vessel motion forecast tool

Addressing a problem and fulfilling a market demand

Winds and waves cause vessel motion that affects port operations

Some 13 000 ships enter South Africa's eight ports annually. These ports process some 10 000 containerised loads per day. Many industries rely on imports and exports via the country's ports, where a safe port environment, with minimal disruptions while loading or offloading cargo, is critical.

Delays at ports, caused by weather events and uncontrollable environmental factors such as wind and waves, are common and have far-reaching impacts. Ports around the world face these factors, which impact their operability and interrupt operations. The motion of moored vessels can contribute to operational hindrances and downtime of the port. It can also result in the breaking of mooring lines during larger environmental events.

One of the main contributing factors to mooring problems is long-period waves. These waves result in varying ship motions at the berths inside a port, making it difficult for port operators to predict the impact of the resulting ship motions. Solutions to manage the impact of long-period waves on moored vessel motion can be very costly and often involve making structural changes to the ports or adopting specialised mooring systems.

Downtime at ports can be reduced with proper port planning and strategies such as where, when and what size vessels can be moored safely for optimal operational conditions.

The technology on offer

A vessel motion forecast tool

A new CSIR-developed tool can predict the motion of moored ships in a port, for both current wave conditions and forecasted wave events, contributing to operational efficiency and port safety. First tested in the Port of Ngqura, northeast of Gqeberha in the Eastern Cape, South Africa, the tool can be set up to be port specific and can be integrated into most existing infrastructure.

The vessel motion forecast tool helps with the management of mooring and long-period wave problems at ports. Predicting the effects of long wave events on moored ships can be challenging for port operators, but the CSIR-developed tool allows them to readily assess the impact of long-period waves on particular vessels at specific berth locations inside the port, removing any guesswork. This is achieved by linking numerous state-of-the-art numerical models, enabling the modelling of complete long-period wave climates and the resulting moored ship motions.

The CSIR has been providing long wave forecasts to the ports of Ngqura, Cape Town and Saldanha Bay for many years, and although this system has been proven to work well, the impact of these long-period waves on moored vessels at the respective ports has not been quantified. Recent experience has highlighted the fact that port operators are unable to readily assess and quantify the impact of long-period waves on a particular vessel based on the forecast alone. Although the port operators might be aware of a long-period wave event on the horizon, they are unable to determine what, if any, effect this will have on port operations. From the prevalence of adverse wave activities experienced at ports, a clear international opportunity for the creation of this tool has been developed from mature capabilities.

Value proposition and competitive advantage

Beating the variables to minimise wave disturbance at berths

The interaction between long-period waves, port geometry and moored ships is complex and to accurately predict or forecast long-period waves, numerical models are implemented. The downside to only having a long-period wave forecast is that it only gives the wave height at specific locations, and it does not provide an indication of moored vessel impact. The wave patterns are generally different for all berth locations, and ship motions are also impacted by factors such as ship size and the loaded state of the ship, resulting in only experienced port operators being able to determine the impact of the long-period wave forecast.

The system is innovative in the way it links various numerical models to perform in unison in an automated process to transform available offshore swell wave data to accurate long-period wave-induced moored vessel data. This is enhanced by a unique user-interface display that identifies potential problems per berth and vessel size at a glance.

The tool consists of a long-period wave and moored ship motions forecast. Different port clients will be able to access the application via a user interface without having to understand the underlying computational model and CSIR-developed algorithms. The tool predicts moored ship motions for various class ships at certain berth locations and a prediction is given for the current wave condition, including any detected forecast wave event that could be of concern. The predicted vessel motions are linked

A moored ship at the Container Terminal in the Port of Cape Town.

Ship-to-shore cranes in service at the Container Terminal in the Port of Cape Town, used to load and unload containers from ships.

to international guideline parameters to determine operability efficiency percentages. The tool also gives an indication of the safety of the moored ship based on mooring force limiting criteria. This allows port operators to establish whether a ship can be safely moored for the current wave conditions, or for any of the detected wave events in the future. Since each ship size reacts differently at each berth location, the port operators can use the tool to do berth planning in the most efficient way for the expected wave conditions.

For system development, info such as port bathymetry, berth layout and ship particulars are required. Measured and forecast wave data are used as input to the system, but this is automated. Measured data is not a requirement, but it does improve the tool's performance. No user input is required once the system is set up.

Market opportunity

Vessel motion: A universal port problem

The system can be implemented at any port where operations and safety are impacted by severe vessel motions.

End users such as the Harbour Master or Port Captain are responsible for the safe operation of vessels entering, berthing and departing ports. The environment is challenging, and weather and human error are the main contributors to incidents in ports.

When used correctly, the tool will indicate impending events and the effect of these events at particular berths to the port authorities.

The new technology demonstrator was first developed for use by the Transnet National Ports Authority in South Africa but is relevant to any port impacted by severe vessel motions. Entities that make use of ports, most notably cargo owners, ship owners, import and export associations, the insurance industry and underwriters, could all benefit from the tool.

Business opportunity

Better manage berth mooring in a specific port

The vessel motion forecast tool can be licensed via CSIR C³ and will include:

- Upfront cost to customise the tool for each port, entailing modelling and integration with hardware; and
- Monthly/annual usage fee to be negotiated based on port complexity, number of vessel types and sizes and environmental factors considered.

Investment and return on investment

Reap the benefits from getting an advanced vessel motion forecast tool on the market

The investment amount of R6 million is relatively modest as the tool has been developed from mature capabilities. The investment is required for the tool to become a standalone tool; additional modelling to cover other port features; and environmental factors; and marketing activities to secure uptake of the tool.

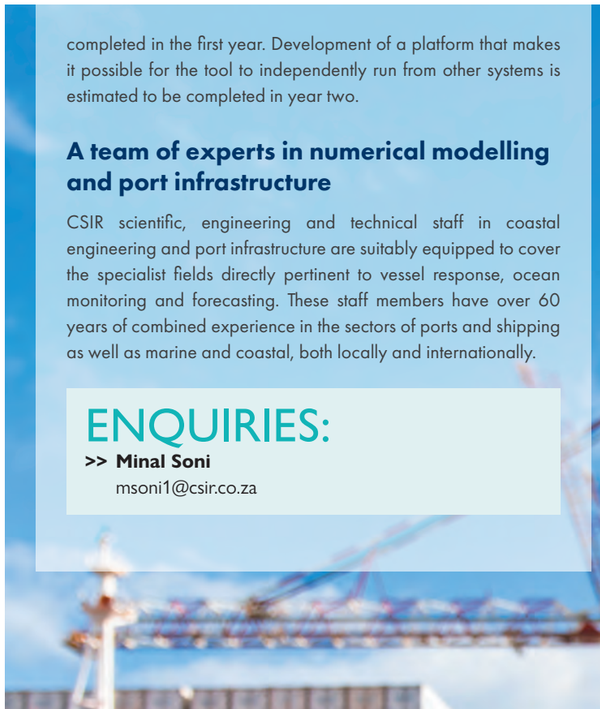
Milestones and timelines

Additional modelling, and changes to the algorithm and user interface of the tool to incorporate the effect of other environmental forces on vessels, such as wind and swell waves that penetrate a port, are estimated to be completed in the first year. Development of a platform that makes it possible for the tool to independently run from other systems is estimated to be completed in year two.

A team of experts in numerical modelling and port infrastructure

CSIR scientific, engineering and technical staff in coastal engineering and port infrastructure are suitably equipped to cover the specialist fields directly pertinent to vessel response, ocean monitoring and forecasting. These staff members have over 60 years of combined experience in the sectors of ports and shipping as well as marine and coastal, both locally and internationally.

ENQUIRIES:
>> **Minal Soni**
msoni1@csir.co.za



Verifying moored ship motions along the Container Terminal for the implementation of the CSIR-developed vessel motion forecast tool, in the Port of Cape Town, South Africa.

A CSIR-developed asset and fleet management system, first developed for use in military contexts, such as above, provides a holistic view of fleet and assets. Airports, manufacturing plants, power plants and research labs are adopting these technologies for smoother, safer and more secure operations.

IF IT'S VALUABLE, PROTECT IT: 24/7 ASSET AND FLEET MONITORING

A web-based system with real-time information on asset and fleet location and condition

Addressing a problem and fulfilling a market demand

The challenging business of tracking and monitoring asset health

Fleet owners and distribution agents face a myriad of challenges. These include crimes such as cargo theft and hijackings; vehicle misuse; and high costs of fuel, insurance and maintenance, including mechanical failures and power outages affecting traffic flow.

The CSIR has developed a web-based integrative tool that is used as a virtual 'operational command centre' to provide information regarding personnel and vehicles for better management of assets, costs and delivery of services timeously and efficiently.

The tool includes a 24/7/365 live tracking and monitoring capability of fleet diagnostics, health and status. This means one can assess the readiness of an asset for deployment in terms of its availability, service history and frequency of use and wear.

The system architecture has extensibility capability to provide several situational awareness use cases beyond asset and fleet management, for example in border control and disaster support deployments.

The technology on offer

One integrated, real-time view of multiple operations

The CSIR-developed asset and fleet management system is a decision support tool that enables effective and efficient management of operational assets and the safety of operators – around the clock.

The system architecture is multi-layered and can be customised for different use cases, such as vehicle tracking, military deployments, border control and disaster response management.

Value proposition and competitive advantage

Asset information kept up to date and secure

The vehicle tracking industry has grown quite significantly over the years. However, vehicle movement data are shared across reaction teams and kept in data centres where it is vulnerable to cyber attacks.

Uniquely, the CSIR-developed solution offers users control over their data, which is only visible to those who require real-time access – and to no other third party. This eliminates eavesdropping for mission-critical deployments in military and security operations.

Also, while competing products may offer some similar capabilities, the CSIR system has unique features that employ artificial intelligence to provide extra safety features, such as driver behaviour monitoring which helps accident avoidance by alerts sent to the command node.

The system's asset management option enables the management of complex warehouses, proving the location of essential equipment as well as their useful status. Mission planners thus have exact information on the location and status of critical equipment.

The system, which includes security access control and business reporting on asset utilisation, also provides ease of integration into an organisation's existing workflow and business processes through a novel gateway.

The system provides free draw geo-fencing by customers, allowing users to dynamically select areas of interest, such as exclusion and inclusion zones for their vehicles and assets. Most products on the market have predefined geo-fences particularly defined around crime hot spots, national borders and specific road terrains.

Market opportunity

Intelligent systems to better manage assets and operations

The use of command and control systems has long since expanded to sectors beyond defence. Asset tracking of high-value assets has benefited from self-reporting internet of things GPS modules that require low power and have a long battery life. Yet, the major players in the development and deployment of command-and-control systems remain multinationals that have a strong link to their domestic military industry.

Business opportunity

Licensing the full solution or software-as-a-service

The CSIR-developed operational control centre asset and fleet management system is available for licensing through CSIR C³. This will entail a value-based client deployment of the solution as well as technology transfer revenue. A technically trained small, medium and micro enterprise (SMME) will undertake the routine maintenance of the solution once deployed, while the enhancement and maintenance will remain the prerogative of the CSIR.

The solution is also available as a software-as-a-service. In this scenario, the CSIR will host the system on behalf of entities that don't wish to invest in the required infrastructure but need control of the data.

The device installation (tracking units/GPS modules) will be subcontracted to a vetted SMME, while system configuration will be undertaken by the CSIR or its supporting SMME.

Investment and return on investment

Becoming a licensee or appointed entity to deliver the service to clients

Investment in the order of R30 million is required to produce a baseline scaleable and extensible asset and fleet management system. The current version has been successfully piloted in the defence space and revealed areas of improvement to address customisation needs.

The development effort is expected to span over two years and entails growing the service offering's functionalities, enhancing the machine learning analytics and refining various internet of things technologies and protocols. Third-party communication is determined by data and bandwidth costs as provided by mobile telecommunication companies.

Milestones and timeline

The minimum viable product requires additions or customised services for it to have an enhanced impact on the user community. Further experimentation with the user community is planned. These developments will take place in year one and will be followed by industrial-scale testing in year two and full-scale industrialisation and commercialisation in year three.

Experts in systems and software engineering

The team behind this technology includes experts in systems engineering and integration, and software engineering honed on integrative command and security systems.

ENQUIRIES:

>> Innocent Siziba
isiziba@csir.co.za

PATIENTS ON ANTIRETROVIRALS TO BENEFIT FROM A NEW-GENERATION DIAGNOSTIC KIT FOR EARLY DETECTION OF ACUTE KIDNEY INJURY

A kit for the early detection of kidney injury

Addressing a problem and fulfilling a market demand

Dated assay technology and a lack of accurate acute kidney injury diagnostics

Acute kidney injury presents as a rapid decrease in renal function and can be caused by severe trauma, illness, surgery or chronic medication – such as the use of antiretroviral treatment.

Many assays used in disease detection were developed decades ago and their performance is lacking. This is the case with the diagnosis of kidney injury. Diagnosis is based on enzymatic tests for increased serum creatinine levels and a decline in glomerular filtration rate. But glomerular filtration rate often generates misleading results as serum creatinine levels and renal filtration are in a state of continuous homeostasis, even under normal kidney function.

A decline in glomerular filtration rate, coupled with increased blood urea nitrogen and serum creatinine levels are hallmarks of acute kidney injury; however, the rate of increase in blood urea nitrogen and serum creatinine levels does not necessarily occur in parallel to decreasing glomerular filtration rate. Serum creatinine levels are also affected by non-disease-related factors such as age, diet, muscle mass and physical activity. Another major criticism of increased serum creatinine levels as a marker for kidney function decline is that it manifests after significant kidney damage has occurred, meaning that early changes are not detected.

More recently, genetic-based diagnostic tests have been developed to guide optimal treatment, such as antiretroviral regimens. Although these can provide information on patient predisposition toward drug hypersensitivity, they add little value once patients are on a particular treatment, as the static nature of the genome does not permit continuous monitoring of the treatment as it progresses.

The technology on offer

A diagnostic for the early detection of acute kidney injury

To address the challenges outlined, CSIR researchers applied a novel approach powered by liquid chromatography-mass spectrometry-based proteome profiling to develop a diagnostic test capable of monitoring HIV/Aids patients on antiretrovirals, specifically Tenofovir disoproxil fumarate (hereafter referred to as Tenofovir), for the early onset of acute kidney injury. The research team monitored renal function using urine as the biological sample; it is non-invasive and the abundant biofluid in the form of urine is directly associated with the kidneys as the site of the disease – thus making it ideal as a prognostic indicator for acute kidney disease.

