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SKILLS FOR THE FUTURE

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CSIR
Touching lives through innovation

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MEET A LASER PHYSICIST
Spend a day with Dr Darryl Naidoo at the CSIR Photonics Centre where he builds laser systems and uses light-based applications to serve the mining and health industries.

MEET A MOLECULAR BIOLOGIST
Spend a day with Dr Mutsa Takundwa as she works with cancer cell samples to develop precision treatments for the African population.

MEET A METALLURGIST
Spend a day with Dr Lerato Raganya as she creates biomaterials for implants used in reconstructive surgeries.

SKILLS FOR THE FUTURE

The advent of the fourth industrial revolution, climate change and the Covid-19 pandemic have all contributed to shaping global conversations around the future of work. For us, these are important conversations, as the CSIR is committed to helping build a state with the skills and expertise needed for a prosperous future.

The CSIR's human capital strategy focuses on strengthening and building a strong pipeline in science, engineering and technology (SET) through ongoing initiatives such as bursary, internship and graduate-in-training programmes, as well as studentships, which have attracted and exposed young people to careers in science – a key component to building a robust National System of Innovation in South Africa.

South Africa is part of the *Reskilling Revolution,* an initiative of the World Economic Forum (WEF), which was launched in January 2020. It is a coordinated and multistakeholder effort to provide the training and development to reskill one billion people by 2030. In its *Jobs of Tomorrow White Paper* series, the WEF investigated proactive job creation investments that yield broad societal returns. This assessment of the needed increase in social and green jobs is a call to action for businesses and governments to invest in job creation and training to help create more inclusive and sustainable economies and societies around the world.

South Africa's Department of Home Affairs regularly updates a list of jobs and skills deemed critical to the South African economy. In 2023, more than a hundred such jobs were identified, many in the SET and innovation domains. Most of the careers featured in this edition of *ScienceScope* fall in this category. In featuring some of the dynamic individuals of Team CSIR, we hope that you will be inspired to either pursue a featured career type, reskill, join our team – or approach our experts to help your business find solutions to the challenges it faces.

Dr Thulani Dlamini
CSIR Chief Executive Officer

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MICROBIOLOGIST
Dr Essa Suleman

RESEARCH CHEMIST
Dr Viren Chunilall

SHEQ MANAGER
Masopha Moshoeshoe

CAREER TYPE: OCEANOGRAPHER

RELATED CAREERS
Climate researcher, marine biologist, marine policy writer, ocean scientist

ACADEMIC HISTORY
- BSc (Marine Biology and Oceanography), University of Cape Town, 1998
- BSc (Hons) (Oceanography), University of Cape Town, 1999
- MSc (Oceanography), University of Cape Town, 2001
- PhD (Oceanography), University of Cape Town and the National Oceanography Centre, United Kingdom, 2007

BRINGING ALL ABOARD TO SAVE THE SOUTHERN OCEAN

Famed and feared by seafarers, the Southern Ocean is key in the fate of the planet. In a changing climate, understanding what brews in its waters and addressing the challenges it faces, is what steers the research of CSIR oceanographer Dr Sandy Thomalla. Thomalla was recently promoted to research group leader of the Southern Ocean Carbon-Climate Observatory (SOCCO), and her laser-focused aim is unpacking the links between carbon and climate change in the southernmost waters of the world.

Tackling climate change, one of the main problems of the 21st century, is no easy feat. As a global phenomenon, climate change is impacting the oceans through warmer temperatures, ice-melt, rising sea water levels and acidification, to name just a few. The Southern Ocean is particularly sensitive to these adjustments and what's more, it plays a disproportionate role in buffering the impacts of climate change by adsorbing excess heat and a significant proportion of the anthropogenic carbon dioxide that is emitted through the burning of fossil fuels. Dr Sandy Thomalla's research group at SOCCO is working hard to understand exactly how the Southern Ocean performs this important role and how sensitive this ability is to our changing climate.

> "ALTHOUGH I HAVE BEEN WITH SOCCO FROM THE VERY BEGINNING, IT WAS NOT MY BRAINCHILD AND I FEEL EXTREMELY GRATEFUL AND HUMBLED TO BE HANDED THE HELM OF THIS LEGACY."
>
> *– Dr Sandy Thomalla*

As on land, microscopic plants in the ocean, called phytoplankton, help regulate the natural carbon cycle, and this is where Thomalla's area of expertise lies as a biogeochemical oceanographer. Her research focuses on gathering information to better understand what controls phytoplankton growth and

CSIR research group leader Dr Sandy Thomalla has participated in many research expeditions and is dedicated to building research capacity for young ocean scientists.

distribution, which provides valuable insights into the Southern Ocean ecosystem function and its ongoing role in the global carbon cycle.

Thomalla first joined SOCCO as a postdoctoral student more than a decade ago, after she completed her PhD, when she met the predecessor of her current role, Dr Pedro Monteiro, on a French Southern Ocean research cruise. "He had previously offered me the opportunity to do a postdoc, which I actually declined twice," she chuckles. "I was hesitant to return to South Africa. I had been exposed to much more advanced technology and innovation in Europe and the United Kingdom and felt, at the time, that we were just a little behind."

However, Monteiro outlined how the South African government was investing substantial resources into the S.A. Agulhas II – a new state-of-the-art polar research vessel. He also took the time to share his vision of SOCCO with her and, as they say, the rest is history.

A MULTIDISCIPLINARY APPROACH TO UNDERSTAND THE SOUTHERN OCEAN

Thomalla is highly driven in her work to acquire as much data as possible by running tests on samples retrieved from research cruises to the Southern Ocean, using satellite remote sensing observations of the ocean and deploying autonomous underwater robots to measure the ocean. Obtaining this information is no easy task, as the waters that envelope the Antarctic continent continue to remain a big mystery to mankind.

Figuring out the resilience of the Southern Ocean is one of the aspects that the research team is working towards. What remains undiscovered to Thomalla and her collaborators, is the extent of its sensitivity to climate-induced change.

Significant trends are already being observed in the light and nutrient environment of phytoplankton, which is a contributing factor towards this ocean's vulnerability to climate change. Among scientific peers, Thomalla is regarded as an international authority on phytoplankton, and she has developed innovative techniques to determine its condition and states. "The Southern Ocean is becoming stormier, and, in turn, the storms are changing the mixing regime of the ocean. This is impacting the light environment by mixing phytoplankton deep into the water column and the nutrient reservoir by accessing deep nutrient-rich waters, both of which are key determinants of phytoplankton growth."

PIONEERING OCEAN ROBOTICS IN SOUTH AFRICA

Innovative technology, underwater robots, wave gliders and floats, high-resolution satellite imagery and incubation experiments on research vessels all produce data and observations that Thomalla and her team integrate to have

an improved understanding of how this unique ecosystem functions. These findings are then incorporated into Earth system models for better predictions of the trajectories of the Southern Ocean's role in climate change. This complex work is made possible with the applied expertise and skills of modellers, biological oceanographers and physical oceanographers.

"We operate on the hypothesis that fine-scale ocean dynamics are key to understanding the role of the Southern Ocean in trends of atmospheric carbon dioxide and climate change. If you are not able to resolve the system at the scales of variability that characterise it, then you will not get a proper handle on the mechanisms that will drive its variability in the long term. This is why we need innovative approaches to measure these fine scales of variability using ocean robotics, remote sensing and machine learning," says Thomalla.

The work is collaborative in nature, at national and international scales, and is funded by the Department of Science and Innovation, the CSIR, the National Research Foundation and, to a lesser extent, the European Horizon 2020 programme.

EVERY SINGLE CRUISE IS A CAREER HIGHLIGHT

Thomalla cites all 25 of the research expeditions that she has participated in as career highlights. She thoroughly loves being at sea. "Encountering huge stormy seas, seeing ice-covered oceans, and hanging out with the penguins and the seals, is incredible. Crossing the equator and witnessing the bluest of blue, mirror-like oceans with flying fish that pop out of the water, is just amazing," she says.

Describing her fellow scientists as passionate, open-minded individuals, Thomalla acknowledges that people have also been a highlight in her career. She has formed valuable relationships and made several friends through her professional career. SOCCO's flagship Human Capital Development Programme has played a transformational role that has granted her the fortune of mentoring many a young student. "To watch the students grow, and see how they mature and become scientists who stand on their own feet, is very rewarding. It is a huge part of what we all do at SOCCO."

CONTRARY TO POPULAR BELIEF

The biggest misconception about her role as an ocean scientist is that she is doing her science out at sea all the time. Thomalla says, "As much as 90% of one's time is spent in front of the computer, crunching data and numbers, reading, writing, interpreting and communicating your research findings."

Thomalla points out that the completion of a PhD will not necessarily result in a science-only career. "As your career

Dr Sandy Thomalla demonstrates the sampling of different depths of Southern Ocean water from profiling equipment.

Interpreting carbon dioxide flux data collected by a surface wave glider in the Southern Ocean.

grows, it is inevitable that you will be writing funding proposals, managing those funds, serving on working groups and attending to organisational administration."

TECHNOLOGICAL ADVANCES BENEFITTING OCEAN AND CLIMATE SCIENCE

Modelling, machine learning, satellite remote sensing and robotics are changing oceanography.

"Five decades ago, this work would involve a lot of lab work, being at sea and obtaining very low spatial and temporal scale resolution of data. Now we are relying more on robotics, satellite and machine learning data products, and models to generate global coverage of, for example, carbon dioxide flux."

Asked to provide advice to an up-and-coming oceanographer, she says that the future of science is in programming, and she insists that an aspiring oceanographer must learn how to programme early on in their career.

SAVING THE SEAS AND FOLLOWING HER CALLING

Thomalla's research is much more than mere scientific curiosity. Her love for the ocean is 'a family affair', stemming from spending her childhood holidays at the coast with her father, an avid yachtsman. But over the years, this love has grown into a widely respected knowledge base. SOCCO is on the brink of almost 100 peer-reviewed publications since its formation and, recently, Thomalla received word that one of her research papers has been published in *Science*, with another currently in review in *Nature Climate Change*.

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CAREER TYPE: CONSERVATION BIOLOGIST

RELATED CAREERS
Life scientist, natural resource manager, ecologist, environmental researcher

ACADEMIC HISTORY
- BSc, University of the Witwatersrand, 1989
- Higher Diploma (Development Planning), University of the Witwatersrand, 1990
- BSc (Hons) (Zoology), University of the Witwatersrand, 1991
- MSc (Quantitative Conservation Biology), University of the Witwatersrand, 1993
- PhD (Zoology), Stellenbosch University, 2014

ANSWERING A CAREER CALLING FOR CONSERVATION AND DEVELOPMENT

Dr Sarah Davies shares her impressive career story and urges scientific and research networks to be prepared to partner, produce knowledge and implement projects to conserve critical ecosystems for people and nature to thrive.

The enjoyment of camping during family holidays magnified Dr Sarah Davies' childhood aspirations of becoming a game ranger, and it may have influenced her decision to establish firm academic roots in zoology and botany. Applying herself to the study of animal behaviour in highly social animals such as ants and meerkats sparked her curiosity about the interactions between conservation and society.

Davies was inspired to pursue postgraduate studies in development planning. After spending a year learning about development planning, she enrolled for a Master's degree in conservation biology, focusing on how people could improve the natural forage sources available for livestock on communal grazing lands.

> "THE CSIR HAS AN INSPIRING HISTORY OF WORKING IN SOCIAL-ECOLOGICAL SYSTEMS AND ADDRESSING THE CHALLENGES FACED BY MEGA-BIODIVERSE COUNTRIES SUCH AS SOUTH AFRICA."
>
> ***– Dr Sarah Davies***

Applying practice to theory, she was stationed in Acornhoek in Mpumalanga to study how community members managed to feed their livestock during the late winter months when drought is common, and vegetation is scarce. "They wouldn't just allow their animals to graze but would harvest foliage from various shrubs and trees that were out of reach of the livestock, especially the smaller stock like goats, to serve as a source of

The CSIR's Dr Sarah Davies is committed to protecting natural habitats for a healthy planet.

extra feed for their animals – resulting in much higher nutritional intake by the animals," Davies says. These efforts helped the animals to survive the late dry season until the onset of the rains. After working in social and development research for a non-governmental organisation around the time of South Africa's transition to democracy, Davies joined the CSIR in Stellenbosch, working on environmental impact assessment and conservation planning projects. This was a unique opportunity to learn more about the interface between social and ecological systems as a way of addressing South Africa's development challenges. Thereafter, she joined the Centre for Invasion Biology at Stellenbosch University as the manager of this national network of researchers and students working on the impacts of biological invasions. Part of her role was ensuring that research projects proceeded smoothly and facilitating collaborative research and scientific activities. During this time, she completed her PhD on the history and mechanisms of biological invasions, using a small-bodied frog species as the model animal.

Her path circled back to the CSIR when, in 2022, Davies returned to lead the CSIR's research in biodiversity and ecosystem services. "The CSIR has an inspiring history of working in social-ecological systems and addressing the challenges faced by mega-biodiverse countries such as South Africa," she says.

Dr Sarah Davies in her natural habitat, observing a river's water flow.

NATURE-BASED SOLUTIONS FOR RESILIENT FUTURES

The CSIR team in biodiversity and ecosystem services has played a key role in research that focuses on determining the extent to which fires, floods and invasive plant-related risks affect living landscapes, as well as how business, government and civil society can increase their resilience to natural disasters and extreme events.

Davies is involved in projects that focus on protecting the country's biodiversity and understanding the role that ecosystem services play in maintaining human societies and economies. In one Parliamentary Grant-funded project, the research team is focusing on improved risk management for businesses that experience environmental risks – this will be applicable to most businesses as climate change alters the distribution and availability of natural resources and the occurrence of extreme events. The aim is to assist businesses in becoming more resilient in the face of natural disasters, such as fires, floods and droughts, by carefully considering the pressures and impacts on the landscapes in which they work, which will allow them to better predict the associated risks to their business and plan their responses. The group believes that this will become an essential approach to business biodiversity management in the next five years.

Other projects to support environmental management are developing an open-source tool to predict the costs of clearing invasive plants, understanding the impacts that invasive plants have on groundwater, and protecting South Africa's long-term water security.

BUSTING MYTHS ABOUT BEING A BIOLOGIST

Davies urges the youth and early career professionals to remain cautious of prevailing misconceptions that having a career as a conservationist or life scientist is all about altruism and low earning potential, as she believes that it is possible to earn a good living and have an interesting and fulfilling work life.

Often, science is perceived to be a male-dominated discipline, accompanied by the notion that women in science encounter unacknowledged barriers to their advancement. "However, the biodiversity field as a career, particularly in South Africa, is, in fact, slightly female dominated," Davies says. "Conservation and biodiversity are fields in which women are doing exceptionally well and leading exciting developments."

KEY TO OUR CONTINUITY

As the impacts of climate change intensify, the challenges for people and ecosystems are mounting. This is resulting in novel fields of study that provide new data and methods that are available to all biodiversity professionals. These new tools can be used to assess and predict climatic change, biodiversity loss and restorations and social trends. "We must ensure that we understand how they can be applied to assist in overcoming the existential challenges that humanity is facing," she says.

CSIR women working in biodiversity, from left, senior researcher Dr Lindi Smith-Adao, researcher Dr Linda Luvuno, senior researcher Dr Michelle Audouin, researcher Dr Ilse Kotzee, research group leader Dr Sarah Davies and senior researcher Dr Phumza Ntshotsho.

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CAREER TYPE: HYDROGEOLOGIST

RELATED CAREERS
Environmental scientist, geoscientist, hydrologist

ACADEMIC HISTORY
- BA (Hons) (Geography), North-West University, 1997
- MSc (Hydrogeology), University of the Western Cape, 2005
- PhD (Hydrogeology), University of the Western Cape, 2009

GROUNDWATER: HIDDEN AND POORLY UNDERSTOOD, BUT KEY TO LIFE

Dr Harrison Pienaar is passionate about capacitating and developing efficient, focused and results-driven teams within the hydrogeology research space. As a CSIR research group leader, Pienaar provides strategic and technical leadership on research into smart water use. His research group provides research, development and innovation solutions to improve water management systems in South Africa for the public and private sectors.

As expert scientists, hydrogeologists work in multidisciplinary teams. Dr Harrison Pienaar finds these interdisciplinary approaches, where experts from a variety of fields work towards a common goal, highly stimulating. By its nature, hydrogeology is a collaborative undertaking. It entails the application of physics, chemistry and biology, combined with engineering principles, in a geological framework that may be muddled at times due to its natural variability and complexity.

An exciting development for Pienaar is that today, more than 25 years after setting out on this career path, hydrogeologists work towards solving some of the biggest challenges facing the world,

> "HYDROGEOLOGY USED TO FOCUS MAINLY ON THE SEARCH FOR AND EXPLOITATION OF GROUNDWATER. THE AWARENESS THAT THE LOSS OF GROUNDWATER QUALITY IS CAUSING SOCIOECONOMIC PROBLEMS, HAS LED TO NEW AREAS IN THE FIELD OF HYDROGEOLOGY."
>
> *– Dr Harrison Pienaar*

including sustainable water supply, food security and energy production, as well as environmental protection and adapting to climate change.

He maintains that collaboration among experts from more disciplines in the groundwater domain is required to achieve sustainable solutions to many challenges. "Hydrogeology used to focus mainly on the search for and exploitation of groundwater. However, the awareness that the loss of groundwater quality has

caused socioeconomic problems has led to new areas in the field of hydrogeology such as the transportation and transformation of pollutants, as well as studies to describe, enhance and remediate the environments affected by water pollution," he says.

Pienaar says that the skills needed for a career in hydrogeology will not be replaced by skills related to artificial intelligence (AI). In recent decades, with the development of computing technology, numerical models are often employed to simulate water quality processes. However, these numerical models, which are interpreted without subject knowledge, create a large gap between model developers and practitioners.

"However," he adds, "the advancement in AI during the past decade makes it possible to integrate these technologies into numerical modelling systems to bridge the gaps. These models require a large dataset for training and validation." Pienaar maintains that researchers should continue to investigate AI methods for enhancing the forecasting of groundwater quality.

According to Pienaar, one of the challenges of hydrogeology is that it is often poorly understood because of groundwater's hidden nature.

"In addition, assessments often rely on indirect measurements and long-term investigations, as well as investments to fully determine the behaviour of complex aquifer systems. Water users and decision-makers often demand quick fixes accompanied by an underinvestment in resources in this domain," he says.

Generally speaking, the legal aspect of hydrogeology is underestimated. Pienaar says that when a new groundwater resource has been developed, irrespective of whether it is on private land or property, legal requirements according to the National Water Act, 1998 (Act 36 of 1998) need to be considered.

