70

CELEBRATING SEVENTY YEARS

2014/15 ANNUAL REPORT

CSIR

our future through science

CELEBRATING
70 Years
Ideas that work

Seventy years after being established by an Act of Parliament in October 1945, the CSIR remains committed to contributing, through multidisciplinary research and technological innovation, to the improved quality of life of the people of South Africa.

The organisation strives to contribute to the attainment of the goals of the *National Development Plan 2030*.

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

FROM OUR LEADERSHIP

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The Council for Scientific and Industrial Research (CSIR) was established on 5 October 1945. The CSIR's mandate is as stipulated in the Scientific Research Council Act (Act 46 of 1988, as amended by Act 71 of 1990), section 3: Objects of CSIR:

"The objects of the CSIR are, through directed and particularly multidisciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act."

The CSIR's Executive Authority is the Minister of Science and Technology.

Foreword

BY THE MINISTER OF SCIENCE AND TECHNOLOGY

South Africa has overcome many challenges in its progress to democracy and is once more confronting a critical set of challenges. A failure to respond assertively to the dangers posed by unemployment, inequality and poverty will place our democracy in serious peril.

All sectors of our society will have to work together to develop and implement solutions, and there is a special role to be played by science and technology. Few other areas of human endeavour have the potential to so fundamentally transform our society, to make the massive strides that will, over time, make real progress towards ending poverty, and reducing inequality and unemployment. As part of this larger effort the CSIR, with its mandate to foster scientific and industrial development, has a critical role to play in ensuring that our scientific resources are deployed to address these threats.

We are operating in an economically constrained environment and, as a consequence, organisations like the CSIR must consciously marshal the evidence to demonstrate, in a compelling manner, that investments in research and innovation do, and will continue to, lead to greater prosperity, more jobs, and more entrepreneurs. In this annual report the CSIR presents the results of its research and innovation activities and, in so doing, demonstrates the role that it is playing in applying research and innovation to address these challenges.

One such example is the Biomanufacturing and Industry Development Centre. This Centre supports small, medium and microenterprises (SMMEs) by giving them access to world-class biomanufacturing facilities and research expertise. Since its launch in October 2013, the Centre has created 26 permanent jobs and 56 temporary jobs and more than 80 individuals have received training. These facilities will continue to ensure that we are able to make optimal use of the time and resources we have already invested in the biomanufacturing sector.

This report presents other examples that speak directly to job creation, including the support that the Aerospace Industry Support Initiative has provided to three SMMEs that are now commercialising local aerospace technologies; as well as the work of the CSIR Technology Localisation Implementation Unit which assists local manufacturers to produce and sell products that would, otherwise, have to be imported.

The CSIR is doing important work in responding to major trends that will increasingly affect our continent – by developing tools that allow us to plan more carefully in the context of rapid urbanisation; by producing innovative responses to questions of sustainable use of our energy resources; and by addressing the dangers posed by global climate change. In the latter case our unique geographic position at the southern tip of Africa and surrounded by the Southern Oceans as well as our long-standing research efforts in Antarctica and the Marion Islands have allowed us to make an important contribution to the global scientific understanding of the science of climate change and its biological effects.

It is clear that many of our problems can only ever be truly resolved at the interdisciplinary and supra-national level, and at the continental level in particular. We are inextricably linked to our neighbours on the continent, and the issues we need to deal with are, at their root, very similar. We cannot afford to turn inward, to focus

only on resolving our own problems and then hope to survive and prosper. There are, in this annual report, many pleasing examples of continental collaboration, but I would urge the CSIR to approach every problem with one eye on how we can collectively progress with our neighbours. The complex developmental challenges confronting African countries have created an opportunity to be at the forefront of global scientific discovery, and we need to be ready to seize that opportunity.

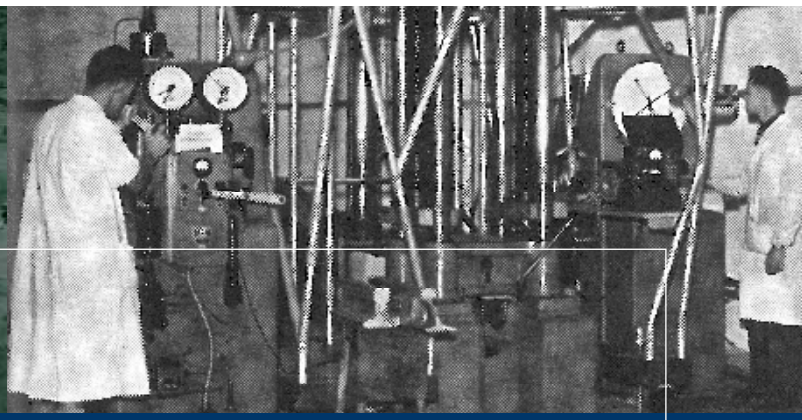
I congratulate the CSIR on its 'Ideas that work' campaign. It is important that the value of our scientific investment resides not only in academic publications, technical reports or policy documents but is readily accessible to the people of South Africa who are, ultimately, the true owners and beneficiaries of this work.

Finally, the CSIR can once again be proud of its excellent performance in the past financial year, and for producing value through its scientific work. My congratulations to the Board, leadership and staff of the CSIR. I look forward to your continued support as we work together to demonstrate the many benefits that are derived from investing in science and technology.

Naledi Pandor

Mrs Naledi Pandor

I CONGRATULATE THE CSIR ON ITS 'IDEAS THAT WORK' CAMPAIGN. IT IS IMPORTANT THAT THE VALUE OF OUR SCIENTIFIC INVESTMENT RESIDES NOT ONLY IN ACADEMIC PUBLICATIONS, TECHNICAL REPORTS OR POLICY DOCUMENTS BUT IS READILY ACCESSIBLE TO THE PEOPLE OF SOUTH AFRICA WHO ARE, ULTIMATELY, THE TRUE OWNERS AND BENEFICIARIES OF THIS WORK.



CELEBRATING
70 Years
Ideas that work

From left, the CSIR's main site in Pretoria during the early years following the organisation being established by an Act of Parliament in 1945; researchers undertaking testing of wire ropes for the mining industry, a specialised service that is still being undertaken today; one of the newest buildings on site, the CSIR Knowledge Commons; and CSIR biotechnologist Zandile Nxumalo using modern equipment to develop digital pathology technology to train experts remotely. Advanced facilities, such as those housed at the National Centre for Nanostructured Materials (bottom left), have replaced older facilities and buildings as they existed some 70 years ago (bottom right).

Chairman's overview

The CSIR has a mandate so broad that almost nothing is excluded – it has a responsibility to contribute towards resolving the immediate problems faced by our country, using science and technology to address the systemic effects of inequality and lack of opportunity, as well as preparing the ground for the infrastructure and industries that will serve our future generations.

In the main the CSIR performs the many tasks demanded of it with great aplomb, and there is no reason to believe that it will not continue to do so. One aspect of the CSIR's accomplishments is captured by the organisation's realisation of its key performance indicators – during the past financial year the CSIR met or exceeded each of the set targets. However, the true value of the CSIR's work is not captured simply by performance indicators, and this report contains many examples of the valuable contributions that have been made by the CSIR in the past year, from areas as diverse as climate change to drug discovery, from 3D printing of aerospace components to the use of South African clays in nano-manufacturing. In addition, and perhaps as important, the CSIR's contributions are made within an organisational context that values scientific excellence, financial sustainability, good governance and transformation, and that has a workforce committed to improving the quality of life of all South Africans.

However, as is often the case in fast-moving and demanding environments, we have no opportunity to rest on our laurels – there are always more challenges we have to meet and there are always ways in which we can continue to improve even on the high standards we have set for ourselves. While the past achievements of the CSIR are rightly lauded, it is ever more likely that we will be judged on the value that we promise to deliver and our ability to continually match the scale of the challenge that faces our country.

In the past year the CSIR has made great strides in improving its profile among the general public, through the 'Ideas that work' campaign, transferring the excellence which has been the hallmark of its targeted scientific publications to a more general audience. We will of course continue with that good work. One area that requires a special focus is the role that the CSIR can play in motivating and educating young people, particularly those in high school and undergraduates, about the value of a career in science. An important component of such a programme may include two inter-linked components – the more effective use of the CSIR campus and its associated research infrastructure and the virtual presence of the CSIR. The CSIR campus is an impressive site. We have a collection of smart minds and high-tech facilities all dedicated to using science and technology for the common good, and we need to use it more effectively as a marketing and motivational tool. It should become a place that our young people can easily visit to get a sense of the importance and excitement that accompanies a career in applied science, and to inspire them to apply themselves in order to join the ranks of those scientists. At the same time we need to upgrade the virtual presence of the CSIR so that those young people who cannot visit our facilities physically are also able to get a better sense of what we do. The existing campaigns have almost certainly whet the appetite of young people about the CSIR and we must take this opportunity to introduce them to the marvels of science that lie behind those final products.

While this annual report documents the good work we are already doing with and for industry, this is one area in which we can never do enough. Industrial development policies and frameworks can only go so far in creating the employment opportunities this country needs – we need to continue to apply our minds and, together with our stakeholders and partners, find new and creative ways of working with industry to improve competitiveness and design future solutions and products.

Finally, the CSIR must continue to be an attractive home for the very best scientific talent, an institution that values learning and innovation, an institution that recognises both the human curiosity and need to explore that so define our species, and the ability to harness that need for the common good.

I wish to thank the staff and leadership of the CSIR for their hard work and for the excellent performance that has resulted from that effort, and the Department of Science and Technology for its guidance and oversight. The Board is looking forward to working with all our stakeholders in taking the CSIR to ever-greater achievements.

Professor Thokozani Majozi

THE CSIR MUST CONTINUE TO BE AN ATTRACTIVE HOME FOR THE VERY BEST SCIENTIFIC TALENT, AN INSTITUTION THAT VALUES LEARNING AND INNOVATION, AN INSTITUTION THAT RECOGNISES BOTH THE HUMAN CURIOSITY AND NEED TO EXPLORE THAT SO DEFINE OUR SPECIES, AND THE ABILITY TO HARNESS THAT NEED FOR THE COMMON GOOD.

CEO's introduction

The CSIR, as a science-based research and development (R&D) organisation, is under increasing pressure to justify the resources that it consumes. The organisation is not alone in facing this challenge – across the globe the effects of low economic growth rates and competing demands on public funds have meant that ever-tougher questions are being asked about the value delivered by investment in R&D. It may no longer be sufficient to simply point to the many successes that have resulted from past investments in science, the fundamental ways in which technology improved the quality of our lives, and the many innovations that have so embedded themselves in our everyday lives that we could scarcely imagine life without them. Our investment in scientific R&D must now, in addition, be justified in a number of different and inter-linked ways. We must, in the first instance, draw clearer and more compelling links between our current work and the impact that already has, and potentially will, result from those interventions. Secondly, we need to show how the investment in scientific R&D is able to deliver immediate value for our country through, for example, increasing efficiencies within the private and public sectors, improving our ability to understand the environments within which we work and therefore to make better decisions, and to improve our national ability to deliver services. Finally, we have to demonstrate that we can deliver value for money by focusing ever more strongly on the issues that are of the greatest strategic importance.

One component of this imperative to draw clear and compelling links between our scientific work and its impact is to tell that story in an engaging and understandable manner – to demystify the link between the potentially esoteric work and world of our scientists and the broader society in which they operate. The CSIR has, in the past year, made a significant effort to improve this aspect of our communications strategy with the launch of a media campaign (Ideas that Work) to showcase some of our innovations and the scientists who have contributed to these ideas. There were two main aims we hoped to achieve. Firstly, to increase the profile of science and technology generally by showing the practical value and application of scientific ideas. Secondly, we wanted to excite and motivate the young people of South Africa about the potential of a career in science. Our future really does depend on making the best use of our human resources, and we hope that this effort will contribute to larger initiatives to build a new generation of scientists and engineers eager to use their skills to create a better life for all. For further details on the campaign, please visit the website csirideasthatwork.co.za.

Science has never been, and will never be, a panacea to all our problems. We must choose its area of application wisely and ensure that, among the many possible avenues of intervention we find those where we can make the biggest difference. This means that we may better understand how we have made these choices in the past, and the consequences of those choices. In order to ensure that we give the people of South Africa the best value for their money we have to reduce or eliminate the resources allocated to initiatives that are less important or are not

WE NEED TO SHOW HOW THE INVESTMENT IN SCIENTIFIC R&D IS ABLE TO DELIVER IMMEDIATE VALUE FOR OUR COUNTRY THROUGH, FOR EXAMPLE, INCREASING EFFICIENCIES WITHIN THE PRIVATE AND PUBLIC SECTORS, IMPROVING OUR ABILITY TO UNDERSTAND THE ENVIRONMENTS WITHIN WHICH WE WORK AND THEREFORE TO MAKE BETTER DECISIONS, AND TO IMPROVE OUR NATIONAL ABILITY TO DELIVER SERVICES.

delivering the results we expect, and focus our energies on areas where the strategic need is greatest and where we are making good progress.

We have, once again, achieved our performance targets for the financial year. While this is no small achievement, these results do not, and are certainly not designed to, reflect the breadth and value of our scientific work. In this report you will find many examples of that work and the immediate difference that the CSIR is making. In particular I would like to mention the National Cleaner Production Centre of South Africa whose work has contributed significantly to the more efficient use of energy. As a result of improvements introduced as part of this initiative we have, over the past three years, saved enough energy to power 120 000 households for a year. The organisation has also developed modelling and simulation tools in support of more efficient urban planning by municipalities and is supporting SMMEs in developing aerospace technologies.

Other examples speak to the longer-term value of our work – those include the beneficiation of nano-clays, the use of 3D printing techniques to produce titanium components for aircraft, the exciting work being done by our colleagues in the energy sector on structural solutions for stimulating the South African photovoltaic market, and the ongoing development of lithium-ion batteries that use South Africa's abundant manganese reserves.

A key component of our work is supporting national institutions in their service delivery missions – this report contains examples of our work with South African National Parks to combat rhino poaching, to improve our capabilities to safeguard our borders, and to assist Transnet across a range of areas, including transport modelling and the optimisation of their port operations. In the restricted space available I have not been able to do justice to the range, complexity and value of our work – I urge you to read through the details provided in this publication and if that piques your interest please visit our website (www.csir.co.za) and find out more about our work.

The CSIR has, in compliance with the Use of Official Languages Act (No. 12 of 2012), published its draft language policy. In summary, we will strive to make information about our work more accessible to our stake holders by adopting English, isiZulu and Sepedi as our required three official languages, while also making available information in additional languages where necessary.

All of these achievements, and our ability to move from ideas to products and ultimately to impact, are only possible through the hard work of our scientists, the support staff who ensure that we have a sustainable environment conducive to learning and innovation, and of course the ongoing support of our stakeholders, most notably the Department of Science and Technology.