The application of machine learning to extract highly specific molecular patterns for acute kidney injury adds to the novelty of the approach. Using multiplexed protein panels (or signatures), rather than single protein molecules as has been the status quo, allows much more accurate detection of kidney damage before it becomes significant or irreversible, in addition to being able to differentiate between the various stages of kidney injury, which current clinical tests are not capable of doing efficiently. This makes it possible to address the most urgent needs regarding the diagnosis of kidney diseases: early and accurate detection, monitoring the response to therapy and predicting progression across the various stages of kidney injury.

Value proposition and competitive advantage

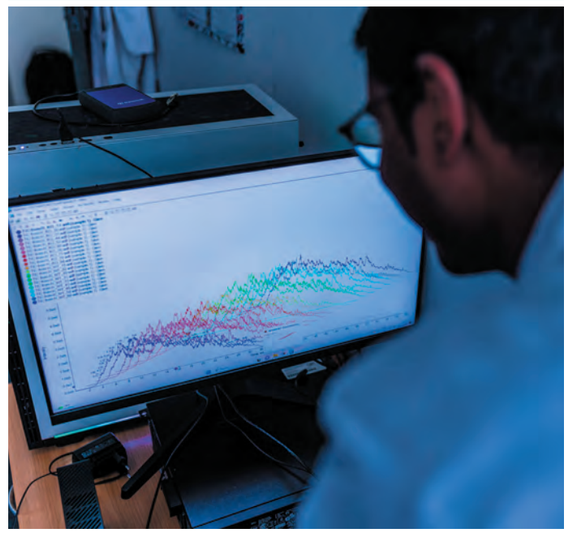
An accurate diagnostic that differentiates between different stages of kidney injury

One of the main drivers for the adoption of the novel diagnostic model(s) for acute kidney injury resulting from Tenofovir treatment, is the significantly improved performance compared to current clinical tests for kidney injury, namely serum creatinine levels and glomerular filtration rate. For example, despite >50% loss of renal function in some patients, serum creatinine levels remain normal while the glomerular filtration rate also shows only moderate specificity for renal dysfunction. In contrast, the CSIR-developed and verified multiplexed protein panel exhibits specificity and sensitivity of above 90%.

In addition, the technology makes it possible to differentiate between different stages of kidney injury. Ultimately, this leap in predictive power for Tenofovir-associated acute kidney injury detection will allow better guidance of antiretroviral regimens for improved patient health and reduce costs for the health system.

Considering the cost of dialysis and kidney replacement, the financial impact of late/inaccurate acute kidney injury detection that can be avoided by early and more accurate diagnostic tests, is enormous. In addition to this burden on the health system, many patients are not able to access the treatment as it is available in less than 10% of public hospitals in South Africa.

Protein extracts from patient urine samples being quantified using an ultraviolet-visible spectrophotometer.



Mass spectrometry raw data being inspected prior to biomarker analysis.

The clinical team is unaware of any intervention that adequately addresses the challenge of early and accurate detection of Tenofovir-associated acute kidney injury in HIV/Aids patients. Traditionally, renal injury detection is performed by monitoring the glomerular filtration rate, serum creatinine, blood urea nitrogen, creatinine clearance and urinary electrolytes, as well as through microscopic examination of the urine sediment and radiological studies. These, however, are insensitive and nonspecific indicators that do not allow for early detection of the disease.

The main competitive advantage is derived from the diagnostic accuracy of the multiplexed test at a specificity and selectivity of ~90%; and the ability to differentiate between the various stages of kidney damage and thus detect early proteome changes induced by the antiretroviral regime.

Market opportunity

Providing a solution for those who require constant monitoring for kidney injury when using antiretrovirals

The diagnostic kit is for Tenofovir-associated acute kidney injury and thus the serviceable market could be estimated from the number of HIV/Aids patients receiving this form of treatment. In 2020, there were approximately 23 million HIV/Aids patients on these regimes across the potential target markets of East and Southern Africa, West and Central Africa, Asia and Pacific, and Latin America. The current recommendation in South Africa is for ongoing (bi-yearly) screening to monitor for altered kidney function and potential acute kidney injury occurrence. This would result in a medium-term target market of ~30.2 million annual tests (East and Southern Africa) and an initial market of ~8 million annual tests in South Africa.

A 5% yearly growth in available market size for acute kidney injury tests in East and Southern Africa has been estimated based on new infections.

An additional indirect market for the new diagnostic kit is that of the Hepatitis B Virus, where Tenofovir-based treatment has proven to be an effective treatment option that will require a diagnostic screen to monitor kidney function. With ~248 million people worldwide estimated to be chronically infected with this virus, and with ~4.5 million new annual infections, this presents a viable new market opportunity for the acute kidney injury detection kit.

Customers include private and public sector routine testing laboratories that currently provide assays using alternate biomarkers in Africa, Latin America, Asia and the Pacific. It also includes government, donor agencies, and philanthropic organisations that support HIV/Aids treatment in several developing countries.

Business opportunity

Producing and selling acute kidney injury diagnostic kits

The initial serviceable market in South Africa is estimated at 8 million annual tests, whereas the East and Southern African market is estimated at 22.2 million annual tests. A preliminary techno-economic assessment based on the serviceable market in South Africa and the East and Southern African market over 10 years indicates a net present value of R158 million.

The proteomics laboratory where CSIR researchers started their research into biomarkers for acute kidney injury.

A high-resolution mass spectrometer suitable for in-depth proteomics analysis.

Magnetic beads in suspension used for automated sample preparation of patient urine samples.

Investment and return on investment

Invest to capitalise on the need for an accurate acute kidney injury diagnostic kit

An investment of R55.7 million is required for clinical validation and utility, which include diagnostic kit optimisation and robustness test, external evaluation and clinical trials, upscaling (including capital costs) and registration with the South African Health Products Regulatory Authority.

Milestones and timelines

A commercial partner (licensee/start-up) is expected to turn a slight profit in year two and a notable profit in year three.

A team of proteomics experts

The research and development team has over 40 years of combined expertise in mass spectrometry-based proteomics and includes three CSIR senior researchers and one senior technician. They are highly experienced in working with high-end equipment suitable for high-throughput clinical proteomics studies.

Furthermore, the team has secured a clinical and implementation partner, Prof. Neil Martinson of the University of the Witwatersrand, as an advisor. He is also the Chief Executive Director at the Perinatal HIV Research Unit at the Chris Hani Baragwanath Hospital and an Assistant Professor at the Johns Hopkins University Centre for TB Research.

ENQUIRIES:
>> Charmaine Twala
ctwala@csir.co.za

DISEASES DETECTED USING A TINY 'LAB ON A PHONE'

A smartphone-based diagnostic tool to detect diseases brings the lab to remote areas

Addressing a problem and fulfilling a market demand

The quest for on-the-spot sample analysis to detect pathogens

South Africans living in rural or remote areas must travel long distances to receive medical attention or treatment. Also, clinics and hospitals require expensive equipment and trained technicians to perform clinical laboratory tests and analyse the sample before a diagnosis can be issued. Sending samples to laboratories can delay the treatment of the patients while their condition deteriorates.

To address these challenges, there is a dire need for the development of point-of-care diagnostic devices that will take diagnoses from central laboratories or clinics to environments desperately in need of quick diagnostic services. In addition, the solution needs to be simple to use so that a trained technician is not required; inexpensive; independent of other instruments or equipment; and suitable for use in any location.

The technology on offer

Spectrometry that cuts through the hassles of testing for diseases

The CSIR has developed a smartphone technology that is used as a detection system for analysing biomolecular assays or chemical reactions. The smartphone is used to capture one or more images of the biomolecular assays, which are processed by way of bespoke hardware and software to provide analytical data, such as test results, associated with the biomolecular assays, in a cost-effective manner. Furthermore, since a smartphone has internet connectivity, the analytical data test results can be stored in the cloud or transmitted to desired recipients.

The technology that will be embedded in the smartphone is economically advantageous because it uses low-cost materials.

Value proposition and competitive advantage

Bringing the lab to remote areas

Traditional technologies employed to analyse biomolecular assays are expensive, bulky and many can only be used in a laboratory environment by trained laboratory personnel. Using a standard smartphone as a means to analyse biomolecular assays addresses these hurdles.

The technology does not require any modification to the smartphone and is thus convenient, user-friendly and cost-effective. The smartphone device uses cheap components which cost less than R10, thus making the technology cost effective.

Market opportunity

Extending the reach of healthcare

End users are typically healthcare operators in outlying or low-income communities. Private and public medical laboratories can use the technology for performing routine diagnostic tests. The device can also be used outside the laboratory by patients to measure disease biomarkers in the comfort of their homes. Researchers, clinics and law enforcement agencies such as the Forensic Science Laboratory of the South African Police Services can also make use of the technology.

Business opportunity

Offering a technology partnership in a licensable product

The product is at level 7 of the internationally accepted technology readiness scale, a universal statement indicating that a prototype can be demonstrated in an operational environment. It has undergone in-practice testing at the CSIR Medical Centre.

The technology offers several pathways to commercialisation. Further investment and development of the technology is required for de-risking.

It can be licensed to an intermediary industry player in the diagnostics space to deploy and offer the technology and or services to end users.

Another option is for sharing risk and partnering with service providers and intermediaries in a joint venture to offer the technology and services to end users.

It is also possible for the CSIR to first develop the technology fully and directly commercialise (an incubation model), offering technology and services directly to end users. Once at a mature level and established in the market, it can be spun out as an independent business with a commercial partner.

A smartphone camera, combined with novel in-built hardware and software, performing spectrometric analysis of bio-samples.

Investment and return on investment

Invest in a lab on a phone

A R25 million investment is required over two years. This will cover refinement of the HIV, tuberculosis and severe acute respiratory syndrome coronavirus 2 diagnostics capability; biosensor hardware design refinement, including miniaturisation; and ensuring South African Health Products Regulatory Authority conformance – all to be undertaken in the first six to nine months. The next phase will be the development of the mobile app, prototype integration and validation through field testing, and final design and implementation into the product prototype.

Combining expertise in physics, chemistry and biophotonics

The team behind the smartphone system includes CSIR senior researchers at post-PhD level in areas such as physics, chemistry, biophotonics, engineering and pharmaceutics. The team is supported by the CSIR's proven capability in healthcare product development and certification, built over many years.

ENQUIRIES:
>> Innocent Siziba
isiziba@csir.co.za

Researchers have developed a formulated prototype monoclonal antibody generated from *Nicotiana benthamiana* plants grown in controlled conditions.

PLANT-MADE MONOCLONAL ANTIBODIES TO TREAT AND PREVENT A RANGE OF DISEASES

A portfolio of therapeutic and protective monoclonal antibodies

Addressing a problem and fulfilling a market demand

An increasing demand for monoclonal antibodies and an attractive alternative to costly mammalian options

Monoclonal antibodies (mAbs) are immune system proteins that are used in targeted drug therapy and prophylaxis and are in high demand around the world to fight diseases.

Despite advancements in biomedical technology, current methods for producing mAbs – primarily mammalian cell cultures – can be costly, time-consuming, and pose scalability challenges. Additionally, potential risks like viral contamination in these cultures further complicate matters.

With the global mAbs market expected to exceed USD300 billion by 2025, there is a pressing demand for innovative production methods that can meet the increasing global need. Our combination of non-communicable and infectious disease mAbs will supply an enormous African and global market and impact global health. In the African context, the need for locally produced, affordable mAbs is even more pressing due to the continent's unique health challenges, and barriers to accessing expensive imported treatments. As such, a local, efficient and cost-effective method of mAb production is critically needed.

The technology on offer

A portfolio of therapeutic and protective monoclonal antibodies

CSIR researchers have developed a pipeline of mAb products using an innovative plant-based platform. This technology leverages fleetingly agroinfiltrated plants to produce mAbs with an efficiency and scalability that significantly outpaces current methods. Desired antibody genes are introduced into plants, which then serve as bioreactors, expressing the antibodies in a cost-effective, environmentally friendly and animal-free way, while retaining their critical quality attributes, including post-translational modifications. As part of the portfolio of products, researchers engineered humanised glycosylation and tyrosine sulfation into CSIR-developed HIV mAbs, resulting in potent efficacy. The research team has produced a series of mAbs for treating cancer, autoimmune disorders and infectious diseases like HIV/Aids, rabies and Covid-19.

Value proposition and competitive advantage

Safer, cheaper and faster than other production methods

The plant-based mAb production platform offers a transformative solution to the global demand for these vital therapeutics and prophylactics. By harnessing the power of plant systems, the CSIR-developed approach produces mAbs at a fraction of the current cost (a reduction of up to 50% in the cost of goods), dramatically reducing production time and providing unparalleled scalability. Moreover, plant systems offer an animal-free and lower risk of viral and prion contamination compared to mammalian cultures, ensuring safer products. The technology is set to democratise access to these essential therapeutics across Africa, where they are needed most.

The CSIR-developed antibodies hold several competitive advantages. They offer a safer, faster, more affordable and scalable alternative to current mAb production methods. With the advanced transient agroinfiltration techniques and engineered plants, the reduced upstream capital expenditure costs significantly surpass competitors. For example, the CSIR's leading pipeline product, Rabivir, will be available at a highly cost-competitive price to the public health sector of developing countries. Moreover, the technology enables rapid scalability to meet surges in demand, making it highly responsive to market needs, including emergencies like outbreaks, pandemics, biological warfare, or emerging disease threats.

Market opportunity

Monoclonal antibodies: The fastest-growing class of pharmaceuticals

With the global mAbs market projected to grow annually at a rate of 11%, and reach over USD300 billion by 2025, the opportunity is tremendous. The South African monoclonal antibodies market was valued at USD403.96 million in 2022 and is expected to reach USD969.72 million by 2028, growing at a compound annual growth rate of 15.76%. Monoclonal antibodies represent the fastest growing class of pharmaceuticals and their global access is currently patchy. By focusing on the African region, this innovation addresses a market that is currently overlooked, thus reducing competition and increasing the growth potential.

Business opportunity

Secure a licence to produce biopharmaceutical products using plant-based production know-how or negotiate a production contract

Various business collaboration opportunities are available for uptake of the CSIR-developed monoclonal antibodies through CSIR C³. These include licensing agreements stipulating royalties on the sale of mAb biopharmaceutical products for rabies, HIV and cancers.

Investment and return on investment

Invest to capitalise on the world's pursuit of monoclonal antibodies and an under-served African market

An initial investment of R25 million is required to conduct pre-clinical studies for the leading products. This funding will be used to further mature the pipeline and recruit key talent, expediting the commercialisation timeline.