Pienaar encourages young researchers to become more actively involved in water research through various platforms facilitated by the Water Institute of Southern Africa, the Department of Water and Sanitation's Learning Academy, the Department of Science and Innovation, the Water Research Commission and the National Research Foundation.

He says that there is great career potential in the emerging field of hydrogeology, both locally and abroad, and that a wide range of industries, which include construction, manufacturing, mining, environmental research and hazardous waste, require hydrogeological services.

The CSIR's Dr Harrison Pienaar in a CSIR water laboratory (above) and during a fieldtrip.

CSIR researchers regularly undertake fieldwork, for example, at the Cradle of Humankind World Heritage site in Gauteng with project partners from Stockholm University in Sweden and in North West for Moses Kotane Local Municipality.

ENQUIRIES:

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hpienaar@csir.co.za

CAREER TYPE: ARTIFICIAL INTELLIGENCE ENGINEER

RELATED CAREERS
Machine learning engineer, robotics engineer, data scientist, big data engineer

ACADEMIC HISTORY
- BCom (Informatics), University of Pretoria, 2016

AN ARTIFICIAL INTELLIGENCE ENGINEER DEVELOPS, PROGRAMS AND TRAINS THE COMPLEX NETWORKS OF ALGORITHMS THAT MAKE UP ARTIFICIAL INTELLIGENCE FOR IT TO FUNCTION LIKE A HUMAN BRAIN.

ARTIFICIAL INTELLIGENCE TO THE RESCUE

MIMICKING HUMAN INTELLIGENCE TO IMPROVE LIVES

Marshal Khosa's first interaction with a Pentium III Mercer desktop, at the tender age of 13, planted the seeds that blossomed into a passion for engineering. After initially enrolling for a Bachelor of Science in computer science at the University of Pretoria, he switched to a Bachelor of Commerce in informatics. He was determined to acquire the skills that would equip him to design, develop, implement and maintain a technological system within different ecosystems.

Marshal Khosa started his career as a business developer. This brought about the opportunity to collaborate with the Massachusetts Institute of Technology as part of their Global Start-up Labs programme, which aims to foster technology entrepreneurship through startup incubators in emerging markets around the world. This earned him the best teamwork award for his outstanding leadership of the teams in the programme.

Today, Khosa works as a senior artificial intelligence (AI) engineer at the CSIR. He helps drive the CSIR's vision of incorporating digitally enabled technologies to improve operational efficiencies within companies, organisations and government. "As an AI engineer, I wear many hats, such as that of a data scientist, machine learning engineer, software developer, technical project leader and mentor," he says.

He collaborates with junior and senior colleagues to design, maintain and implement AI systems that can perform tasks such as natural language processing, computer vision and decision-making. He says, "Over and above that, I am responsible for researching new AI techniques and technologies, and implementing them in real-world applications."

Khosa works with clients in the public and private sectors. "In one project, we are developing machine learning and AI systems to improve decision-making in education systems by making predictions on the success rates of learners. In another, we are introducing AI in the agriculture space to assist with crop yield management. We have developed an AI-driven precision agriculture system that uses machine learning models to analyse crops from various perspectives, such as chlorophyll levels. This helps farmers optimise their crop yields."

Marshal Khosa develops digitally enabled technologies to improve operational efficiencies in the private and public sector.

Khosa views AI as the optimal way to use technology to carry out mundane, time-consuming and impossible tasks. "For as long as we create the intelligence behind the technology, being replaced by AI is utterly impossible, as technology will always need someone to either improve or maintain it – contrary to the myth," he says.

"My tenure at the CSIR has not been long, but I have had the great milestone of my very first publication as a CSIR employee. I look forward to making an impact by introducing AI in the e-Government and e-Business spaces in South Africa, and seeing more people working in the field, so that the impact can be multiplied."

"To become a good AI engineer, one needs critical skills in algorithm design and mathematical modelling. You have to be curious, creative, open-minded and a critical thinker. If you are interested in this profession, you need to nourish and hone your own intellect before you will have the ability to engineer machines that develop intelligence artificially."

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CAREER TYPE: ELECTRONIC AND TELECOMMUNICATIONS TECHNOLOGIST

RELATED CAREERS

Computer engineer, control engineer, electronic engineer, instrumentation engineer, signal processing engineer

ACADEMIC HISTORY

- National Diploma, Electrical Engineering (Light Current), Tshwane University of Technology, 2004
- BTech (Electrical Engineering: Telecommunication Technology), Tshwane University of Technology, 2005
- MTech (Electrical Engineering: High Frequency Technology), Tshwane University of Technology, 2008
- MSc (Electronic Engineering), Ecole Superieure D'Ingenieurs en Electrotechnique et Electronnique, Paris, France, 2010
- DTech (Electrical Engineering), Tshwane University of Technology, 2016

A CAREER DEDICATED TO CONNECTING THE UNCONNECTED

Born and bred in Ga-Maphalle village in rural Limpopo, Dr Moshe Masonta has experienced the digital divide firsthand. It propelled and inspired him to pursue his studies, which culminated in a string of qualifications, including an MTech, MSc and DTech.

DRIVEN BY THE DIGITAL DIVIDE

Financial constraints prevented Dr Moshe Masonta from pursuing tertiary studies right after matric, but did little to smother his dream. He applied at Telkom and this first job became the stepping stone to a career in the telecommunications sector and funded his studies in electronics.

"I witnessed the digital divide between urban and rural areas in South Africa and wanted to contribute towards addressing this problem," he says. "Looking back, I see my own resilience and tenacity, which were the driving force behind my studies at the Tshwane University of Technology (TUT) and later in Paris, France, where I obtained an MSc degree.

As a telecommunication engineer, Masonta focuses on designing and developing systems and components for wireless communication. He works as a principal technologist and research group leader of the CSIR's spectrum access and management innovation group.

> "I WITNESSED THE DIGITAL DIVIDE BETWEEN URBAN AND RURAL AREAS IN SOUTH AFRICA AND WANTED TO HELP ADDRESS THIS PROBLEM."
>
> ***– Dr Moshe Masonta***

Masonta and his team are working on implementing television white space (TVWS) broadband technologies to provide connectivity to rural areas. The technology is making it possible to re-use TV bands for broadband access in sparsely populated areas. In South Africa, regulations to allow the use of TVWS are already in place and are under development in several other African countries. The CSIR-developed technology provides an opportunity for wireless internet service providers to offer affordable broadband services to rural households and enterprises, empowering rural digital entrepreneurs.

Currently, the team is working to accelerate the technical support, monitoring and evaluation for rural TVWS network operators following the installation of the respective small, medium and micro enterprises' wireless networks, funded by the United Nations Development Programme and the United Kingdom's Foreign, Commonwealth and Development Office.

Masonta enjoys working in research and development and its application. "The mobile network research laboratory enables us to share techniques for wireless networks such as 5G (the fifth generation of cellular technology). This is made possible by the adoption of artificial intelligence and machine learning in wireless networks. It is where we share solutions for intelligent spectrum," he says.

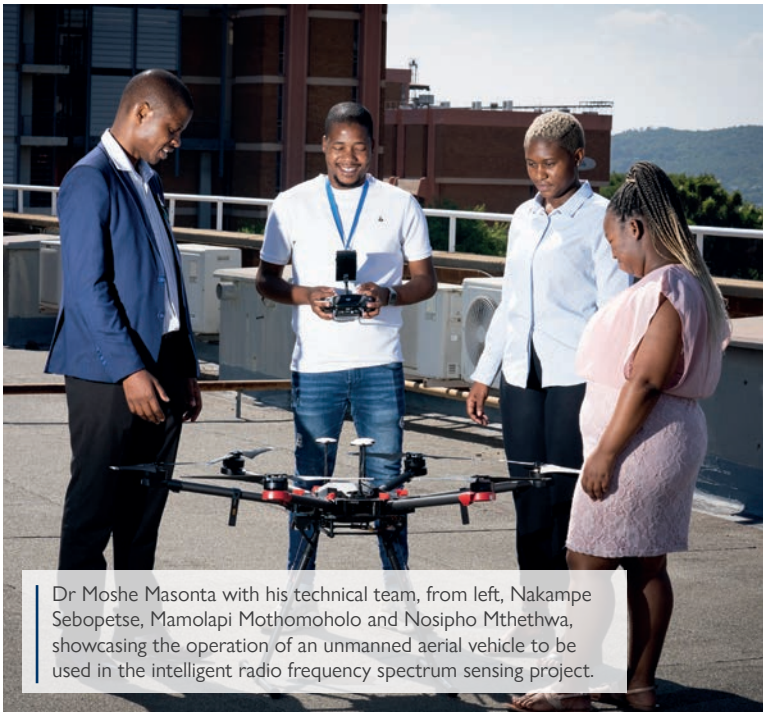
Driven by the aspiration to have a "Dr" title, Masonta continued studying and obtained his second Master's degree from a French-based engineering school, Ecole Superieure D'Ingenieurs en Electrotechnique et Electronnique in Paris, France, where he spent 12 months working on his Master's research project. He subsequently completed his Doctorate in 2016 at TUT.

Masonta provides strategic and research leadership to a team of 14 – from undergraduate interns to principal researchers. "The work that my team and I do has a direct impact on improving the livelihood of communities by bridging the digital divide. This is one of the multiple reasons I enjoy working at the CSIR; we are living the CSIR mandate of changing lives through technology."

"The role of a research group leader is challenging," says Masonta. "As leader of the team, I have to ensure that my team members' needs are addressed on a daily basis; while simultaneously looking for new business opportunities to secure research and development contracts."

"The research space requires us to be on top of the latest published research in our field. This helps me when co-supervising students, peer-reviewing articles and producing content for peer-reviewed publications," he adds.

Masonta believes that there is a skills scarcity in telecommunication engineering at national and global levels. "It is crucial that the telecommunications engineering sector provides an enabling environment for innovative technologies, especially considering the potential of the fourth industrial revolution. For example, without high-speed broadband networks, the potential impact of artificial intelligence, robotics, augmented reality, virtual reality and the internet of things will remain a dream, especially to the millions of unconnected citizens."



Dr Moshe Masonta with his technical team, from left, Nakampe Sebopetse, Mamolapi Mothomoholo and Nosipho Mthethwa, showcasing the operation of an unmanned aerial vehicle to be used in the intelligent radio frequency spectrum sensing project.

He says that there is also a huge demand for spectrum management specialists, especially women. "I would like to encourage young women to consider entering our field; they cannot go wrong – whether they end up in the formal sector or as entrepreneurs," he says.

Masonta cautions that his sector also deals with its fair share of myths. One example is the dissemination of false information at the height of Covid-19 in 2020/21 regarding the relationship between Covid-19 and 5G mobile networks. Many in society were led to believe that radio frequency communication causes all kinds of diseases. Addressing these myths remains a challenge.

Being given the opportunity to contribute to this evolving industry, which requires regional and global radio frequency spectrum harmonisation, efficient spectrum management, technology interoperability and conformance, is a dream come true for the rural kid who started out on the wrong side of the digital divide.

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CAREER TYPE: CYBERSECURITY RESEARCHER

RELATED CAREERS
Software developer, cybersecurity specialist

ACADEMIC HISTORY
- BSc (Computer Science), University of KwaZulu-Natal, 2010
- BSc (Hons) (Computer Science), University of KwaZulu-Natal, 2011
- MSc (Computer Science), University of KwaZulu-Natal, 2013
- PhD (Computer Science), University of Cape Town, 2017

A CAREER IN CYBERSECURITY: WHEN VULNERABILITIES IS THE NAME OF THE GAME

FINDING THEM, FIXING THEM, FINDING OUT HOW THEY WERE DISCOVERED AND WHO DISCOVERED THEM

Dr Zubeida Dawood leads the CSIR's research in information and cybersecurity. The research focuses on governance, privacy and the trust elements of cybersecurity.

With a job in the cybersecurity space, Dr Zubeida Dawood finds herself dealing with matters of national security. She often manages projects with sensitive information for clients and organisations, locally and internationally. Other projects have direct benefits for businesses in South Africa, such as the work on a software toolkit that will support organisations to comply with the Protection of Personal Information Act, 2013 (Act 4 of 2013) to help manage consent by customers and clients. She also develops tailored cybersecurity strategies and policies for various organisations.

Dawood says that South Africa has been making efforts towards being more cyber safe. While several laws have been put in place to support the government, officials and authorities have been unable to fully implement these laws due to lack of knowledge and experience in cybersecurity. Furthermore, there is a lack of cybersecurity professionals in the country.

> "A COMMON MISCONCEPTION IS THAT ONE NEEDS TO BE EXTRAORDINARILY SMART OR A GENIUS TO BECOME A CYBERSECURITY RESEARCHER."
>
> ***– Dr Zubeida Dawood***

Dawood believes that a common misconception about engineers and scientists is that they have all the answers. "On the contrary," she says, "we have many unanswered questions and are working towards solving them. As we solve and investigate, new discoveries are made." Another misconception is that one

Dr Zubeida Dawood in the Virtual Cybersecurity Operations Centre at the CSIR. The Centre offers specialised cybersecurity services such as event monitoring, event handling, security analysis, and synchronised management of devices, networks and applications to maintain security and compliance for clients.

needs to be extraordinarily smart or a genius to become a cybersecurity researcher. "To be successful in this career, it is far more important to be consistent, disciplined and open to change in the field."

To get into this field of work, one needs to study a BSc in computer science. This requires one to have passed mathematics and at least one science subject with a level 6 or 7 to get a university entrance. Students also need to have a passion for solving problems.

"I have been a CSIR bursar since my first year at university and studied my way up to a doctoral degree, which I completed after four gruelling years," she says.

"I find satisfaction in having some say in the research and development (R&D) work we do," says Dawood. "By keeping abreast of the latest trends and challenges in the field, one can apply for grants and funding directed at topical and interesting R&D projects. It is also inspiring and humbling to work alongside brilliant researchers and technologists," she continues. Dawood's own brilliance was acknowledged in 2022 when she won the Emerging Leader Award at the CSIR Excellence Awards.

Looking at the future, Dawood wants to keep developing and investing in her research team. For herself, she has her eyes firmly set on becoming a chief researcher, the highest rung on the CSIR career ladder.

ENQUIRIES:

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CAREER TYPE: DATA SCIENTIST

RELATED CAREERS
Data analyst, data architect, quantitative analyst

ACADEMIC HISTORY
- BSc (Statistics and Chemistry), University of the Western Cape, 2001
- BSc (Hons) (Statistics), University of the Western Cape, 2003
- MSc (Statistics) University of the Western Cape, 2007

SOLVING REAL-WORLD PROBLEMS USING DATA SCIENCE

She grew up in Lusikisiki in the Eastern Cape with no exposure to computers. And yet, despite using a computer for the first time at university, Nontembeko Dudeni-Tlhone today has a flourishing career in data science. Data science drives business efficiencies and changes the world for the better. The field is growing at a rapid pace and is taking the technological revolution to newer heights.

As a young child with a rural upbringing, Nontembeko Dudeni-Tlhone could not have predicted that she would develop a passion for data science. She ended up specialising in fields that she only discovered at university. She recalls, "Choosing subjects for my BSc was random and frustrating – I was assisted by the faculty officer to select subjects. Statistics, together with mathematics, computer science and chemistry happened to be on my course list. This was the first time I learned about statistics as a field of study."

Today she is a CSIR senior researcher in data science. Data science is a broad field in the digital space. Dudeni-Tlhone brings knowledge in predictive modelling, classification and clustering, as well as the associated activities, which involve conceptualisation, data sourcing, processing, analysis, documentation and presentation of solutions that are fourth industrial revolution-driven.

> "MY PATH HAS BEEN ONE OF LEARNING, EMBRACING GUIDANCE FROM OTHERS, ADJUSTING MY MINDSET WHEN NEEDED AND KEEPING FAITH IN THE FACE OF UNCERTAINTY."
>
> *– Nontembeko Dudeni-Tlhone*

Dudeni-Tlhone says that data scientists typically explore organisational data, especially large data sets, to extract knowledge and insights that support data-driven decisions and identify patterns that can lead to improved products and services. Ultimately, a data scientist will study current data or gather new data to solve business issues and use analytical, statistical and computational methods, including machine learning, deep learning and reinforcement learning algorithms to extract valuable information.

Nontembeko Dudeni-Tlhone looks for new ways to explore large data sets to extract knowledge and insights.

Dudeni-Tlhone has worked on projects to predict election results (in collaboration with the South African Broadcasting Corporation), develop an optimal capacity-building model for the National Prosecuting Authority, model remotely sensed data for environmental monitoring and develop a pharmacovigilance analytics platform to monitor the safety of the Covid-19 vaccine in South Africa for the South African Health Products Regulatory Authority.

Over the past 16 years, she has gained great exposure and experience within the data science industry. One of her major achievements was being promoted to senior researcher. "I have been exposed to various research problems and industry needs that have enabled steady growth, from being a candidate researcher to now embarking on a doctoral degree," she says.

Her advice to young people who want to embark on this career path is to recognise the many opportunities associated with data science and tackle them with passion. "There are many possibilities associated with this career and you can literally learn something new every day," says Dudeni-Tlhone.

ENQUIRIES:

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CAREER TYPE: SOFTWARE DEVELOPER

RELATED CAREERS
Coder, computer scientist, mathematician, programmer, systems engineer

ACADEMIC HISTORY
- BSc (Electrical Engineering) University of Witwatersrand, 1990
- BSc (Hons) (Electrical Engineering), University of the Witwatersrand, 1991

CREATING SOFTWARE SOLUTIONS THAT HELP CLIENTS FULFIL THEIR MANDATES

Advances in technology have made storing and sharing information much easier. Software developers have managed to put information that, in the past, would have piled up in back rooms and factories, into digital format that can be hosted on virtual platforms. Meet CSIR senior researcher Kirsten Du Toit, who works on such systems to help the health industry.

Kirsten Du Toit went to an all-girls high school and went on to become an expert in a field mostly dominated by men. She was one of three women studying electrical engineering at the University of the Witwatersrand during her undergraduate years.

Her professional career began on the cusp of software development, when manual tasks were being digitally automated. She joined the CSIR because she was looking for a place that would give her the freedom to conduct directed research as well as apply the findings of that research to impactful work. Her team looks at how digital solutions can be used by clients to address on-the-ground challenges. They advise on best-fit software architecture and hosting platforms, depending on whether the client would like to host their data on a cloud-based platform or use their own storage platforms. The team also recommends the type of database, software language and front-end framework to use, also known as the best-fit stack. They design monitoring solutions suited to the application, select tools for testing the software, decide on methods to secure the data and software, and ensure that the final design and implementation can be easily scaled and maintained by the client.