Finally I would like to welcome the new Board and thank them for the many fruitful engagements that have already taken place. I look forward to working with them to continue to refine and improve the work of the CSIR.

Dr Sibusiso Sibisi

RESEARCH, DEVELOPMENT AND IMPLEMENTATION

PROJECT HIGHLIGHTS

The CSIR responds to national priorities in line with its mandate. The organisation is mandated to conduct multidisciplinary research and technological innovation to foster industrial and scientific development.

Work undertaken at the CSIR is therefore aimed at supporting industrial development as well as enhancing the capabilities of government in the areas of service delivery, policy development and information management.

This section features a selection of directed research and development undertaken to benefit the country in the areas of industry, defence and security, the built environment, the natural environment, energy, health and in shaping a digital future. It also covers examples of research and development partnerships in Africa.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

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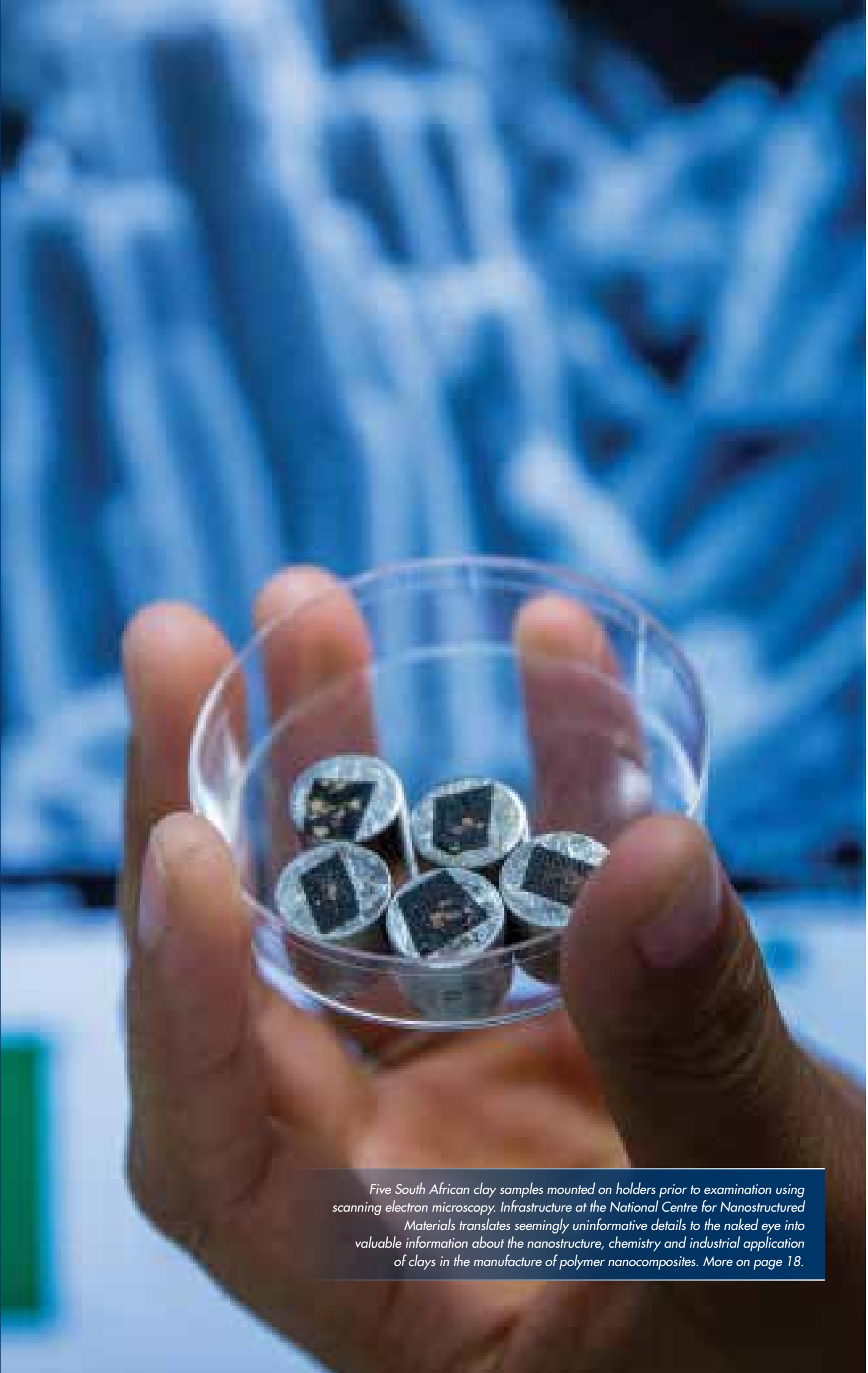
Research, development and innovation are widely recognised as being pivotal for industrial development and are listed by the *National Development Plan 2030* as being essential to ensure that South Africa remains competitive.

The CSIR's contribution lies in developing and transferring manufacturing technologies that improve the competitiveness of existing South African industries and creating new manufacturing opportunities. The organisation focuses primarily on the beneficiation of South African minerals across the value chain; supporting biotechnology-based businesses with new products and processes; developing additive manufacturing platforms for the aerospace and automotive industries; developing new advanced materials and composites; and using information and communications technologies to enhance industrial competitiveness. The CSIR also manages industry support programmes for the aerospace, biomanufacturing and foundry sectors as well as programmes that support technology localisation and technology-based small, medium and micro enterprises.



Five South African clay samples mounted on holders prior to examination using scanning electron microscopy. Infrastructure at the National Centre for Nanostructured Materials translates seemingly uninformative details to the naked eye into valuable information about the nanostructure, chemistry and industrial application of clays in the manufacture of polymer nanocomposites. More on page 18.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

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In brief

The CSIR and Aerosud, an aeronautical engineering and manufacturing company, have designed and developed a large 3D printer for titanium parts as part of project Aeroswift. The 3D printer will produce large, complex metal parts and large volumes of smaller metal parts.

Marius Vermeulen, project manager: additive manufacturing at the Aerosud Innovation and Training Centre inspects the Aeroswift additive manufacturing system built in collaboration with the CSIR, where components with a length of up to 2 m are produced.

Advanced 3D printer for metal components built in the pursuit of lighter aircraft

The challenge: Adding value to a local mineral resource while solving the need for lighter aerospace components

South Africa has large reserves of titanium-bearing minerals. Titanium is the material of choice in the aerospace industry, where the quest for lighter aircraft continues. By developing technologies to manufacture titanium products, the country can become a significant contributor to the global aerospace market. Cost-effective methods for producing titanium and titanium products offer the potential of a vibrant new South African industry sector.

The world's two biggest aircraft manufacturers, Boeing and Airbus, are developing aircraft using composite materials. The composition of aircraft is changing from aluminium-based materials to composite-based fuselage structures. Both the Airbus 350 and Boeing 787 have significantly lower weight due to the use of composites in their structures.

The challenge with composite materials is that they cannot be joined to aluminium because joining the two materials results in galvanic corrosion. Titanium, which does not have this problem, is a possible replacement material.

Research and development: The road to high-value, high-performance titanium components for the aerospace industry

Project Aeroswift started in 2008 when Aerosud and the CSIR demonstrated a new approach to laser-based metal powder fusion, which could potentially be applied to the 3D printing of metal components for various industry sectors.

Aerosud was looking at new technologies which would afford the aeronautics company a competitive advantage. The CSIR had already been involved in laser-based manufacturing, having just started to explore additive manufacturing as a new manufacturing technology which relies on laser-based technologies.

Joint work on a concept and a feasibility study started, with a view to demonstrating proof of concept. In 2009, engineers demonstrated that they could significantly increase the consolidation rate of titanium powders in both the processes of full laser melting and selective laser melting to produce components.

The key in this process was the manipulation of the laser beam by using significantly higher laser powers as well as employing technologies to pre-heat the powder.

The consortium approached the Department of Science and Technology (DST) with the concept of a high-speed, large-area additive manufacturing system, Aeroswift. The proposal was to design and develop a system which could produce large components with a length of up to 2 m.

The Aeroswift platform demanded new technology developments. Any optical system requires laser switching and beam delivery technologies, but with the Aeroswift platform various additional factors came into play, such as how engineers handle large amounts of materials and powders, how they protect the optics inside the processing environment, how they handle generated heat and the stresses induced during the melting of the powder, and how they handle the prevention of oxidation of the powder during the printing processes.

Aerosud and CSIR engineers designed, developed, tested and implemented a range of new technologies to cater for all these factors and built demonstrators to verify processes, culminating in the full Aeroswift platform at the end of 2014.

The team successfully demonstrated the platform's increased metal-build rates, which are higher than commercial powder-bed fusion systems.

Engineers have since started with the project's second phase, which looks at process development and optimisation. Processes also have to be developed for producing different parts. The DST and industry put in place a titanium strategy for the country, aligned to the Titanium Centre of Competence, to ensure that it exploits the whole value chain which looks at development of titanium powders and metals from raw material.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

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In brief

Three highly promising local aerospace technologies with great potential for successful commercialisation have emerged as a result of assistance from the Aerospace Industry Support Initiative (AISI).

The CAT 200 KS, a micro gas turbine engine developed by Cape Aerospace Technologies.

Providing critical support to niche aerospace enterprises

The challenge: Identifying promising aerospace opportunities

The AISI has a mandate to bolster the local aerospace industry through the funding of viable technologies that can be successfully industrialised and through the identification of niche areas where South African aerospace companies can become global leaders and create jobs.

The AISI, which is managed and hosted by the CSIR, is an initiative of the Department of Trade and Industry and aims to strengthen South Africa's aerospace industry locally as well as globally.

Developing new aerospace enterprises

The AISI has developed a reliable selection process to identify small, medium and micro enterprises (SMMEs) and associated technologies for support. Investigations into technology readiness levels, assessments by industry experts and potential for co-investment are used to identify technologies that are commercially viable.

Three of the technology-based SMMEs that have demonstrated their commercial viability include Heliocentric Technologies ZA, the first in South Africa to provide radiation screening and mitigation services for satellite components; NewSpace Systems, a company that employs a unique stellar gyroscope to function as a reliable attitude control system for nanosatellites; and Cape Aerospace Technologies, a company that has developed a micro gas turbine engine that has the potential to be used in unmanned aerial vehicles (UAVs).

Simulating the exposure of satellite parts to radiation to test their longevity

Radiation effects on satellite electronic components have proven to be a major problem that affects the longevity of satellites in space. These electronic components are required to undergo radiation screening before final installation on satellites. Previously, no facility in South Africa was able to perform this function and local satellite manufacturers had to have the satellite components screened by an international organisation.

Heliocentric Technologies ZA has become the first company in South Africa to be able to locally provide radiation screening and mitigation services for satellite components. The company's robust, reliable screening instruments and processes, which accurately simulate prolonged exposure to radiation, were developed over a period of 18 months and utilise facilities at iThemba LABS in Cape Town. With development now completed, the company has started to market its services.

Keeping satellites in perfect orbit

Satellites use different systems for orbit and attitude control. These control systems ensure the intended orbit of the satellite is followed and calculate the necessary adjustments, should they drift out of orbit.

NewSpace Systems is developing a novel attitude control system for low-cost, small and nanosatellites. The stellar gyroscope is an innovative solution to solve the problem of drift in traditional gyroscope solutions. The importance of this solution for space avionics is that it solves the problem of accurate attitude knowledge during the period the spacecraft is in eclipse and can no longer orientate itself relative to the Sun. It is a key technology for achieving higher performance in smaller spacecraft since it achieves fine pointing accuracy at lower cost, reducing the use of spacecraft resources. The system is robust to the aging effects of radiation damage and is therefore highly reliable.

Powering UAVs with micro engines

The lack of a capability in propulsion systems in South Africa has been identified as a deficiency in the aerospace industry. The clear market and strategic need for the South African industry to develop a propulsion sector, and the past investment in gas turbine technology, present an opportunity to develop a niche sector through support for a single product with potential to expand into different markets.

In an effort to reignite the local micro gas turbine propulsion market, Cape Aerospace Technologies has developed the CAT 200 KS gas turbine engine. The successful design, development, manufacturing and testing of the CAT 200 KS has resulted in the first new gas turbine prototype running in South Africa since the late 1980s.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

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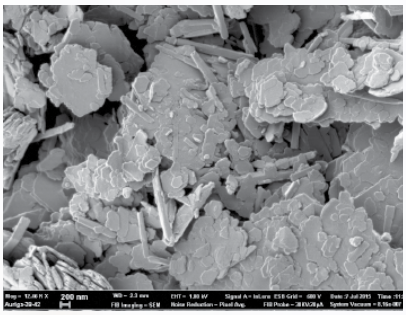
In brief

The CSIR has created a range of cheaper nanoclay minerals that can be used in the manufacturing of various plastics to make them stronger, lighter, smoother and far more scratch, ultraviolet and fire-resistant, without having to sacrifice any of the inherent mechanical properties of these plastics.

One spoonful of nanoclay can lead to a hundred times its own volume in enhanced-property polymers.



Scanning electron microscope images of typical nanoclays.

Images: Sharon Eggers, CSIR

Locally produced nanoclays for vastly enhanced plastics

The challenge: The quest for better plastics using nanoclay minerals

Glass fibre is often used to harden plastics but in the process the plastic loses some of its toughness and smoothness and become significantly more brittle. Typically, around 32% to 40% glass fibre is added in the manufacturing of plastics to attain the desired properties. In contrast, only 3% to 5% nanoclay is required to provide the plastic with enhanced mechanical properties without sacrificing any of the inherent properties of the plastic.

Nanoclays are nanoparticles of layered mineral silicates with unique properties that can enhance polymer nanocomposites used for plastics. The CSIR is looking at how best to beneficiate South Africa's nanoclay minerals, with the specific aim to modify minerals to be compatible with and enhance the inherent properties of plastics used in the industry.

Plastics manufactured with nanoclay minerals are significantly stronger, lighter, smoother and far more scratch, UV and fire-resistant than traditional glass fibre plastics. The CSIR is working on various ways that local nanoclay minerals can be beneficiated in the plastics industry.

Research and development: Optimising nanoclay minerals for use in polymer matrices

Because of their extremely small size and unique structure, nanoparticles exhibit novel properties that are being researched and exploited for biomedical, optic, electronic and other applications.

Nanoclay research at the CSIR has focused on two aspects – firstly, how best to surface-modify nanoclay minerals. Pristine nanoclay minerals are hydrophilic (readily dissolving in water) and do not easily mix with polymers because most polymer matrices are hydrophobic (tending not to dissolve in water). To make nanoclay minerals more readily mixable with plastics, one must convert the natural hydrophilic surface of the mineral to an organophilic surface (with an affinity for organic compounds) through surface-modification at the nanoscale. The modification lowers the surface energy of the nanoclay particles and improves the wetting characteristics of the polymer matrix. Secondly, the CSIR investigates how best to disperse the nanoclay minerals in a polymer matrix. Nanoclay cannot simply be added to a polymer matrix, but requires the right temperature and processing conditions to properly mix with the plastic.