Milestones and timelines

During the first two years, the investigational new drug-enabling studies for the leading prototype will be finalised. In years three and four, a pilot production facility will be expanded and licensed in collaboration with the CSIR and a clinical trial application for phase I studies will be submitted. Year five and six plans centre on penetration of key African markets; commencement of revenue generation through contracts and licensing agreements; and investment in research and development for potential expansion into other plant-based therapeutics. Year six and onwards will see operational profitability; possible expansion into other global markets, or acquisition by big pharma; and clinical development of the next pipeline molecule.

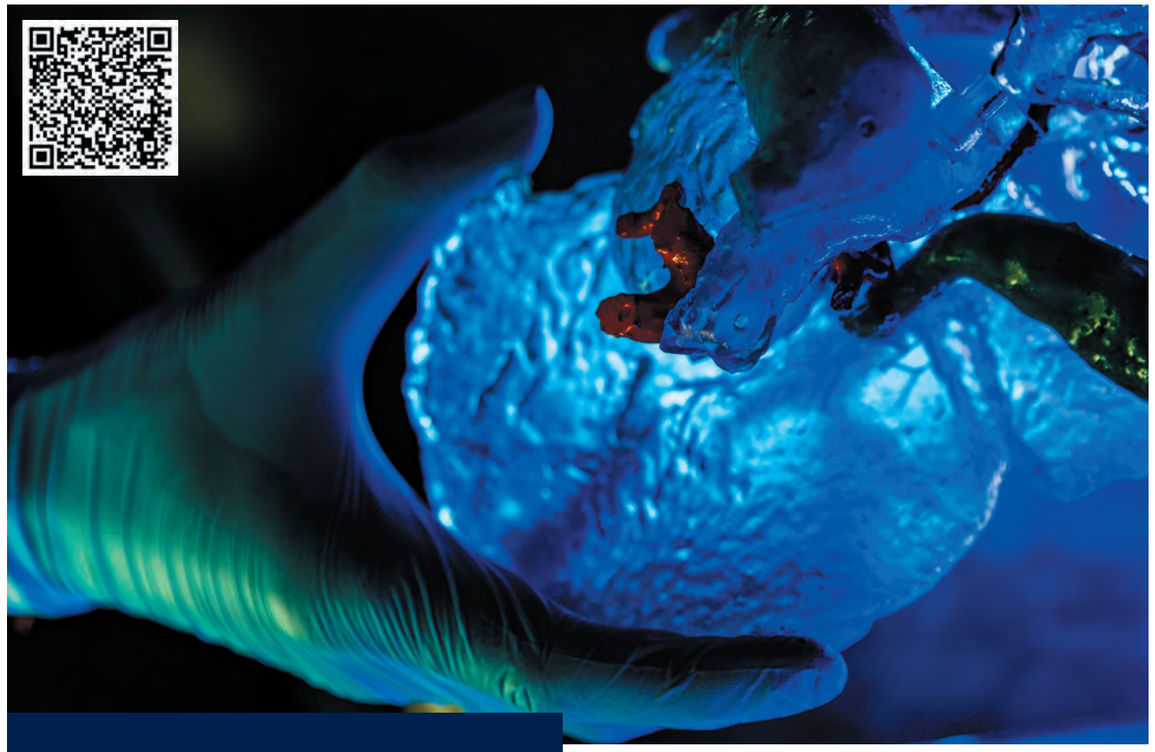
A team of experts in plant-based production of biopharmaceuticals

The technical team is a highly experienced biotechnology team. The project chief researcher is a PhD-level biomanufacturing expert with a focus on plant genetic engineering and bioprocess development, with numerous patents and publications to his name. The team brings more than 15 years of research and industry experience. The technical business development staff has a successful track record in establishing and nurturing partnerships in the biopharmaceutical industry, both in Africa and globally.

The project has an advisory board comprising prominent researchers, clinicians and pharmaceutical industry leaders in the field of monoclonal antibodies and bioproduction systems.

The diverse project team has the necessary knowledge, skills and experience to help bring this innovative technology to the African market, thereby making a significant impact on the continent's healthcare landscape and health product self-sufficiency.

ENQUIRIES:
>> **Charmaine Twala**
ctwala@csir.co.za



LIVER-IN-A-DISH SCREENING SERVICE: ASSESSING DRUG SAFETY IN AFRICAN POPULATIONS

A genome-engineered stem cell tool that mimics the metabolism of pharmaceuticals in genetically diverse African populations

Addressing a problem and responding to market demand

Drug regimens have not been optimised for individuals of African descent

Drug regimens have not been optimised for individuals of African descent. This is due to several converging factors, including Africa's diverse genetics, disproportionate disease burdens (and consequently a high dependency on specific drug regimens), as well as under-representation of local population groups in clinical trials. Consequently, adverse diverse drug reactions are responsible for one in 12 people being admitted to hospital in South Africa where hospital services account for approximately R 125 billion in healthcare spending annually.

The South African Health Products Regulatory Authority (SAHPRA) is responsible for assessing and approving all potentially marketed drugs based on, among other key features, efficacy and safety data from clinical trials. However, understanding the magnitude of impact, which observed adverse drug reactions may have within a specific population, and evaluating previously unreported adverse drug reaction during post-marketing surveillance, is a challenge because clinical trials predominantly enrol Caucasian populations (from Europe and North America). South Africa encompasses vast genetic diversity (including within the liver drug metabolising genes, thus impacting best treatment outcomes), consequently there is limited preclinical or clinical data to support data-driven decision-making for drug approval and marketing.

Therefore, innovative tools that contribute to evidence-based decision-making, in the context of optimised drug regimens, are needed on the continent. Such a tool must be inexpensive, reproducible, physiologically functional (i.e., act like our liver cells) and contain African-relevant genetic variants of interest.

The technology on offer

A cellular tool to mimic liver metabolism of pharmaceuticals inclusive of African genetic diversity

Combining synthetic biology tools, including induced pluripotent stem cell technology and CRISPR genome engineering – a technique in which a specific sequence of DNA can be precisely modified inside a cell – the CSIR has created a nano-scale cellular tool that mimics liver metabolism of drugs inclusive of African genetic diversity.

CSIR researchers demonstrated functionality of this bioengineered liver-in-a-dish using liquid chromatography tandem mass spectrometry, the gold standard for assessing drug metabolism. Using this method, the CSIR team was able to confirm the metabolism of the sedative drug, midazolam, in the liver-in-a-dish model as occurs within cells in the human liver. This indicates that a key phase I metabolising gene, *CYP3A4*, is functional in the CSIR-developed African liver-in-a-dish. The gene is responsible for the metabolism of 50% of the drugs on the market, including drug classes such as antidepressants, antipsychotics, antihypertensives and painkillers. The technology therefore provides a significant degree of confidence to pursue the development of the technology to a minimum viable product within the next two years.

The innovation makes it possible to understand how individuals of African descent might metabolise new drugs and to understand adverse drug reactions in diverse populations.

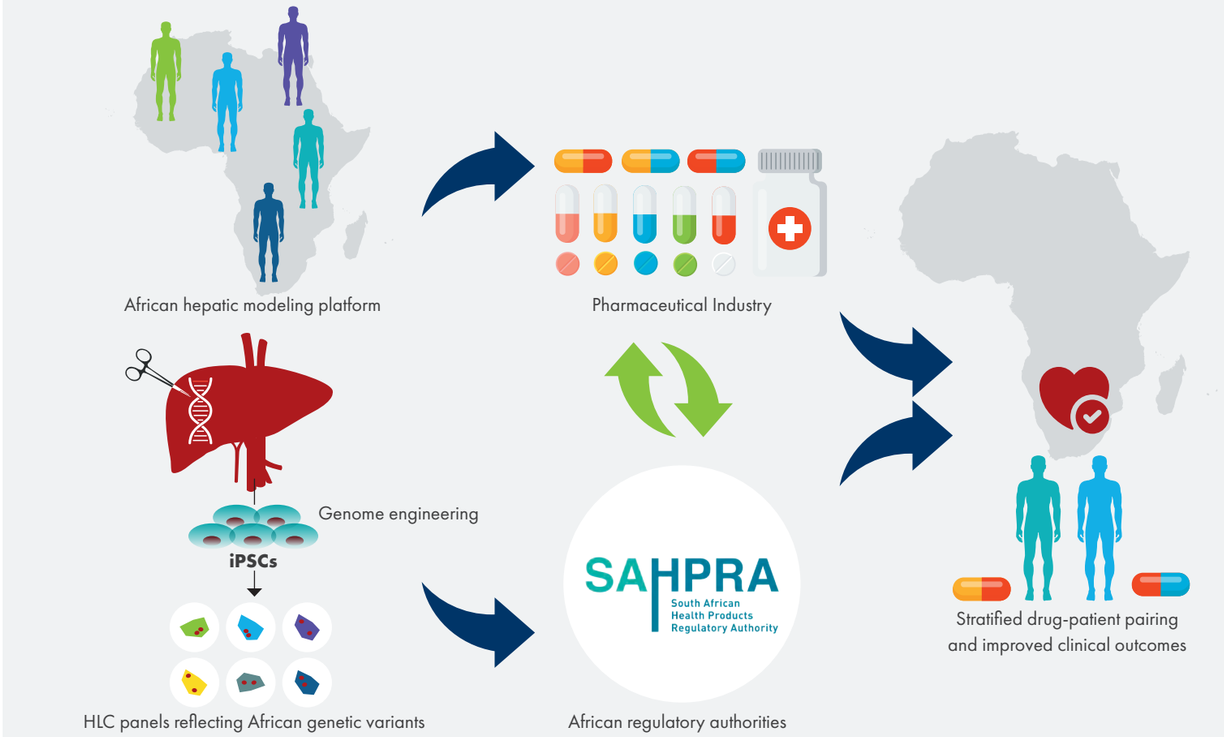
Value proposition and competitive advantage

Incorporating critical African genetic diversity when determining the safety and efficacy of drug regimens

The African liver-in-a-dish screening service provides several advantages over existing models in addressing the lack of data to inform optimal treatment options given the lack of representative local clinical trials.

Existing immortalised cells are predominantly cancer-derived and lack African genetic diversity. Primary human hepatocytes – the cells making up some 80% of the liver's mass – are the gold standard in cellular testing but can only be derived from ethically sourced liver biopsies and thus are a rare commodity in Africa. An induced pluripotent stem cell-derived liver holds the combined potential of being of unlimited supply and representative of African genetic diversity. Therefore, this tool offers the advantage of being easily accessible, while incorporating critical African diversity.

The value proposition lies in the convergence of having localised the necessary technologies, and access to local cellular sources which represent unique genetic liver gene mutations not found in Caucasian populations. This enables an African-centric view of drug metabolism.



Liver-in-a dish screening service value proposition. Within the scope of an African hepatic modelling platform, the CSIR-developed product is derived from African induced pluripotent stem cells.

Market opportunity

Serving markets with genetic diversity

The impact and management of adverse drug reactions in South Africa is estimated at R93 billion per annum due to increased hospitalisation and additional clinical investigations. In South Africa, the total addressable market for pharmaceutical companies is estimated at US USD2.7 million, based on an average of 140 new compounds applications to SAHPRA per annum. Notably this estimate does not include the potential of moving into the Southern African Development Community and other parts of sub-Saharan Africa, with potential to serve global populations characterised by genetic diversity.

Investment and return on investment

Investing in technology for data-driven decision-making of drug approval

Adoption of the CSIR-developed cellular tool would be advantageous for drug screening during the approval of drugs (new and approved chemical entities) developed by pharmaceutical companies seeking market entry in South Africa. The cost for the service would be covered by pharmaceutical companies, who would benefit from access to data to advance their market opportunities in other global diverse populations. Specifically, pharmaceutical companies would gain access to drug metabolism data coupled to rich genetic backgrounds that are not readily accessible in the global North and which are becoming more relevant to preclinical drug design requirements imposed by the Food and Drug Administration and European Medicines Agency. This compliance would further support African regulatory agencies and support local clinical research organisation capabilities and growth through evidence-based decision making – therefore enabling proactive drug surveillance.

The cost to generate a minimum viable product – to create functional bioengineered liver-in-a-dish – is R25 million.

Milestones and timelines

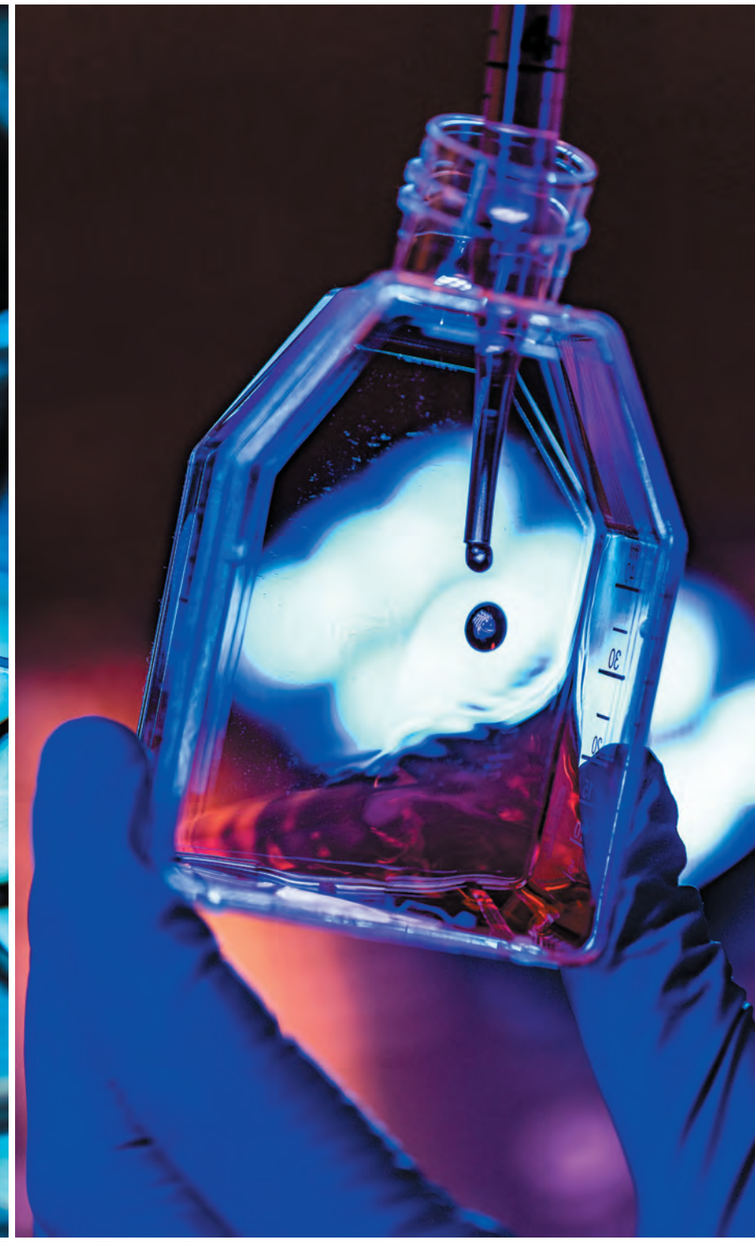
Pre-commercialisation activities for the development of a minimal viable product are estimated to take two years. In year three, the product will be validated in conjunction with a local clinical research organisation.