> "DELIVERING SOFTWARE THAT HAS REALLY HAD AN IMPACT IN SOUTH AFRICA, IS WHAT MAKES ALL THE LONG HOURS WORTHWHILE."
>
> *– Kirsten Du Toit*

"We use shared tools to define and allocate coding tasks and to report back on task status. We meet daily to discuss and solve problems and every two weeks to create, remove and prioritise tasks. There are many different approaches to writing code and we normally settle into the best fit for the project and the team experience," she says.

Kirsten du Toit believes that software developers have never had as much power to effect change as they do today.

Du Toit spends most of her time working on software projects in the health space that facilitate the tracking of services provided by the Department of Health.

"We have worked on a project to uniquely identify and maintain electronic central records of patients who visit healthcare facilities. What has made this project unique, is that the collection and management of the data can all be done offline or in areas with sparse access to the internet. Similar software written by the team is used to record the Covid-19 vaccinations that have been administered across the country and smart certificate software that creates a digitally signed PDF as proof of vaccination," she says.

Du Toit says working with skilled, creative, innovative and conscientious members of different teams to deliver software that has really had an impact in South Africa is what makes all the long hours worthwhile.

She is excited about where her field is going, especially how artificial intelligence tools will allow developers to enter problem statements in natural language and be provided with fully coded functions and applications. Her zeal to learn new applications is what is needed to be successful in her career, as things change quite quickly. She looks forward to applying these new tools in her current and future projects to ensure better performance for her clients.

ENQUIRIES:

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CAREER TYPE: URBAN AND REGIONAL PLANNER

RELATED CAREERS
Planning and development surveyor, urban geographer, planning consultant

ACADEMIC HISTORY
- Bachelor of Town and Regional Planning, University of Pretoria, 2014
- Master of Town and Regional Planning, University of Pretoria, 2020

URBAN AND REGIONAL PLANNING: DEVELOPING CLIMATE-RESILIENT CITIES AND TOWNS

Cities are made up of complex systems and interactions between human activity, natural systems and technological systems – all of which change rapidly. These systems and interactions require planners and scientists to use digital tools and techniques such as modelling to develop novel insights on how cities function. Meet Amy Pieterse, an urban planner and senior researcher in the CSIR's urban and regional dynamic research group, who does exactly this.

Urban and regional planners are typically involved in the development and use of land across scales to create communities, accommodate population growth and revitalise physical facilities in towns, cities, counties and metropolitan areas. Urban and regional planners are regulated by the Planning Profession Act, 2002 (Act 36 of 2002) through the South African Council for Planners, with which Pieterse is registered.

Pieterse has several concurrent programmes that provide planning support to local government. As an urban planner, she pivots between designing and carrying out fundamental research and working directly with local government to apply research-based solutions. Depending on the scope of the project, Pieterse often finds herself fulfilling the role of project manager, analysing policy, engaging with stakeholders, undertaking spatial analysis, developing planning support systems and tools, and training users on such systems.

URBAN PLANNING AND THE NOVEL GREENBOOK

Pieterse currently plays a leading role in the GreenBook (greenbook.co.za), a planning support system that the CSIR developed and launched in 2019. The core team continues to work on several projects that focus on rolling the GreenBook out to local government in a bid to support this tier of government's ability to undertake long-term planning that is cognisant of climate change, hazards and vulnerabilities. GreenBook stakeholders include the South African national government, the insurance industry, non-profit organisations and local government.

Pieterse completed her Master's in town and regional planning at the University of Pretoria in 2020. Thereafter, she embarked on a six-month research programme at the Technical University of Berlin, where she developed a PhD proposal as part of the Global Centre of Spatial Methods for Urban Sustainability. She subsequently began working on her PhD at the University of Pretoria's Department of Town and Regional Planning.

CSIR senior researcher Amy Pieterse presenting research on the the Greenbook, a CSIR-developed planning support system.

Working on the GreenBook project has been a highlight in Pieterse's career. The project has brought about significant growth as an urban planner and researcher, as well as a myriad of opportunities to present the novel work locally and internationally. Pieterse and other members of the team have presented at notable conferences such as the 2018 Adaptation Futures Conference, the 2019 African Climate Risks Conference, and the 2021 UK Met Office Climate Science Conference, where Pieterse delivered a keynote address.

Pieterse encourages budding town planners to find their specific interests within this space and make use of opportunities to explore the depth and breadth of urban planning. Her passion lies in pursuing research and development within her space. "On completion of my PhD, I would like to pursue more applied research and advance thinking and approaches to planning support science, developing planning support systems, and climate change adaptation planning in cities," she says.

Pieterse states that there is a growing demand for urban and regional planners in South Africa. Good urban planners are essential to the sustainable development of South Africa, be it through working in the public or private sector, in research, or non-government.

Artificial intelligence (AI) has proven potential to add great value to Pieterse's space. "AI could provide incredible opportunities to support understanding and analysis in urban and regional planning. However, it is not able to account for the very human ability to come up with creative solutions to 'wicked problems' such as the impact of climate change or socio-spatial inequality. Therefore, urban and regional planning as a career remains dependent on human thinking," she concludes.

ENQUIRIES:

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CAREER TYPE: CIVIL ENGINEER

RELATED CAREERS

Structural engineer, construction engineer, geotechnical engineer, transport engineer, civil engineering researcher, civil engineering technologist

ACADEMIC HISTORY

- BSc (Zoology), University of Pretoria, 2013
- BEng (Civil Engineering), University of Pretoria, 2018
- BEng (Hons) (Transportation Engineering), 2020

CIVIL ENGINEERING: MORE THAN BUILDING BRIDGES

Michandre Smit is breaking the stereotypes about civil engineering being about drawing and buildings. Her passion for civil engineering lies in pavement engineering, where she has steadily been carving out a niche in the use of unconventional materials and techniques in roadmaking. Her career has given her the opportunity to work with engineers from around the world.

Michandre Smit's dream to be a civil engineer was influenced by her architect father. As a youngster growing up in Pretoria, she admired buildings – their shapes, sizes and demand for creativity. "My dad's career as an architect contributed to my love for the building industry and the idea that one day I can tell my children that I helped to build or develop something that had a lasting impact in our country," Smit says.

A pavement civil engineer primarily focuses on researching new materials used in roadmaking. At the CSIR, Smit uses the heavy vehicle simulator (HVS), which was developed by the CSIR in the 1970s and continues to be used by transport agencies around the globe to this day.

> "THE USE OF BACTERIA TO STRENGTHEN THE SOIL LAYER CAPTURED MY ATTENTION. WE USE BACTERIA THAT ALREADY EXIST IN THE SOIL TO BIND WITH THE SOIL PARTICLES, THEREBY MAKING THE SOIL LAYER OF THE PAVEMENT STRONGER."
>
> ***– Michandre Smit***

"The HVS is an accelerated road-testing machine – it simulates the effect of traffic and equips us to test the durability and performance of the road," says Smit. She uses the data collected from several measuring instruments installed in the pavement and determines the life of a pavement. Smit explains, "We can determine different engineering properties of each layer of the pavement and then, ultimately, tell you how long each layer will last and if the design is actually going to work for the intended purpose." She says the astronomical cost of roadmaking makes it crucial that roads be designed to last.

The CSIR's Michandre Smit uses the heavy vehicle simulator in her work to test unconventional roadmaking materials and techniques.

NEW ROAD MATERIALS

Smit is also working on a project that uses bacteria that is already present in soil to create some stabilisation in a process called microbial-induced calcium carbonate precipitation. She uses a chemical agent to activate the bacteria and then, as a defence mechanism, the microorganisms produce calcite around themselves, thus binding the soil particles around it and making the soil layer stronger.

Furthermore, Smit is conducting HVS testing on nano-silane-treated base and sub-base materials, which is a product that makes pavements waterproof and increases their strength. "We are also conducting tests at the University of Pretoria Engineering 4.0, where we are looking at a geogrid for an international company based in the United Kingdom. We want to see if the geogrid strengthens and stabilises the sub-base material. In addition to that, I will be doing HVS testing on a pavement that has plastic in the asphalt layer. The goal of the project is to see if we can reduce the amount of plastic waste circulating in the environment by disposing of it in roads, and to demonstrate that using alternative local materials is possible without compromising the performance of the road," Smit says. Testing roads that have been constructed using unconventional pavement materials excites Smit. She had always hoped to do something different with her civil engineering qualification and she is doing exactly that. "Many civil engineers end up in design or construction. I wanted to make a difference in how we use materials, so my job makes me happy."

A highlight for Smit was travelling to the United States of America and working with the United State Army corps of engineers and the Florida Department of Transport, which are users of the HVS.

A CAREER IN PAVEMENT ENGINEERING

Smit says one of the biggest misconceptions about civil engineers is that they only build bridges and buildings, when, in fact, there are several career paths to take. In terms of pavement engineering, many assume that roads consist of only the surface layer. "People do not realise that we go quite deep into the ground to build layers with increasing strength," she says.

"There is a big shortage of engineers who specialise in pavements in South Africa – a great many of the great pavement engineers have retired and the pipeline of such engineers has not been sufficiently replenished. We need young people in civil engineering with a focus on and passion for research to face the challenges that our country and world are facing."

THE FUTURE OF CIVIL ENGINEERING

She is optimistic about the future of civil engineering in pavements, thanks to the advancement in fourth industrial revolution technologies. New techniques and methods of making pavements are being introduced. "Considering the development of electric vehicles, we will run out of bitumen, which is derived from the petroleum industry and used in the surface layer of asphalt pavements. In addition to this, the energy crisis in South Africa and a move to greener alternatives should spur us on to find ways to generate electricity from our roads," she says. Materials like nano-silane and geogrids have the potential to make it cheaper to build roads at the same or higher standard than our traditional materials.

ENQUIRIES:

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CAREER TYPE: PORT AND COASTAL ENGINEER

RELATED CAREERS
Water resources engineer, structural engineer, oceanographer

ACADEMIC HISTORY
- BEng (Civil Engineering), Stellenbosch University, 2009
- MEng (Port and Coastal Engineering), Stellenbosch University, 2020

MAKING WAVES IN PORT RESEARCH AND INNOVATION

Carl Wehlitz is a senior port and coastal engineer who has conducted numerous 2D and 3D physical model studies for local and international clients. Wehlitz manages the CSIR's hydraulics laboratory in Stellenbosch, where the CSIR investigates and validates designs of coastal systems, marine infrastructure and port terminal layouts. This is done by constructing small-scale replicas of the designs and then subjecting it to realistic storm events using state-of-the-art machines to generate the wave conditions.

A PECULIAR AND PROSPEROUS PATH

Carl Wehlitz's secondary education is one that prepared him for the career he has today, and he believes that it equipped him to address the often highly technical challenges that he faces in his career as a port and coastal engineer. "I had to defy the stereotypes and stigmas attached to attending a technical school. The specialised focus I received prepared me for the technical insights required in the engineering field and it continues to serve me well – I still implement several of the skills I learned at school in my career and field today."

As a young man, he aspired to a career in engineering and completed his undergraduate degree in civil engineering before entering the job market. It was only after entering the professional work environment that he was exposed to port and coastal engineering. He enrolled for a Master's degree to prepare himself to interpret and understand the diversity of marine designs – a field about which, today, he is passionate.

> "WE WANT TO USE NATURE-BASED SOLUTIONS TO ENHANCE OUR PORT AND COASTAL ENGINEERING DESIGNS AND REDUCE THE INFRINGEMENT ON THE NATURAL ENVIRONMENT."
>
> *– Carl Wehlitz*

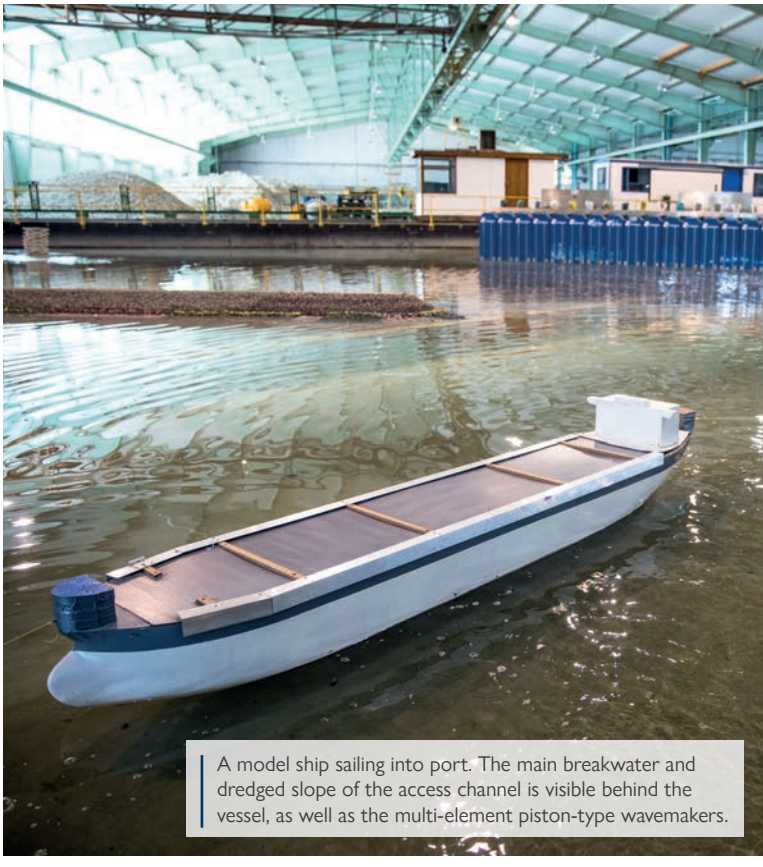
A HOMEGROWN SPECIALIST

Wehlitz joined the CSIR in 2015 after nearly five years an expatriate and was grateful to be able to return to South Africa. His return kick-started his career as a researcher in port and coastal engineering as he entered the world of physical modelling. Physical models enable one to realistically replicate, as well as observe, all the conditions that are required to test the behaviour and durability of a design. Design validation through physical modelling forms part of the detailed design process,

CSIR senior engineer Carl Wehlitz demonstrates different rock profiles inside the narrow glass panel flume. This flume is the most popular facility for conducting 2D physical model studies as it allows the structure and wave propagation to be viewed from the side.

and it is where Wehlitz and his team engage with engineering consultancies and clients that plan on constructing or expanding port facilities and infrastructure such as breakwaters, revetments, quay walls and jetties. Other projects also include validating designs for recreational facilities and shore protections measures, such as tidal pools, groyne fields and sea walls. The project concept is subjected to various test simulations during which the detailed design is confirmed. This is where Wehlitz and his team play a critical role, where in most instances, the detailed design will not be approved or endorsed by the client without the execution of a physical model study. "Anyone can build a scaled replica, but our expertise is required to do it right and to make sense of the outcome," he says.

Port and coastal engineering is a unique field because the conditions in the operating environments differ vastly and are very specific to the project area. Existing elements such as the natural shape of the seafloor and the severity of the oceanic conditions have a large role to play in the design process, and then there are the unpredictable parameters like climate change and sea level rise that are becoming increasingly important, especially for future generations. Physical modelling is a cost-effective engineering process that gives the client the opportunity to achieve optimum results by validating various options and selecting the best one. The impact of all the different natural variables on the project can be factored in and then considered



A model ship sailing into port. The main breakwater and dredged slope of the access channel is visible behind the vessel, as well as the multi-element piston-type wavemakers.

for enhancements, where necessary. The CSIR's physical modelling laboratory is the only facility of its kind in Africa and the largest in the southern hemisphere.

EXPANSIONS FOR DEVELOPMENT

Wehlitz says that his team recently finalised a large physical modelling study for a port terminal expansion in Thailand where the client plans to expand its handling and storage capacity at its petrochemical facility. The upgrades are crucial for this facility and will contribute towards enhancing its image as the largest of its kind in the Gulf of Thailand, and the eighth largest in the world.

"This was a very interesting study because it allowed us to focus on nearly all aspects of physical modelling, providing the client with an all-inclusive service. The study comprised both 2D and 3D physical modelling, and included analysis of breakwater, revetment and caisson stability, wave overtopping, and wave forces. It took the team seven months to complete and was the largest that we had in the last decade. I was very proud of the team effort," he says.

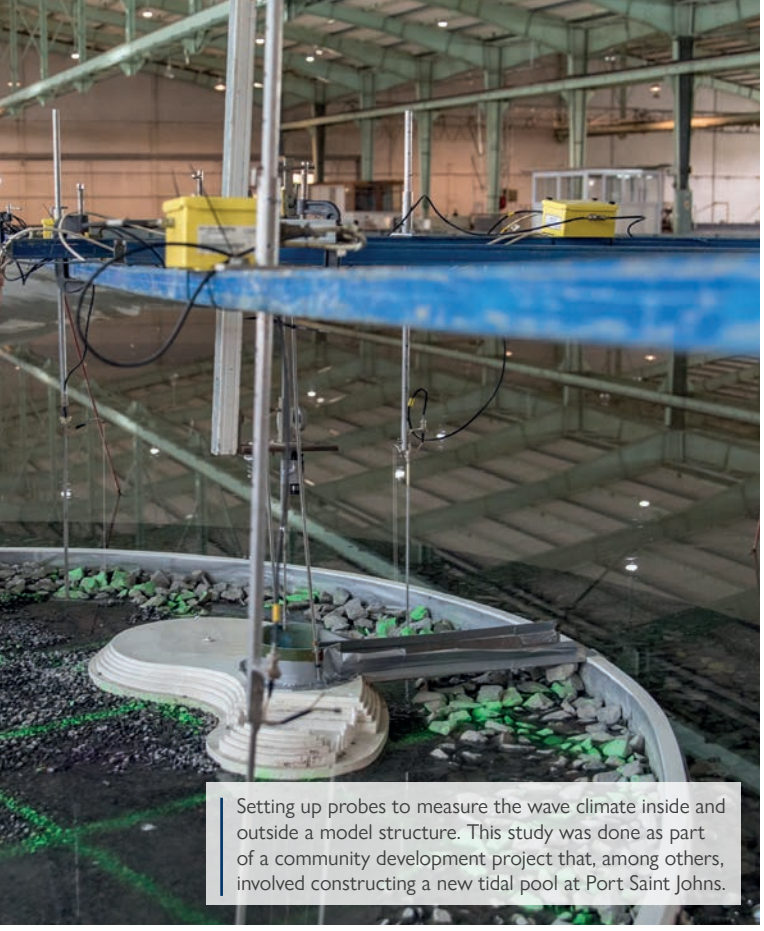
There are a number of large physical model projects in the pipeline, one of which involves doing a stability study for an international breakwater in the Middle East and will require the CSIR having to offer a wavefield of approximately 36 metres in length.