By using nanoclays, any kind of plastic used in the industry, including packaging plastics, engineering plastics, biodegradable plastics and PVC (one of the most widely produced synthetic plastic polymers), can potentially benefit from enhanced nanoclay-enabled properties. In the use of PVC piping, UV radiation has been a huge challenge because UV rays disintegrate PVC over time. Nanoclays can, however, now be used to make UV-resistant PVC.

The CSIR has begun small-scale production of nanoclays at one tenth of the average cost of similar nanoclays in the international market. This is as a result of the availability of cheaper production methods and the fact that South Africa boasts sizeable nanoclay mineral deposits. Full-scale commercial production of these nanoclays is expected to start in the last quarter of 2015.

Outcome

Plastics manufacturers have begun to realise that although nanoclays are still significantly more expensive than glass fibre, the cost is outweighed by the many benefits. Because only 3% to 5% nanoclay is needed rather than 32% to 40% glass fibre, using nanoclays is a cost-effective solution resulting in plastics with enhanced properties and performance.

To date, the main clients using these CSIR-produced nanoclays have been the PVC pipe industry, the packaging industry and the automotive industry.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

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In brief

The integration of various facilities and capabilities into a one-stop occupational health and safety platform for South African mining offers significant benefits to this industry. Well-developed facilities are critical to this undertaking and the CSIR has, over many years, invested in a range of facilities that are contributing to health and safety in this sector. The facilities include a testing and training facility for fires and explosions, an air and dust laboratory, a wire rope testing facility, infrastructure for the testing of self-contained self-rescuers as well as a mechanical testing facility.

A steel rope diameter is measured prior to destructive testing.

The rubber mouthpiece and noseclip are CSIR innovations used in self-contained self-rescuers.

Inspection of a rope fracture at the CSIR mechanical laboratory.

An occupational health and safety platform to support South African mining

The challenge: Reducing the risk to human life

The South African mining industry plays a key role in the country's economic development and employs over 500 000 workers. However, mining is inherently dangerous – methane and coal dust mixtures cause fatal explosions in coal mines and airborne pollutants expose mineworkers to respirable crystalline silica and other health hazards. Steel wire ropes – the lifeline of mine shafts – deteriorate over time and must be tested to ensure safe operation.

Support for health and safety testing in the mining industry

The CSIR's mining research and testing facilities make the organisation an ideal partner for the Mine Health and Safety Council, as the CSIR's contributions are directly linked to various critical issues in mine health and safety in South Africa.

Oxygen during underground emergencies

In 1996, the CSIR established a monitoring programme for self-contained self-rescuers at the direction of the Chief Inspector of Mines, resulting in improved reliability of these life-saving devices. This breathing apparatus produces oxygen for underground workers during emergency escapes. The CSIR is the only accredited testing authority for self-contained self-rescuers in South Africa. These tests are necessary to detect any deterioration in functional performance. More than 200 mines participate in the self-contained self-rescuer monitoring programme and more than 2 200 units are tested annually.

During 2014, 13 underground fires were officially reported and 49 self-contained self-rescuers were used, with no malfunction reported.

Training in explosion suppression

The Kloppersbos testing, training and research facility was established in 1985 as a Department of Mineral Resources (DMR) facility managed by the CSIR. It offers awareness training seminars and training in explosion suppression to underground workers and has a unique combination of testing and research and development facilities.

Some 4 000 mineworkers from various coal and platinum mines as well as students from tertiary institutions visited Kloppersbos during 2013 and 2014 for awareness training.

Testing the integrity of wire ropes

The CSIR operates the only independent and accredited wire rope testing facility in South Africa and is authorised by the DMR to conduct statutory testing of winder ropes to determine breaking strength and general condition.

The steel rope laboratory tests in excess of 2 000 winder rope specimens annually and notifies a mine immediately if the rope fails to meet the minimum strength criteria. It is the only facility able to accommodate the large-rope diameters used in South Africa's ultra-deep mines. It also tests the strength of conveyor belt splices to ensure safe operation.

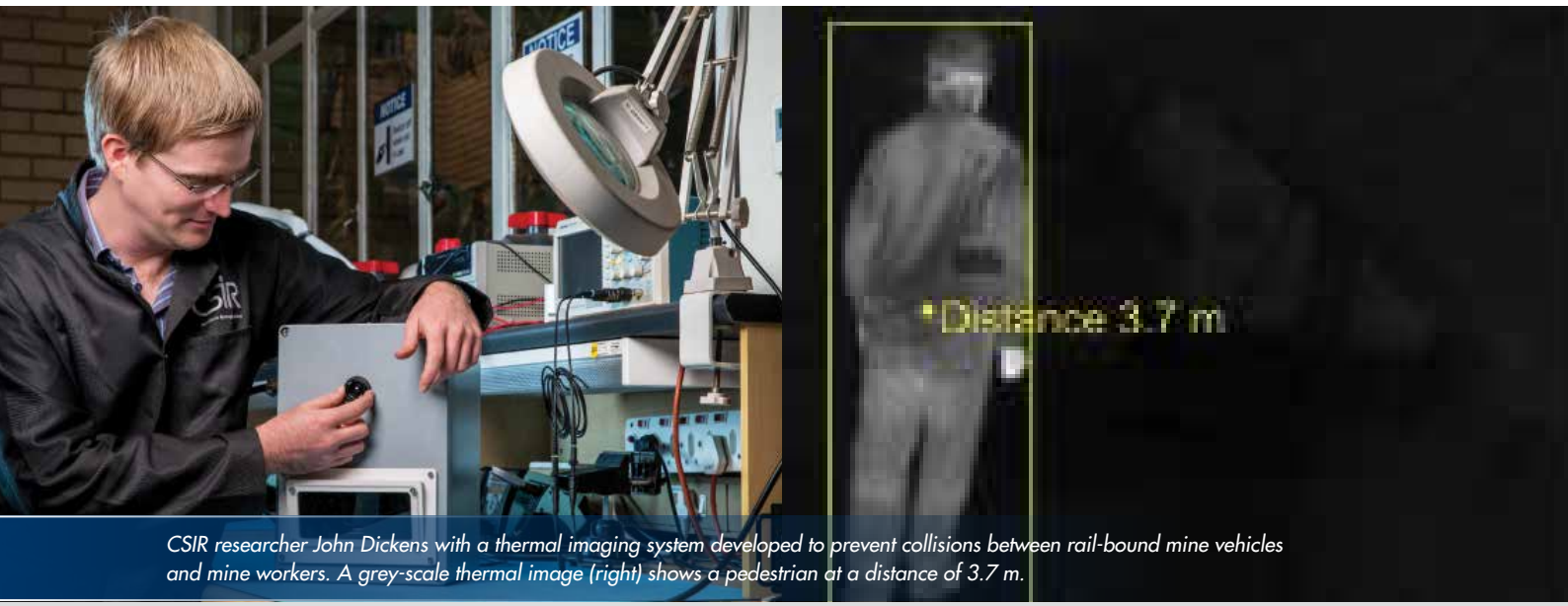
Testing material strength

The CSIR operates two of the largest mechanical testing machines in South Africa as well as other testing equipment. Evaluation of the compressive resistance of roof support systems in underground mines is done regularly, as well as proof-load testing and destructive tensile testing to evaluate mechanical properties of, for example, lifting equipment.

Dust as a health hazard

Air and dust laboratories provide testing services to the mining industry to monitor the human health hazards contained in airborne dust. Tests for air and dust focus on airborne dust and diesel particulate matter; in each case there are workplace exposure limits that must be monitored. Monitoring of concentrations of respirable dust and diesel particulates plays a significant role in the goals of the mining sector to eliminate silicosis, a lung disease caused by respirable crystalline silica. The departments of Mineral Resources, Environmental Affairs and Labour rely on these services to monitor compliance by the mines and industries to the specified limits.

INDUSTRY



CSIR researcher John Dickens with a thermal imaging system developed to prevent collisions between rail-bound mine vehicles and mine workers. A grey-scale thermal image (right) shows a pedestrian at a distance of 3.7 m.

Creating a thermal imaging system to prevent mine accidents

Engineers at the CSIR have developed a novel thermal imagery system to help prevent collisions between rail-bound mine vehicles and mineworkers. Thermal imaging systems make use of infrared technology to create images of the heat signatures of objects and environments. Because of the strong contrast between the heat signatures of people – such as mineworkers – and the environment in mine shafts, thermal images are ideal to monitor human movement within mines.

While fatalities in South African mines have decreased in recent years, more needs to be done to further reduce fatalities. The number of deaths and injuries from rail-bound vehicle-related accidents in South Africa's mines are second only to those caused by rock-falls, with some 39 deaths attributed to such accidents in 2014.

New legislation will make it compulsory for rail-bound mine vehicles to be equipped with some kind of collision avoidance system.

The CSIR-developed system makes it possible for rail-bound vehicles to be programmed to slow down when passing people and to initiate an emergency stop when a person is in the direct path of the vehicle. Because these systems can be automated and can pick up human heat signatures even in conditions of low-visibility, the system can also be used to monitor the movement of persons in and out of the mine and can be used to combat illegal mining.

The system is being commercialised by South African mining-technology company, Ubora Innovation.

THE CSIR-DEVELOPED SYSTEM MAKES IT POSSIBLE FOR RAIL-BOUND VEHICLES TO BE PROGRAMMED TO SLOW DOWN WHEN PASSING PEOPLE AND TO INITIATE AN EMERGENCY STOP WHEN A PERSON IS IN THE DIRECT PATH OF THE VEHICLE.

The first image-plane tests carried out in the CSIR medium-speed wind tunnel, using the half model of the airframe used in a project that investigated the use of joined-wing configurations and morphing-wing solutions.

Investigating ways to create more efficient aircraft for future air transport

The CSIR is participating in an international multi-disciplinary effort to design and create aeroplanes that will benefit from enhanced aerodynamic properties and advanced adaptive technologies that would make for lighter, more efficient and more manoeuvrable aircraft, resulting in significantly reduced operational costs.

The CSIR is doing this work as a consortium member of a European Union-funded project, called *Novel air vehicle configurations from fluttering wings to morphing flight*. The central concept behind the proposed new designs is the use of joined-wing configurations and morphing-wing solutions.

An aircraft flies best at a single, predetermined design point, which is the speed, altitude and cruise conditions at which it was designed to best perform at. At all other flight conditions outside of the design point, for instance at lower or faster speeds or at higher or lower altitudes, the aircraft works less efficiently. The need for this traditional design approach is driven by the structural limits and weight of aircraft materials and outdated aerodynamic designs.

In new designs, advanced materials and aerodynamic solutions are employed to allow a wing structure to 'morph' during flight to better adapt to varying flying conditions and to enhance manoeuvrability. These technologies can enable more cost-effective air transportation by reducing weight and drag, which equates to the need for less fuel.

In this project, researchers and engineers are studying the possibility of moving the control surfaces of an aircraft, mainly the wings, during flight, by using smart, flexible materials and adaptive technologies to enable the aircraft to fly at a large number of operating points while maintaining maximum efficiency. This will make flight more efficient and cost-effective. The international team is also developing the tools that will allow the analyses and simulations necessary to evaluate the effectiveness of these proposed solutions.

As part of these efforts, consortium members from Brazil and Europe travelled to South Africa to attend high-speed tests at the CSIR medium-speed wind tunnel, where tests of the morphing wing concepts fitted onto a medium-range transport aircraft configuration were carried out. These tests in the CSIR transonic medium-speed wind tunnel included the comparison between a reference regional airliner configuration and the same configuration with the theoretical morphed configurations of the control surfaces applied to it by simulating flight speeds at operational cruise altitude.

The results were informative, showing that the gains provided by morphing solutions are not cost effective for medium-range aircraft but would be more suitable for business jets and transcontinental long-range airliners.

INDUSTRY

CSIR interns Itumeleng Kobane, Mpho Malaka and Happy Mathekga working alongside Makekele Wiheminah Somo-Tladi of Elvema Nutritions (Pty) Ltd, seen second from right. The CSIR provides the enterprise with technical expertise in food manufacturing processes.

First enterprises benefit from programme to develop SA biomanufacturing industry

The CSIR Biomanufacturing Industry Development Programme has supported six enterprises that produce bio-products for industrial, cosmetic and nutritional applications since its launch in October 2013.

The programme helps small, medium and micro enterprises to develop and commercialise biotechnology-based products and technologies. Supported by the Jobs Fund initiative and the Department of Science and Technology, the programme is the result of South Africa's commitment to developing a biomanufacturing economic sector.

To accelerate the translation of research and development into market-ready products, the programme initially focused on upgrading infrastructure and building the necessary skills. Enterprises are now supported in developing new products, ensuring regulatory compliance, upscaling technologies and small-scale manufacturing of products for market testing.

The first enterprises to receive such support were Abxtracts, ReSyn Biosciences, Linda Aromas, Phepisa Natural Resources Institute, JVS Biotech and Elvema Nutrition. Resyn Biosciences has exited the programme, with five products developed and transferred to the company. The company produces products for the life-sciences research and development market. Its microsphere technology maximises the surface area for molecules to bind targets very specifically. The company recently received a prestigious new product award at the *Society for Lab Automation and Screening conference* in Washington in the USA.

Seventeen CSIR scientists and engineers are employed in the programme and a minimum of 20 interns are trained each year in the fields of agro and bioprocessing. In addition to the vocational training offered to interns, the programme has provided training to 39 entrepreneurs and their staff through agro and bioprocessing workshops, as well as bioentrepreneurship training in partnership with the Technology Innovation Agency.

The programme is set to be expanded to also support higher education and research institutes to translate their inventions into market-ready products.

SEVENTEEN CSIR SCIENTISTS AND ENGINEERS ARE EMPLOYED IN THE PROGRAMME AND A MINIMUM OF 20 INTERNS ARE TRAINED EACH YEAR IN THE FIELDS OF AGRO AND BIOPROCESSING.

A sheet with a blend of essential oils can prevent decay in table grapes during exportation.

A biocontrol sheet protects table grapes against decay

CSIR researchers, in collaboration with the Agricultural Research Council (ARC), have developed a light-weight biocontrol sheet which can be used as a carrier of natural fumigants to prevent post-harvest decay in table grapes.

The European Union, which accounts for more than 80% of the South African grape export market, is issuing stringent regulations for the use of sulphur dioxide-based preservatives for fresh produce due to their harmful side-effects. Treatment with sulphur dioxide is, however, still the standard treatment to prevent colonisation of table grapes by fungi such as *Botrytis cinerea*, also known as botrytis bunch rot or grey mould.