A team of experts in genome engineering and cellular modelling

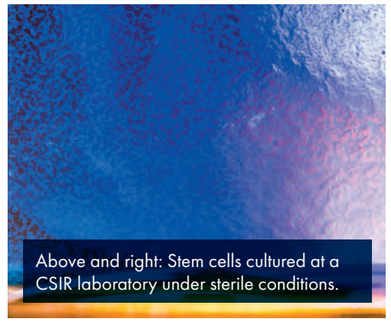
The technical team comprises highly experienced postdoctoral researchers with expertise in advanced cellular modelling, stem cell technologies and genome engineering. The nano-scale cellular tool is generated within a specialised biosafety-certified tissue culture laboratory.

ENQUIRIES:

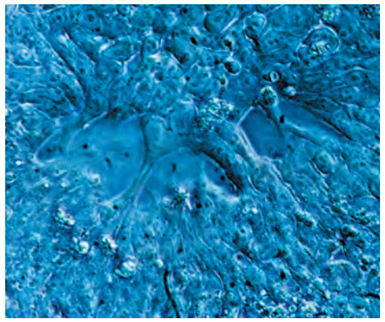
>> Charmaine Twala
ctwala@csir.co.za



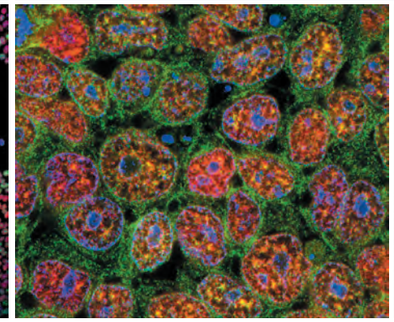
Above and left: Stem cell-derived liver tissue generated at the CSIR using a novel method developed by the CSIR research team.

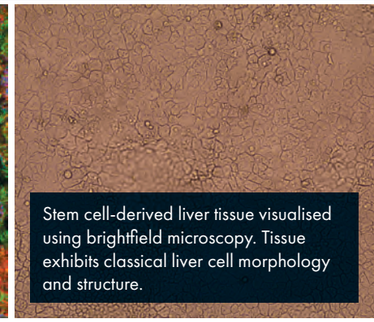


Above and right: Stem cells cultured at a CSIR laboratory under sterile conditions.



Above and right: Stem cell cultures visualised using flourescent microscopy to label markers of pluripotency.





Stem cell-derived liver tissue visualised using brightfield microscopy. Tissue exhibits classical liver cell morphology and structure.

KEEPING CREW SAFE – FROM ABOVE

A manual turret: Gunner protection for personnel carriers

Addressing a problem and fulfilling a market demand

Personnel carriers vulnerable to hostile fire

Typically, personnel carriers do exactly as the name suggests – they are armoured vehicles designed and equipped to transport troops to and from operational deployments. However, increasingly, these vehicles traverse combat scenarios without the availability of fitted armament to offer defence. A complete vehicle re-design to integrate armament is a costly exercise.

The CSIR has developed a turret that can be installed on an existing armoured personnel carrier to contain a firing crew and a variety of weapons. The turret provides relative safety for the gunmen, offers a 360° firing range and is lightweight enough to avoid adding an unnecessary weight burden to the vehicle.

The technology on offer

Adding lethality to troop carriers under threat

The CSIR developed a turret that can be used on the Mamba Mk III used by the South African National Defence Force (SANDF). Mounted on the roof of the vehicle, the turret provides an arc of fire of 360° and offers protection for the gunner from small arms fire. The SANDF requirement was for the turret to render the same ballistic protection levels as the Mamba Mk III's crew compartment. The turret is rotated manually (not motorised as most are) to allow for the gunner to have control of the arc of fire.

The design of the turret is unique; it allows for multi-weapon mounts, is robust yet lightweight, and the unit can be retrofitted to any personnel carrier such as those used in peace-keeping efforts with the African Union and border safeguarding.

Value proposition and competitive advantage

Retrofitting to add firepower to existing platforms

The 360° manual turret is a unique design that can be retrofitted to existing armoured personnel carriers and is deemed to be a robust and cost-effective solution to enhance the capability of existing vehicles. Typically, turrets are installed by original equipment manufacturers, designed specifically for their vehicles.

Globally, the manual turret can be fitted to several vehicles, including the Mamba, Casspir and Casspir NG2000, Mbombe-4, Maatla, Marauder, Nyoka and the Maverick.

Market opportunity

Opportunities for local and global sales

The potential market size for the manual turret is approximately R1.4 billion at an estimated unit price of R400 000 per turret.

A preliminary estimate of potential demand for the turret to be retrofitted to armoured personnel carriers is approximately 3 500 units globally. This includes the South African market as well as the Southern African Development Community, the rest of Africa and the rest of the world. A foothold already exists in the local market.

The CSIR can assist with custom design modifications, should this be required in a particular installation.

Business opportunity

Technology development and vehicle production partnership

It is estimated that approximately R25 million is required to support the commercialisation of the 360° manual turret. A phased-gate funding approach is proposed towards commercialisation. The total commercialisation project funding estimate includes local partner development. It is envisaged that a local partnership with entities that have relevant manufacturing capabilities is established for the production of the Mamba turret as part of a CSIR supplier development initiative.

The funding requirement for the first phase is R5 million to cover, among others, business development, design enhancement, detailed data pack finalisation, quality management and risk assessment. The commercialisation process as envisaged, is expected to be completed within two years.

A team of experts in mechanics, vehicle mobility and operational deployment

CSIR experts in landward sciences have vast experience in understanding the mobility scenarios, requirements and challenges faced by troops in operational deployments on the continent. Vehicle development and validation have been performed at the CSIR for over five decades. Aside from the scientific and mechanical know-how, the team has access to a range of developmental laboratories, workshops and vehicle testing sites.

The CSIR-developed turret can be retrofitted to a range of different personnel carriers to provide protection to the gunner and a 360° arch of fire.

ENQUIRIES:
>> Innocent Siziba
isiziba@csir.co.za

A CSIR-developed camera can locate gunshots by detecting potassium emissions from the muzzle flash.

IMPROVED PUBLIC SECURITY IN CRIME HOTSPOTS

A camera to detect gunshots and gun-related crime

Addressing a problem and responding to market demand

Locating gunshots and criminals in real time to aid swift response and prosecution

Crime-ridden zones in South Africa feature frequent incidents of gun violence threatening public safety and tragic cases of collateral damage. In scenarios where the modus operandi is 'hit and run' and in bouts of gang member altercations, emergency response teams often arrive too late and identifying or accosting the offenders seems an impossibility. Globally, sound-based shot-detection systems have proven an effective means of locating shots and shooters in known crime hotspots, aiding improved prosecution – even deterrence. However, they have disadvantages, including low accuracy and precision in sound classification and positioning, and longer time taken to process the acoustic signal by a human in the loop.

While standard CCTV systems are in place in some such areas, they are not optimised to capture gunshots. A novel optronic intervention can assist in this as well as identifying the weapon used and capturing information about the shooter.

The technology on offer

Gunshot and shooter location detection in real time

A camera, roughly the size of that used for CCTV, can locate gunshots by detecting potassium emissions from the muzzle flash. Dubbed, 'The K-line camera' (K being the symbol for potassium on the periodic table), it can be integrated into a CCTV network in a hotspot area for gun-related crime. Gunshots and the location of the shooter are detected in real time, generating an early warning and recording for forensics investigation support, or reported to an operational command centre.

The camera is intended to be comparable in size, weight, power consumption and cost to commercial-off-the-shelf CCTV cameras.

A planned future version will be for dual use with both situational awareness and gunshot detection processing capabilities at the camera head.

Value proposition and competitive advantage

Small, simple to integrate and cost-effective

The system captures an image of both the signature of the weapon muzzle flash and the shooter instantaneously and generates a warning at the command centre.

Filtering for gunshot incidents in known crime hotspots not only means earlier warning for security and emergency services but also contributes forensics data that can be presented in the court of law during prosecution. Given an array of CCTV gunshot detection cameras looking at the same incident from various viewpoints, a 3D geometrical view of the scene can be generated and mapped for forensics analysis.

The system can be integrated seamlessly with existing CCTV infrastructure without the need for significant infrastructure changes. In addition, it can be built with available components without any custom development. It can operate in both indoor and outdoor environments and various conditions.

Existing commercial solutions make use of an acoustic array of microphones as auxiliary sensors for detecting the sound of the gunshot, and pointing a pan-tilt-zoom camera in the direction of the incident. Weapon shooting scenes are usually dynamic with the shooter and the target in constant motion. This could lead to inaccurate capture of the shooter, especially for a zoomed-in, narrow field of view.

Although there are already active players in the integrative security space, there is a market gap for cameras that perform gunshot detection without reliance on auxiliary sensors for primary detection, such as acoustic and radar sensors. This has the benefit of a small deployment footprint, low complexity in infrastructure management, and low cost of acquisition and maintenance.

Market opportunity

Instant detection, weapon identification and imaging of the shooter directly from the video feed with improved angular accuracy, precision and cost

Video surveillance and video-surveillance-as-a-service had a market size of USD41.4 billion in 2019 and are forecast to rise to USD76.1 billion by 2025. A relatively smaller market exists in South America, Africa and the Middle East at USD4.3 billion.

A near-similar system deployed as part of a pilot project in the Western Cape uses acoustic sensors to detect a potential gunshot and rotate cameras in the direction of the shot. The system works with human operators in the background to confirm the gunshot and log it as such. The end-users pay a subscription fee for the service.

Competitors for the K-line gunshot detection systems are infrared, acoustic and radar-based sensors. These sensors have their limitations in performance, such as clutter for infrared-based sensors; sound clutter from various sources in dense areas, and building obscuration for acoustic sensors. Radar-based sensors can be bulky and costly and are limited in performance in urban areas due to reflections and obscuration from tall buildings. However, all these sensors work as auxiliary sensors to generate primary detections for CCTV.

The K-line system has a lower deployment footprint and maintenance costs through the use of a single camera technology.

Market opportunity

Licensing of the gunshot detection camera technology

The gunshot detection camera technology is available for licensing to an industry partner with CSIR C³ deriving royalties and licence fees from sales. Local and global industry players who are system integrators and service providers have created a market for subscription-based services where end-users are not burdened with infrastructure ownership and the associated maintenance costs. They provide a turnkey solution and service at a fee.

The target market is thus video surveillance and video-surveillance-as-a-service. The key trend in this market is CCTV cameras with artificial intelligence enhancement for computer vision, with the latest innovation being the on-camera processing of video images to minimise server infrastructure costs.

A smart camera with gunshot detection capabilities will be an attractive prospect for this market.

Investment and return on investment

Investing to become the most advanced gunshot detection camera on the market

Funding in the order of R30 million is required over three years. The system is at technology readiness level 4 to 5. Technology risk reduction related to the real-time processing of gunshot signatures at distances in the range of 50 m to 100 m will be undertaken. Testing with a wider range of firearms has to be carried out so that the capability of identifying different muzzle flash signatures over distances of 50 m to 100 m becomes another feature to set the technology apart from the competition.

During the three years, a preproduction model will be finalised and – ideally with a partner from industry – testing, evaluation and licensing will be undertaken.

A team of experts in optronics, image processing and machine learning

The CSIR's optronics team has expertise in designing, building, optical testing and evaluation, image processing and machine learning applied to optronics systems. Various optical systems designed and developed by the CSIR are in operation, such as the K-line camera onboard the ZACUBE-2 satellite, a long-range camera used in the Kruger National Park and other systems for international clients.

ENQUIRIES:
>> Innocent Siziba
isiziba@csir.co.za

A CSIR-developed radar-based hostile fire indicator can now protect helicopters against small-arms attacks.

PROTECTING HELICOPTERS USED IN SECURITY, POLICING AND MILITARY OPERATIONS FROM SMALL ARMS FIRE

A radar system to alert helicopters to small-arms attacks

Addressing a problem and fulfilling a market demand

Helicopter vulnerability to enemy fire

Helicopters are particularly vulnerable to small arms fire as they are often used close to the ground, in the range of hidden snipers, during peace support missions, counter poaching and policing. The number of such incidences has been increasing, and along with it, the need to protect these assets and the crews involved.

A CSIR-developed hostile fire indication sensor provides awareness to helicopter pilots and crew that they are being fired on, and indicates where the shooter is located – allowing the initiation of immediate evasive or reactive tactics.

The technology on offer

Radar-based system spots shots and shooters

Radar technology is well suited to solutions such as those to protect helicopters. The CSIR was approached by SAAB Grintek Defence, a leading supplier of aircraft self-protection suites, to collaboratively develop a radar-based hostile fire indicator sensor to add to its existing platform protection system for helicopters.

The radar solution developed has been proven through flight trials of a concept demonstrator which detects bullets passing within a 50 m radius of the helicopter, providing a warning 'bubble' around the aircraft. The system alerts the pilot and crew that they are being fired on and indicates where the shooter is located, allowing the immediate initiation of evasive or reactive tactics.

The radar-based hostile fire indicator system consists of four radar sensors, positioned around the helicopter, each covering a 90° sector of the surrounds. The radar sensors transmit radio frequency energy and sense the echo returns from objects in the environment. The system can discard returns from other objects by measuring several key parameters such as range and velocity to discern the distinctive signature of a bullet.

A central computer receives the data from each sensor and processes it to detect the presence of a bullet. Threat information is provided to the pilot on a cockpit display in real time.

Value proposition and competitive advantage

System uses full benefits of unique radar sensor detection capability

Other options for protection, based on, for example, ultra-violet, infrared and acoustic technologies have been proposed for bullet detection but do not compare well to the benefits of using radar-based sensors instead. Acoustic systems are challenged by the noise generated by the helicopter as well as the scene and are not effective where shots are silenced or shooters are firing from thickets and foliage.

A key market requirement is to avoid false alarms. The radar detects the bullet itself – rather than related elements in the scene. It can measure important characteristics and the profile of a bullet, resulting in fewer false alarm signals compared to other technologies.