MEETING PORT PIONEERS

Wehlitz says the port and coastal engineering field is relatively small compared to other engineering disciplines and, as a result, there are a handful of port and coastal engineering pioneers who have made tremendous contributions in this niche field. He derives tremendous career satisfaction in being able to contribute towards coastal engineering endeavours that will lead to creating a legacy. Having the opportunity to meet some of the notable icons in coastal engineering has had an incredible impact on him as a professional. He shares, "One is aware of who the legends are and what they have achieved. When the opportunity to engage with them arises, you realise that they are just normal people like the rest of us, but normal people who acted on their ideas."

AS NATURE INTENDED – ABIDING BY PHYSICAL LAWS

"In the physical modelling field, some think that the engineer is able to magically master and steer the processes to align with (client) expectations. The reality is that modellers manage unforeseeable physical principles and constraints. We adhere to engineering practices and the rest depends on physical (natural) processes. We cannot tweak the laws of physics, and the outcome is what it is, regardless of how many times we conduct the modelling exercise," he cautions.



Setting up probes to measure the wave climate inside and outside a model structure. This study was done as part of a community development project that, among others, involved constructing a new tidal pool at Port Saint Johns.

HARMONISING BUILT AND ECOLOGICAL INFRASTRUCTURE

South Africa has a wealth of natural ecosystems and diverse species and, to ensure its safeguarding, Wehlitz and his colleagues are developing an engineering framework that will help engineers and developers to incorporate nature in their designs.

"We want to use nature-based solutions to enhance our port and coastal engineering designs, and reduce the infringement on the natural environment," Wehlitz says.

ENQUIRIES:

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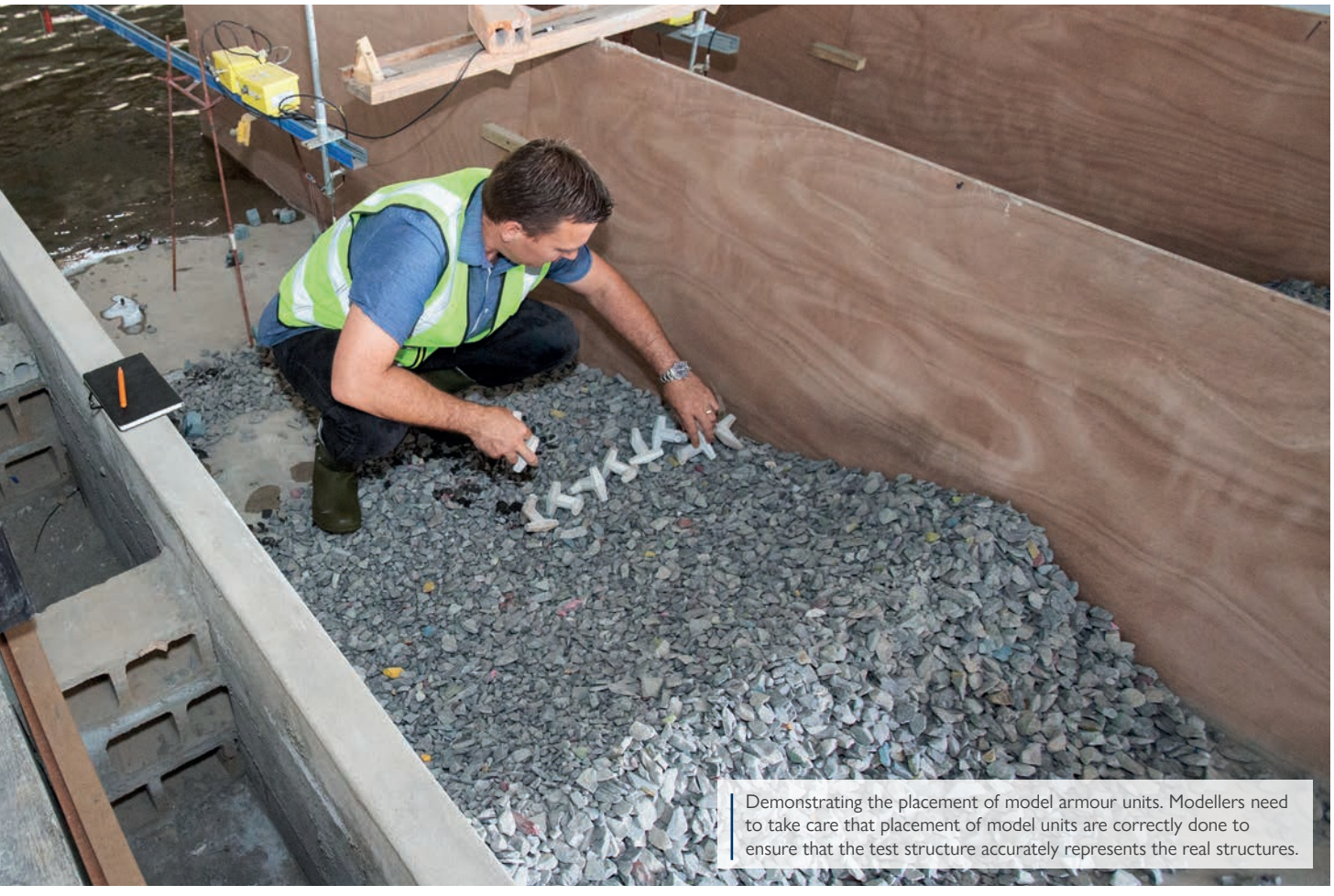

Demonstrating the placement of model armour units. Modellers need to take care that placement of model units are correctly done to ensure that the test structure accurately represents the real structures.

CAREER TYPE: MECHANICAL ENGINEER

RELATED CAREERS
Aerospace engineer, mechatronics engineer, industrial engineer

ACADEMIC HISTORY
- BEng (Mechanical), Stellenbosch University, 2005
- MSc Eng (Mechanical), Stellenbosch University, 2009

MAN ON A MISSION: SAVING LIVES IN THE SEAS AND ON MOUNTAIN PEAKS

Following the completion of his postgraduate degree at Stellenbosch University, for Richard Mattheyse, it proved to be a simple transition from being a student at the Faculty of Engineering to, quite literally, moving across the road and joining the CSIR in Stellenbosch. Today, he continues to add value to the collective efforts of the CSIR's technology for special operations group, with its mission of supporting the needs of the Special Forces in the South African National Defence Force.

Richard Mattheyse works on the mechanical design engineering aspects of projects for one of the CSIR's longstanding clients, the Special Forces of the South African National Defence Force (SANDF). Here he helps develop specialised products from concept designs to prototypes and, eventually, fully fledged products. Some of the projects entail many years of trials and testing, while others are shorter in duration and could relate to regular, but specialised, maintenance tasks or smaller development and modification projects for the Special Forces. "Our mission is to make the mission possible," he says.

> "NOT EVERYBODY HAS THE OPPORTUNITY TO DO THIS AS A DAY JOB."
>
> *– Richard Mattheyse*

His job requires highly specialised skills and the ability to integrate various engineering disciplines and their associated operational requirements. Often, project needs are not made explicit upfront, and this makes it critical for a mechanical engineer to be highly proficient in his field. An advanced level of expertise, understanding the client's user requirements and being familiar with the environment in which the product will be used can make or break the project.

What excites Mattheyse is the cradle-to-grave development process. "We conceptualise the mechanical design from scratch;

South African Navy divers test a system that helps ensure the safety of submarine crews.

use robust and state-of-the-art technology that is reliable, and then integrate that into a hardware solution for our clients. We test designs in the field and make modifications until the client is satisfied with the product," he says.

The stealthy, black submarines of the South African Navy, with their ability to remain undetected in deep ocean waters, are an essential part of the country's defence infrastructure. Keeping the mariners on board safe at all times is non-negotiable and, for many years, the CSIR has contributed to projects aimed at enhancing their safety.

As a client of the CSIR, the Maritime Branch of the Special Forces of the SANDF benefits from Mattheyse's experience as a commercial diver. Testing of some of the engineered products takes place under the sea and, due to the rigorous examination of a product prior to its finalisation for the client, it only made sense to ensure that Mattheyse and some of his team members are qualified commercial divers. Keeping this capability alive ensures that the five-member team can conduct the product testing independently.

From left at the CSIR's test tank, are CSIR principal engineer Etienne Gunter, CSIR senior engineer Richard Mattheyse, CSIR technician Ayanda Sabata, CSIR senior technician Sabelo Tshapile, CSIR senior engineer Adriaan Smuts and CSIR senior engineer Andrew Khosa.

Mattheyse is also a member of the Mountain Club of South Africa's Search and Rescue team, a role that he fulfils in his personal time and capacity. "Our role is to get medical professionals to the patient and then ensure the safe extraction of all parties from the mountain," he says.

"Our focus is on technical rescue involving rope systems and helicopters," he continues. The helicopter team works with the South African Air Force and Air Mercy Services, which is contracted by the Western Cape Department of Health.

Mattheyse cites his career highlights as doing fieldwork and witnessing CSIR designs become fully operational. He singles out experiencing the impact of teamwork in a project in which the CSIR helped design and test a submarine escape system, followed by a practical demonstration involving live escapees.

"Not everybody gets the opportunity to do what I do as a day job," he says. "I am very lucky to have an element of adventure in my job, and I enjoy having the opportunity to do so beyond the confines of my work role. As much as I enjoy what I get to do for a living, it is not my life. There is life outside of work."

Commenting on the misconceptions about his job, Mattheyse chuckles, "Some think we just make bombs because we are the defence and security guys! Very little of what we do involves explosives. We offer a large variety of services for the client other than making things go 'bang!'".

Mattheyse says his group is on a growth trajectory and he is involved in processes to recruit more staff and expand the CSIR facilities. Driven by the imminent growth of the team, career aspirations for Mattheyse centre on honing his technical leadership abilities.

ENQUIRIES:

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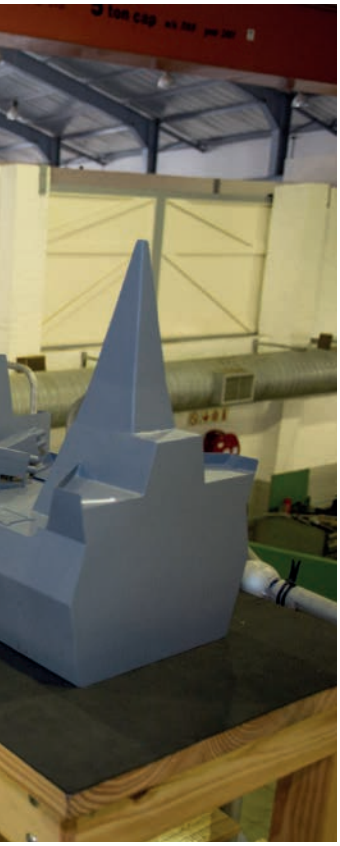
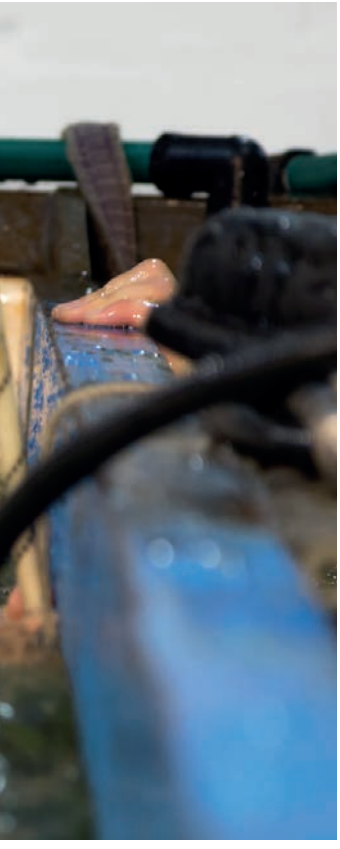
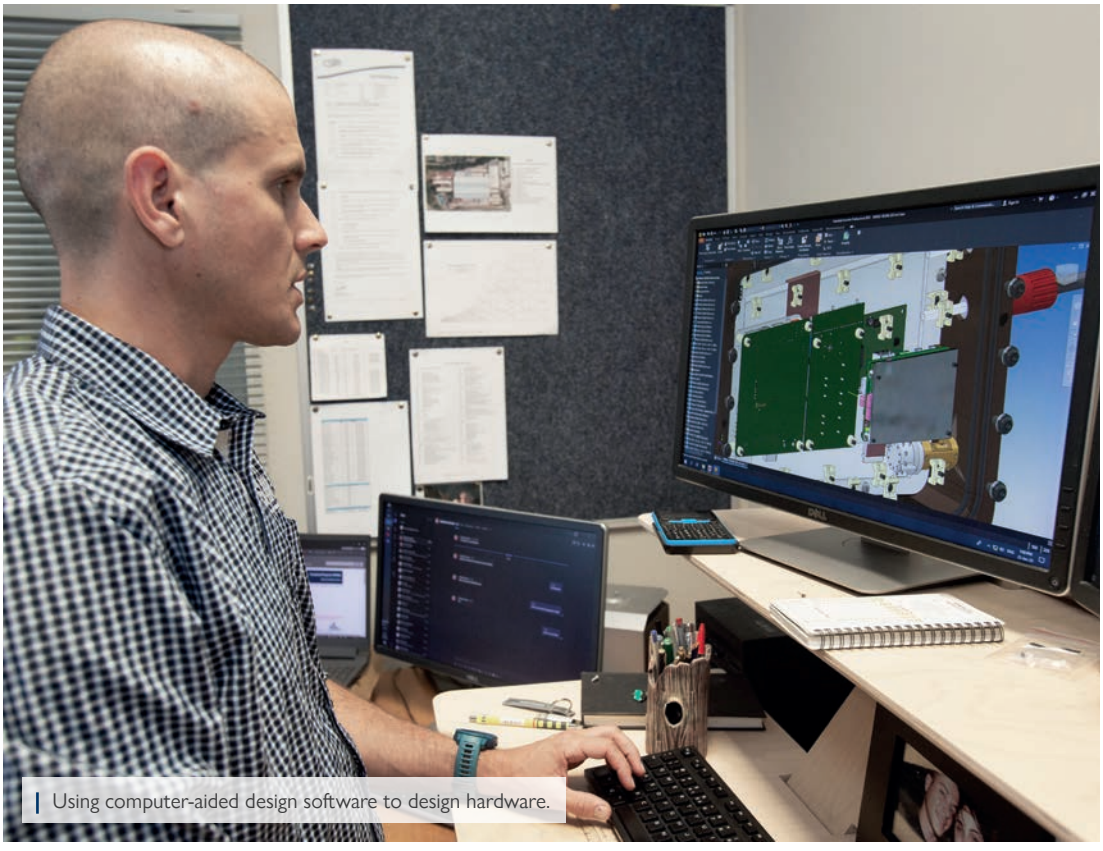
A scale model for a South African Navy project proposal.

Diving during prototype testing.



The CSIR's technology for special operations workshop.





Using computer-aided design software to design hardware.

CAREER TYPE: ELECTRONIC ENGINEER

RELATED CAREERS
Radar engineer, programmer, software designer (modelling and simulation), image processing

ACADEMIC HISTORY
- BSc (Electronic Engineering), University of KwaZulu-Natal, 2008
- BSc (Hons) (Microelectronic Engineering), University of Pretoria, 2010
- Master's (Microelectronic Engineering), University of Pretoria, 2015

A SOLDIER FOR SCIENCE IN THE UNSEEN BATTLE

As the CSIR's research group leader for digital electronic warfare, Reeshen Reddy combines his passion for technology with his passion of helping people around the world.

Reeshen Reddy showed an interest in analytical activities such as chess, and team activities such as soccer, early on. But it was when his father brought home their first computer – an 8-bit PC called the Commodore 64 – that his curiosity about technology and how things work set him off on a journey into science.

A mathematics and technical drawing teacher based in KwaZulu-Natal at the time, Reddy's father did microwave and cellphone repairs on weekends. "This gave me even more insight into electronics and taught me not to touch a soldering iron," Reddy quips.

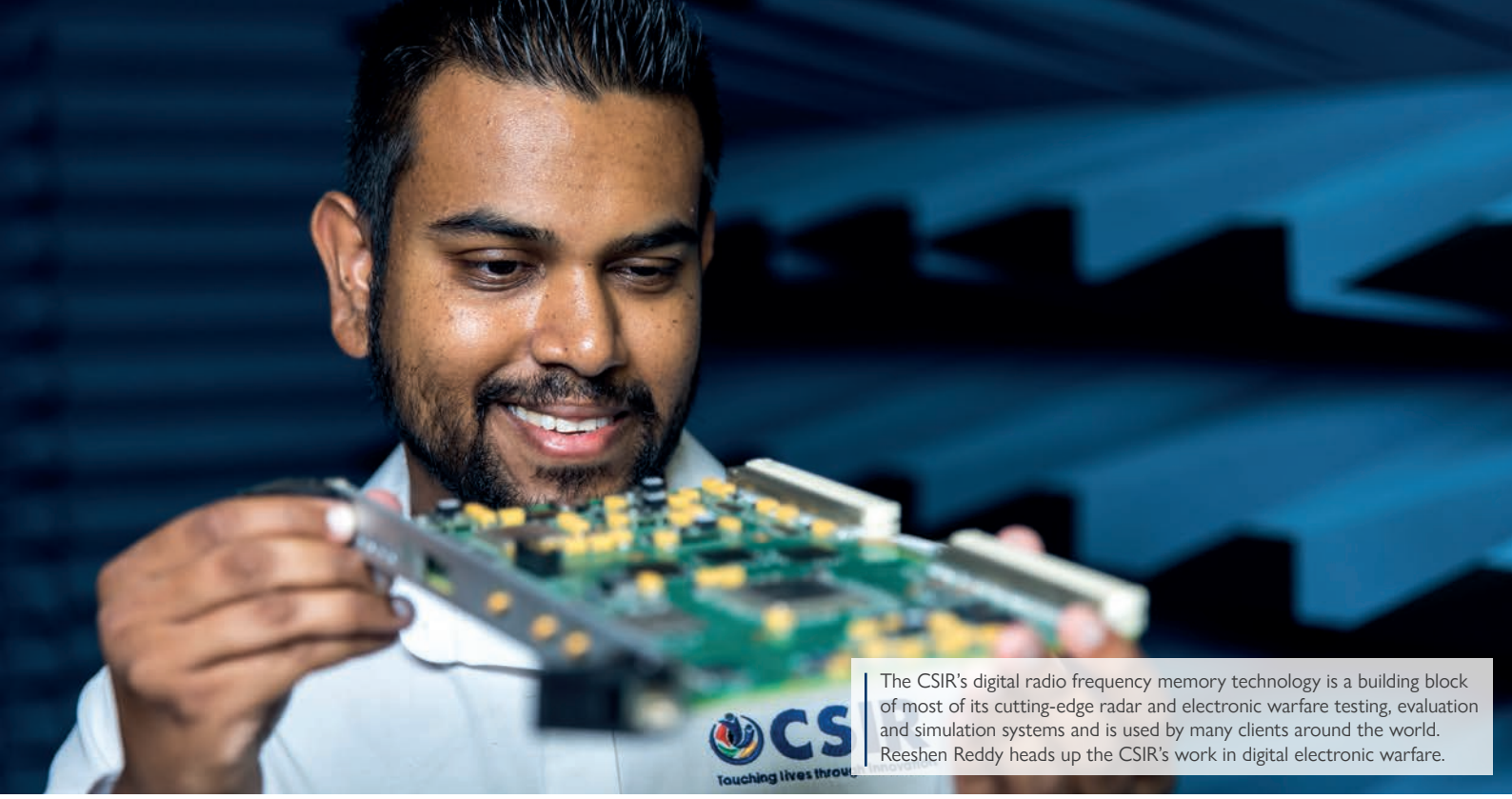
"Electronic warfare is as cool as it sounds," Reddy continues. "It involves mastering the use of the electromagnetic spectrum – a crucial resource that we depend on for modern communications and sensors – for military operations to ensure national security," he says.