Researchers at the ARC are investigating essential oils as natural fumigants and as safer alternatives. These include oils extracted from citrus peels, an agricultural waste product. The CSIR has, as part of this programme, developed a delivery system that slowly releases sufficient doses of essential oil-derived volatiles to inhibit the post-harvest grey mould in table grapes, without affecting their colour, taste and aroma. A further challenge was to make the product cost-effective to limit the financial impact on farmers.

The research team has successfully incorporated the blend of various essential oils into a thin multilayer plastic sheet. Tests have shown that these sheets, placed in boxes of grapes, significantly reduced the incidence of decay during a five-week shelf-life period for two table grape cultivars without any effect on the fruit's quality, taste or aroma.

The product has attracted the attention of a commercialisation partner and is being refined. During 2014, the researchers significantly reduced the thickness of the sheet down to 30 microns at the request of the industry and to minimise the weight of packaging for the export market.

Sheets developed by the CSIR form the basis of a biocontrol delivery system to protect table grapes against decay.

INDUSTRY

Laser cladding by powder injection is an advanced laser material processing technique which is used in manufacturing, part-repair, coating and metallic rapid prototyping. Top right: The mobile version of this system makes it possible to repair large components, such as turbine rotors, on-site.

Refurbishing large industrial components using a mobile laser system

CSIR engineers designed and constructed a mobile laser welding system that can repair components on-site, eliminating the need to transport large or valuable components.

The system uses a high-power industrial laser. The power source for this type of laser is typically housed in a built-for-purpose facility. The machine components that have to be repaired are often so large (the size of an entire warehouse) that they can only be transported to the facility for refurbishment with considerable time and effort. Repairing the components on location saves industry the time and money it would have cost to transport the components to a refurbishment facility. It also saves on the downtime of its operation through the loss of a functional component.

With laser cladding technology, a high-power industrial laser generates a small puddle of molten metal on the surface of a metal. New material in the form of a metal powder is injected into this weld pool. When the laser beam and powder injection system are traversed across the work piece, the metal surface and newly deposited layer solidify, creating a new layer of material. This new layer is metallurgically bonded to the base material, ensuring excellent adhesion of the new layer to the original metal surface. In the mobile system, the laser source is coupled to a mobile robotic delivery arm that handles the beam delivery and powder-feeding systems.

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

CSIR ENGINEERS DESIGNED AND CONSTRUCTED A MOBILE LASER WELDING SYSTEM THAT CAN REPAIR COMPONENTS ON-SITE, ELIMINATING THE NEED TO TRANSPORT LARGE OR VALUABLE COMPONENTS.

Charlie Inama, an operator at Interohm, with a sample of the asbestos-free cement board insulator.

Asbestos-free cement insulators for industry

The CSIR has assisted original equipment manufacturer Insulectric (Pty) Ltd with the development of an asbestos-free cement board insulator.

Insulectric specialises in high-temperature electrical insulation. Following South African legislation in 2008 prohibiting production and import of asbestos-containing products, Insulectric had to import asbestos-free cement board insulators as no locally manufactured products were available.

In partnership with the Technology Localisation Implementation Unit (a Department of Science and Technology initiative hosted by the CSIR), the CSIR assisted locally owned Insulectric with the development of an asbestos-free cement board insulator which is as effective as traditional asbestos boards.

The CSIR-developed product has been tested in accordance with the high-voltage standards of the South African Bureau of Standards, as well as for mechanical properties, thermal shock resistance and computer numerical control machinability, a manufacturing process involving the use of computers to control machine tools.

This composite cement board insulation product is now entering the commercialisation phase as advanced research and testing are matched to requirements of the industry, and local and international demand.

The re-commissioned manufacturing plant Insulectric-Interohm will manufacture this product as the only manufacturer of asbestos-free cement board insulators in South Africa. In addition to adherence to legislation banning the manufacturing of asbestos products and thereby avoiding the health risks of exposure to airborne asbestos fibres, this development ensures future import replacement of seven different foreign-sourced products and job creation through introduction of extra shifts to make these new products.

The CSIR-developed product was tested by the South African Bureau of Standards.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

DEFENCE AND SECURITY

The link between safety and security and our continued socioeconomic development is stated unequivocally in the *National Development Plan 2030*. The CSIR contributes to a safe and secure South Africa by supporting the building of a capable state and by developing technologies to ensure safer communities.

The CSIR's main focus areas in this domain are information security; improved tactical and situation awareness, which include assisting the South African National Parks in combating threats to wildlife and securing our national borders; as well as command control and coordination solutions for multi-agency operations.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

DEFENCE & SECURITY

In brief

South African National Parks (SANParks) has partnered with the CSIR on the use of technology to combat rhino poaching. The CSIR supports SANParks with technology evaluation and advice, improved systems for surveillance and detection as well as secure tools for the collection and analysis of data pertaining to poaching tactics and trends.

The CSIR assisted South African National Parks rangers through training and specialised equipment to better prepare them during counter-poaching operations.

Employing technology in the fight against rhino poaching

The challenge: Halting rhino poaching

The number of rhino poaching incidents has escalated drastically in the past decade as the demand for poached rhino horn increased. Worth more than its weight in gold, rhino horn is at the heart of flourishing illegal trade activities. Housing the largest concentration of rhinos in South Africa – and also worst hit by poachers – the Kruger National Park has become the focus of a number of interventions to protect the animals and improve the ability of park officials to deal with poachers.

Research and development: A holistic technology intervention to tackle rhino poaching on all fronts

To help SANParks in its surveillance and detection capabilities and to increase the effectiveness of its counter-poaching operations, the CSIR has developed technology interventions focused on improved mobility, advanced surveillance systems and training for special ranger squads. The CSIR has also established a command centre where poaching intelligence is gathered and analysed.

The work draws on the CSIR's multidisciplinary skills base and involves a number of government departments and agencies that need to coordinate efforts.

A counter-poaching command post

A facility that serves as a nerve centre has been established where surveillance reports and data about poaching events, country-wide border crossings and other operational information is collated, shared and analysed. It also serves as a command post for immediate-reaction task forces that are dispatched from a nearby airstrip.

A CSIR-developed and customised system is at the heart of the comprehensive intelligence gathering undertaking and has been installed at the centre. Rangers and other parties involved in combatting rhino poaching – from private game rangers and tourists to the South African Police Service – all log incident data of various types. By forming a holistic picture of incidents and trends, SANParks staff members are able to understand the behaviour patterns of poachers and develop pro-active response strategies.

Shaping conservationists to be effective tactical rangers

Many rangers are now at the forefront of the war on poaching, whereas traditionally they were mostly focused on environmental management. SANParks secured a donation from the Howard G. Buffet Foundation to invest in improving the counter-poaching capabilities of rangers through the acquisition of helicopters, surveillance systems and ranger equipment and through the training of rangers. In the past, ranger weapon systems were primarily optimised for wildlife management, but due to the increased threat posed by armed poachers, these systems had to be adapted and modified for self-defence during counter-poaching activities.

The CSIR works closely with rangers to understand their operational requirements and develop appropriate specialised training, improved ranger mobility, clothing and protection, equipment and weapons.

In partnership with StopRhinoPoaching.com and the Mpumalanga Tourism and Parks Agency, the CSIR converted a standard 4 x 4 trailer into a mobile tactical unit that can be used by rangers during counter-poaching operations. The tactical trailer enables the deployment of rangers in areas without infrastructure.

Securing communications

In September 2014, the CSIR introduced a web-based platform dedicated to raising awareness on rhino poaching in partnership with StopRhinoPoaching.com, and Seecrypt, a provider of encryption technologies for commercial voice and messaging applications. The partnership is aimed at delivering military-grade, secure communications to the teams working on counter-poaching projects. Feedback from the CSIR's operational evaluation was used by Seecrypt to further optimise secure communication platforms. A secure message broadcasting solution is now being used by various individuals who work in this field.

DEFENCE & SECURITY

The simulation and training platform developed by the CSIR and Cybicom Atlas Defence to help with procedural training for deck landing officers on the South African Navy frigates.

New simulator to help train SA Navy staff for landings on frigate decks

The CSIR and Cybicom Atlas Defence have jointly developed a simulation and training platform for South African Navy (SAN) operations. The distributed, integrated simulation system was developed to help with procedural training for deck landing officers on the SAN frigates.

The SAN operates a number of Lynx maritime helicopters that land and take off from the decks of its frigates. A deck landing officer on the frigate guides the helicopter pilot safely onto the deck. Training of the deck landing officer and pilots become especially valuable in difficult sea conditions when the changing angle of the deck complicates the landing or take-off.

The newly developed helicopter flight deck trainer is designed to provide joint training for flight deck controllers and marine helicopter pilots. It provides a safe, cost-effective solution to train personnel in a realistic and controlled environment. The flight deck trainer is a flexible, modular system that can be supplied in various levels, from a simple, portable desktop trainer, to a multichannel, high-performance tracking system that can accommodate multiple trainees and provide a 360-degree high-fidelity simulation with full-environment simulation.

The distributed simulation environment integrates three man-in-the-loop simulator stations. The first is a CSIR-developed helicopter flight simulator with pilot interface that models the helicopter, the airflow over the deck and the ship interaction dynamics, complete with an image-generation system that displays the external world view to the pilot. The second simulation component is a ship bridge simulator developed by Cybicom Atlas Defence that includes sea-state, rain and cloud-cover models with a bridge interface for the captain. The third simulator station is a deck landing officer station also developed by Cybicom Atlas Defence.

The CSIR and Cybicom Atlas Defence are also working towards industrialising the training system. This will create a product suitable for small-scale production that will cater to both the commercial and defence markets. This is being undertaken with the support of the Aerospace Industry Support Initiative (AISI). The AISI is an initiative of the Department of Trade and Industry hosted and managed within the CSIR.

A 360-degree high-fidelity simulation with full-environment simulation.

Priaash Ramadien of the CSIR demonstrates a platform that integrates and processes data from different sensors and communication devices at the organisation's concept development and experimentation centre.

Experimental defence scenarios brought to life

The CSIR has established a new centre where information from any range of diverse systems can be integrated and simultaneously displayed in near real-time to visualise different experimental defence scenarios. The concept development and experimentation centre is expected to help with the testing of national safety and security capabilities and the development of solutions that will support government agencies tasked with national safety and security.

The centre, which creates levels of situation awareness not previously possible, can be used for anything from defence training or operations planning to creating border security response strategies and centrally monitoring counter-poaching efforts.

The CSIR's advanced Cmore platform, partly funded by Armscor, is used in the centre to monitor and map, for example, counter-poaching operations. This platform integrates and processes data from various sensors and communication devices, including smartphones, to provide intelligence support to operational decision-makers.

The centre allows for a flexible environment with a strong networking, multimedia and server infrastructure in which different information display configurations can be easily and quickly prepared to be used for different experimental scenarios to aid in better planning. It employs equipment and software platforms that can support, display, analyse, integrate and interpret diverse sets of data quickly and efficiently.

Experiments conducted included border safeguarding experiments with interdepartmental participation, supporting community policing forums and operations of the South African Police Service, as well as supporting the Presidential inauguration.

THE CENTRE, WHICH CREATES LEVELS OF SITUATION AWARENESS NOT PREVIOUSLY POSSIBLE, CAN BE USED FOR ANYTHING FROM DEFENCE TRAINING OR OPERATIONS PLANNING TO CREATING BORDER SECURITY RESPONSE STRATEGIES AND CENTRALLY MONITORING COUNTER-POACHING EFFORTS.

DEFENCE & SECURITY

A variety of sensor platforms were deployed during a border safeguarding experiment in November 2014, including unmanned aerial systems (left) and sophisticated camera systems (right). Monitoring sites were set up, such as the one below as well as a main nerve centre at the Saldanha military base in the Western Cape from where officials, industry partners and members of the armed forces attended live streaming sessions of the experiment.

Integrating technologies for a more secure border

A CSIR and defence industry team consisting of 85 scientists and engineers took part in a border safeguarding experiment to evaluate the command and control processes of the South African National Defence Force (SANDF) and government agencies with related roles.

Various sensor technologies and platforms developed by the CSIR and others in the defence industry were positioned along the West Coast border to accurately simulate a border safeguarding deployment. Technologies deployed during the experiment in November 2014 included manned and unmanned aerial systems, radar, optronics and electronic sensor systems that are used underwater and on the sea surface.

Day and night operations were simulated to mirror actual security threats to the South African border. Depending on the type of incident, the government department mandated to deal with the specific issue, responded. Part of the experiment was to encourage discussions between departments on who should take the lead based on different scenarios. The responding department's strengths and weaknesses in its decision-making processes were evaluated.

The experiment enabled the SANDF to exploit new technologies and look at innovative ways of incorporating these technologies into operational processes that will ultimately enhance its capabilities.

The CSIR's Ayanda Tyatyantsi sets up camera parameters on the number plate detection sensor.

Smart sensors developed to combat crime in SA National Parks

The CSIR has developed a mobile automated number plate recognition system that allows authorities to respond quickly to stolen or suspicious vehicles entering or leaving a designated area. The technology, which makes it possible to scan vehicle registration plates and identify vehicles reported as stolen, is used in the fight against crime within South Africa's national parks. Four systems have been deployed at the Kruger National Park.

The system scans the registration of every vehicle entering the park. This information is then passed through a stolen vehicle database that scans for matches in real-time. A match is flagged and communicated to a situation awareness system that alerts the relevant authorities.

The system is portable and can be rapidly deployed to any location – it does not need high-bandwidth communication links or permanent external power sources. It is designed in a modular fashion that allows it to accommodate a number of sensors and processes. This means that the system is not limited to number plate recognition – the addition of more modules will allow it to process, for example, the shape, size or colour of vehicles.

Another application of the technology currently being investigated is the use of an acoustic array to triangulate the location of gun shots or other audio events. A single unit is able to detect the acoustic profile of a gunshot and multiple units can pinpoint the position of the gunman. Reporting these events in near-real time will be instrumental in combating poaching in South Africa's national parks as well as to pinpoint crimes in residential areas.