Market opportunity

Industrial partnership with leading player with a track record in the sector

The industry partnership between the CSIR and SAAB Grintek Defence is synergistic and favourably positions the project for success. The CSIR benefits from the partnership with an established global player in the intended marketplace in that the company brings a trusted and ready delivery channel into a sector that is heavily influenced by proven track record.

As a systems house, SAAB Grintek Defence also brings extensive experience in taking new technology to the market, including maturing technology through both industrialisation and commercialisation. The company produces the Integrated Defence Aids Suite (IDAS), which is a proven self-protection suite for aircraft, containing various missile warning receivers and countermeasures. Through Saab International (Sweden), this system has become one of the leading self-protection suites in the world.

Market opportunity

Small, effective shot detection for multiple platforms

The primary opportunity lies in joining a proven and robust technology development partnership and – together with the CSIR and SAAB – taking the hostile fire indicator system to the helicopter and military markets. The product is appropriate for new helicopters and can also be retrofitted to existing assets. The existing SAAB footprint of users of the IDAS system is a ready interface to the aircraft platform market.

Bullet detection proven through live firings with system installed on helicopter.

Such a small radar that detects high-speed small projectiles has numerous other applications and can be adapted for the protection of vehicles and military bases, extracting more value from the technology.

Business opportunity

From demonstrator to prototype – and beyond

Having proven the technology with a sensor size valid for market uptake, funding is required for taking the concept demonstrator to prototype stage, followed by industrialisation, flight certification and scaled-up production.

An investment of R30 million will fund a two-year development phase. Year one will focus on product concept update and refinement based on updated market insights, sensor hardware design refinement (miniaturisation, ensuring environmental conformance, etc.) and real-time implementation of the proven detection processor. Year two will be dedicated to prototype integration and validation through field testing, and the final design update and implementation into product prototype. The development phase will be followed by an industrialisation, flight certification and scale-up phase.

Nearly eight decades of CSIR expertise in radar to support the system

The CSIR team comprises electronic engineers backed by many decades of organisational capability building. The team has worked with clients globally on the development of cutting-edge radar systems. Working with electronic experts ensures that systems undergo rigorous testing through collegial outsmarting. The team is further bolstered by access to sophisticated software and simulation suites, and world-class facilities and laboratories.

ENQUIRIES:

>> Innocent Siziba
isiziba@csir.co.za

WIDE-AREA SURVEILLANCE SECURITY SOLUTION PROVEN TO REDUCE RHINO POACHING

A wide-area surveillance system that detects and classifies moving entities automatically

Addressing a problem and fulfilling a market demand

Unlawful entry in secure areas

In recent years, the scourge of rhino poaching has been making headlines around the world. In 2015, an astounding 1 305 rhinos were poached. This has come down to a, still critical, 448 rhinos in 2022. The fight continues to protect the rhino for our children and grandchildren.

The CSIR has developed the next generation ground-based surveillance and classification radar that enables automated detection and classification of movement over a wide area, enabling proactive protection of wildlife and other security applications.

Building on an earlier success - Meerkat 1

The Kruger National Park – home to a significant share of the world's rhino population – suffered significant losses. Evidence showed that groups would enter on foot and stay in the park for some time. Due to its size, and considering available resources, it was extremely difficult to protect the rhino. Even when perpetrators were caught, it was typically after an animal had already been killed.

As a result, the CSIR and SANParks investigated technology options for solutions that would detect criminals upon entry – before they could strike. The solution would need to operate day and night, detect suspicious activity, withstand extreme weather conditions and be relatively easy to deploy at different hotspots. Also, with animals roaming free in the park, a system based on motion would present challenges.

With a track record in radar solution development spanning over seven decades and a sound understanding of concepts of operations from the military domain, the CSIR was able to deliver the Meerkat 1 Wide Area Surveillance System. The system contributed to the Kruger National Park virtually eradicating rhino poaching within areas where it was deployed. The Meerkat system is dependent on the camera and an operator (human-in-the-loop) to perform classification of movement within an area of interest.

The system provides automated surveillance over a large area, making it ideal for many applications in the radar surveillance market – from wildlife protection and land or maritime border safeguarding to the protection of critical infrastructure or national key points.

> "The benefit (of the deployment of Meerkat in the Kruger National Park) to SANParks was above and beyond the expected." – Lt Gen (Ret) Johan Jooste, Programme Manager: Law Enforcement and Security, Department of Forestry, Fisheries and the Environment (previously Head of Special Operations, SANParks).

The technology on offer

Automated ground-based surveillance and classification radar radar utilising artificial intelligence-based entity recognition

With the insights gained from Meerkat 1, the CSIR developed the Ground-based Surveillance and Classification Radar (GSCR), a next-generation system. The radar is an automated, wide-area surveillance system that can pick up human movement – distinguished from animals and trees – and generate an alert that would see intruders caught before they can do harm. The system has been experimentally deployed in the Kruger National Park.

The GSCR system is also suited to other security applications, including large critical infrastructure protection such as power or production plants, farms and safeguarding of protected border zones.

The system utilises the CSIR's C-Band phased array technology providing a flexible and upgradeable architecture with no moving parts, as well as a powerful artificial intelligence radar-based target classification research base.

Radar provides the ability to observe all movement over a wide area, updated every few seconds. Intruders are detected over the entire area being protected and tracked so that security forces can be directed to intercept them.

No operator is needed: The system operates fully autonomously, and performs automatic classification of detected targets, enabling an automatic alarm.

Over five years, the technology has seen ongoing refinement – and successful deployment.

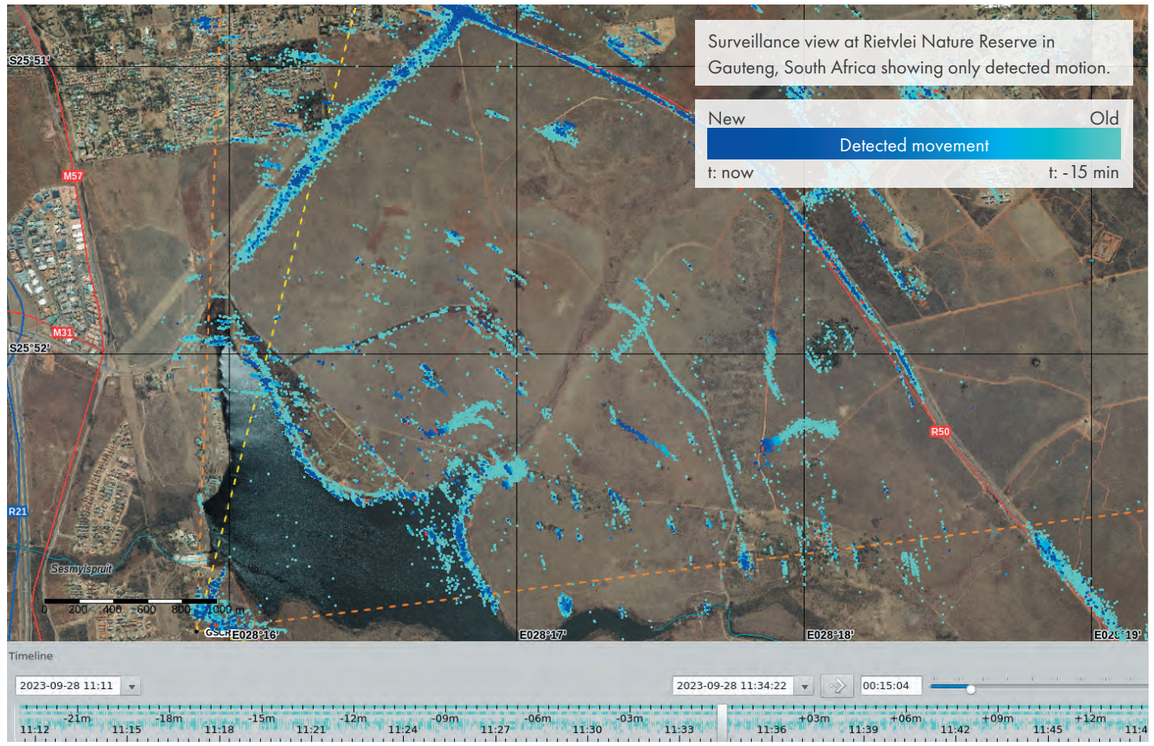
Value proposition and competitive advantage

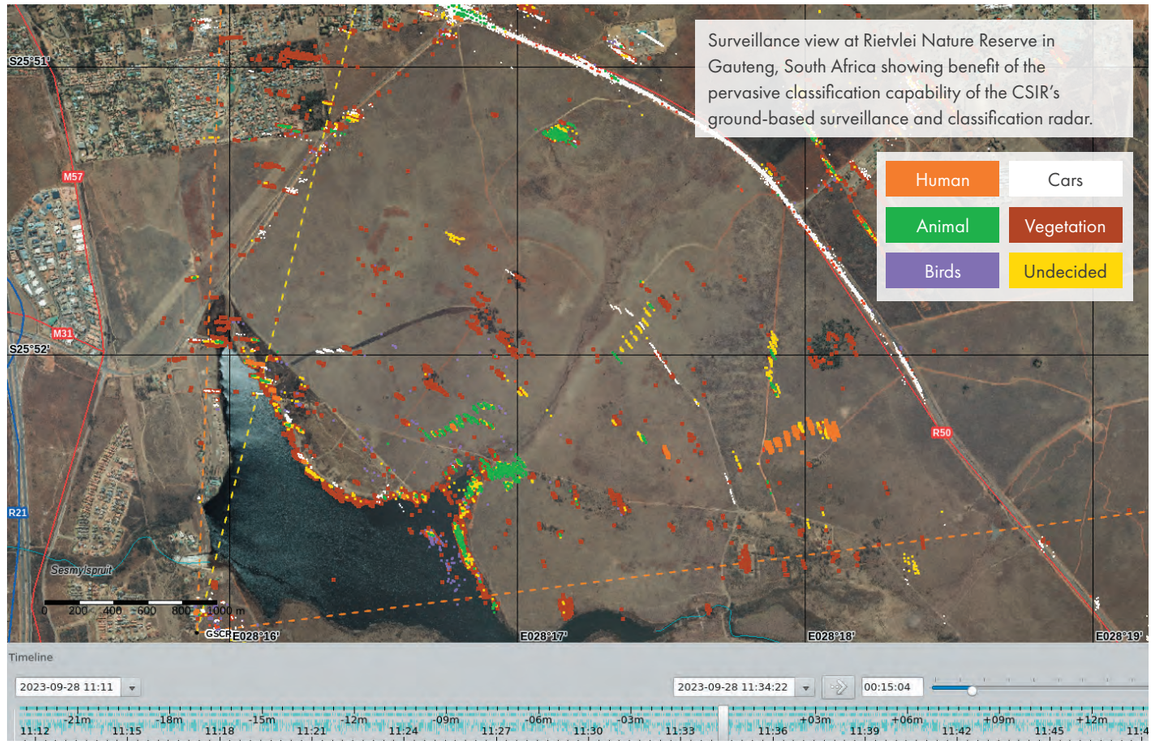
Detection, classification and alerting – without the need for an operator

The system can detect and classify moving entities – automatically. No additional camera and operator are needed.

It provides a continuous map view with accurate position which can be used to direct security forces to intercept. The CSIR scaleable phased-array technology, developed over many years and common to other radars systems, makes the system easier and cheaper to maintain, with reduced lifecycle costs.

Based on the above features, the system improves the concept of operations and significantly contributes to security efforts and the agility of teams of rangers.





The key value proposition of the system is that it provides automated surveillance over a large area allowing early detection of perpetrators. The perpetrators are tracked for a significant period to allow reaction forces to respond. The fixed antenna panels have no moving parts, allowing easy installation and maintenance.

Furthermore, it is scalable – it can easily be adapted to suit the application, based on requirements for radar detection ranges and angle measurement accuracy, or to align to the budget available.

Market opportunity

A growing market for automated security surveillance

The technology has a myriad of applications in the radar surveillance market – from wildlife protection and land or maritime border safeguarding to the protection of critical infrastructure or national key points. With a strong foothold, strong relationships and a proven track record in place, the strategic focus will initially remain on wildlife protection and then expand into security and border surveillance applications.

In terms of wildlife protection, there are approximately 42 game reserves in South Africa of which 19 are under SANParks management. Although poaching in the Kruger National Park may have significantly reduced, it has increased in other areas, such as KwaZulu-Natal.

Additionally, there are more than 200 national and game reserves in Africa's safari countries. Namibia is experiencing a rise in rhino poaching in its national parks, especially in Etosha National Park, where rhino poaching has doubled from 2021 to 2022.

Several other national parks in the Southern African Development Community and East African regions are also experiencing a high level of rhino poaching.

The team conducted market studies in 2020 that showed there is a market opportunity to commercialise the surveillance systems in identified market segments, with prospects of selling in the order of five to ten units over a two-year interval for wildlife protection.

Since the system is already at a progressed technology readiness level, it enables effective engagement and demonstration to clients. The concept demonstrator is currently being prepared for operational deployment for a client in KwaZulu-Natal.

In terms of land border safeguarding, there are a total of 54 land border control points in South Africa. Interactions with key stakeholders in the security sector confirmed the need for such a surveillance system.

Business opportunity

Partnership for sales and industrialisation into Africa

The current approach is to first focus on South Africa, expand into Africa, and then seek international partners.

Locally, the strategy is to continue engagement with early adopters, acting as launch partners to prove the technology solution and drive market penetration. Promising engagements for collaboration and possible uptake include the Kruger National Park, Hluhluwe Imfolozi Park, and a border safeguarding experiment with the Department of Defence.

Plans are afoot to industrialise the manufacturing of the system with industry partners to reduce production costs.

Investment and return on investment

Investment in more operational prototypes

An investment of R15 million is required to realise a product prototype that will be delivered to launch partners for operation to demonstrate the impact and value of the system over a development and completion period of two years. This will be utilised to develop the market, through evidence of strong success, similar to what was achieved with Meerkat 1.

A proven team of radar experts with operational experience

The project team is highly experienced, with expertise in the development of radar systems – both in terms of design and development and hardware and software. The team also has the required signal processing and algorithm development knowledge.

The CSIR radar team is highly experienced, with expertise in the development and delivery of radar systems that are utilised operationally. In addition, the team has a track record that include a system that has been operational in the field for more than five years, making a significant contribution to counter poaching operations. The team has a multidisciplinary skills set in hardware and software design and development as well as in radar signal processing and algorithm development to realise project goals and objectives.

ENQUIRIES:

>> Innocent Siziba
isiziba@csir.co.za

Bringing fourth industrial revolution technologies to agriculture.