"You can't see the electromagnetic spectrum with the naked eye but devices such as TVs, radios, smartphones and global positioning systems all rely on unimpeded access to it. That is why electronic warfare is often known as the 'unseen battlefield'," he explains.

> "MY DREAM JOB INVOLVES THE INTERSECTION OF STRATEGY, BUSINESS AND TECHNOLOGY – TO IMAGINE AND THEN BRING TO REALITY HIGH-TECH PRODUCTS…EXACTLY WHAT I AM DOING RIGHT NOW."
>
> ***– Reeshen Reddy***

His job is a multifaceted one, combining strategy, technology development, business acumen and engineering management. Reddy says, "Electronic warfare relies heavily on the use of modern electronics and offers engineers the opportunity to do innovative and high-tech work. I lead a team of 15 highly talented engineers who, together, are developing the next generation of electronic warfare technologies.

"Consider that we are working alongside the radar experts who build the very systems we try to outsmart – the office is a fun place!"



The CSIR's digital radio frequency memory technology is a building block of most of its cutting-edge radar and electronic warfare testing, evaluation and simulation systems and is used by many clients around the world. Reeshen Reddy heads up the CSIR's work in digital electronic warfare.

Reddy warns against a popular misperception: "Electronic warfare is not about promoting war and killing people. Precisely the opposite; peace and stability are necessary for societies to prosper," he emphasises. "Electronic warfare helps protect us and contributes to national security by ensuring that we have situational awareness and access to the electromagnetic spectrum."

At school level, strong analytical subjects such as mathematics, physical science and computer science, paired with strong communication skills learned in subjects like English, are important. Most practitioners acquire postgraduate qualifications.

"Most importantly, the passion, curiosity and hunger to learn are crucial as the field of electronic warfare is constantly evolving," Reddy points out.

In terms of other requirements of the job, the list includes travelling often, presenting and interacting with high-profile clients, managing the pressure that comes with deadlines, dealing with legal and contracting issues and marketing. "Modern engineering systems are not a one-person show, so being a good team player with a positive attitude is vital," he adds.

Although electronic warfare is a highly specialised field, the underlying skill sets cut across other sectors. For example, Reddy's experience includes working in embedded systems, digital signal processing, firmware, hardware and software engineering in aerospace and telecommunications.

Countries such as China, France, Germany, India, Israel, Italy, Russia and Turkey have strong capabilities in electronic warfare.

The CSIR team has built a track record of delivering complex, sophisticated radar and electronic warfare systems and measurement facilities over many years.

"In fact, electronic warfare experts are highly sought after by international headhunters. This does not tempt me; I love my country and have made the decision to grow the next generation of South African electronic warfare engineers and products," Reddy says.

As for professional associations, Reddy is a member of the Association of Old Crows, an international body that promotes electronic warfare, a senior member of the Institute of Electric and Electronic Engineers and a registered professional engineer with the Engineering Council of South Africa. These professional activities help build networks and give back to the community.

Reddy emphasises the valuable input of role models and mentors. "I have had many mentors who were far wiser and smarter than me," he explains. "Colleagues such as Dr Kaven Naidoo, for his ability to handle complex situations; Denis Milton, a legend in the South African electronic warfare community who taught me the importance of professional integrity; Danny Naicker, who showed me the drive to be innovative; and Klasie Olivier, from whom I learned the value of working in a structured manner."

ENQUIRIES:

>> Reeshen Reddy
rreddy@csir.co.za

CAREER TYPE: OPTRONICS RESEARCHER

RELATED CAREERS

Optical engineer, electronic and software engineer, physicist, radiometrist, systems engineer, image processing engineer

ACADEMIC HISTORY

- BEng, University of Pretoria, 2010
- BEng (Hons), University of Pretoria, 2012
- MSc (Engineering) (cum laude), University of Pretoria, 2014
- PhD (Engineering), University of Johannesburg, 2021

A VISUALS VIRTUOSO SETS HIS SIGHT ON WIDE AREA SURVEILLANCE

"Working in the defence environment on drone detection, missile tracking and laser systems is not exactly dinosaurs with laser-shooting eyes followed by a swarm of micro missiles, but it's close." He may try to downplay the exciting world of optronics and cyber-physical systems, but it is clear that CSIR principal researcher Dr Gene Stoltz found a domain in which the intricacies stemming from the interaction between complex systems, satisfy his curiosity and passion.

For CSIR principal researcher Dr Gene Stoltz, aiming to understand the world is more of a lifestyle than a career. "Science, mathematics and knowledge have always inspired me. The great Greek philosophers, the mathematical geniuses, and the awe-inspiring literature giants all provide insight and motivation," he says. "I have always found 'passion' intriguing."

Within the field of optronic sensor systems, Stoltz develops algorithms and models complex systems to understand the interactions that occur within these systems. As this is a multidisciplinary domain, he draws on his background in electronics, optics, radiometry, physics, electromagnetism, software and systems engineering, control systems and machine learning.

> A HIGHLIGHT IS REPEATEDLY DISCOVERING THAT I UNDERSTAND THE LIMITS OF WHAT I UNDERSTAND.
>
> *– Dr Gene Stoltz*

Because his work is largely in the defence domain, he does not elaborate on the projects in which he is involved. "My current application is the development of a cyber-physical system for wide area surveillance – basically a fancy long-range camera that can see hot things and find tree shadows in starlight," he offers.

While studying electronic engineering, Stoltz worked part time for a company that developed stationary monitoring systems in acoustics, light sensors and imaging. Over time, he did a part-

time postgraduate course in pattern recognition and machine learning.

"This was my first exposure to imaging systems and the intricacies required for real-world application," he explains. He ventured further into application development, doing power electronics, radio frequency transceiver development, control systems and electronic production.

After completing his Master's degree part time, it was farewell to the production environment and he opted to seek out a more research-oriented vocation. An opportunity to work in an optics development company as a sensor integration specialist presented itself, and he grabbed it. "The job took me back to pattern recognition and machine vision," he explains. "I performed a fair amount of laboratory work on optical benches in production and analysis and delved deep into imaging sensors."

LOVING IT AS MUCH AS YOUR HOBBY

"Every time things work, it is fulfilling," Stoltz says. "Like when the system you designed performs within the designed specifications, or the model you built simulates according to the real-world measurements."

With a penchant for research, the CSIR was a natural attraction. Working on image processing in the CSIR's research group for optronics sensor systems, Stoltz completed his doctorate in infrared imaging on a part-time basis.

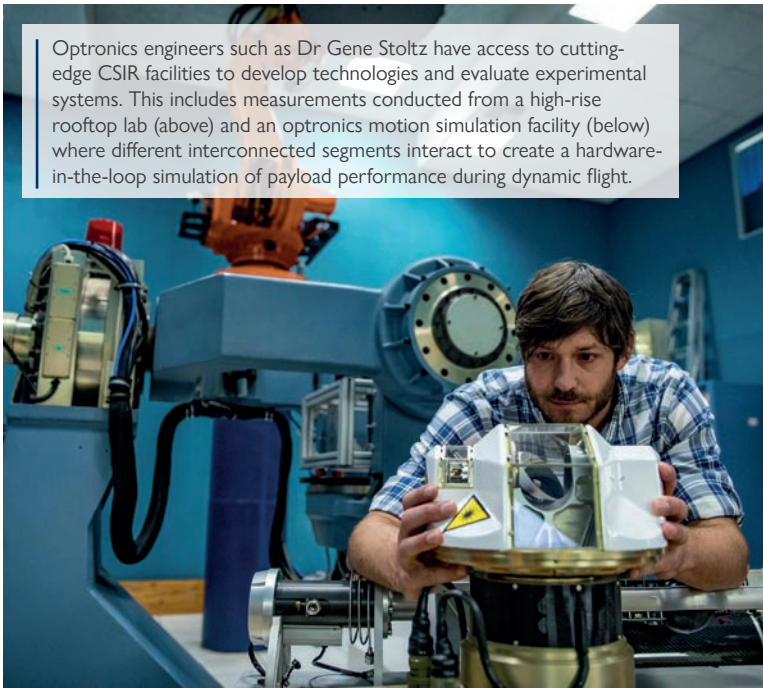
"In a sense, the university training you receive gives you knowledge and guides you on how to think, but the additional training you require is more like tinkering at home, trying things, and being interested in the topic," he says. "Interested in the sense that you handle it almost like your hobby." This 'hobby' also moved him to take on additional subjects in applied mathematics and physics, because they interested him.

Problem solving, he might undertake himself, but teamwork is a requirement in this line of work. "I usually do the hard thinking for specific problems alone, but the systemic solution to the larger problem of a multi-faceted project is performed in teams," Stoltz explains.

"The value of teamwork was very evident during the Covid-19 pandemic, when it was difficult to access laboratories and socially interact with colleagues," he adds. "This had an effect on idea propagation and hallway discussions that assist in the thought processes required to solve problems."

ADVICE ON A CAREER IN OPTRONICS

What would he say is the starting point to a career in this domain? "I would say your grade 12 performance should be at least A's for science and mathematics, and an "A" in opening, closing and sometimes breaking your parents' electronics. Otherwise, engineering may not be for you." But he is quick to warn: "Don't misunderstand: I do not fix cameras or toasters!"



Optronics engineers such as Dr Gene Stoltz have access to cutting-edge CSIR facilities to develop technologies and evaluate experimental systems. This includes measurements conducted from a high-rise rooftop lab (above) and an optronics motion simulation facility (below) where different interconnected segments interact to create a hardware-in-the-loop simulation of payload performance during dynamic flight.

Optics is a broad field. Skills in this domain are scarce and the applications wide. Internationally, countries like China, the Netherlands, Turkey and the United Kingdom generate leading outputs in sensors, lenses, firmware and optical design, respectively.

How would he market this career to young engineers? "I do not think one can 'sell' a passion and a type of curiosity, but this career provides various ways to extend your knowledge and even improves daily lives through appropriate application."

ENQUIRIES:

>> Dr Gene Stoltz
gstoltz@csir.co.za

CAREER TYPE: AERONAUTICAL ENGINEER

RELATED CAREERS
Software developer, data scientist, robotics engineer, systems engineer

ACADEMIC HISTORY
- BSc (Hons) (Aeronautical Engineering), University of the Witwatersrand, 2019

PASSION AND PERSEVERANCE TO SOAR IN AERONAUTICS

An aircraft that takes off vertically? Propulsion systems using hydrogen fuel cells? These are just some of the exciting technological developments that Lindokuhle Zwane encounters in his work as an aeronautical engineer at the CSIR.

Lindokuhle Zwane remembers his 15-year-old self trying to figure out how he would one day work in aeronautics. This was after meeting an aeronautics engineer for the first time – Dr Robert Hurlin, who was a director at his high school.

Today he has an Honours degree and works mainly on defence and military projects in support of the country's safekeeping.

"I work on a range of projects in aviation. At the moment, I am working on the design of a wing for an unmanned aerial vehicle that, once completed, will be able to take off and land vertically. This type of vehicle can be used when operating from environments that do not have usable runways," he explains.

He works with a range of experts in fields such as aerodynamics, modelling and simulation and structural design. Zwane and his team are considered to be leaders in the field, especially in Africa. They have access to facilities such as wind tunnels and simulation workbenches used on projects for important local and international aviation and aeronautics clients.

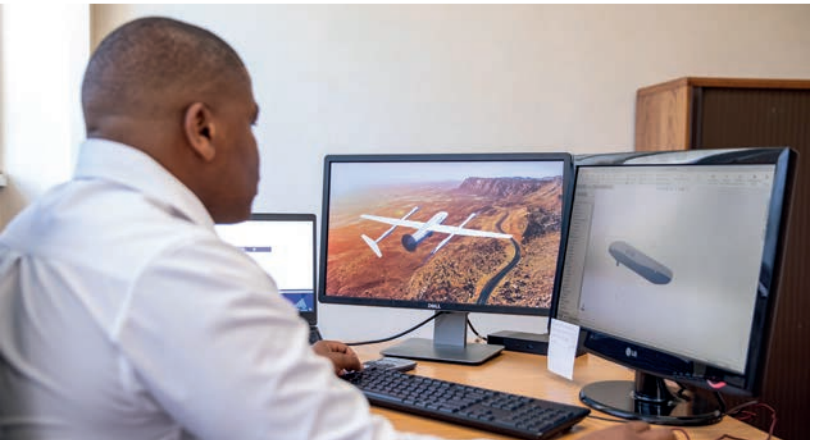
> "I DO NOT KNOW A COMPANY OR INSTITUTION IN SOUTH AFRICA OF WHICH THE SCOPE IN WORK AND INFRASTRUCTURE IN AVIATION AND AERONAUTICS COMPARES TO THAT OF THE CSIR."
>
> ***– Lindokuhle Zwane***

After completing his studies, Zwane joined the CSIR through the Graduate-in-Training Programme. "To enter the field of aeronautical engineering, one needs to take mathematics and physical science in grade 12 and achieve the minimum admission points required for university entrance," he says.

He emphasises the need to have an inherent passion for aviation and aerospace if one wants to get into the aeronautics space. "The absence of such a passion will make it hard to persevere through the difficult times, either when studying or at work."

Do you need to be super smart to work in aeronautics? "Although this would help," he says, "my experience has been that those who are hardworking and passionate about the field

The CSIR's Lindokuhle Zwane in the Unmanned Aerial Vehicle Laboratory where he is designing the wing of a hydrogen-powered unmanned aerial vehicle.



can succeed." Zwane believes that one also needs professional humility, respect for others and a strong work ethic to be successful.

He adds that the profession is still male dominated and that the CSIR is keen to attract more women to this domain.

"My immediate goal is to make meaningful contributions in the development and implementation of new technologies in the South African aeronautics industry," Zwane says when asked about his plans for the future. "I also intend to pursue a Master's in aeronautical engineering in the near future."

ENQUIRIES:

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lzwane2@csir.co.za

CAREER TYPE: PHYSICIST

RELATED CAREERS
Photonics researcher, laser scientist, data scientist

ACADEMIC HISTORY
- BSc, University of KwaZulu-Natal, 2007
- BSc (Hons), University of KwaZulu-Natal, 2008
- MSc (Physics), specialising in lasers, University of KwaZulu-Natal, 2012
- PhD (Physics), specialising in lasers, University of Stellenbosch, 2015

THE FOODIE WHO FELL FOR PHOTONICS

His career considerations included being a chef at his own restaurant, managing a sports team or running a car company as the CEO, no less. But fortunately, it was science that won Dr Darryl Naidoo over, years ago. Today, he heads a team at the CSIR focusing on the development of novel laser systems.

It was attention-grabbing exposure to physics in his first year at university that hooked Dr Darryl Naidoo on creating, building and working with light. "Critical thinking and problem solving are aspects that I look for in a job – how to improve and efficiently run a business, for example," he says. "But building lasers is also a dream job; it is challenging, rewarding and fun."

The CSIR Photonics Centre is home to a range of experts in photonics and spectroscopy, working in fields such as biophotonics, mainly health and diagnostic tools; additive manufacturing, using a range of materials; and laser-based applications such as surface refurbishment, welding and cutting, and other light-based systems.

At present, Naidoo and his team are working on a laser system for sorting diamonds. The laser is used to detect whether a substance is a diamond or not. This is done for diamonds at a variety of carats and is based on the principle of Raman spectroscopy, in which a sample is analysed by using light to create (excite) molecular vibration and then interpreting this interaction. The work is done under contract for a large mining company looking to deploy the system in Africa.

> IT IS A MISCONCEPTION THAT YOU HAVE TO BE EXTRAORDINARILY INTELLIGENT TO WORK IN THE FIELD OF LASERS. IT'S ALL ABOUT HARD WORK, DEDICATION AND THE WILLINGNESS TO LEARN.
>
> *– Dr Darryl Naidoo*

"Using lasers to identify diamonds is not new," Naidoo comments. "But we have found ways to make the system more efficient in its interaction with matter."

One of Naidoo's top achievements was building a fractal laser. "Fractals are one of nature's most beautiful phenomena, found on physical objects like snowflakes or certain seashells – even Romanesco broccoli," Naidoo says, bringing in his love of gourmet food once more.

The CSIR's Dr Darryl Naidoo is an expert in the use of light for a variety of applications.

Watch the video!

"We demonstrated that light can also be fractal," he adds. "Building and demonstrating this concept with a laser was challenging but has exposed new approaches in using lasers for sensing in astronomy and gases."

"The pleasure of this job is seeing your ideas come to life," Naidoo insists. "There's no better feeling than having an idea and making it work. And with very high-quality work, it gets recognised in high-impact journal articles and even mainstream news," he adds.

And challenges? "The biggest challenge is accepting failure. We fail 80% of the time but work for the 20% of success," he says. "It's challenging to remain motivated, but failing is a learning experience that helps you get better in the future!"

The first steps along this journey started with strong skills in maths and physics in grade 12. Additional courses in coding, entrepreneurship and even marketing helped to convey and explain the intricacies of science to clients and users. "The ability to present and communicate your work to other scientists or even the public is a very important skill," Naidoo emphasises.

He says personal traits that will go a long way in this job include attention to detail, self-motivation, patience and not being too critical of oneself. "The willingness to learn and adapt is also critical. The quicker you adapt to new scenarios, the greater success you will have. During the Covid-19 lockdowns, it was impossible to build lasers while sitting at home, but it also showed the team other ways of being efficient and coming up with new ideas that were relevant to the pandemic."

South Africa has a strong research platform in physics and the work is considered among the very best in the world. Yet, it remains a niche job. The countries that lead this field globally are China, Germany, Japan and the United States of America (USA).