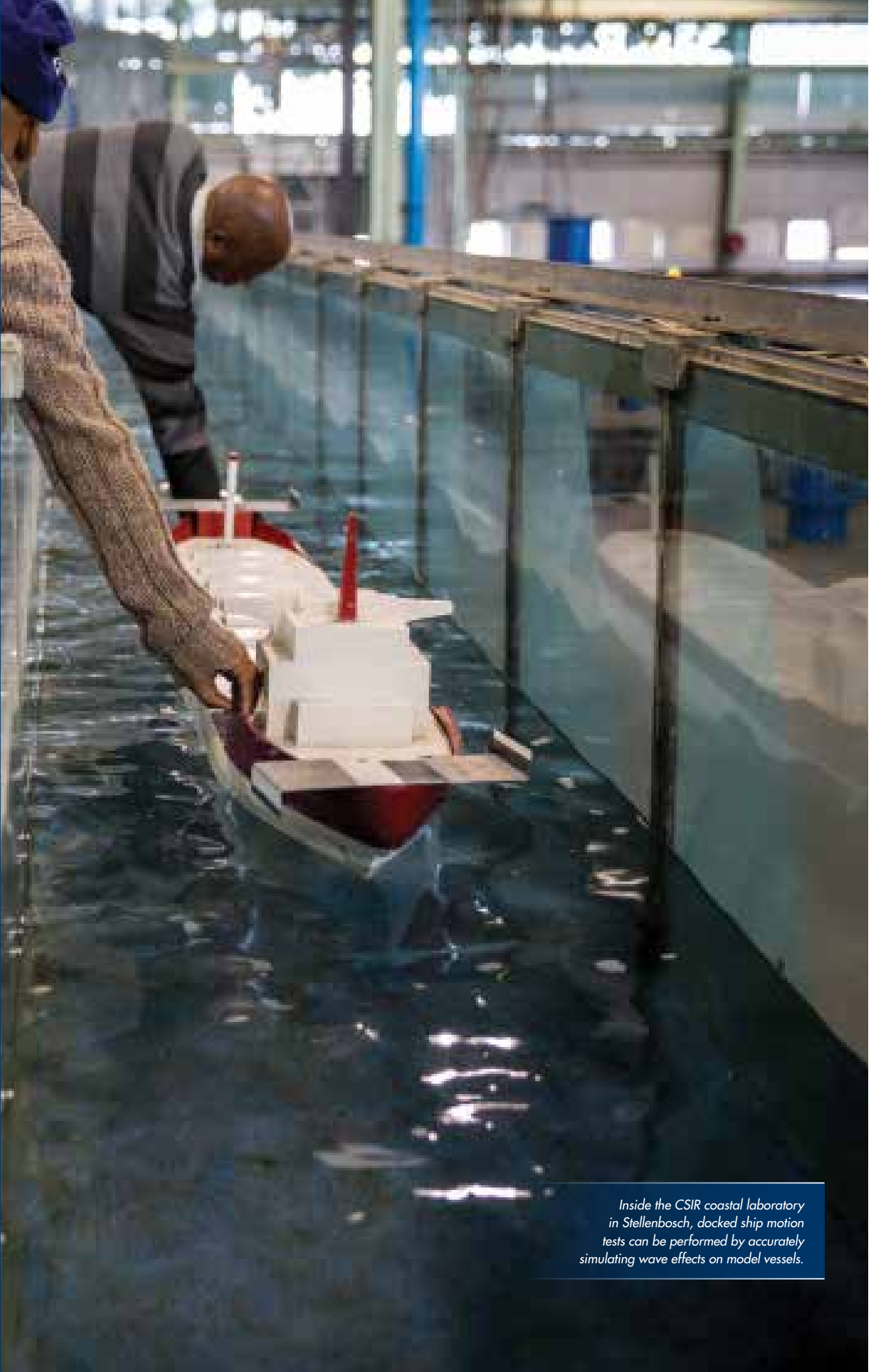
THE SYSTEM SCANS THE REGISTRATION OF EVERY VEHICLE ENTERING THE PARK. THIS INFORMATION IS THEN PASSED THROUGH A STOLEN VEHICLE DATABASE THAT SCANS FOR MATCHES IN REAL-TIME.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE BUILT ENVIRONMENT

The *National Development Plan 2030* acknowledges that infrastructure is not just essential for faster economic growth and higher employment, but it also provides citizens with the means to improve their own lives and boost their incomes.

The CSIR's contribution lies in the use of science, engineering and technology to contribute to the development and maintenance of the country's economic infrastructure and the transformation of human settlements. The organisation's main focus areas are the integration of data in decision-support systems for planning and maintaining settlements; improving the efficiency of buildings and developing new building materials and construction methodologies; developing design methods and maintenance procedures for road, port and railway infrastructure; and developing models and methods for more efficient public and freight transport.



Inside the CSIR coastal laboratory in Stellenbosch, docked ship motion tests can be performed by accurately simulating wave effects on model vessels.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE

BUILT ENVIRONMENT

With advanced, customised open-source software, the CSIR is able to make accurate future projections of urban growth for better city planning.

Helping South Africa to plan for sustainable urban growth

In brief

The CSIR is collaborating with national and local government, cities and other stakeholders, to better plan for urban growth and spatial development. The collaboration will help facilitate the transformation and integration of South Africa's cities and towns, a service delivery and supporting sustainable futures for households and human settlements.

The challenge: Ensuring better integration, sustainable growth

South Africa's complex cultural history and the legacy of apartheid have made urban development and spatial planning a particularly daunting challenge. Some of the key challenges that our urban centres will continue to face are the ongoing growth in the demand for services and economic opportunities, coupled with a continued urgency for transformation. This means not only addressing racially segregated apartheid landscapes, but also improving the quality of life within urban areas through increased access to services and economic opportunities, and more effective and affordable public transport – making it more cost and time efficient for especially households living in poverty to access urban opportunities.

Most South African cities have remained largely segregated and although urban land ownership patterns have changed, significant inequality in land ownership remains a problem at national

level. The practice has been to build low-income housing on low-cost, poorly located and underdeveloped land, rather than on higher value, well-located land. Because of this, the poor still live on the fringes of cities and rural areas, with less access to services, and are forced to make long commutes to work.

The inclusive, sustainable and efficient growth of SA's cities and towns is identified in the National Development Plan as a major priority for government and stakeholders.

Research and development in spatial planning

The CSIR is involved in various policy processes, innovative technology developments and decision-support projects to contribute to shaping the urban development conversation. These include tools to guide urban housing and infrastructure investment decisions such as the Spatial Temporal Evidence for Planning South Africa (stepSA) initiative, which is aimed at evidence-based urban growth planning; the drafting of the *Integrated Urban Development Framework* policy document; the compilation of the *2016 State of Cities Report* and software models able to make predictions on expected population growth and future service needs.

The CSIR, the Department of Science and Technology and participating metros have over the past few years made significant progress through the stepSA initiative to build a capability that can support better housing and infrastructure investment decisions within cities and avoid costly mistakes with long-term structural implications.

Research and spatial trend analyses conducted by the CSIR and the Human Sciences Research Council identified the fluidity of movement between cities, towns and rural settlements, and made note of continued trends such as ongoing urbanisation, the increasingly youthful population in urban areas, and a growth in households living in poverty. The research was used by the Department of Rural Development and Land Reform to inform the recent draft of the *Integrated Urban Development Framework*.

Towards smarter land readjustment

One of the ways that cities can increase integration is by making better use of underused, underdeveloped land. The CSIR is helping to examine city-wide strategies to identify underused land that can be earmarked for low-income housing. This includes land readjustment approaches where local government approaches private land owners who have informal settlements on their land adjacent to publicly owned land, to pool the land, redevelop and subdivide it, and include a range of residential and commercial developments.

Urban simulation models

The CSIR is further assisting urban planning strategy by making use of tailored software for spatial simulations and urban growth modelling. The open-source software platforms *UrbanSim* (for urban simulations) and *OpenTripPlanner* (for transport route and traffic simulations) were adapted by CSIR researchers for use in the South African context. These software tools allow for spatially based scenario planning, i.e. the ability to predict the consequences of investments in housing and transportation, and to present that information to decision-makers in an accessible form.

Through such innovative processes, public investment can more effectively support the differentiated and fast changing needs and requirements of the highly mobile urban population, and contribute to more sustainable and robust development of the country's cities, towns and rural landscapes.

Outcomes

The CSIR is assisting the South African Cities Network with compiling the *2016 State of Cities Report*. For the first time, South Africa is able to track key growth and population movement trends within and between cities, towns and rural areas, compare progress with spatial transformation at sub-city level across various cities, and start utilising that to simulate the spatial implication of growth scenarios.

The organisation is also assisting the Tshwane and Nelson Mandela Bay metropolitan municipalities with urban simulations, using the mentioned software tools, to create population growth and spatial population distributions over the next 30 years, for various scenarios. The projections are used to make better decisions on spatial planning, public transport corridors and infrastructure investment.

CSIR researchers are employing the *UrbanSim* software platform to identify, against the backdrop of expected population growth in specific areas, where new service centres such as schools, fire stations, police stations, hospitals and clinics ought to be located – which helps address quality of life in urban and rural settlements.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE

BUILT ENVIRONMENT

Towards a water-secure future for the City of uMhlathuze

In brief

The CSIR is committed to supporting local government in providing effective and efficient service delivery through scientific and technological solutions. The organisation's work in the uMhlathuze municipality addresses the serious water shortage in the area. Recent projects include the completion of feasibility studies for the reuse of effluent and sludge, the presentation of a lake management plan and developing a simulation model for bulk water management.

Challenge: Droughts and development impact water security

The uMhlathuze municipality, which is located around the town of Richards Bay in KwaZulu-Natal, is facing a serious water shortage which has already led to water restrictions. Based on population growth projections, it is estimated that the city's water requirement will almost double by 2025. To address this threat, the city is working towards understanding the factors that influence the entire water supply chain and to find environmentally friendly and sustainable ways to meet this increased demand.

Research and development

The CSIR is assisting the city by conducting various studies looking at water sources and usage as well as the feasibility of wastewater and sludge reuse.

Evaluating the state of water sources

Lake Mzingazi is the primary bulk water resource for the Richards Bay community as well as agricultural and commercial users. It is also an important ecosystem for several plant and animal species.

Urbanisation and densification of rural areas around the lake have resulted in a risk that the water quality and quantity could be compromised. The uMhlathuze municipality now uses more water than Lake Mzingazi can provide. The CSIR has produced a lake management plan that assessed the state of the lake and identified remedial actions that should be implemented. These include protecting wetlands and vegetation that mitigate the erosion of lakeshore banks and the promotion of environmentally friendly agricultural practices to limit the threat of leached fertilisers and agrochemicals. Other factors that threaten the Mzingazi ecosystem include sand mining that causes erosion, alien vegetation displacing endemic vegetation, as well as insufficient sewage and solid waste removal systems in informal residential areas that pollute surface and ground water. CSIR researchers recommended that a buffer zone be established around the lake margin that restricts human access and therefore protects the lake against the impact of agricultural activities, low-lying development and recreational activities. The city has subsequently commissioned a similar management plan for Lake Cubhu, which is also threatened.

Reuse of sludge

Realising the importance of finding environmentally friendly and sustainable solutions to the water crisis, the city has prioritised investigations into the feasibility of wastewater and sludge reuse.

Sewage sludge and solids, which build up at local water treatment works, need to be removed regularly and at a cost. The city was concerned about the management of sludge at five of its water treatment works because of the limited space available to store dry sludge within the boundaries of the works and commissioned the CSIR to investigate reuse options.

The CSIR analysed the sludge to determine its classification in terms of national guidelines for the use and disposal of wastewater sludge. These guidelines prescribe the re-use options available for the sludge currently being stored at

each of the wastewater treatment works. The researchers recommended which sludge could be reused and what additional treatment it needed. Possibilities for re-use included recommendations for agricultural and non-agricultural applications (both with special restrictions and monitoring), including biogas and energy production.

Wastewater treatment

The city requested proposals for the reuse of wastewater from two sewage pump stations, as this wastewater is currently discharging into the sea. The researchers recommended building a regional treatment facility and advised the city on a biological nutrient removal process and the construction of a pipeline to discharge the treated water back to Lake Mzingazi. Alternatively, the treated effluent could be used by industries immediately surrounding the plant, provided that the water quality specifications for the lake and surrounding industry are met.

The CSIR and the city are in discussions with National Treasury and the Development Bank of Southern Africa to look at the feasibility of the suggested infrastructure upgrades needed for the reuse of sludge and wastewater.

Simulation model for bulk water management

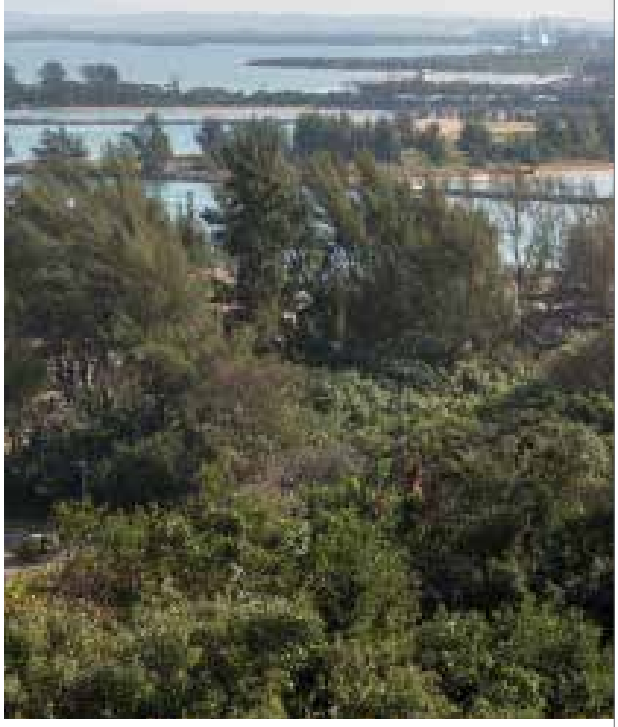
The CSIR compiled a bulk water management plan for the city. The researchers developed a hydraulic model for the city to simulate the water supply network of reservoirs and their upstream infrastructure. This information can be used to project future water requirements in order to plan infrastructure upgrades which are crucial for a water-secure future.

Green Drop status

Government's Green Drop certification programme for wastewater is an initiative to ensure that municipal wastewater treatment works run optimally, so that treated effluent complies with regulatory limits and does not pollute the water bodies into which it is discharged. For the assessment period July 2011–June 2012, three of the city's wastewater treatment plants (Ngwelezane, eNseleni and Vulindlela) achieved Green Drop certification status as published in the *Green Drop Report 2013*. The CSIR started working with the city on the Green Drop project in July 2012, and has assisted the city in maintaining its effluent compliance and quality.

Water monitoring

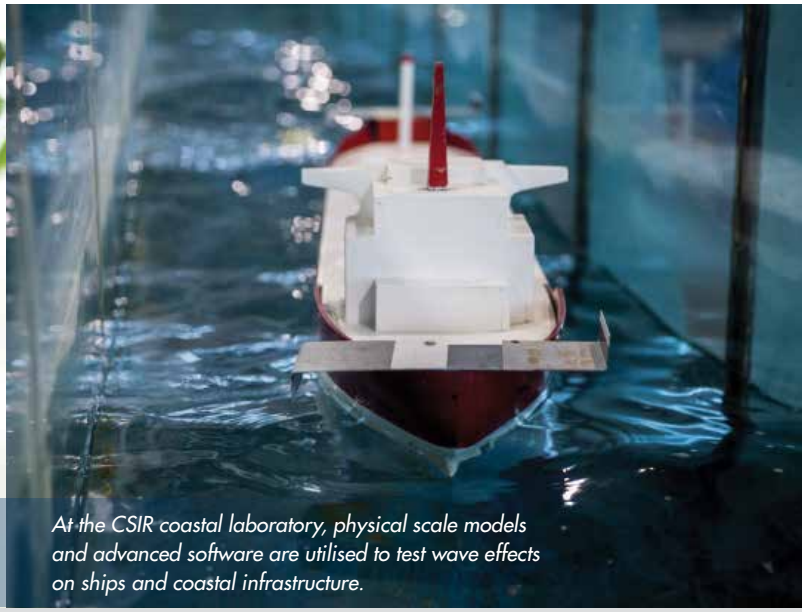
The CSIR conducts real-time monitoring of the water quality in the uMhlathuze and eThekwini municipalities. Sensors are used to collect and communicate data to a central point for monitoring, evaluation and reporting purposes.