PROVIDING SA AGRICULTURE WITH DIGITAL SOLUTIONS FOR BETTER YIELDS AND CROP

A precision agriculture information system to unlock smart agriculture

Addressing a problem and responding to market demand

A growing population and climate change threaten food security in SA

South Africans' future access to safe food is in question as the country's population is predicted to grow by 43% by 2035. To ensure food security, food production needs to increase at the same rate.

Field crops make up 23% of South Africa's total farming income at an approximate worth of R69 billion; account for the largest portion of cultivated cropland in South Africa; and employ some 124 000 people – about 16% of the total commercial agricultural workforce.

Maize is the most important staple food in South Africa and the broader southern African region. The farming of maize is increasingly challenged by climate change and variability, the emergence of new pests and diseases such as fall armyworms, increasing costs of inputs and decreasing interest of younger generations to partake in farming.

Smart agriculture involving the use of fourth industrial revolution (4IR) technologies is a means to mitigate the challenges faced by the country's agricultural sector.

The technology on offer

An information system that pinpoints variability in crop growth conditions for best decision-making

Precision agriculture is a management strategy that uses a range of technologies to gather, process and analyse remote sensing data (obtained from a drone or satellite) to guide targeted actions that improve the efficiency, productivity and sustainability of agricultural operations.

The CSIR has developed a unique precision agriculture information system for crops such as maize, potatoes and vegetables. It provides regular farm-based information on the spatial variability of crop growth conditions to foster precision farm management and supply chain management decisions throughout the agricultural value chain.

The precision agriculture information platform, accessed via the internet on desktop and mobile platforms, is being commercialised via CSIR C³.

Levels of Earth observation products (data) for precision agriculture

Level 1	Level 2	Level 3	Level 4
Processed satellite or drone data: • Atmospherically corrected images • Vegetation indices i.e. indicators of crop health • Regional vegetative drought severity levels • Regional rainfall and temperature data	Soil and crop variables: • Soil moisture and nutrient maps • Growth stages • Crop cover and biomass maps • Crop nutrient and water use maps • Weed infestation maps • Pest or disease detection • Yield forecast	Temporal and spatial anomaly detection: • Soil moisture and nutrient stress levels • Biomass growth deficiencies • Crop nutrient and water use deficiencies • Weed, pest infestation levels • Performance benchmarking	Management recommendations: • Planting, e.g. timing and planting density • Fertiliser application (time, place and rate) • Irrigation application • Disease, pest and weed management

The system utilises Earth observation, climate change modelling, big data and data analytics to support decision-making in land-use planning, to predict yields and inform markets, and to monitor pests and diseases. The system provides actionable information on soil and crop condition to farmers at a farm scale and in near real time.

Value proposition and competitive advantage

A farmer-friendly platform information system to optimise yields

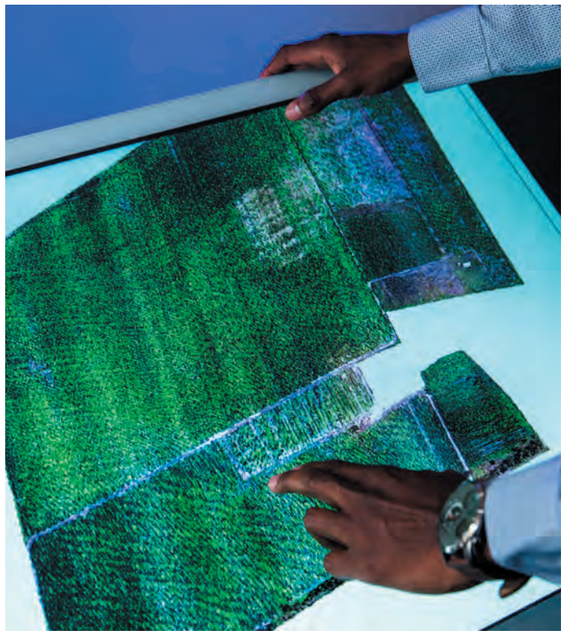
The CSIR-developed precision agriculture information system provides a holistic approach to support agricultural practices on farms, compared to other precision agriculture platforms in the market that provide limited information.

The system is a simple, farmer-friendly platform that can be used by emerging farmers. Feedback from piloting the system among these emerging South African farmers suggests that system uptake is promising.

In addition to precision agriculture information, the platform provides actionable solutions and approaches to address challenges at various levels of the agricultural value chain.

The system enables a farmer to:

- Monitor crop performance throughout the growing season;
- Manage crops effectively based on specific bio-physical parameters;



Raw satellite image of a crop field.

- Determine agricultural practices based on weather and climate information;
- Identify early-stage agricultural problems followed by timely implementation of corrective measures; and
- Decide on inputs and resources.

South Africa currently does not have a platform that provides actional insights on soil and crop biophysical/biochemical conditions at the farm scale that meets the specific requirements of small- to medium-scale farmers.

Market opportunity

A broad agricultural user base

Based on market interactions, the potential markets for the CSIR-developed system include government departments such as the provincial departments of agriculture, farmer associations, emerging farmers, commercial farmers, farmer support programmes, agricultural businesses, insurance companies, and banks.

Business opportunity

A flexible business model to suit agricultural users

The platform creates value by providing information that supports the broad agricultural use base. The business model consists of:

- Subscriptions: A monthly or annual fee is charged for the use of the system, with the customer base mainly consisting of farmers.
- A pay-as-you-go option: Users select specific services and are charged accordingly. This is costed based on the user selection, with the customer base mainly comprising farmers.
- Licensing: The system can be licensed to users, who will mostly be associations, organisations and government departments.
- Advertising: Once the user base has significantly grown, an advertising function can be included. Companies will be charged for advert placement.

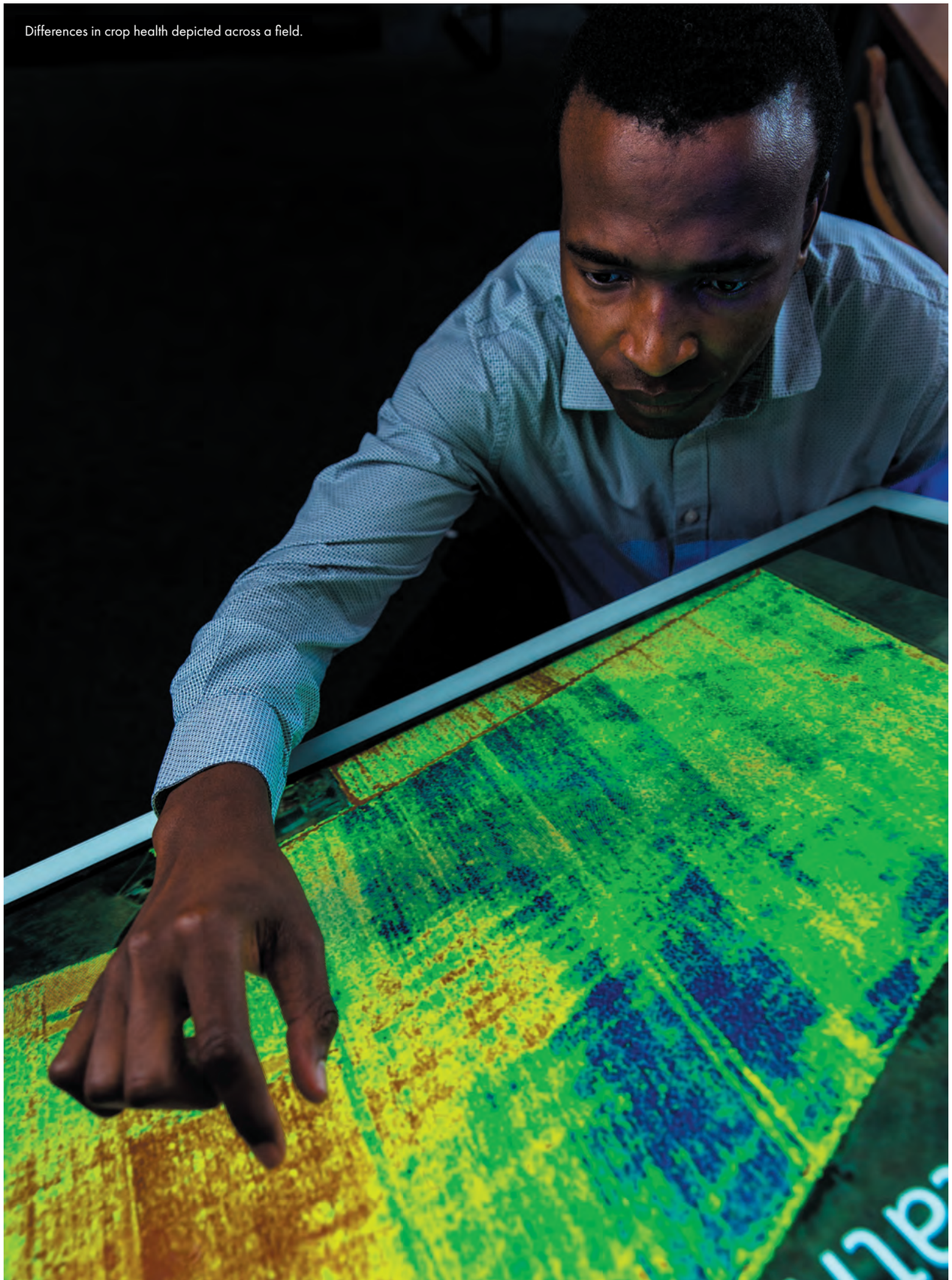
Investment and return on investment

Invest to capitalise on the rise of 4IR and pressures to farm profitably

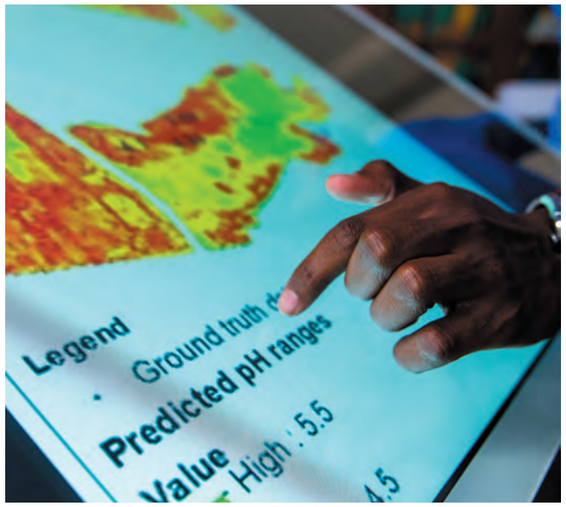
The platform requires an approximate investment of R2 million per year for the continuous monitoring and updating of the functionalities of the system, including related interpretations for ease of communication with emerging farmers and users; as well as for infrastructure related to Amazon Web Services, including storage, data processing, web service hosting and delivery to users.

The financial sustainability of the CSIR-developed precision agriculture information system depends on ensuring large quantities of agricultural land areas are observed and supported.

Based on existing business development plans, an agricultural land area of 1 000 000 ha will be monitored by year 10. Secondary services will be gradually included in the platform to enhance financial sustainability. These include advertising and extension services. The envisaged long-term outlook for the system is to provide an agricultural doorway to users, incorporating various functionalities.



Differences in crop health depicted across a field.



Estimates of soil pH levels across a field.

Calibration of a drone system.

Preliminary indications are that the sustainability of the system can be realised from year six onward.

Milestones and timelines

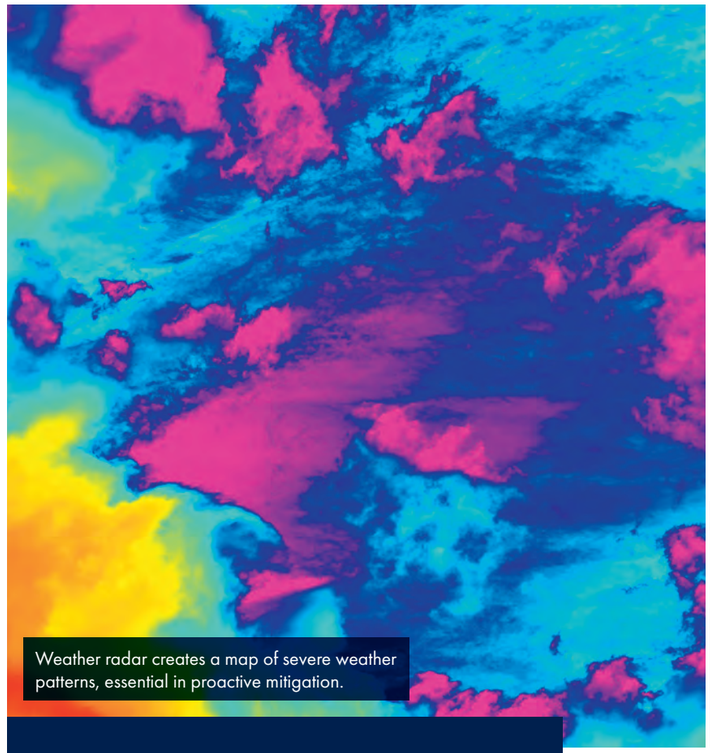
A prototype demonstration will be ready at the end of year one; market testing and product improvement will be undertaken in year two; and product roll out will take place in year three.

A team of experts in remote sensing and information and communications technologies

The technical team is highly experienced in algorithm development, modelling and software development.

ENQUIRIES:

>> **Charmaine Twala**
ctwala@csir.co.za



Weather radar creates a map of severe weather patterns, essential in proactive mitigation.

CSIR scaleable phased-array technology.

IMPROVED WEATHER MONITORING FOR A WORLD BATTERED BY EXTREME WEATHER EVENTS

Modern radar antenna technology for weather forecasting and monitoring

Addressing a problem and fulfilling a market demand

Weather-related disasters threaten lives and livelihoods

Around the world, a changing climate has led to the destruction of infrastructure and the loss of human life. Weather-related anomalies and disasters – heatwaves, severe storms and large-scale flooding – have been on the increase. This has emphasised the need for effective means of detecting weather conditions and, in particular, means of early warning so that mitigating measures can be implemented proactively, where possible.

This is driving growth in the market for weather radar to continuously map the motion and intensity of weather patterns over a broad area. Accurate monitoring and forecasting are used pervasively across sectors such as aviation, agriculture, tourism and maritime operators.

As a result, countries are investing in weather radar coverage and more accurate and capable weather radar systems. Advanced antennas are expected to be the fastest-growing segment of weather radar components.

The rising technology advances in antennas are enabling ever-improving sensing. Major weather radar manufacturers are seeking to modernise their product lines with such advanced antennas to remain relevant and meet market needs.