He recommends joining professional bodies such as Optica, the Society of Photo-Optical Instrumentation Engineers, an international not-for-profit professional society for optics and photonics technology, and the Institute of Electrical and Electronics Engineers, which is based in the USA but has chapters around the world, including South Africa.

When asked about his role models, his mother and sister top the list. "Having someone by your side makes a huge difference," he says. "Professionally, my MSc and PhD supervisor, Prof. Andrew Forbes, was both a role model and mentor who really helped me grow. My colleagues also inspire me."

Naidoo says the age of electronics is slowly being taken over by the age of photonics. "The internet is all light-based now – self-driving cars use light, industrial manufacturing uses high-power lasers, and the list goes on. Then there are quantum computers, the internet of things and the fourth industrial revolution," he says.

"Light and lasers play a massive role in our everyday lives without us even knowing the extent. It's certainly a field for the future and being a part of it now will ensure opportunities in the future."

ENQUIRIES:

>> Dr Darryl Naidoo
dnaidoo3@csir.co.za

CAREER TYPE: INDUSTRIAL ENGINEER

RELATED CAREERS
Engineer, business engineer, process engineer, product engineer

ACADEMIC HISTORY
- BEng (Industrial Engineering), University of Pretoria, 2018
- BEng (Hons) (Industrial Engineering), University of Pretoria, 2019
- MEng (Industrial Engineering), University of Pretoria, 2021

A RESEARCHER'S INDUSTRIOUS JOURNEY TO PROBLEM-SOLVING

Like many South Africans, Anieke Swanepoel finds herself stuck in traffic caused by too few options for moving and transporting goods. Unlike many South Africans, Swanepoel has the opportunity, as an industrial engineer at the CSIR, to change this by devising plans to resolve the issue. She is part of the CSIR team that is looking into building a repository that will serve as a central database for all things transport and logistics for South Africa.

Anieke Swanepoel is the perfect example of how the CSIR grows researchers who have scarce skills through a development pipeline. Her industrial engineering studies were funded through the organisation's bursary programme. She then joined the organisation as part of the Graduate-in-Training Programme and today tutors and mentors young graduates who are part of the Youth Employment Services Programme.

Swanepoel admits that making the switch from computer engineering to industrial engineering halfway through her studies was not an easy decision. However, she knows it was the right decision for her.

> "SOME FELLOW STUDENTS LOOKED DOWN ON INDUSTRIAL ENGINEERING BECAUSE YOU DON'T SPECIALISE IN A PARTICULAR THING, BUT IT'S THAT FLEXIBILITY THAT ATTRACTED ME TO IT."
>
> *– Anieke Swanepoel*

"Some fellow students looked down on industrial engineering because you don't specialise in a particular thing, but it's that flexibility that attracted me to it," she says.

Industrial engineers look at simplifying complex processes, systems or organisations. They work on developing, improving and implementing integrated systems of people, information and equipment by using data and mathematical calculations.

Swanepoel is excited about the projects she is working on. One of them involves creating a logistics observatory. This will be a

central database related to the transport and logistics industry, looking at data around the ease of movement on South Africa's transport networks, including its borders. The aim of the project is to allow different users in the sector to extract information that helps in their decision-making.

On the future of industrial engineering, Swanepoel says, "I've never encountered a problem or project that does not require the expertise of an industrial engineer. Our studies equip us with a multitude of skills, from technical to soft skills.

We are currently developing the ILIMA mobile application, which utilises technologies from the fourth industrial revolution. The app will assist small-scale farmers with reaching more market opportunities through increased visibility and supply chain traceability," she says.

ENQUIRIES:

>> Anieke Swanepoel
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The CSIR's Anieke Swanepoel is part of a team that is developing a mobile app that assists small-scale farmers with reaching more market opportunities through increased visibility and supply chain traceability.

CAREER TYPE: MECHATRONICS ENGINEER

RELATED CAREERS
Robotics engineer, electro-mechanical engineer

ACADEMIC HISTORY
- BEng (Mechatronics), Nelson Mandela University, 2018
- MEng (Mechatronics), Nelson Mandela University, 2020

REVOLUTIONISING INDUSTRY: MAKING MACHINES SMARTER AND MORE EFFICIENT

Mechatronics engineering is a rapidly growing field that combines the principles of mechanical engineering, electrical engineering and computer science to create advanced systems and devices. Mechatronics engineers play a critical role in designing, developing and controlling these systems, which are used in a wide range of industries such as robotics, industrial automation, medical technology and transportation.

Kyla Purdon is a mechatronics engineer who is at the forefront of developing cutting-edge technology for mobile robotics. With a passion for innovation and dedication to her field, she has made significant contributions to the autonomous navigation and mapping field.

Purdon's most recent project is a mobile robotic platform called Voyager. Voyager was designed to map an area quickly and efficiently. The platform is equipped with a variety of sensors and cameras that allow it to gather detailed information about its surroundings. This information can then be used to create accurate three-dimensional maps of the area, which can be used for a wide range of applications such as navigation, search and rescue, and surveying.

The robotic platform is also equipped with advanced algorithms that enable it to navigate through challenging terrain and environments with ease. The technology has the potential to greatly improve efficiency in industries such as mining, construction and agriculture, where workers often have to navigate dangerous or difficult-to-reach areas.

Purdon's team is now working on the robotic platform's autonomous driving aspect, allowing it to navigate to predetermined locations and complete tasks autonomously. This technology has the potential to revolutionise transportation and logistics, as autonomous vehicles can complete tasks quicker and more efficiently than human drivers.

A related field is the development of drones or unmanned aerial vehicles, which have had a significant impact on a variety of industries and applications such as search and rescue, surveillance, firefighting, photography and mapping. "Drones have the potential to revolutionise many industries and improve our daily lives and it is fulfilling to be part of the CSIR team that develops these innovations," she says.

Her dedication and passion for her work are evident in her numerous projects and industry partnerships. Her contributions to the field have not only advanced the capabilities of the CSIR in this field but have also pushed the boundaries of what is possible with autonomous technology.

The CSIR's Kyla Purdon assembles a mobile robotic platform used for mapping (above) and a sensor payload (for her PhD) using lidar and a camera for mapping and 3D object detection (right).

"One of the key challenges facing mechatronics engineers is the need to seamlessly integrate mechanical, electrical and computer systems to create a cohesive and efficient whole. Mechatronics engineers use a variety of tools and techniques such as control systems theory and programming languages to design and develop systems. This is a growing industry with ample opportunity to learn new things," she says.

Purdon says that young mechatronics engineers should learn that they will make mistakes along the way, but that it is important to learn from these mistakes and avoid making them again. She quotes Bill Ackman, who famously said, "Experience is making mistakes and learning from them."

ENQUIRIES:

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kpurdon@csir.co.za

CAREER TYPE: MECHATRONICS ENGINEER

RELATED CAREERS
Electro mechanical engineer, robotics engineer, automation engineer, mechanical design engineer, software engineer

ACADEMIC HISTORY
- BSc (Electronics), University of KwaZulu-Natal, 1996

BLENDING MECHANICS, ELECTRONICS AND SOFTWARE TO CREATE INNOVATIVE SOLUTIONS

Danny Naicker has always had a love for solving problems. Growing up, he was intrigued by the way things worked and would often take things apart to understand their inner workings. This passion led him to pursue a career in engineering. Now, as a fully fledged engineer, Naicker applies his problem-solving skills to real-world challenges and creates innovative solutions.

Danny Naicker is a highly skilled principal mechatronics engineer specialising in developing electromechanical systems. With a strong background in mechanical engineering, electrical engineering and computer science, he is well-equipped to tackle the complex challenges that come with designing and building these systems.

"As an engineer, my job involves helping people solve problems through technology and it is great to see one's efforts adding value and making a difference," he says.

> "IT'S INCREDIBLY SATISFYING TO SEE MY DESIGNS COME TO LIFE AND TO KNOW THAT I'M CONTRIBUTING TO SOMETHING THAT COULD HAVE A REAL IMPACT ON THE WORLD."
>
> *– Danny Naicker*

CONDITION MONITORING FOR LOCOMOTIVES

In one of his most recent projects, he led the development of a condition monitoring system for locomotives. Conditioning monitoring systems are designed to track the performance and health of equipment such as locomotives. This information is used to predict when the equipment will require maintenance and to identify any potential issues before they become critical.

The system Naicker and his team have developed for locomotives is unique in that it is locally manufactured and supported, and combines various interfaces to sensors and data analysis techniques that may be implemented directly on the system to provide a comprehensive view of the locomotive's health.

His work on this project was instrumental in helping Transnet improve the reliability and safety of its locomotives. By identifying potential issues before they occur, Transnet will be able to reduce the number of unexpected breakdowns and costly repairs. Additionally, the system aims to help reduce the locomotives' downtime and increase their lifespan.

A JOB WORTH DOING

"Every day, I'm excited to come to work and try out new things. Whether it is building a new system from scratch or testing out a new component, there is always something new and exciting to work on. Being a mechatronics engineer means I get to design, build and test advanced systems that integrate mechanical, electronic and software components. It's incredibly satisfying to see my designs come to life and to know that I'm contributing to something that could have a real impact on the world."

"My belief is that I was born in this country to serve it and if I were to go abroad to further my skills, I would bring that knowledge back and use it in this country," he says.

CSIR principal engineer Danny Naicker with the locomotive condition monitoring system that he has helped design. It tracks the performance and condition of locomotives.

ENQUIRIES:

>> Danny Naicker
dnaicker@csir.co.za

CAREER TYPE: BIOMEDICAL ENGINEER

RELATED CAREERS
Biomedical scientist, medical technology developer

ACADEMIC HISTORY
- BEngSc (Biomedical Engineering), University of the Witwatersrand, 2011
- BSc (Electrical Engineering), University of the Witwatersrand, 2013
- MSc (Biomedical Engineering), University of the Witwatersrand, 2015

WHERE ENGINEERING AND BIOLOGY MEET: NEW MOBILE DIAGNOSTIC TOOLS

Charita Bhikha is a biomedical engineer. She spends her time coding, designing electronics and developing systems that analyses ultrasound patterns from medical devices. She is part of a team of researchers who design and build portable screening tools to help healthcare workers in rural and peri-urban areas diagnose high-risk pregnancies or heart conditions, quickly.

Like any high school learner, Charita Bhikha found choosing what to study and do for the rest of her life a daunting choice. "In high school, I couldn't decide on whether to choose medicine or engineering." An open day at a university in Johannesburg led her to a degree that married the two. She studied biomedical engineering at the University of the Witwatersrand, later focusing on image processing and algorithm development.

Bhikha joined the CSIR in 2017 as a researcher and, within three years, became a senior researcher in a CSIR group focusing on industrial sensors. Her software and electronic design skills make her an invaluable part of the team, as she can design and develop medical devices. These are skills that were outsourced to

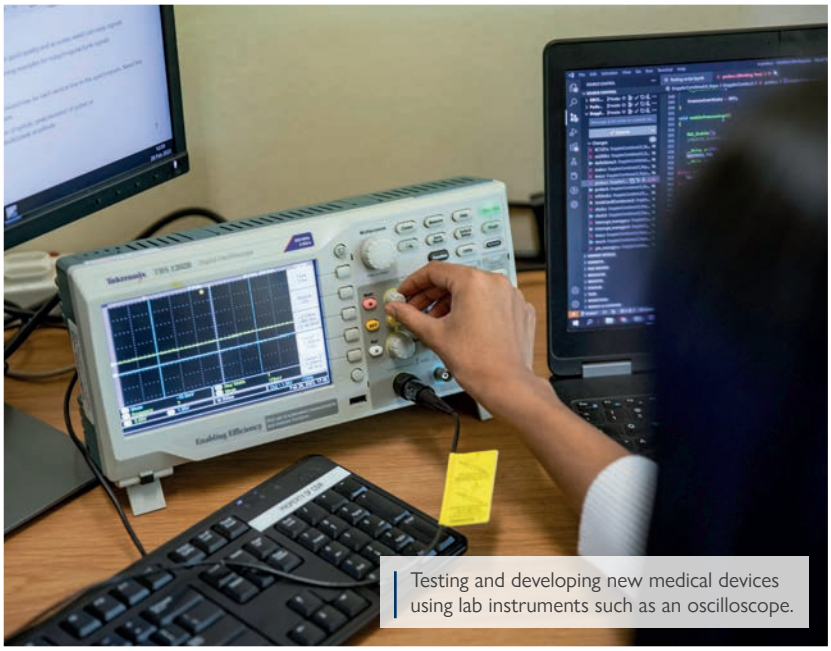
(continued on page 53)

"I GET TO WORK ON THE DETAILED DESIGN OF THE ELECTRONICS AND SOFTWARE AND SEE HOW THESE DEVICES WORK IN THEIR INTENDED AREAS."

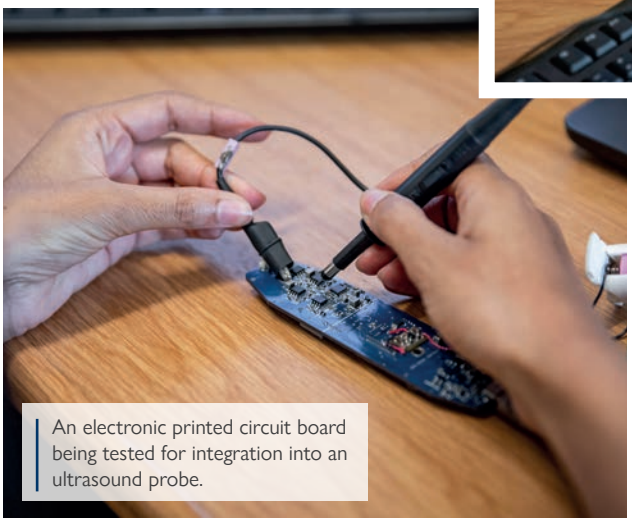
– Charita Bhikha

The University of the Witwatersrand describes biomedical engineering as: "Applying engineering and other quantitative sciences to solving medical and biological problems, such as developing sophisticated X-ray imaging systems, artificial organs, image recognition systems, and medical devices, and providing a quantitative understanding of disease processes."

The Cardiflo ultrasound system is used for the early detection of cardiovascular disease.



Testing and developing new medical devices using lab instruments such as an oscilloscope.



An electronic printed circuit board being tested for integration into an ultrasound probe.

The Umbiflow Doppler ultrasound device being used in a clinic to screen a pregnancy, ensuring fetal well-being.

international researchers in the past. "I get to work on a detailed level of the design of the electronics and software and also see how these medical devices work in their intended areas – usually under-resourced healthcare centres," she says.

Bhikha is currently working on portable medical devices that make use of noninvasive ultrasound technology. One, called Cardiflo, is used to screen for cardiovascular disease in patients and the other, called Umbiflow, to assess fetuses considered to be small for their gestational age at the primary point of care. These two devices offer capabilities that are typically fulfilled by high-tech equipment found in large hospitals.

A FUTURE OF AUTOMATED DIAGNOSIS

Although biomedical engineering is still a new field in South Africa, Bhikha believes that there will come a time when fourth industrial revolution applications will change the way she works. "Automated diagnosis where a device can look at an X-ray or ultrasound and diagnose a patient will help medical workers in finding conditions that may be missed by the human eye," she concludes. Her personal development plans include upskilling to artificial intelligence and deep learning. She believes that these skills will add another layer to her role, which is to develop medical devices to improve human health.

ENQUIRIES:

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CAREER TYPE: METALLURGIST

RELATED CAREERS
Materials scientist, foundry technologist, metallurgical engineer

ACADEMIC HISTORY
- NDip (Engineering Metallurgy), University of Johannesburg, 2009
- BTech (Engineering Metallurgy), University of Johannesburg, 2010
- MSc (Materials Science and Technology), Technische Universität Bergakademie Freiberg, Germany, 2014
- PhD (Engineering Metallurgy), University of Johannesburg, 2021

METAL-MAKER EXTRAORDINAIRE CRAFTS UNIQUE MATERIALS FOR IMPLANTS

One of the biggest challenges in the field of implant materials is finding a balance between cost and performance. Biomaterials, such as titanium and ceramic, are often used in implant procedures because of their biocompatibility and strength. However, these materials can be very expensive, putting the medical devices made from these materials out of reach of many patients. Dr Lerato Raganya's research focuses on finding alternative materials that can provide similar performance at a lower cost.

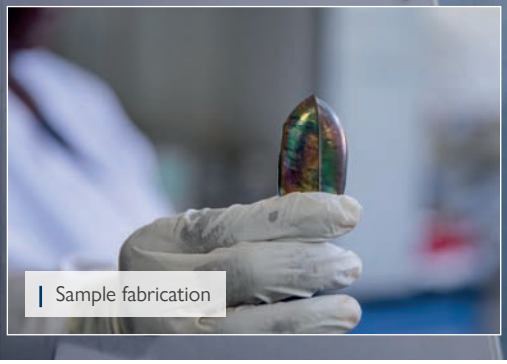
Dr Lerato Raganya is a metallurgist who has devoted her career to developing low-cost implant materials. Implant materials are used in a variety of medical applications, including joint replacements, dental implants and facial reconstruction. These materials must be biocompatible, strong and durable, yet also affordable for patients and healthcare systems.

> "MY JOB AS A METALLURGIST IS NOT JUST ABOUT CREATING NEW MATERIALS, BUT DOING SO TO IMPROVE THE LIVES OF PEOPLE IN NEED OF IMPLANT MATERIALS."
>
> *– Dr Lerato Raganya*

METAL-MAKER GOING ABOUT HER CRAFT

"Metallurgists are like bakers. They work with ingredients, and in our case, the ingredients are metallic materials. For alloy development, we use metallic powders as our starting materials. We blend them and then compress them into a solid, pressed powder. We melt them and allow the new alloy to solidify into a solid product. Once completed, we take the product to a

Watch the video!


Sample fabrication

Alloy preparation


Metallographic preparation for microstructural analysis

metallographic lab for grinding and polishing and eventually end up with solid-material product. We can then look at its structure using a microscope to study the features and determine whether or not we have a product we were initially aiming for," she says.

A FOCUS ON BIOMATERIALS

Raganya's research focuses specifically on metal alloys, such as titanium alloys, that can be produced at a lower cost than traditional implant materials.

"In an effort to reduce the impact of diseases affecting young and old people globally, my team and I develop alternatives to conventional biomaterials. To do this, we look at processes such as alloy fabrication, heat treatments, microstructural characterisation, mechanical testing and corrosion analysis. These can be 3D printed, reducing costs and lowering the barrier to this type of medical support," says Raganya.

Her work has the potential to greatly impact the field of implant materials. By developing low-cost alternatives, she is helping to make these materials more accessible to patients and healthcare systems, particularly in resource-limited settings. Her research also highlights the importance of sustainability in the development of medical technologies.