A view toward the Port of Richards Bay, the hub of the City of uMhlathuze, a municipality challenged by water shortages.

BUILT ENVIRONMENT

CSIR software combines data on education levels, average income and financial wellbeing to show the discrepancy between 'better-off' (green) and 'worse-off' (red) areas in the eThekwini municipality.



At the CSIR coastal laboratory, physical scale models and advanced software are utilised to test wave effects on ships and coastal infrastructure.

Understanding risk scenarios in the City of Durban

The CSIR has designed and developed an indicator system that makes use of existing data sets to better understand and visualise the economic wellbeing of the City of Durban and the wellness of its people.

The researchers developed a computer interface that allows complex manipulations of spatial data, for example those related to the value of assets, flood plains, meteorological indicators, population distributions, income levels, crime rates and amenities.

The novelty of the system is that it allows the municipality's decision-makers to visualise or create indicators from hundreds of datasets, in real time, during planning sessions. This helps them to collectively focus resources for development where most needed.

The system can, for example, combine data related to flood plains with rainfall data to provide information about the probability of flooding. Assets at risk of flooding can be determined from the city's valuation roll, which could be further combined with data about the location of amenities, such as hospitals and police stations. By further factoring in the number of people living in these areas, city planners can better estimate the impact of flooding in communities and use this data to plan interventions.

The long-term intention is to make this system available to more municipalities, and even to apply it at provincial, national or regional level.

CSIR tests new wharf design for St Helena Island

The island of Saint Helena is set to enjoy a boost to tourism and trade upon the completion of the island's first airport and a new permanent wharf in Rupert's Bay. The CSIR conducted docked ship motion tests and breakwater stability tests for the design of the wharf.

St Helena, British overseas territory of about 122 km^2, is situated in the Atlantic Ocean about 3 000 km north-west of Cape Town and has only been accessible with a five-day journey at sea between the Cape Town harbour and the island.

After the United Kingdom (UK) in 2005 approved plans for the construction of an airport on St Helena to boost tourism and trade, it was decided that a new permanent wharf would need to be constructed in Rupert's Bay. The CSIR was asked by UK Aid to assist with docked ship motion tests and breakwater stability tests for the design of the wharf, to determine whether the design would be able to perform as required.

For the tests, an exact scaled model of the wharf design was built at the CSIR's coastal laboratory. The construction of the permanent wharf began at the end of 2014, after the model tests were successfully completed. The tests included a series of simulations under various sea conditions to provide specifications for mooring lines attached to the vessel and to test the stability of the breakwater design against extreme storm events.

The scaled physical models of harbours and breakwaters built at the CSIR coastal laboratory are constructed in fine detail and with great care to ensure utmost accuracy.

Solution for damaged Richards Bay breakwater proposed after extensive tests

After extensive tests on a detailed model of the Richards Bay breakwater, which was partially destroyed in an extreme storm, CSIR researchers identified an affordable solution to repair the breakwater.

Many of the 30 tonne dolos units at the tip of the breakwater suffered breakages during the storm event in 2007, leaving the Richards Bay breakwater partially exposed. Transnet approached the CSIR to create a physical model of the breakwater to test various options for repairing the breakwater.

Rather than rebuilding the concrete roundhead or replacing the breakwater dolos units that were shifted or destroyed, both of which would be extremely costly, the research team proposed chaining the existing dolos units together in clusters to increase their strength and to significantly extend their design life. A similar technique was successfully used some 20 years ago to strengthen the breakwater of the Cape Town harbour. In that case however, only the bottom, load-bearing dolos units were chained to the toe of the breakwater below the ocean surface.

Technicians built a scaled replica of the Richards Bay south breakwater. Upon completion, the scaled-down breakwater was pounded with artificially generated waves that accurately replicate sea conditions. Various methods of repair options were tested – including making no repairs at all, rearranging the existing dolos units around the roundhead and tying them together to increase their robustness and lastly, replacing the damaged portions of the breakwater.

The results showed that with no repairs the breakwater would not be able to withstand a one-in-ten-year storm condition and that constructing a new structure would be prohibitively expensive. Chaining the existing dolos units into clusters is a comparatively cheap method to extend the breakwater's lifespan.

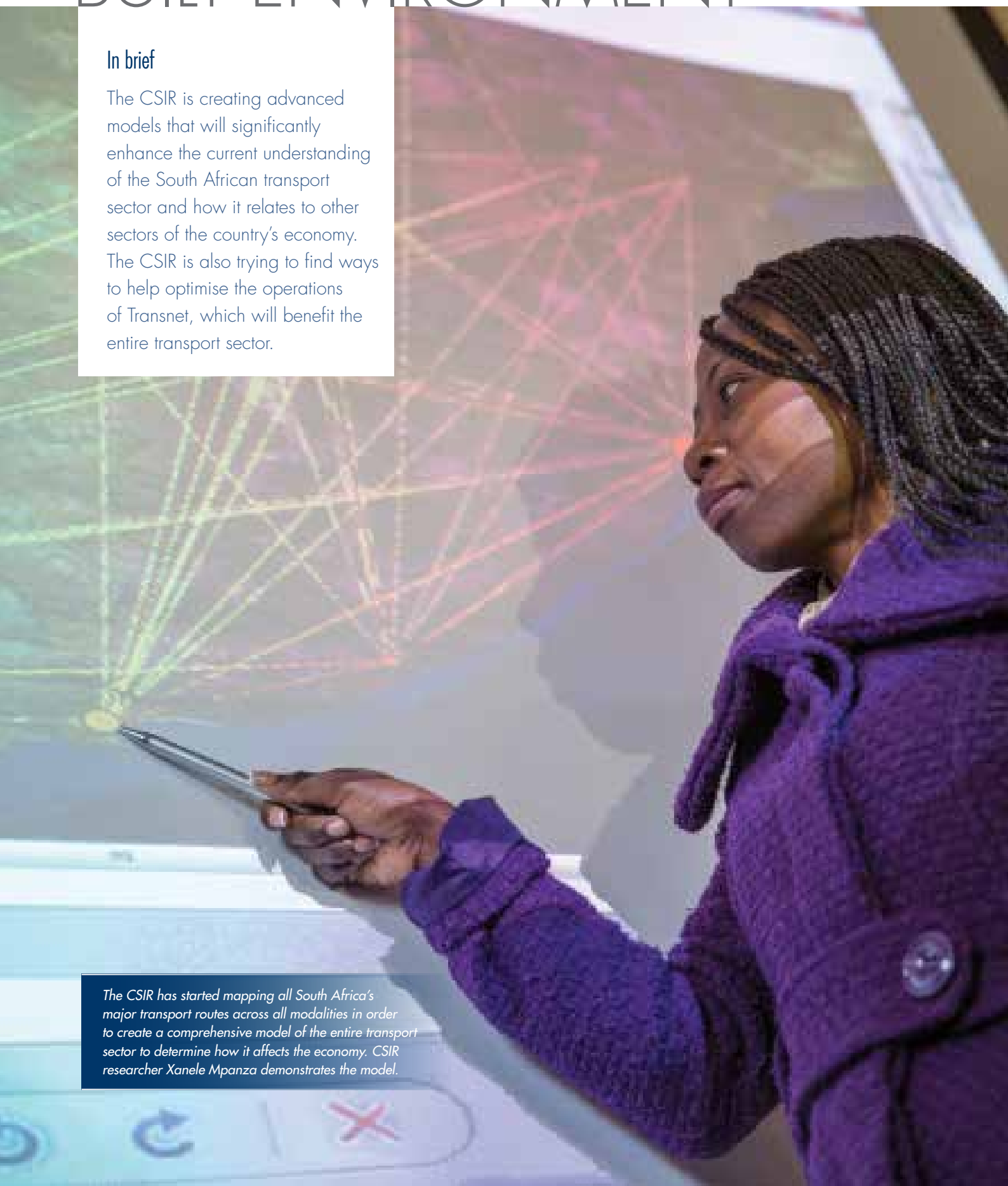
UPON COMPLETION, THE SCALED-DOWN BREAKWATER WAS POUNDED WITH ARTIFICIALLY GENERATED WAVES THAT ACCURATELY REPLICATE SEA CONDITIONS.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE

BUILT ENVIRONMENT

In brief

The CSIR is creating advanced models that will significantly enhance the current understanding of the South African transport sector and how it relates to other sectors of the country's economy. The CSIR is also trying to find ways to help optimise the operations of Transnet, which will benefit the entire transport sector.



The CSIR has started mapping all South Africa's major transport routes across all modalities in order to create a comprehensive model of the entire transport sector to determine how it affects the economy. CSIR researcher Xanele Mpanza demonstrates the model.

Enhancing the understanding of South Africa's transport sector

The challenge: Mapping SA's transport challenges

South Africa faces a myriad of transport-related challenges such as road and rail infrastructure maintenance backlogs, the poor condition of road and rail public transport vehicles, poor public transport services and inadequate public transport in rural areas, all of which adversely affect other sectors and the country's economic development. To help address these challenges, the CSIR is conducting a detailed analysis of the entire transport sector and is creating a comprehensive model of transport interactions between economic sectors. With Transnet being a key player in the country's transport sector, the CSIR is also designing various specific, practical interventions that will assist Transnet in its operations.

Modelling to identify bottlenecks and required interventions

In 2014, work started on a model that will create a thorough understanding of the various interactions and links between all the country's economic sectors – which include the transport, energy, water and health sectors – to develop an advanced multi-sector decision-support capability for government and private sector stakeholders.

The assumption is that all economic sectors are linked and that, together, they contribute to sustainable national development. With the creation of the proposed model, government will gain an understanding of how the different sectors interact and will be able to better identify key areas where intervention is needed, understand the impacts of interventions and trade-off alternative scenarios.

In designing this multi-sector model, a causal model has been developed that serves to identify degrees of causality between different economic sectors. Ultimately, the multi-sector model will be able to identify key variables in each sector, for instance the time it takes a person to walk to the nearest bus stop in the transport sector, and will be able to predict how changing any of the variables will affect other variables, other sectors and the economy as a whole. It will also be able to determine where, in spatial terms, intervention is needed, and how long it will take for specific interventions to have the desired effect. The specifications for this model are being refined before work on the prototype starts.

The CSIR is also completing its analysis of the South African transport sector for freight and passengers over land, air and water. For this analysis, researchers first defined the various elements that make up the transport sector, identified the stakeholders, the metrics by which stakeholders assess the value of the transport system and the factors that influence the metrics. Such factors have complex inter-relationships and consequently a model was developed to map the causality between all variables in the transport sector.

A detailed transport network model is being built to map the country's transport networks across all modalities. For this model, the country's passenger and freight networks have been mapped. Next the CSIR wants to extend and combine the causal and network models to be able to see where bottlenecks occur and which factors or variables are causing them.

This will allow key players in the transport sector, stakeholders and government to make better decisions with regard to managing investment or operations, or adjust route schedules or services for the transport sector to be more efficient.

All role players in the transport sector, including Transnet, as well as all users of the country's transport system will benefit from these models. The models will also help the Department of Transport with invaluable information to inform policy frameworks and legislation.

Research and development projects to help optimise Transnet operations

Having entered into a partnership with Transnet, the CSIR is involved in a range of projects to help the entity optimise its operations across the transport sector. These projects include the development of a new locally designed locomotive control system; refining laser refurbishment and manufacturing processes for locomotive and wagon components; creating a streamlined business model for Transnet's operations on the African continent; and developing modelling and simulation software that will enhance Transnet's wagon production line. In months to come, numerous additional Transnet partner projects will be announced.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE

NATURAL ENVIRONMENT

South Africa's *National Development Plan 2030* acknowledges that sustainable development is not only about being economically and socially sustainable, but also about being environmentally sustainable, and that all of these facets need to be equally heeded in order for the country to remain competitive.

The CSIR's contribution to environmental sustainability lies in the use of science and technology to improve our understanding of the scale and impact of climate change and to improve our ability to adapt to these changes; to design and implement interventions that will facilitate the growth of the green economy and help manage natural resources such as water as well as the marine and coastal environment.

Laboratory testing of a CSIR-developed adsorbent that removes heavy metals.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE

NATURAL ENVIRONMENT

In brief

Acid mine drainage (AMD) is one of the biggest threats to water resources, human health and the environment in South Africa. In many cases its impact is exacerbated by agricultural practices and other developments that disrupt the structure and flow of water bodies. The CSIR is investigating a range of issues related to AMD and has developed and implemented solutions to help reduce the impact.

Orange-coloured iron hydroxide precipitate in a wetland resulting as a result of acid mine drainage from a surface coal mine. CSIR experts in water chemistry and botany have found that certain indigenous vegetation types are able to rehabilitate rivers polluted with metals such as iron, aluminium and manganese. Seven plant species prevalent on the banks of the Upper Olifants River were found to bioaccumulate these metals.

Measuring and mitigating the impact of acid mine drainage

The challenge: The acid mine drainage threat

The South African mining sector is an important contributor to the South African economy. However, one of the negative effects of mining is the release of chemical contaminants into water resources, which can cause environmental damage and threaten the health and safety of people.

AMD occurs when highly acidic water, usually containing high concentrations of metals, sulphides and salts, drains from underground mine shafts, or discharges from open pits and mine waste dumps. It often occurs where mining has been abandoned and results in the acid mine water flowing into streams and other water sources.

Research and development: Examining the extent of pollution and ways to mitigate it

CSIR research focuses on measuring the extent of AMD and developing methods to mitigate its impact on water sources.

A low-cost water treatment solution

In response to the mining industry's need for improved water treatment technologies, the CSIR has developed low-cost adsorbents for the removal of toxic pollutants such as heavy metals from water.

Researchers used clay nanocomposites to develop the adsorbents and showed that it could rapidly remove hexavalent chromium – which is linked to cancer and immunity disorders – from water to within allowable discharge limits, using very small quantities of adsorbents. In addition to its low cost and ease of use, the adsorbent can be reused up to five times for further adsorption cycles, without significant loss in capacity.

Researchers scaled up the synthesis of the adsorbent from one gram to 5 kg batches and are exploring options for large-scale manufacturing.