The CSIR's proven low-cost scalable C-band phased-antenna technology is well positioned for competitive adoption in modern weather radar systems. This has been validated through engagement with a major weather radar supplier in the United States of America (USA).

The technology on offer

Tiled antenna builds up the weather picture

Traditional weather radar utilises a dish-based antenna to form fixed beams in elevation. The antenna is scanned in azimuth to form a 360-degree map of the world.

The CSIR's C-band phased-array antenna technology, enabling active electronic steering, is at the cutting edge of modern radar technology and can be innovatively incorporated into compelling weather radar applications.

A modern phased-array antenna consists of many small antennas (patches), which, by independently controlling the driving signal to the patches, results in a radar beam that can be rapidly steered without moving the antenna. By using the phased array to scan the beam in elevation, while the antenna still rotates in azimuth, a cost-effective small mobile weather radar can be realised that can optimally measure weather at different heights to form an improved 3D weather map.

The CSIR's technology – with its flexibility in beam steering provided by the phased-array antennas – is also well positioned to fulfil another emerging market requirement. Increasingly, governments are requiring weather radar to also perform aircraft detection to maximise return on investment by avoiding the need for another radar in the same vicinity, and in the same way, also minimise the need for additional bandwidth.

Value proposition and competitive advantage

Proven phased-array technology

The CSIR low-cost C-band phased-array technology is a scalable building block (antenna panel) that allows the realisation of different-sized antennas by tiling the antenna panels vertically and horizontally. The panels have been matured across three generations and are now proven building blocks that are being used on multiple radar innovations at the CSIR, including multiple search radars, airborne radars and spaceborne radars.

The panels have been commoditised and are ordered as integrated, tested panels from local industry. In addition, the designs to integrate multiple panels to form larger antennas are also mature.

The weather radar antenna opportunity is a mechanism to extract further value from mature radar building blocks by supplying array antennas to well-chosen, established weather radar suppliers that are well positioned in specific markets.

Market opportunity

Opportunities for commercialisation of advanced antennas

The primary opportunity is to partner with an existing weather radar supplier in the USA who has indicated that the CSIR C-band array technology is uniquely positioned to enable it to develop a low-cost C-band weather radar to respond to planned acquisitions in the USA defence domain and the rest of the global market. The first opportunity is expected to be for the delivery of more than 50 systems with a conservative margin estimate of USD50 000 per antenna, resulting in a potential return of R45 million from such a sale.

The 2022 floods in KwaZulu-Natal wreaked havoc in the Port of Durban and surrounds.

This will open the door for many more sales, given the global and proven footprint of the weather radar partner. The scaleability of the antenna panels also opens an opportunity to, in the longer term, capitilise on the strong interest for antennas for higher end weather radars.

In addition, the CSIR is in discussion with the South African Weather Services to develop a replacement radar for the country's weather network and to potentially commercialise these into the rest of Africa.

Business opportunity

Technology development and production partnership

Given the mature nature of the antenna technology, the technical risk in realising the antenna is largely low. The advantage of partnering with an established weather radar supplier is to benefit from a strong industry-relevant understanding of the required price and other market-related insights, needed to strengthen the prospects for commercial success.

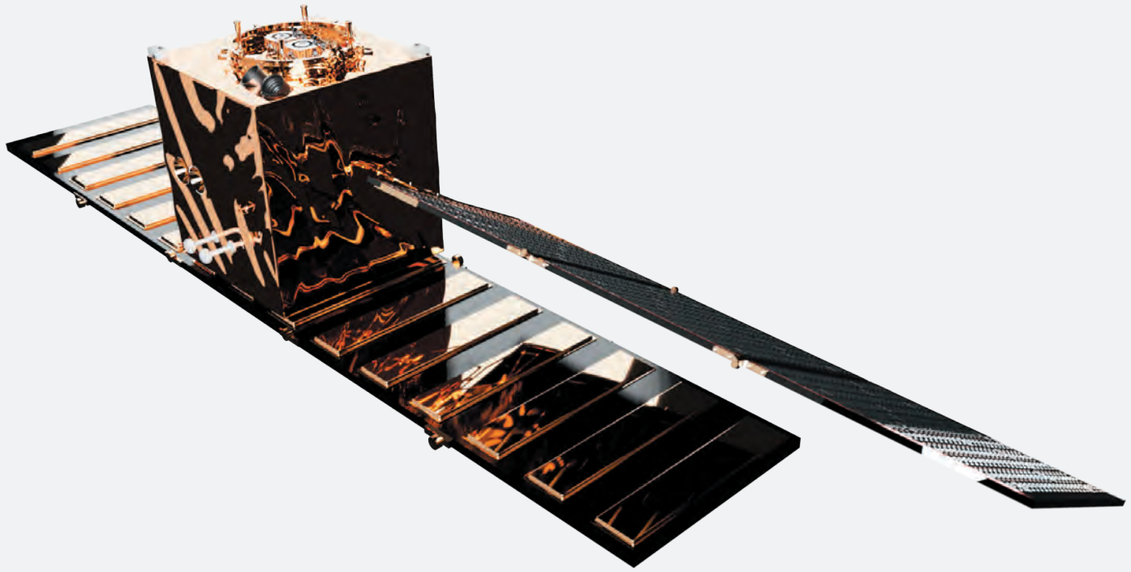
Investment is required to realise the product-level antenna for the primary opportunity. The development is phased with the first step being the completion of the current feasibility phase and upgrading the technology with multipolarisation capability, followed by the realisation of a prototype antenna and then the establishment of the production partnerships and process. This requires an investment of R25 million, for which there is ample scope for returns to be generated and for early payback to be achieved as the antennas are delivered to the industry partner and weather radars are sold.

A team with a track record and strong global network in place

The CSIR radar development team has a track record in the development of advanced and complex radar systems locally as well as for international clients. The applicable C-band phased-array technology is mature and commoditised and has been proven through its use in multiple radar innovations at the CSIR.

ENQUIRIES:

>> Innocent Siziba
isiziba@csir.co.za



A computer-aided design model of the DragonFly-C synthetic aperture radar (SAR) satellite utilising the Dragonfly satellite bus and a SAR-C payload (deployed configuration) as designed by the CSIR.

RADAR-BASED PAYLOADS FOR EARTH OBSERVATION: PRECISE AND PRICED RIGHT

The next generation of Earth observation technology with all-weather, day and night capability

Addressing a problem and fulfilling a market demand

Understanding and closely observing our planet

Remote sensing of the Earth has become of critical importance to ensure a sustainable future for the planet. At all scales and across many sectors – from government departments to local municipalities, and from multinational insurance businesses to small-scale farmers – remote sensing data are used for improved decision-making, better logistics and better planning.

Spaceborne synthetic aperture radar (SAR) systems can deliver remotely sensed data in all weather conditions and during day and night, due to the active microwave sensor modality. As such, SAR is fast becoming a crucial complementary technology to the more traditional optical observation of the Earth. In particular, SAR sensors provide the ability to monitor the Earth at all times (even during severe storms) and extract information that is difficult to extract through other sensor modalities. This includes detecting fine-scale surface deformation after earthquakes, monitoring large swaths of the ocean for oil spills, detecting crop health and crop yield, monitoring infrastructure development, providing information during floods or detecting military targets of interest – even in foliage.

The technology on offer

C-band SAR satellite payloads

The CSIR has developed C-band phased array radar technology to a sufficient level of maturity for use in surveillance radar products and airborne SAR demonstrators. These array antennas provide wide-band capability that allows fine-resolution SAR imaging – as demonstrated on the airborne C-Owl SAR technology demonstrator. The team has also demonstrated real-time processing capabilities and fine-resolution (sub-metric) imaging capability – taking the technology closer to readiness for space-borne radar application. Through research and development funded by the Department of Science and Innovation, portions of the technology have also been radiation tested and the design and development of the first space-capable sub-array which, in production, can be used to realise a full SAR satellite payload, is well underway.

Coupled with the significant capability in imaging radar system design, development, integration and test capability, the opportunity exists to now scale the technology from the lab to develop custom SAR payloads for missions aimed at particular sectors and user needs, such as serving African markets yet untapped by the international commercial SAR industry.

The CSIR C-band SAR technology enables fine-resolution SAR imaging at range resolutions as fine as 25cm with advanced digital beamforming modes to enable high-resolution wide-swath imaging. The technology was developed to be scalable, modular and highly manufacturable to enable constellation deployment. Firmware and software for the control of the key subsystem elements are completed and current developments are focusing on the development of the system-level embedded software and system-level verification of the SAR payload designs.

Value proposition and competitive advantage

The C-band spaceborne SAR market

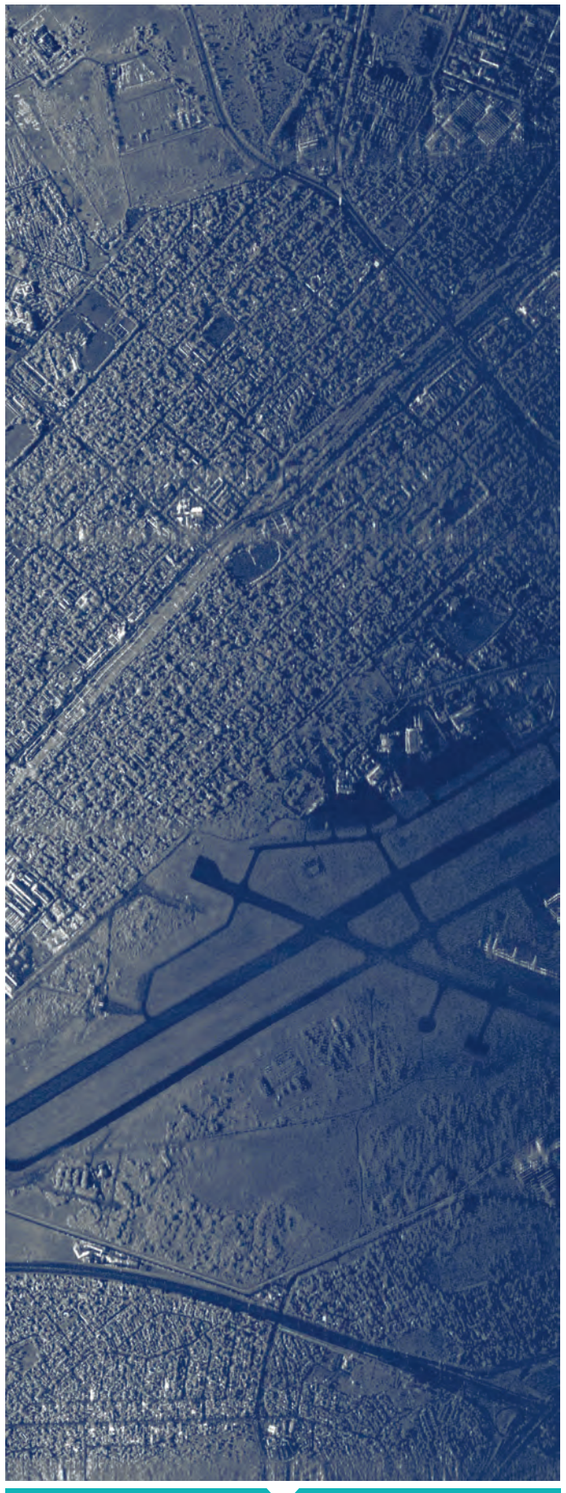
Other players in the field of commercial spaceborne SAR largely make use of X-band payloads and satellites which, although powerful, focus primarily on the level of resolution. SAR applications, however, especially in agriculture, ocean monitoring and subsidence monitoring, require lower frequencies such as L- and C-band to provide longer coherence times and the required physical interactions to measure the information needed.

The CSIR solution, which uses low-cost C-band components but provides high-performance outputs, targets a niche market by achieving commercial-grade cost points and near X-band resolution with the benefits of C-band coherence and information content. Also, the CSIR and the local space industry have combined efforts to achieve higher ratios of satellite utilisation, enabling larger area coverage rates than typical commercial competitor satellites.

All this will enable cost-effective missions in the areas of agriculture, maritime domain awareness, subsidence monitoring, mining, security and defence applications – applications that can address requirements in the international, African and local markets.

Strong partnerships with local satellite industry

The CSIR has formed strong partnerships with the local satellite industry in South Africa to enable the design of the full satellite solution, including the design of the powerful buses required to host a SAR payload.



C-band synthetic aperture radar image created over Centurion, Gauteng in 2022, using CSIR C-band (5.5GHz) radar technology.

The South African satellite industry has a strong heritage in using commercial off-the-shelf components to achieve satellite mission success. This track record, combined with the CSIR's radar capability, provides a unique opportunity to create SAR missions that deliver high-quality data at affordable and competitive prices globally.

Market opportunity

C-band SAR satellites and the international market

The global Earth observation market is expected to double over the next decade. The global revenue across Earth observation data and value-added services was estimated at €2.8 billion in 2021 and is expected to reach €5.5 billion (EUSPA, 2022). Revenue generated from data within the African and Middle Eastern markets was approximately €29 million, with revenue generated from value-added services estimated at €156 million.

Commercial SAR satellite use has been one of the fastest growing market segments within this low Earth orbit Earth observation market – aside from communication satellites. In particular, the number of SAR satellites globally has grown nearly exponentially over the last five years.

Being an active sensor, the work rate of SAR satellites is typically only a few minutes per orbit, limited both by data download rate and satellite power budget. The saturation point of the market is deemed to be a long way away. To achieve global coverage at a temporal rate of interest, one would require thousands of SAR satellites.

Almost all of the current commercial satellites are X-band and as such the CSIR-developed C-band solution addresses a clear market niche.

Investment and return on investment

Significant return on investment potential through the sale of SAR payloads

The project requires approximately R200 million to create the first SAR-C payload flight model, fully qualified and ready for launch. This compares well with the investments needed by other satellite producers.

Once the first payload has been developed and proven, there is scope to achieve considerable profit from the sale of future payloads, with figures of R25 million profit per payload possible in certain scenarios. Significant return on investment is, therefore, possible through the sale of SAR payloads once more than 10 payloads are sold. For example, the sale of a modest but effective constellation of 16 satellites developed over five years (for which the CSIR has already identified potential clients) would yield an estimated R150 million profit. This excludes other forms of income that might also be generated from the technology base of the SAR payloads.

In addition to the payload business case, the business could further be extended around creating a company that owns and operates the satellites and sells the data and applications on the global market.

Milestone and timelines

Development of the first payload will take approximately two years. Thereafter, payloads can be produced and integrated at a rate of roughly four to six per year. The production and sale of 10 payloads to achieve breakeven will thus roughly take four years and a constellation of 16 satellites can be developed within five years.