IT ALL STARTS WITH ACCESS TO SCIENCE AND MATHEMATICS

She is a passionate advocate for increasing access to science, technology, engineering and mathematics for girls and boys in rural areas in Africa. She has worked with non-profit and corporate organisations to provide funding to local learners in need and has also financially supported undergraduate students under her supervision with her National Research Foundation (NRF) funding.

She urges young researchers to explore funding opportunities and contact organisations such as the NRF, which provides students and researchers with funding to conduct research in areas that knowledge gaps have been identified.

ENQUIRIES:

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CAREER TYPE: GEOSCIENTIST

RELATED CAREERS
Mining geologist, engineering geologist, geotechnical engineer, rock engineer

ACADEMIC HISTORY
- BSc (Geology) University of the Witwatersrand, 2012
- BSc (Hons) (Geology) University of the Witwatersrand, 2013
- MSc (Geology) University of the Witwatersrand, 2016

UNDERSTANDING WHAT LIES BENEATH EARTH'S SURFACE

Fascinated by the idea of designing and constructing structures that can withstand the forces of nature and support human activity, Zamaswazi Nkosi grew up believing that she would find her footing in the civil engineering field someday. However, as she progressed through her education, she found herself drawn more toward the study of geology and Earth sciences and realised that her love for science, data analysis and environmental issues aligned better with a career in geoscience.

In her job as geoscientist at the CSIR's mining cluster, Nkosi focuses on rock engineering, geology and geophysics. She is passionate about using her abilities to resolve problems in the mining sector. She believes that geoscientists must be able to adapt to and adopt new technologies, methods, processes and discoveries. "I contribute to the development and use of high-resolution geophysical tools such as 3D and 2D ground-penetrating radar and explore their applicability in addressing mining challenges," she says.

Professionalism and hard work are enshrined in her upbringing, as her parents – who were successful in their own career fields – were a source of consistent support in her pursuit of her goals and interests. Nkosi's parents shaped her interests and values and instilled in her a love of learning and critical thinking. Her supervisor and professor, who encouraged her to push boundaries and pursue her passions, also played an integral role in carving out her career journey.

> "A COMMON MISCONCEPTION IS THAT GEOSCIENTISTS IN THE MINING INDUSTRY ARE ONLY CONCERNED WITH EXTRACTING AS MUCH ORE AS POSSIBLE, WITHOUT REGARD FOR ENVIRONMENTAL OR SOCIAL IMPACTS."
>
> *– Zamaswazi Nkosi*

Nkosi studied mathematics, physical science, geography, engineering graphics and design in high school, which enabled her to enrol in engineering studies at university level. She believes that analytical thinking is a key trait required when opting for a career in geosciences. "Geoscientists need to be able to analyse

The CSIR's Zamaswazi Nkosi holding a drill core sample to be analysed in a rock strength testing machine.

large amounts of data to understand geological patterns and predict mineral reserves; they must be able to think critically and logically," she asserts. Coupled with this trait, she believes that a geoscientist should have strong communication skills, perseverance, strong ethics and be a team player.

As part of her project obligations at the CSIR, Nkosi makes use of specialised technology for underground support and mapping. She also develops and tests alternative underground support suitable for current and future mines. Wearing her rock-engineering cap, likewise, she assists with the development and assessment of technologies that support efficient mine design layouts.

Constant industry developments have encouraged Nkosi to remain on the cutting edge of her field through continuous research. One of the ways through which she achieved this, was becoming part of prominent professional bodies in her field. She is a member of the Geological Society of South Africa and the South African Council for Natural Scientific Professions.

"Anyone interested in pursuing a career as a geoscientist in the mining industry should remain curious, adaptable and committed to ongoing learning and development, as the sector is constantly changing, and new technologies and methodologies are emerging all the time," she states.

Nkosi has received funding for her work from the Department of Science and Innovation-National Research Fund (NRF) Centre of Excellence for Integrated Mineral and Energy Resource Analysis Fund and the NRF-CSIR Young Researchers Establishment Fund. In 2022, she received the Emerging Researcher Award at the CSIR Future Production: Mining Excellence Awards.

At the heart of Nkosi's aspiration is the desire to support the CSIR's innovation roadmap strategy for mining by keeping abreast of the latest developments in geoscience technologies, as well as working collaboratively with key stakeholders for the sustainability of the mining sector. She also seeks to complete her PhD in geophysics and rock engineering and deepen her understanding of the mineral resources sector in the mining context.

ENQUIRIES:

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CAREER TYPE: MINING ENGINEER

RELATED CAREERS
Rock engineer, geologist

ACADEMIC HISTORY
- BSc (Mining Engineering), University of the Witwatersrand, 2015
- Blasting certificate for hard rock metalliferous mines, Department of Mineral Resources and Energy, 2017
- Advanced certificate in mine environmental control, Minerals Council of South Africa, 2018

A THIRD-GENERATION MINE EXPERT PURSUES HIS DREAM OF MAKING A DIFFERENCE IN MINING

Growing up, Vuyo Tsotsotso found inspiration from his grandfather and uncle who worked in the mining industry for decades. Although he knew that his career would be in the mining domain, he wanted to do something that would impact the mining industry across the country – an ambition that led to his career in scientific research. Although he drew inspiration from his uncle and grandfather, his mother, a teacher and journalist, influenced his awareness of research.

Vuyo Tsotsotso formulates, plans and implements mining-related project work aligned with the CSIR's mining strategy. To help improve occupational health and safety, productivity and efficiency in mines, Tsotsotso and his colleagues re-imagine future mining solutions through research, development and innovation.

"It's amusing – most people don't believe that I have always wanted to be a researcher in the mining sector," he chuckles.

> "I AM SET ON MAKING AN IMPACT IN THE SOUTH AFRICAN MINING INDUSTRY, AS OPPOSED TO WORKING AT A SINGLE MINE. THIS HAS LED ME TO A CAREER IN RESEARCH."
>
> *– Vuyo Tsotsotso*

One of Tsotsotso's career highlights has been leading the Isidingo Drill Challenge, which entailed addressing challenges with traditional drill technology employed in South African gold and platinum group metal mines. The core aim was to improve the efficiency and safety when drilling in mines, while concurrently creating new opportunities for local original equipment manufacturers in the mining value chain.

The initiative ultimately delivered two rock drill units that are lighter, safer and drill faster. "It was humbling to be part of an

Above: CSIR engineer Vuyo Tsotsotso. Left: The core body temperature monitor is used for heat stress management in the mining industry.

initiative that rendered products that will enhance the local mining sector," he says.

Tsotsotso believes that mathematics and physical science are the cornerstones of a career in scientific research and that these subjects formed a significant basis for his own development. However, he also believes that participating in the arts and sports could invoke creativity and curiosity, which could translate well in scientific fields where novel solutions have to be found.

"The most common misperception is that being a researcher is a repetitive, desk-based job that has little to no fieldwork," he says. "Once people hear the word 'researcher', they assume that the job just entails a lot of reading and writing and nothing more specialised than that."

Instead, he says, the job entails a lot of fieldwork at mines, as well as stakeholder engagement, a requirement needed to stay in touch with changes and operational matters in the mining sector. He advises that those who are interested a mining research career should have a solid, practical and theoretical background in mining.

The quest to be at the forefront of the fourth industrial revolution (4IR) in the mining industry is a dream that Tsotsotso takes seriously. He reveals that the introduction of 4IR technology has expedited the mechanisation and automisation potential of mining operations. This has the potential to significantly optimise mining, improve health and safety by removing or protecting mine workers from otherwise hazardous environments and ultimately reduce operating costs.

Tsotsotso is currently studying towards becoming a fully accredited occupational hygienist with the South Africa Institute of Occupational Health.

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CAREER TYPE: GEOPHYSICIST

RELATED CAREERS
Rock engineer, geologist, image processing specialist

ACADEMIC HISTORY
- BSc (Hons) (Geophysics), University of Pretoria, 1993
- MSc (Geophysics), University of Pretoria, 1997
- PhD (Geophysics), Lancaster University, United Kingdom, 2009

TECH ADVANCES BOOST GEOPHYSICISTS' ABILITY TO SEE WHAT LIES BENEATH

A high school teacher's enthusiasm inspired Dr Michael van Schoor to pursue a career in science. Today, as a CSIR principal researcher, he specialises in mining geophysics.

Geophysics can be used to locate or image a variety of buried features, in varied applications, for example, utilities, subsurface cavities, archaeological structures, clandestine burials, tree roots and soil profiles. In support of the CSIR's mining clients, Van Schoor and his team are often called upon by companies that want to understand the geometry and characteristics of an orebody or to determine the presence of unseen hazardous geological structures ahead of the mining face that could impede extraction or compromise the safety of mineworkers.

Rapid advances in drone technologies, light detection and ranging have brought added capabilities to the field of geophysics. Areas and sites that are large or difficult to access can now be mapped in more detail and faster than before. While the introduction of such technologies also implies the creation of larger data sets, fields like machine learning and artificial intelligence are also being used more and more to assist in the analysis of these large data sets.

"Emerging geophysical technologies are coming to the fore to address long-standing problems in mining," he says. "For example, we can use ground-penetrating radar to assess the stability and integrity of hanging walls, which form the roof of an underground excavation." Another example is the use of electrical resistance tomography for mapping slump structures and other intrusive geological structures, which disrupt the continuity of the orebody ahead of the mining face.

Van Schoor cautions on misperceptions about geophysics, which have been exaggerated in popular media such as films and television shows. "For example, it was suggested in the film Jurassic Park that seismic imaging can be used to 'see' a buried dinosaur skeleton at depth in great detail," he says. "The reality is that every geophysical method has its own strengths, weaknesses and limitations."

Another misperception is that the performance of geophysical imaging can be directly compared to that of medical imaging. "In the case of medical imaging, much higher mapping accuracies are possible by, for example X-ray or sonar because the basic interior structure of the body is already well constrained and understood and because medical subjects can be targeted with

Dr Michael van Schoor led a team of CSIR mining experts who authored a book on deep-level gold and platinum mining.

measurements from many sides and angles, with better coverage than is generally possible in Earth sciences," he says. Youngsters who are intrigued by what lies beneath the Earth's surface would need to excel at mathematics and physics. Computer studies that include coding would also be beneficial.

The CSIR has embarked on a strategic drive to support the modernisation of the mining sector by harnessing new technologies and capabilities. "We are constantly trying to introduce new and exciting emerging technologies," Van Schoor says. "Much of our research efforts centres on the integration of different technologies since the integrated use of multiple technologies generally increases the problem-solving capability when compared to using just a single technology."

Does that mean that geophysicists can go around spotting gold and diamonds? Unfortunately, not. Van Schoor explains, "We often detect minerals indirectly, for example, we could possibly detect a quartz vein that contains gold, not because of the gold but because the quartz vein offers a physical contrast with the host rock or because the associated minerals, such as sulphides, have a distinctive geophysical signature," he says. "The same is true for diamonds. We can delineate kimberlite zones within other rocks, but not the actual diamonds."

ENQUIRIES:

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CAREER TYPE: MOLECULAR BIOLOGIST

RELATED CAREERS
Geneticist, biologist, microbiologist, biotechnology researcher

ACADEMIC HISTORY
- BSc (Chemistry, Molecular and Physiological Biology) (cum laude), University of Namibia, 2007
- MSc (Applied Molecular Biology) (cum laude), University of Namibia, 2009
- PhD (Molecular Biology) (cum laude), University of Namibia, 2014

PERSONALISED MEDICINE FOR AFRICAN PATIENTS

Dr Mutsa Takundwa always knew that she wanted to help improve people's health. Naturally, she thought being a doctor would give her this opportunity. But after falling ill during her first practical, when she had to dissect a sheep's lung, she realised that medicine was not her path. Instead, she found her way into molecular biology.

CSIR senior researcher Dr Mutsa Takundwa uses automated equipment to rapidly test millions of cancer cell samples for biological activity. The process is called high-throughput screening and is used in, especially drug discovery.

On what a typical day in her field of work looks like, she says, "We extract cancer cells from patient samples and run these cells through high-throughput screening and our library of approximately 750 drugs, to see which drug will kill different cancer cells in individual patients."

Takundwa says that the data from these tests can help them better advise doctors on whether the prescribed medication is working or if another course of treatment should be prescribed. This personalised approach to prescribed medicine is done with the aim of finding the correct drugs to avoid adverse drug reactions, such as an allergic reaction or other reactions that can lead to hospitalisation. Her team has found that such reactions are more common in the African population because most clinical trials are conducted in Europe and the Americas.

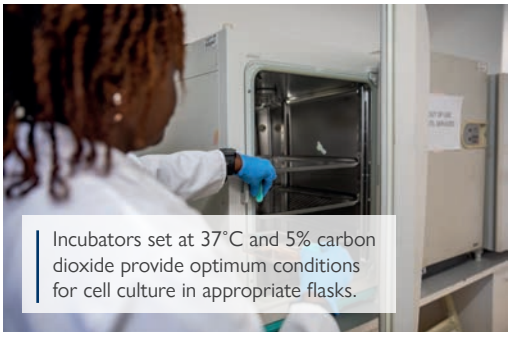
> "THERE IS DEFINITELY A SHIFT FROM THIS ONE-SIZE FITS ALL APPROACH TO MORE PERSONALISED AND PRECISE MEDICINE TO IMPROVE SURVIVAL RATES."
>
> *– Dr Mutsa Takundwa*

Takundwa says that her earlier choice to become a doctor was influenced by her lack of knowledge of the vast field of medical research. "During my time as a student at university, I became more aware of the evolution of medicine – and not only in a clinical setting – and realised that it was accessible to more women of colour," she says.

She adds that today's budding researcher will enter a space centred on an individual's medical journey, driven by data. The team is looking to create a repository of data from a variety of cancer types, including ovarian and breast cancer, which have

Dr Mutsa Takundwa grows patient cancer cells from the resected tumor in the lab and views it under the microscope to establish growth patterns.

Optimsed media is used to grow cells under laminar flow and sterile conditions in a tissue culture lab.



Incubators set at 37°C and 5% carbon dioxide provide optimum conditions for cell culture in appropriate flasks.

Pipetting for cell counts with trypan blue exclusion assay and haemacytometer.

increasingly affected the African population in recent years. Takundwa says molecular biologists work with large volumes of samples, so hard skills such as being precise and paying attention to detail are important in her field of work. However, it's the soft skills, such as empathy and being a team player, that are vital.

The future of molecular biology is evolving rapidly, with high-throughput platforms being able to analyse more samples and give researchers deeper insight into how patients react to medication at a faster rate, thus improving the time it takes to give them proper treatment.

ENQUIRIES:

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CAREER TYPE: BIOCHEMIST

RELATED CAREERS
Materials scientist, biomedical scientist, medical scientist

ACADEMIC HISTORY
- BSc Hons (Biochemistry), University of Limpopo, 2012
- MSc (Biochemistry), University of Johannesburg, 2016
- PhD (Biochemistry), University of Pretoria, 2020

RELIEVING THE BURDEN OF DISEASE THROUGH NANOTECHNOLOGY

Dr Valentine Saasa, a CSIR biochemist, uses her chemistry training and expertise in nanomedicine and materials to find pain-free diagnostic methods for different diseases, such as cancer and diabetes mellitus, using human breath.

Dr Valentine Saasa is a rising star in the biochemistry field, with career highlights that are earning her recognition from more established researchers and colleagues. Her most notable achievement to date is working on a diabetes mellitus breathalyser, which is in the process of being taken up by an industry partner for commercialisation. The innovation is currently undergoing clinical trials.

In 2019, Saasa was selected along with other young South African scientists to attend the Lindau Nobel Laurette meeting in Germany, a prestigious event where 2 000 young scientist from around the globe engage with 200 Nobel Laurette winners for a week. She was also acknowledged by the President of South Africa, Cyril Ramaphosa, during a parliamentary council meeting in 2018 for her work on the breathalyser technology that monitors and diagnoses diabetes mellitus using human breath instead of blood. The project has the potential to revolutionise the health sector in South Africa.

MISCONCEPTIONS ABOUT BIOCHEMISTRY

There are misconceptions about every career, Saasa points out. She says the misconception about being a biochemist and a woman is that you only focus on your career to succeed and, in the process, abandon all other aspects of your life.

"It is possible to be a woman scientist, a wife, a mother and a pro-active member of your community. You do not have to choose one over the other; it is a matter of balancing your life overall," she says.

She advises people who are interested in this career to be ambitious and go after what they want, as it is possible and doable.

She says, "It is important to find a mentor who is in a field similar to the one to which you want to be exposed. Mentors are experienced people who walked the journey before you and they will make your transition easier and guide you on the best career options."

The CSIR's Dr Valentine Saasa synthesising nanosensors for use in medical diagnostics.

CAREER DEVELOPMENT IN NANOSCIENCE

The rise of nanotechnology has transformed industries ranging from consumer electronics to textile manufacturing and cosmetics by unlocking new materials and processes at the nanoscale.

Nanotechnologies can significantly improve medical diagnostics by making them less expensive and convenient. Saasa cites smart pills as an example, as they enable doctors and patients to monitor a staggering number of diseases.

"The way a smart pill works will depend on the disease it is meant to treat or diagnose. In general, smart pills use nanoscale sensors that are designed to detect the presence of disease before the symptoms may be apparent to the patient, alternatively the patient can be treated using nano-based devices," she says.

Saasa enthuses over the potential of nano-based devices that can help patients who suffer from diseases that require daily monitoring. She cites diabetes as an example, a disease that affects more than 450 million people globally.

"The primary method of managing and monitoring diabetes requires patients to use a needle-based glucose monitor several times per day, which is painful and inconvenient and can also lead to infections. We monitor the disease using nano-based devices, which require human breath instead of blood.

"As a product of mentorship and great supervision, I believe that it is also my responsibility to mentor or supervise young researchers so that they become great scientists, researchers and/or innovators through Master's and PhD student supervision as a way of developing others and increasing the number of scientists, especially black scientists," she concludes.

ENQUIRIES:

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CAREER TYPE: BIOTECHNOLOGIST

RELATED CAREERS
Agricultural and food science technologist, biomanufacturing engineer, microbiologist, biochemist

ACADEMIC HISTORY
- BTech (Biotechnology), Tshwane University of Technology, 2008
- MSc (Biotechnology), Tshwane University of Technology, 2020

BIOTECHNOLOGY: AGRICULTURAL SCIENCE'S NEXT BIG THING

Every farmer's step begins with evaluating the soil. Man-made interventions such as fertilisers, soil tillage and pesticides provide good short-term results, but have a long-term negative impact on the environment. As a result, there is a shift from these interventions to developing agricultural biological and environmentally friendly agents, drawing on fungi and bacteria.