Rehabilitating a wetland in the Zaalklapspruit Wetland system

The Olifants River is located in one of the country's most intensively mined areas, with coal mining often taking place to the detriment of the surrounding wetlands. Wetlands are important as they play a critical role in offsetting the impact of polluted water entering a catchment.

CSIR water researchers assessed the entire upper Olifants River catchment to determine the different point sources of pollution resulting from the various land use activities. This entailed the assessment of the quality of water emanating from sewerage works, mining, agriculture and industries.

A part of the Zaalklapspruit Wetland system was selected for rehabilitation. The CSIR, in collaboration with the South African National Biodiversity Institute and the Working for Wetlands programme of the Department of Environmental Affairs, devised several interventions to address the problem. The wetland was no longer acting as a sponge which diffused the energy of storm waters, but instead these waters carved gullies, leaving the floodplain dry. The rehabilitation process centred on using structures to slow down the waters and diffuse the energy. One intervention was constructing concrete structures as well as earth berms and weirs, funded by Coaltech. Concrete structures were necessary due to the acidic and corrosive nature of incoming water, rather than the conventional gabion structures used in wetland rehabilitation. Gabion structures are rock-filled, wire basket-like structures that limit erosion, trap sediment and re-saturate drained wetland areas. The acidic water would corrode the wire used in these structures.

The Zaalklapspruit Wetland system showed an almost immediate improvement following the intervention, with decreased acidity and decreased levels of dissolved metals in the water flowing through the wetland. The rehabilitation resulted in improved water quality and ecosystem functioning, benefitting farmers, rural communities and other users downstream of the wetland.

Determining the health impact of AMD

South Africans may become exposed to AMD by drinking contaminated water, eating food irrigated with contaminated water or via animal produce in which toxic substances have accumulated through their feeding.

While a national risk assessment study by the CSIR found that the primary route for risk of heavy metal exposure was from the consumption of water and home-grown vegetables, the heavy metal content in the samples could not be attributed as originating solely from AMD, as opposed to other pollution sources such as pesticides.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR THE

NATURAL ENVIRONMENT

In brief

CSIR researchers combined two sets of land-cover data to create the first high-resolution, locally calibrated national map of woody cover for South Africa. They used satellite-based Synthetic Aperture Radar (SAR) mapping with existing Light Detection and Ranging (LIDAR) datasets, derived from airborne surveys, to create the map.

The first locally calibrated national map of South Africa's woody cover was created using a combination of radar datasets acquired by satellite and more detailed LIDAR datasets that were available for certain areas of the country.

Synthetic Aperture Radar (SAR) – A form of radar which is used to create images of an object, such as a landscape. These images can be 2D or 3D representations of the object. SAR uses the motion of the SAR antenna over a target region to a provide finer spatial resolution than is possible with conventional beam-scanning radars. SAR is typically mounted on a moving platform such as an aircraft or spacecraft.

Light Detection and Ranging (LIDAR) – A remote sensing technology that measures distance by illuminating a target with a laser and analysing the reflected light. LIDAR is popularly used as a technology to make high-resolution 3D maps.

SA's first national map of woody cover

The challenge: Mapping SA's woody cover

Vegetation maps showing woody cover have great value for the management of forestry and agricultural resources, biodiversity monitoring, alien plant clearing planning and carbon monitoring for enhanced climate change modelling. To date, South Africa has had to rely on global woody cover maps of poor quality and with coarse resolution, which mainly covered the country's savannah regions. No national, high-resolution, locally calibrated and validated map existed for the country's woody cover.

In 2008 the CSIR collaborated with researchers from the Carnegie Institute of Science in the United States of America, and the University of the Witwatersrand on a project aimed at using LIDAR and hyperspectral sensors to map and compare the differences in the distribution of vegetation inside the Kruger National Park with communal land outside of the park's borders. The collaboration was successful and it was demonstrated that it was possible to create an accurate map of the distribution of vegetation for a selected area. Specifically, the technologies could be used to measure tree height, identify prevailing tree species, map tree cover and to determine woody biomass.

In 2010 it was decided to use these methods at a national scale and to create the first national map of South Africa's woody plant cover.

Research and development: Accessing, processing and integrating datasets for the best result

Although it is possible to use only LIDAR to generate the required maps, the use of an aircraft to traverse the entire country is prohibitively expensive and time-consuming. The research team therefore started out by using satellite-based SAR radar to create a national map, and then used existing LIDAR maps to enhance the data. The detailed and very accurate LIDAR datasets from various identified smaller areas across the country were used to upscale and generalise the SAR map data and to validate its accuracy.

Researchers had to determine which SAR frequency band would be best suited to the task, and which season was the most suitable for the mapping. The CSIR made use of its research agreement with the Japan Aerospace Exploration Agency to use their satellite systems for SAR mapping. It took six months to collect the necessary data to compile the map.

The CSIR is continuously improving and enhancing the map by incorporating data from new LIDAR data sets that become available and is investigating ways of automating the map with software that can automatically incorporate new datasets.

Because both SAR and LIDAR are underused technologies in South Africa, one of the key challenges is to develop the necessary skills to be able to process and interpret these datasets. For this reason, the CSIR started a programme to train PhD students in the processing of SAR and LIDAR data.

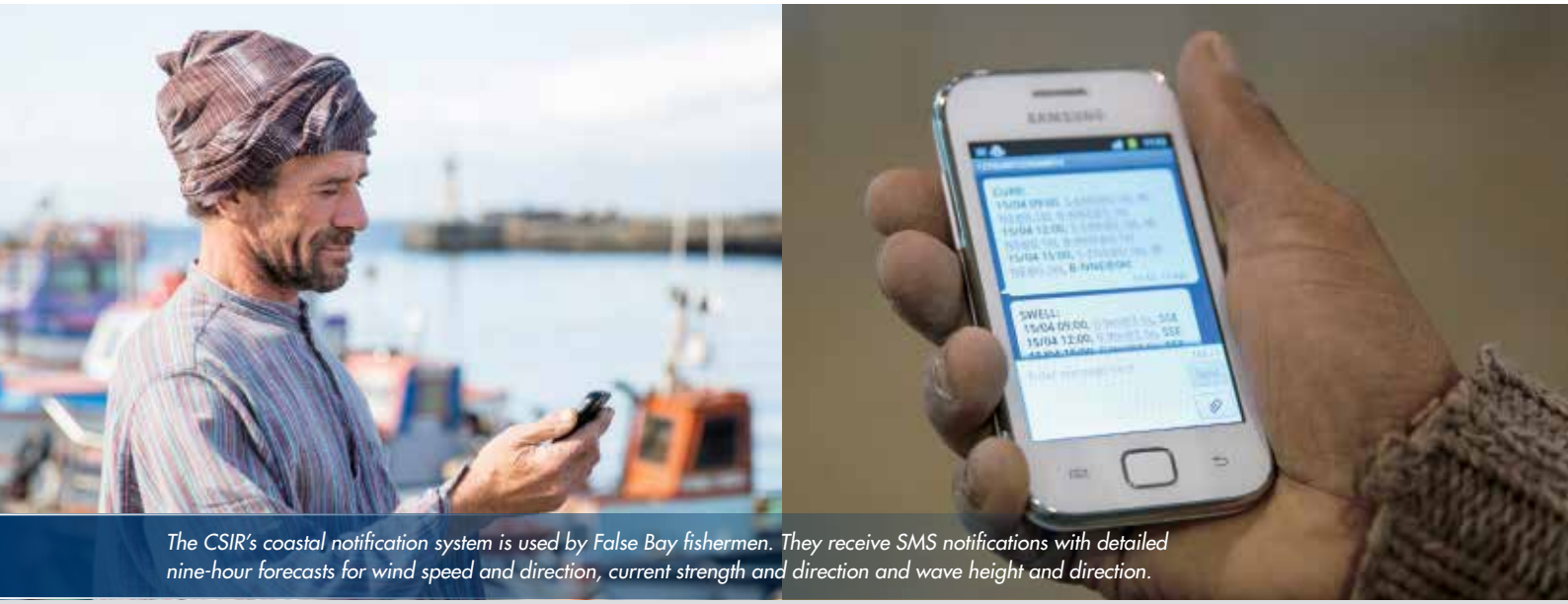
Because biomass and vegetation distribution is subject to environmental changes such as climate change and human development, the national woody cover map will need to be continuously updated. In addition, researchers are looking at mapping more advanced datasets for characterising trees and forests to show not only the percentage of South Africa's surface that is covered by woody plants, but also the distribution of tree biomass and height in the country.

Outcomes: A valuable management tool taken up by decision-makers

The Department of Environmental Affairs is assessing the map's suitability for planning the clearing of alien plants from identified tracts of land.

South African National Parks is also making use of the map to create an inventory of the wetlands in national protected areas and to help identify patterns in the outbreak and spread of bush and veld fires.

NATURAL ENVIRONMENT



The CSIR's coastal notification system is used by False Bay fishermen. They receive SMS notifications with detailed nine-hour forecasts for wind speed and direction, current strength and direction and wave height and direction.

Coastal notification system becomes useful tool for False Bay fishermen

The CSIR has developed a notification system that combines near real-time data sets on climate, weather and ocean currents and waves to create detailed nine-hour forecasts.

The system, which uses SMS messages to distribute the information, is being used by fishermen on small fishing vessels in the False Bay area. It provides accurate information relating to current strength and direction, wave height, direction and frequency, as well as wind speed and direction.

The system was developed to inform small-scale commercial fishing vessels of impending rough sea conditions but because it provides accurate data on the strength and direction of surface and ocean currents, fishermen have started using the service to better plan their fishing. False Bay was chosen as a pilot site for the system because it has a thriving commercial fishing community and because the complex topography around the periphery of the Bay makes it difficult to predict weather conditions at sea.

The model generates the forecasts by using existing large-scale data sets and forecasts, and local CSIR data and models to produce very specific local forecasts of wind and sea conditions.

Before commencing with the pilot study, the CSIR met with officials of the Department of Agriculture, Forestry and Fisheries and local fishermen from False Bay to brief them on how the system intended to work and what it would attempt to accomplish. The feedback from these sessions was used to improve the design of the system.

To use the system, fishermen simply send an SMS code to a specific number and they instantly receive an SMS reply with the latest forecast for the next nine hours. The CSIR is compiling feedback from fishermen to determine how accurate the predictions are compared to the actual experience out on the ocean, to identify any patterns of over- or under-prediction and to further improve the usefulness of the generated data. A business plan is also being developed – in partnership with Wavescape Media, a South African company that provides surf forecasts – to make this service sustainable and to roll it out for the rest of the South African coastline.

THE MODEL GENERATES THE FORECASTS BY USING EXISTING LARGE-SCALE DATA SETS AND FORECASTS, AND LOCAL CSIR DATA AND MODELS TO PRODUCE VERY SPECIFIC LOCAL FORECASTS OF WIND AND SEA CONDITIONS

CSIR researchers have successfully equipped a wave glider, pictured here off the Western Cape coast between Dassen and Robben Islands, with an acoustic echo sounder to better determine fish stock levels along the South African coast.

Wave gliders equipped to help determine fish stock levels

CSIR researchers equipped a sea-faring wave glider with an acoustic echo sounder (sonar) to help determine fish stock levels along the South African coastline.

Unsustainable fishing is a big threat to ocean ecosystems. The Department of Agriculture, Forestry and Fisheries (DAFF) has the responsibility to determine the available fish stock levels in South Africa's Exclusive Economic Zone in order to regulate and allocate fishing quotas. Currently, scientists from DAFF conduct fishing surveys by following a predetermined route along the coast. Once the on-board underwater sonar detects species that resemble fish, a net is drawn to capture a sample of the species. Using this information, fishing quotas are established. This is an expensive and time-consuming process. Sonar wave gliders have the potential to make fish stock surveys significantly more accurate and less labour-intensive.

Wave gliders are unmanned marine vehicles fitted with solar panels and rely on wave propulsion to glide forward, making it possible for the vessels to be deployed at sea for long periods of time. An array of sensors can be mounted on the gliders. These vessels can be steered via satellite, making them ideal for conducting fish stock surveys and for other monitoring purposes.

The CSIR fitted a wave glider with a commercial sonar system to detect fish, and a data-capturing unit to store survey data of fish stock levels. Industry partners, Sea Technology Services and Liquid Robotics supported the CSIR with aspects of data capturing and communication. Data sensed from the ocean are sent from the glider to a satellite and then to the department, allowing for continuous monitoring.

During 2014, the first successful field experiment was conducted between Robben and Dassen Islands. The signal received from the echo sounder was stable and researchers were able to see schools of fish. Since then, research and development has improved the unit to the extent that it can be continuously deployed for months at a time. If successful, the technology will enable DAFF to have continuous access to current data which will allow it to focus its trawling where needed and spend less time at sea. It will also improve the department's understanding of fish behaviour and migration patterns.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

ENERGY

Increasing the diversity of the country's energy production mix is important to mitigate climate change while enhancing supply security. This clear statement in the *National Development Plan 2030* shaped the CSIR's vision in this area: Helping the country achieve an energy-secure and low-carbon national economy.

The organisation develops and implements renewable and alternative energy technologies with a specific focus on innovations in energy storage, system integration and renewable energy technologies, while also contributing to policy formulation and market design.

To demonstrate what a future energy system could look like, the CSIR is pursuing a carbon-neutral campus in which the energy needs of the organisation's Pretoria campus are met through solar, wind and biogas energy sources, with measures to improve energy-efficiency and manage demand.

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

ENERGY

A South African industrial energy efficiency project started in 2010 has assisted over 80 industry plants, such as Consol Glass, to record significant energy savings. Pictured here is the Consol Glass plant in Nigel.

Industrial energy efficiency project saves industry millions

In brief

The Industrial Energy Efficiency Project has, during its first five years, helped more than 80 companies to save a total of 866 GWh in energy through the implementation of energy-management strategies and the optimisation of various high-energy systems.

The challenge: Efficient industrial energy use

Addressing South Africa's energy security requires proactive and effective interventions from both the supply and demand side. Energy efficiency, when implemented in a systematic and sustained manner by large energy users, will significantly reduce the load on the energy grid. It was against this backdrop that the Industrial Energy Efficiency (IEE) Project was introduced in 2010 to contribute to the sustainable transformation of energy use practices in South African industry and to enhance national energy security.

Working together towards energy efficiency

The IEE Project was designed to help transform industry energy-use patterns and adopt a more systematic and holistic approach to energy management. It was implemented by the United Nations Industrial Development Organization

(UNIDO) and the National Cleaner Production Centre of South Africa (NCPC-SA), government's industrial resource-efficiency programme that the CSIR hosts on behalf of the Department of Trade and Industry.

The South African IEE Project was a pilot, the first in what has become a global programme by UNIDO. Its approach to reducing energy use in industry has been successful, resulting in projects being implemented in 12 other developing nations. Funding has been secured for a second phase in South Africa, with larger budgets and more ambitious targets.