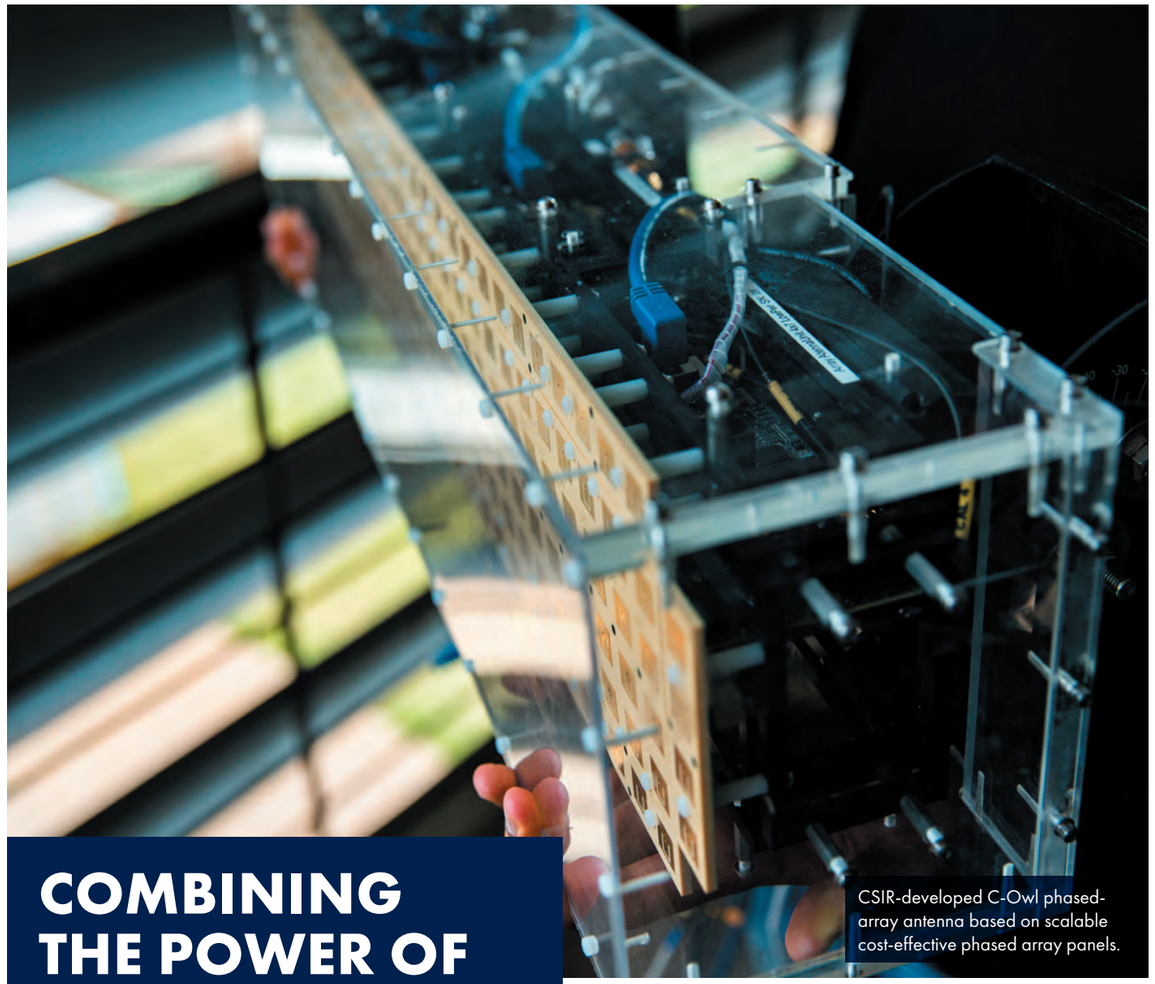
A seasoned team of radar and sensor experts

The C-band SAR satellite payloads developed are rooted in nearly eight decades of CSIR radar innovation. The CSIR team comprises electronic engineers with vast capabilities in the field and a clientele around the globe who are using CSIR-developed cutting-edge radar systems. The team is further bolstered by access to sophisticated software and simulation suites, and world-class facilities.

ENQUIRIES:

>> Innocent Sizibae
isiziba@csir.co.za

The CSIR synthetic aperture radar airborne test facility ready for flight tests aboard a Cessna 208 light manned aircraft.



CSIR-developed C-Owl phased-array antenna based on scalable cost-effective phased array panels.

COMBINING THE POWER OF ALL-WEATHER DAY-AND-NIGHT RADAR WITH THE SAFETY AND GO-ANYWHERE BENEFIT OF UAVS

Synthetic aperture radar for unmanned aerial vehicles

Addressing a problem and fulfilling a market demand

Detecting from a distance and acting in time

In the military and security domains, unmanned aerial vehicles (UAVs) and their applications have become the tool of choice to observe, decide and act – with the benefit of keeping operators out of harm's way. Able to carry everything from parcels, sensors, weapons and even lifesaving medicine, commercial and security markets for UAVs have grown significantly. From small drones used to inspect farm borders, to large fixed-wing UAVs that hover for days on end, these drones are providing valuable surveillance outputs to end users in various markets.

In many security and military applications, surveillance is required day and night, in all weather, over wide areas, and it must be able to detect fine changes that might have remained after an event of interest occurred. Synthetic aperture radar (SAR) sensors solve this challenge by imaging at wavelengths that penetrate cloud, fog, smoke and even foliage, making the activities of enemy forces deemed unseen, very clearly detected.

In many developed countries, long-endurance UAVs that carry SAR payloads have therefore become a de facto requirement for missions in peace support, border control and maritime surveillance. The SAR sensor allows imaging over wide swaths from a standoff location – not alerting the perpetrator and allowing a prompt action or response.

The technology on offer

C-band SAR payload family for UAVs

The CSIR is developing a family of SAR sensors to enable UAVs of different classes access to real-time, fine-resolution imagery. Ranging in size from 7 kg to 70 kg, and aimed at the low-, medium- and high-altitude UAV markets, these sensors are based on CSIR C-band (5.5 GHz) phased-array technology and – coupled with advanced ground-moving target indication modes – can provide day-and-night all-weather imaging, real-time processing and targeting.

The technology for the medium-altitude UAV was chosen as the starting point, given the significant number of medium-altitude long-endurance UAVs under development in South Africa and around the world.

The CSIR approach was to develop the sensor to be installed together with current optical payloads, to exploit the strengths of both by the same UAV.

The C-Owl demonstrator for UAVs has shown the ability to perform real-time high-resolution wide-swath SAR imaging as well as perform ground-moving target indication, with all information presented in real-time on a GIS map display, georeferenced to allow near real-time decision-making.

This payload technology enables imaging at resolutions as fine as 25 cm pixel size, with swaths up to 50 km for high-altitude long-endurance UAVs and with standard graphics processing unit-based real-time processing using modern back-projection techniques that enable imaging in VideoSAR modes, even in arbitrary flight paths.

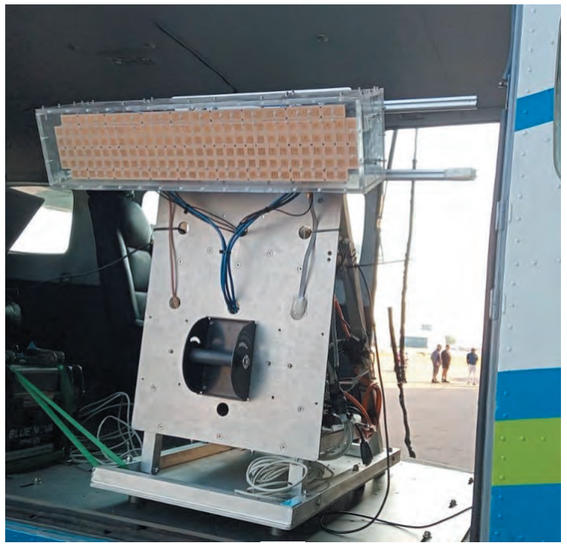
Designs for the smaller and larger class of UAVs have also been completed and the 7 kg class system is under development.

Coupled with the significant capability in imaging radar system design, development, integration and test capability, the opportunity exists to now adopt the technology from the airborne flight tests to the UAV market, to achieve even greater impact and generate economic benefit in the process.

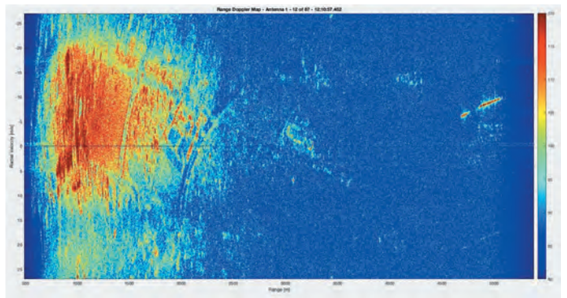
Value proposition and competitive advantage

Entering the UAV SAR market with the CSIR as partner

SAR sensors for UAVs can broadly be categorised into those designed as a replacement for the optical gimbal and those carried as a belly-mounted or under-wing pod. Removing the gimbal reduces the ability of the platform to collect evidence and investigate targets at ultrafine resolution from up close. Naturally, a solution that allows the optical gimbal to remain in



The CSIR C-Owl UAV synthetic aperture radar demonstrator installed on a Cessna 208 for flight tests.



Above and middle: Doppler map and real-time synthetic aperture displays captured during flight tests.

place will enable the UAV to achieve a greater spectrum of objectives. However, adding pod-based solutions often impact performance, due to the available size for antennas and processing in the pod.

The CSIR has developed customisable phased-array antenna designs which allow in-skin on-fuselage mounting of the antenna components, with processing and other components mounted inside the UAV electronics bay. This allows the addition of the SAR payload without adding significant extra drag and without affecting the optical gimbal operation.

As such, the CSIR's SAR technology base allows another entry point into the UAV market and addresses a gap for bespoke antenna solutions that do not require complete redevelopment for every UAV, but that can be adapted to fit a particular UAV's needs. Processing backends range from low-mass payloads with dual channel ground moving target indication to larger virtual path cross-connect options with up to eight channels of digital beamforming being available.

The flexibility allows customers the ability to choose the approach that fits their platform the best.

Market opportunity

The UAV SAR market

According to a research report published by *Spherical Insights and Consulting*, the global SAR market size was valued at USD3.8 billion in 2022 and the worldwide SAR market size is expected to reach USD 10.7 billion by 2032.

In South Africa and Africa specifically, UAV platforms are growing in applications and several small, medium and large platform providers are developing new platforms for niche applications. All of these platforms require SAR sensors for specific military and security missions and given that many of the foreign-supplied systems come with export restrictions, the CSIR sensor family is uniquely positioned to access this market.

Investment and return on investment

Radar for medium-altitude long-endurance UAVs close to industrialisation

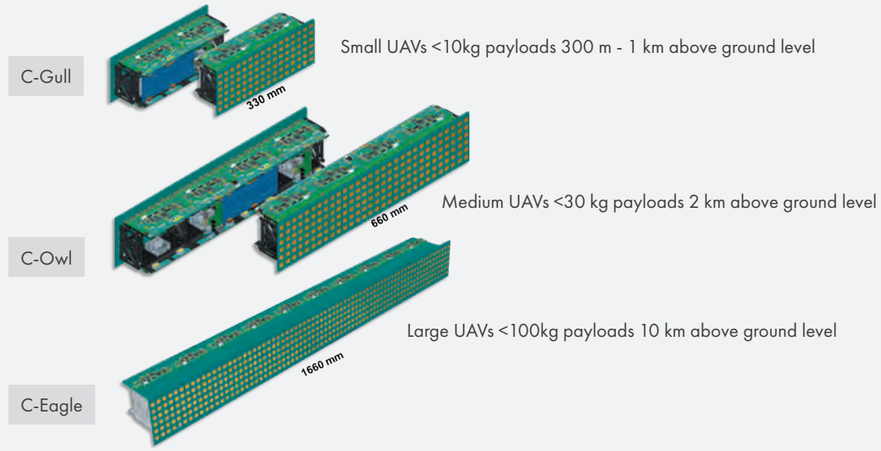
With the C-Owl demonstrator already developed, the CSIR technology for UAV SAR for medium-altitude, long-endurance UAVs and airborne platforms is very close to industrialisation. All elements, including ground stations and real-time processors, have been developed and tested in relevant environments, and the integrated sensor has been flight-tested. The next step is to produce the product baseline versions of the hardware and software.

For the high-altitude, long-endurance UAV market, an estimate of R40-50 million is set to produce the first products, ready to test and scale for production.

The low-mass 7 kg sensor will likely require a similar investment to complete the design, test and evaluation phase, while the high-altitude long-endurance UAV version with its more advanced modes of operation and much longer ranges, requires an investment of R80-100 million to achieve a product baseline.

View from the aircraft while flight-testing the CSIR C-band synthetic aperture radar airborne test facility.

CSIR-developed lego-like building block C-band array technology



Scalable C-band array technology enables custom SAR payloads for small, medium and large unmanned aerial vehicles.

The CSIR's technology catalogue for this opportunity offers flexibility and scope to pursue several commercialisation pathways and business models, ranging from partnering with industry on specific sensor payload segments, to the possible establishment, incubation and acceleration of a start-up to commercialise a specific payload product range. For example, where a SAR payload start-up is established using the CSIR technology base through licensing and specialising in the marketing, sale, installation and support of a family of SAR sensors in the small, medium and large UAV market, there may be potential to rapidly achieve annual sales in the order of R150 million that could generate profit of over R50 million per year, within five years from start-up of commercial operations, on a conservative base case of production, pricing and market uptake, with the scope to realise decent returns.

Milestones and timelines

Development of the first payloads of the small and medium class will take approximately 18 months. The development of the payloads for high-altitude long-endurance requires an added step to produce higher-power amplifiers based on the design already performed for a surveillance radar product at the CSIR and will require a timeline of approximately two years to achieve the first product baseline.

A seasoned team of radar and sensor experts

The SAR team is a diverse group of CSIR engineers with experience in radar, imaging radar, signal processing, radio frequency design, digital design, mechanical design, phased-array antenna design and more. The CSIR has access to specialised facilities such as radio frequency anechoic chambers and high frequency (up to 40 GHz) measurement facilities. The team has several years of experience in flight testing SAR systems and also has access to several experimental SAR systems which can be used for further development.

ENQUIRIES:

>> Innocent Siziba

isiziba@csir.co.za

NOTES:


CSIR C3
collaborate.create.commercialise.