CSIR senior researcher Yrielle Roets-Dlamini works in bioprocess development, focusing on the development of agricultural agents such as biofertilisers and biocontrol products that contain active biological agents (bacteria). She develops growing processes for microorganisms of interest and formulating them into market-ready products.

CAREER JOURNEY

Roets-Dlamini's journey at the CSIR is the epitome of growth and development – from an intern to a senior researcher: "I joined the CSIR as an intern, rose through the ranks and completed my MSc, which allowed me to become a senior researcher. I am now looking forward to commencing with my PhD studies," she says.

Other than her own development, she has been a key member of a team that focuses on the training and development of other students, interns and junior employees. The skills transfer initiatives and job training provided by the group have given her a high level of job fulfilment.

She recently published a first-author journal paper and her first technology demonstrator has been accepted at technology readiness level 6.

Regarding the misconceptions that people have about science courses – that they have few to no job opportunities, particularly biotechnology in Africa – she says: "The biotechnology space is vast and varies significantly between disciplines, thereby making a myriad of opportunities available for different careers."

"Do not be discouraged about starting a career in science. It brings a lot of fulfilment. However, be prepared for a steep learning curve and, if possible, take your academic background to a PhD level (and beyond) to become an established researcher. It is important to develop in a particular area of the biotech space, as it allows you to specialise in a particular domain," she says.

SOIL HEALTH'S IMPORTANCE FOR SUSTAINABLE AGRICULTURE

Incorrect application of man-made interventions has polluted the soil, with dire consequences for microorganisms; plant, animal and human life.

The CSIR's Yrielle Roets-Dlamini enhancing the growth of a plant using a growth-promoting fungi.

Roets-Dlamini highlights the importance of soil health in the agricultural biotechnology space. "Soil health is the foundation of sustainable agriculture. I believe that in the agricultural biotechnology space, research and development focusing on soil health is vital. Healthy soil influences the cultivation of healthy produce and animals, and contributes to the health of the human population," she says.

"I have a keen interest in the production of biopharmaceuticals, alternative meat and proteins for human consumption. These initiatives are a key focal area of human health and nutrition, which will influence the overall health and wellbeing of the human population and the planet," Roets-Dlamini adds.

She looks forward to completing her PhD – which will focus on the development of a biological agent for use in local agricultural practices and the development of other commercial bio-based products – which she will do in parallel with her research and development activities at the CSIR.

ENQUIRIES:

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CAREER TYPE: BIOMATERIALS RESEARCHER

RELATED CAREERS
Biotechnologist, materials scientist

ACADEMIC HISTORY
- NDip (Analytical Chemistry), Tshwane University of Technology, 2007
- BTech (Chemistry), Tshwane University of Technology, 2011
- MTech (Chemistry), Tshwane University of Technology, 2013
- PhD (Pharmaceutical Sciences), University of Angers, France, 2017
- PhD (Chemical Sciences), University of Liège, Belgium, 2018

FINDING EFFECTIVE AND AFFORDABLE SOLUTIONS FOR THE HEALTH SECTOR

According to the World Health Organization (2022), noncommunicable diseases such as cancer, cardiovascular diseases and diabetes are increasingly becoming the main cause of mortality in sub-Saharan Africa, where the diseases were responsible for 37% of deaths in 2019, rising from 24% in 2000, largely due to weaknesses in the implementation of critical control measures, including prevention, diagnosis and care. CSIR senior researcher Dr Bathabile Ramalapa focuses on finding effective and affordable solutions for the management and treatment of diseases with a high burden in Africa.

Dr Bathabile Ramalapa reformulates existing drug treatments for diabetes to address challenges with absorption, bioavailability and resistance by reconfiguring the treatments using biomaterials. Her expertise lies in the use of biomaterials (materials sourced from nature) for applications in health-related products. She is also working on developing antimicrobial materials that can assist in the management of wound infections suffered by diabetic patients.

CAREER HIGHLIGHTS

The young researcher was recognised as one of the *Rising Stars in Biotechnology under 40 in Africa* by Africa BIO in 2022 and was called to serve as one of the ambassadors for the Science Diplomacy Capital for Africa. She was also previously awarded the European Union Dual PhD Scholarship Grant and the Visiting Scholar Travel Grant by the Bill and Melinda Gates Foundation in the United Kingdom, as well as served as a Novartis Research Scientist Fellow in Switzerland.

"My research work aims to address African health challenges and it is an honour for me to be recognised by organisations that represent the continent," she says.

"Biomaterials are quite safe for use in health products, including drug treatments and, in recent years, research has shown that they may be the most effective option to synthetic drugs," says Ramalapa.

The CSIR's Dr Bathabile Ramalapa using the gel permeation chromatography machine, which can be used to analyse biomaterials or biopolymer drug materials.

CHOOSING BIOMATERIALS AS A CAREER TYPE

When asked to give advice regarding a career in biomaterials, she says that conducting research and development in health, specifically in developing nations such as South Africa, can be challenging.

"The pace of technological advancements in the developed world is rapid, and sometimes hard to stay abreast of, and is set against a background of challenging sociological and economic issues. Therefore, I would advise that one should align one's research with the needs of the country and the continent," she says.

INFLUENTIAL DEVELOPMENT IN BIOMATERIALS

Ramalapa views sustainability in the development and manufacturing of products in any sector as an increasingly important factor and sees it as a great development in this field.

"The demand for greener products to reduce environmental impacts and enhance health and safety is rising. The improved biodegradability or recyclability of biomaterials and the superior performance (biocompatibility) in health applications present exciting opportunities for the design and development of the next generation of smart and responsive biomaterials to meet the demands," says Ramalapa.

CAREER GOALS

This optimistic CSIR researcher sees herself as one of the future leading and globally recognised female scientists in biotechnology. She believes in empowering women to become leaders in the science, technology, engineering and mathematics (STEM) space.

"I want to be an ambassador for the empowerment of women leaders in STEM. My goals for the next few years include facilitating programmes that groom young women scientists to become the leaders of tomorrow," she concludes.

ENQUIRIES:

>> Dr Bathabile Ramalapa
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CAREER TYPE: MICROBIOLOGIST

RELATED CAREERS
Biotechnologist, clinical laboratory scientist, biologist

ACADEMIC HISTORY
- BSc (Microbiology and Biotechnology), University of Cape Town, 2003
- BSc (Hons) (Microbiology), University of Port Elizabeth (now Nelson Mandela University), 2004
- MSc (Microbiology), Nelson Mandela Metropolitan University (now Nelson Mandela University), 2008
- PhD (Microbiology), Nelson Mandela Metropolitan University, (now Nelson Mandela University), 2011

DEVELOPING DIAGNOSTICS, VACCINES AND THERAPEUTICS FOR HUMAN AND ANIMAL HEALTH

CSIR research group leader Dr Essa Suleman leads a team of scientists in the development of recombinant vaccines, diagnostics and therapeutics for a variety of veterinary and zoonotic diseases that pose a threat to agriculture and health.

CSIR principal researcher Dr Essa Suleman leads the development of a lab-on-chip point-of-care molecular diagnostics platform for One Health, an approach that acknowledges that human, animal and plant health are interdependent.

"Several exciting key technologies and developments will have a strong impact on the fields of veterinary diagnostics and vaccines. Microfluidics, isothermal amplification, artificial intelligence and related fourth industrial revolution technologies have a major influence on diagnostics. These technologies enable affordable and faster disease diagnostics that can be deployed at the point-of-need, compared to most conventional diagnostics, which require expensive laboratories, highly trained personnel and expensive equipment for disease diagnostics," Suleman says.

"THIS FIELD IS CHALLENGING AND INDIVIDUALS WHO CHOOSE THIS CAREER PATH MUST HAVE STRONG MOTIVATION TO IMPROVE THE LIVES OF SOUTH AFRICANS THROUGH RESEARCH AND DEVELOPMENT."

The Aquaculture Diagnostics and Health Programme, which focuses on the development of diagnostics and therapeutics – messenger ribonucleic acid (mRNA) vaccines – for pathogens affecting aquaculture, particularly in terms of biosafety and biosecurity, is an area of keen interest for Suleman.

"Freshwater fish farming is an affordable and sustainable source of animal protein and a boost for the African economy. However, as production increases, the industry is affected by an escalating

The CSIR's Dr Essa Suleman develops novel diagnostic assays for veterinary and aquaculture diseases.

rate of diseases that cause economic and feedstock losses. Readily available diagnostic assays will improve the surveillance and detection of diseases," he elaborates.

The advent of Covid-19 resulted in the establishment of a Covid-19 molecular diagnostics laboratory at the CSIR, which provided critical diagnostic services for the detection of the coronavirus to the National Health Laboratory Service and various industry partners, particularly in the mining sector.

"The development of mRNA technologies used for several Covid-19 vaccines has changed the face of vaccine development, personalised medicine and therapeutics forever. The technology has been proven with several mRNA vaccines that are effective against Covid-19. Furthermore, mRNA vaccines and therapeutics are rapidly being developed for other infectious diseases such as respiratory syncytial virus, as well as noncommunicable diseases such as cancer. It is estimated that the global market for mRNA-based technologies (vaccines and therapeutics) will be more than $100 billion by 2031," Suleman says.

His immediate priorities include the commercialisation (licensing and technology transfer) of various technologies for vaccines, diagnostics and therapeutics that are being developed in the group. He also has his sight set on becoming a chief scientist and obtaining a Master's in business administration thereafter.

Suleman advises aspiring researchers to prioritise hard work, patience, resilience, good communication, strong research and scientific skills, as well as entrepreneurship to secure their success as research scientists in the field of vaccines, diagnostics and therapeutics. "The field is challenging and individuals who choose this career path must have strong motivation to improve the lives of South Africans through research and development," he says.

ENQUIRIES:

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CAREER TYPE: RESEARCH CHEMIST

RELATED CAREERS
Chemical engineer, biochemist, analytical chemist, plant process engineer

ACADEMIC HISTORY
- BSc (Chemistry, BioChemistry), University of Durban-Westville, 2000
- BSc (Hons) (Chemistry), University of Durban-Westville, 2001
- MSc (Analytical Chemistry) (cum laude), University of KwaZulu-Natal, 2005
- PhD (Analytical Chemistry), University of KwaZulu-Natal, 2010

GENERATING VALUE FROM WASTE – THE CHALLENGE IS ON!

The paradigm shift in how companies approach waste management is gaining momentum. Companies are adopting environmentally friendly production processes, looking into generating value from waste and working towards a scenario of zero waste to landfill.

The paradigm shift to sustainable production and improved waste management is long overdue. For researchers in the chemicals and biomanufacturing field, this shift has opened up a slew of new opportunities.

Dr Viren Chunilall leads the CSIR's research at the Biorefinery Industry Development Facility (BIDF) in Durban, KwaZulu-Natal. Of particular interest is the transformation of biomass into fuel and chemicals as one of the ways to mitigate global warming and diversify energy sources. Biomass is a renewable, carbon-neutral resource and fuels derived from it usually burn more cleanly than fossil fuels. It can also be a source of valuable chemicals, pharmaceuticals and food additives.

Several kinds of biomass can be converted to fuel and chemicals. Examples are wood and wood waste, agricultural crops, agricultural waste, litter from animal feedlots, waste from food processing operations and sludge from water treatment plants.

Waste valorisation is a process that converts waste materials into valuable products such as chemicals, materials and fuels.

Chunilall is an author of numerous publications in the biomass valorisation domain and has been leading the CSIR's biorefinery work for industries and the public sector for the past year.

He has advised industry on alternative waste biomass technologies and demonstrated waste beneficiation biorefinery technologies to bridge the gap between pre-commercialisation instruments for technology development and full entry at a commercial scale.

"The aim of these projects is to reduce the barriers for developing, testing and adapting biorefinery technologies applied to South African biomass sources, especially for small, medium and micro enterprises. For example, we have a license agreement with Polyftero to produce keratin from waste chicken feathers for cosmetic and bioplastic applications.

"Our facility proposes mechanisms to add value to these waste streams by extracting high-value chemicals," Chunilall adds.

The transformation of waste, by industry, into higher value products intended to add additional revenue streams to current business has been a consistent focal point over the past decade.

CSIR researchers are working on technologies to convert tons of wood waste in the paper, pulp and related industries into high-value products.

The CSIR's Dr Viren Chunilall uses a green solvent (liquid carbon dioxide) for the super critical fluid extraction of high-value chemicals from biomass.

Chunilall supervises and mentors the team of chemical engineers, chemists, microbiologists, doctorate and MSc students, interns and postdoctoral fellows based at the BIDF in KwaZulu-Natal.

To aspiring chemical researchers, Chunilall says, "You must have a growth mindset and be able to challenge your own capabilities. The human body and mind are astonishing if you continue to push yourself out of your comfort zone."

Some of Chunilall's notable career highlights include his appointment as research group leader of the (BIDF), participation in government masterplans for the benefit of society and South Africa, as well as the honour of being a chemistry board member and honorary research fellow at leading South African universities.

All his different roles align with his values of continuous learning and development, capacity building and teamwork. "Capacity building, for example, promotes innovative thinking and engaging with clients and industry partners to develop long-term relationships is pivotal for a successful career," Chunilall says.

Chunilall concludes, "As a firm believer in teamwork, an individual can only accomplish prescribed objectives and key deliverables with the support of a team."

ENQUIRIES:

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CAREER TYPE: SAFETY, HEALTH, ENVIRONMENT AND QUALITY (SHEQ) MANAGER

RELATED CAREERS
Health inspector, quality assurer, safety officer, occupational hygienist

ACADEMIC HISTORY
- NDip (Environmental Health Engineering), Technikon Witwatersrand (now University of the Witwatersrand), 2001
- BSc (Hons) (Environmental Health), University of Johannesburg, 2004

HELPING COMPANIES CHECK THEIR BLIND SPOTS

Look left, right and left again, is probably the safety checklist that people are most familiar with. As we grow older, we get introduced to a checklist for food, driving and what to do in an emergency when entering a building or boarding a plane. Occupational health and safety management systems aim to bring the same alertness in how people and businesses fulfil their duties. This is the mission of CSIR Safety, Health, Environment and Quality General Manager, Masopha Moshoeshoe.

Having led safety, health, environment and quality matters at the CSIR since 2021, Masopha Moshoeshoe says that there are three misconceptions about people in his role. Firstly, people think they are law enforcers and that the service they provide to a business is from a policing context. Secondly, employers look at SHEQ only from a legislative standpoint and approach SHEQ issues as tick box exercises to avoid penalties. Thirdly, and most importantly, is the idea that SHEQ is independent or a plug-in service to an organisation. Moshoeshoe says, "SHEQ is about how the business does its work; for those of us working in this field, it is about walking employers and employees through the risks associated with their job functions and finding the best solution to minimise the chance of injury."

> "SHEQ IS ABOUT HOW THE BUSINESS DOES ITS WORK, TO MINIMISE THE CHANCES OF INJURY."
>
> *– Masopha Moshoeshoe*

Moshoeshoe says his role is that of a co-creator with an organisation, or team and documenting the best way of conducting their duties. He says that laws are there to make individuals mindful of how their duties affect them as individuals and the impact that their work has on the environment.

He adds that different businesses have different needs or associated risks, but that there are still common threads. He has found that at the CSIR, the multidisciplinary approach to doing business requires different risk assessments to ensure people and their surroundings are taken care of. These include how operational units manage waste; whether it is common domestic

waste that can be sorted and recycled or whether it requires specialised methods of discarding, like chemical or industrial waste. Another common health aspect is the personal safety of employees, which includes supplying the correct personal protective equipment to safely conduct research, and providing a safe working office environment that considers ergonomics and detecting potential hazards.

Ergonomics is the scientific study of people at work. It looks at how to prevent soft tissue injuries and musculoskeletal disorders caused by sudden or sustained exposure to force, vibration, repetitive motion and awkward posture.

Moshoeshoe says his role requires him to be multi-skilled. "One needs to understand environmental issues, physics and health sciences, while staying informed about varied local and international safety standards. Apart from knowing legislation and related information, to fulfil his duties, he has realised that communication skills are key.

"A management course taught me that to change people's behaviour, one needs to be able to effectively communicate the risks that may arise if people do not understand their role in creating a safe working environment," he concludes.

Moshoeshoe says his team has changed behaviour at the CSIR by rolling out safety campaigns to raise awareness and developed SHEQ structures with the participation of employees – all of which have contributed to the CSIR achieving its target of zero harm in 2022.

CSIR objectives related to safety, health, environment and quality

- Achieve zero harm by establishing and maintaining a safe, healthy and environmentally sustainable working environment in all CSIR operations through embedding principles of quality in all activities.
- Maintain certification against the international standards for safety, health, environmental and quality management systems.
- Comply with relevant legislative requirements and foster a culture of compliance and excellence.
- Continuously facilitate engagement with key internal and external stakeholders on SHEQ requirements and performance.
- Establish and embed a mature, integrated SHEQ management system.

ENQUIRIES:

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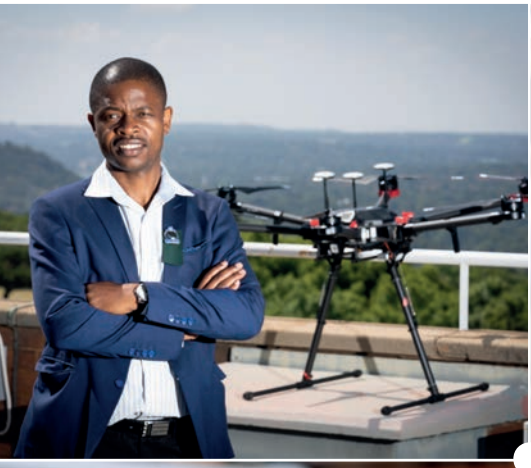
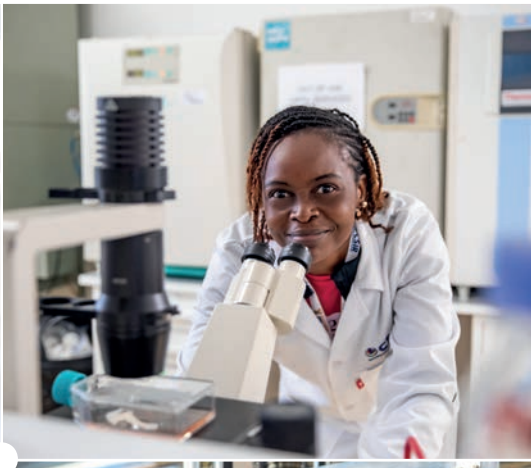
Masopha Moshoeshoe (above) and (below) with Sister Zanele Phiri from the CSIR Medical Centre.





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