Outcomes: Significant energy savings by industry

The IEE Project has, over the past five years, assisted over 80 industry plants to save enough energy to electrify 120 000 middle-income South African homes for 12 months.

The energy saving of 866 GWh achieved (at the energy prices of 2011-2014), equates to a financial saving of R759 million and carbon-emission offset of 800 000 tonnes of carbon dioxide.

Since its inception in early 2010, the IEE Project has trained over 2 500 professionals in specialist energy-efficiency management and supported the national government to develop policies, strategies and standards to enable energy efficiency.

National standards and guidelines set for energy management

The IEE Project promotes energy savings through the implementation of energy-management systems and the optimisation of various high-energy use systems in industrial plants or energy systems optimisation.

Part of the initial work of the IEE Project was to support the adoption of national standards and technical guidelines for energy management. In 2011, the International Organization for Standards (ISO) released the first energy-management standard, ISO 50001. By November 2011, with the support of the IEE Project, the South African Bureau of Standards had adopted the standard as SANS 50001, paving the way for benchmarking and continuous monitoring of energy management.

South Africa currently has fewer than ten companies that are ISO 50001 certified, but all of these have had the support of the IEE Project in some way. The NCPC-SA also trained South Africa's ISO 50001 lead auditors.

Building capacity for long-term impact

One of the cornerstones of the IEE Project was the development of industrial energy-efficiency training courses that enable both plant personnel and consultants to implement energy efficiency at an advanced and an expert level.

The strategy had two benefits. During the training of the experts (of which there are now almost 100), candidates underwent practical in-plant training by international experts and had to implement their own energy-efficiency interventions in an industry plant to attain their certificates. These interventions resulted in actual energy savings in plants. Toyota Durban, ArcelorMittal Saldanha and Tenneco Automotive in the Eastern Cape are all examples of plants that realised energy savings as a direct result of engineers being trained as IEE experts.

Secondly, the training programme has equipped local professionals with the expertise to not only support energy efficiency in industry in the long term, but also to train more experts. A growing number of experts are being trained as facilitators, which means that the IEE Project no longer needs to rely on international experts to do the training. Increasingly, South African experts are beginning to lead training initiatives in other countries implementing IEE.

During 2014/15, the NCPC-SA began a process to develop these training courses into national occupational trade qualifications, which will allow training institutions to offer the courses and further increase the impact of the project. The Energy and Water Sector Education Training Authority, with the NCPC-SA as technical partner, was appointed to lead this process.

Case studies and details on participation are available at www.ncpc.co.za

ENERGY

With the advent of a renewable energy era, new, more advanced batteries are also needed. The CSIR, with its expertise in advanced energy materials, is using South Africa's abundant manganese resources to develop new low-cost lithium-ion batteries.

Producing low-cost lithium-ion batteries using locally sourced manganese

The CSIR has developed a novel method to produce high-voltage cathode material using lithium manganese nickel oxide in advanced lithium-ion batteries. The Technology Innovation Agency approved funding to develop this material at a pilot-scale, taking the work one step closer to commercialisation.

Improving lithium-ion batteries, which have revolutionised many aspects of modern life, mostly centres on the choice of chemicals. One of the main benefits of the envisaged new lithium-ion batteries is low production cost, as its major raw material, manganese, is abundantly available in South Africa. Because it is a high-voltage material, it can be used to develop lithium-ion batteries with high energy. This gives the batteries the ability to be used over an extended period in devices such as portable electronics (including cellphones and tablets), electric vehicles and utility/home energy storage applications.

The funding also provides support for the CSIR to secure intellectual property, which will include lithium-ion battery materials, such as an aluminium-doped lithium manganese oxide and manganese-rich layered material containing lithium manganese nickel cobalt oxide. The support will also enable the CSIR to engage with local industries or partners for commercialisation.

Succeeding with this research will mean that local raw materials, such as manganese, can be utilised and beneficiated to create advanced, world-class energy materials at lower costs than would otherwise have been possible.

IMPROVING LITHIUM-ION BATTERIES, WHICH HAVE REVOLUTIONISED MANY ASPECTS OF MODERN LIFE, MOSTLY CENTRES ON THE CHOICE OF CHEMICALS. ONE OF THE MAIN BENEFITS OF THE ENVISAGED NEW LITHIUM-ION BATTERIES IS LOW PRODUCTION COST.

The CSIR has come up with an innovative tariff concept that could rapidly grow the rooftop solar photovoltaic (PV) market and help make rooftop solar PV one of the cheapest options for increased energy supply.

Stimulating South Africa's rooftop solar PV market through a new tariff concept

The CSIR has developed a concept to stimulate the emerging embedded photovoltaic (PV) market (such as rooftop-mounted solar panels) in South Africa to help address the country's current electricity supply shortage and encourage the use of cleaner energy sources. The proposed concept was adopted as an option in the public consultation paper on embedded generators of the National Energy Regulator of South Africa (NERSA).

Because of drastically reduced prices for PV systems and significantly increased retail electricity tariffs over the last five years, embedded PV generators that generate electricity 'behind a customer's meter' are at retail grid parity in South Africa, which means that they are a cost-competitive supplement to the main electricity supply of many South African customers. The total lifetime costs of a residential PV system are currently between 0.8-0.9 R/kWh, whereas residential electricity tariffs range from 1.1-1.4 R/kWh. Embedded PV is not only attractive for individual electricity customers; it is also a cost-competitive contributor in South Africa for the power system as a whole and a supplement to the fleet of new large, central power generators.

However, the challenge for electricity distributors (such as municipalities and Eskom) is that the amount of PV-generated energy that is consumed 'behind the customer's meter', reduces the total volume of sales and therefore reduces the total amount of their gross margin. This means that the financial resources available to cover the fixed costs of running the electricity grid are reduced.

For these reasons the CSIR developed a net feed-in tariff concept in which existing electricity distributors are made financially indifferent to embedded PV systems, while at the same time decreasing the risk in the business case for PV owners.

The concept creates a 'central power purchasing agency' as a government entity with nationwide reach that has two functions. Firstly, it compensates municipalities financially for all lost gross margins due to energy from embedded PV systems consumed by PV owners, who buy less energy from municipal utilities. Secondly, the agency makes a standard offer to the PV owner to buy any percentage of the PV energy that the customer cannot consume and therefore feeds back into the grid. The agency will pay a guaranteed tariff of approximately 0.7-0.8 R/kWh for this 'excess' part of the PV energy for a period of 20 years. This tariff becomes the guaranteed safety net for the business case of the PV systems.

By employing this concept, the size of the embedded PV market would rapidly grow, contributing significantly to the current power-supply shortage, while at the same time also making embedded PV one of the cheapest options for increased electricity supply.

ENERGY

Lydia Cape, Paul Lochner and Abulele Adams used data from various sources to identify strategic geographical areas suitable for wind and solar photovoltaic projects across South Africa.

Renewable energy development zones identified for South Africa

A strategic environmental assessment conducted by the CSIR has facilitated the implementation of sustainable green energy initiatives in South Africa. The study supports national planning by identifying areas in which large-scale wind and solar photovoltaic (PV) energy facilities can be developed in a manner that limits significant negative impacts on the natural environment, while yielding the highest possible socio-economic benefits to the country. The assessment was commissioned by the Department of Environmental Affairs.

The South African Government's intent on renewable energy is evident from the inclusion of 'Green energy in support of the South African economy' as Strategic Integrated Project 8 of Government's National Infrastructure Plan.

Earlier, approximately 550 renewable energy projects were proposed by independent power producers across the country. However, the absence of spatial integrated planning in this context limited government's ability to take a holistic approach to sustainable renewable energy development.

CSIR environmental scientists identified strategic geographical areas that are suitable for wind and solar PV projects across five provinces: the Western Cape, Eastern Cape, Northern Cape, North West and Free State.

The wind analysis was based on the recently compiled Wind Atlas of South Africa and the solar PV analysis was based on solar irradiation and yield datasets. Starting from raw resource data, a development potential layer was created taking into consideration transmission loss, local municipalities with high social need and high potential for development, priority areas for renewable energy manufacturing, and existing transmission infrastructure.

An environmental and technical constraints mask was then developed to eliminate areas with highly sensitive features, taking into consideration environmental features such as protected areas and areas of known bird and bat sensitivity; existing and future planned land use; existing infrastructure; national plans such as the Square Kilometre Array project; and technical constraints, such as slopes with a gradient of more than 10 degrees.

The mask was overlaid with the highest development potential areas per province. The remaining areas were interrogated in consultation with South African solar PV and wind developers, local and provincial authorities, key stakeholders from the private and public sectors and experts in various fields. Further aspects of sensitivity in terms of aviation, defence, telecommunication, weather services, and noise were determined in consultation with the relevant authorities.

The CSIR has quantified the financial benefits of renewable energy sources (wind and solar) that were added to the national power grid in 2014.

Quantifying the financial benefits of renewables in South Africa

In a study published on the financial benefits of the first wind and solar photovoltaic (PV) projects that were connected to the South African national power grid during 2014, the CSIR found that the total financial benefit of renewables to the country in that year was R5.3 billion.

The study showed that these renewables projects generated 2.2 TWh of electricity in 2014, which saved R3.6 billion worth of fuel for the conventional fleet. The availability of renewables furthermore avoided the curtailment of customer load, with a value of R1.7 billion. The total financial benefit of renewables to the country was therefore R5.3 billion in 2014, compared to R4.5 billion in tariff payments to the owners of the wind and solar PV projects in the same year. This has resulted in a net financial benefit to the country of R0.8 billion.

By quantifying for the first time the financial costs and benefits of renewables in South Africa, based on actual hourly production data, the study is contributing to the discussion around future capacity expansion.

The financial benefits of adding additional renewables to the system will depend on the constraints of the power system going forward and will be quantified in subsequent studies by the CSIR.

However, it is already clear that any new energy generated by wind and PV will generate electricity at significantly lower average tariffs than the first projects that came online during 2014. That is partly because more than 5 000 MW of renewable power generators were already procured and their tariffs are agreed on and known, while only 1 600 MW of the first, most expensive renewables came online during 2014.

The drop in the prices of wind and PV is in line with global observed trends over the last five to ten years, which can be attributed to mass manufacturing, learnings (in production processes and implementation) and technological advancements, resulting in more efficient wind and PV technologies.

In a second phase, the CSIR will set out to develop a methodology to predict the expected fuel savings for new renewables capacities in a 12 to 24 months forward-looking time horizon.

IT IS ALREADY CLEAR THAT ANY NEW ENERGY GENERATED BY WIND AND PV WILL GENERATE ELECTRICITY AT SIGNIFICANTLY LOWER AVERAGE TARIFFS THAN THE FIRST PROJECTS THAT CAME ONLINE DURING 2014.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION FOR

HEALTH

In striving to provide accessible primary health care to all South Africans, the *National Development Plan 2030* acknowledges the importance of developing and implementing appropriate technologies.

The CSIR puts its vast expertise to work to help improve the health of all South Africans. To combat the high burden of disease, researchers develop cost-effective bio-therapeutic technologies and health infrastructure. Efforts to design and adapt technology to improve diagnosis and treatment in under-resourced areas continue.

The organisation works closely with the Department of Health – assisting the department with the design of the information and communications technology architecture for the National Health Insurance plan.

The CSIR also focuses on unlocking the value contained in South Africa's biodiversity and indigenous knowledge, improving food processing technologies and contributing to food security.

An example of reagents being applied to a foldable paper diagnostic device. The CSIR is pursuing the development of paper-based sensor technology for point-of-care diagnostics.

RESEARCH, DEVELOPMENT & IMPLEMENTATION FOR

HEALTH

In brief

Researchers at the CSIR have begun screening thousands of synthetic compounds in an effort to identify those compounds that might form the basis for a new generation of drugs that will permanently disrupt the life-cycle of the malaria parasite. This will eradicate the disease, rather than treat or cure it. An initial library of around 5 000 compounds was screened and a larger library of 250 000 compounds are being screened. Some compounds are already showing promise.

The CSIR has screened thousands of synthetic compounds in order to identify those that might be used for a new generation of drugs that could potentially eradicate malaria. Here compound dye is added to malaria gametocyte samples in order to test the survivability of the parasite.

Towards eradicating malaria by stopping the parasite transmission cycle

The challenge: Eradication as primary goal

For decades scientists have had to work continually to come up with new drugs to treat malaria, due to the disease's ability to develop drug resistance. To get around this, scientists often combine different anti-malarials to better treat malaria patients.

Nonetheless, virtually every anti-malarial drug currently in use is ineffective in certain populations due to increased drug resistance. This has led to a recent renewed global drive to not only improve strategies for controlling the disease, but to achieve its eradication. However, this is unachievable without new tools to interrupt transmission. For this reason, researchers from the CSIR and the universities of Pretoria and the Witwatersrand have partnered with the Medicines for Malaria Venture (MMV) to develop a new generation of drugs; not to cure malaria, but to permanently disrupt the life-cycle of the malaria parasite.

Research and development: Finding compounds to disrupt, rather than treat

The malaria parasite has proven very resilient and adaptable and as a result, globally, the focus has gradually shifted from treatment to eradication. The CSIR and its collaborators have made significant strides in identifying compounds that could eliminate the disease rather than to treat it.

Malaria is transmitted to humans when a person is bitten by an infected mosquito and the malaria parasite, in the form of sporozoites, travels to the liver where it undergoes development for several days. Thereafter the parasites enter the bloodstream and starts to replicate, causing the human host to become symptomatic. Some of the parasites then transform into gametocytes. The life-cycle is completed when another mosquito bites the infected person and consumes the gametocytes, in the process becoming a new carrier of malaria.

It is this cycle that the new generation of drugs will attempt to disrupt. Researchers are looking for drugs that can stop the malaria parasites from transforming beyond gametocytes by blocking certain biological pathways. If there are no viable gametocytes, the transmission of malaria from humans to mosquitoes becomes impossible and over time the disease will die out.

In order to start developing drugs that will be able to block human to mosquito transmission, thousands of synthetic compounds have to be subjected to screening by exposing them to the parasite. In the screening of compounds, researchers are looking for those compounds that can prevent the parasite from metabolising certain substrates. If the parasite is unable to metabolise these substrates, it will be rendered inactive and the life-cycle will be disrupted.

The CSIR has a vast library of synthetic compounds. Some 5 000 of these compounds have been screened and a number of compounds were found that can be taken to the next stage of the drug development pipeline. These compounds need to be made more compatible with the human body, in terms of absorption, efficacy, distribution, metabolism and excretion, before it can be tested as a viable drug. In other words, the compound needs to block critical pathways in the malaria parasite without causing adverse side-effects in humans.

After the successful screening of the first batch of compounds, the MMV has teamed up with the CSIR and the Medical Research Council to extend its work to also screen a new, much larger library of around 250 000 compounds using automated high-throughput robotic screening technology. The research continues.

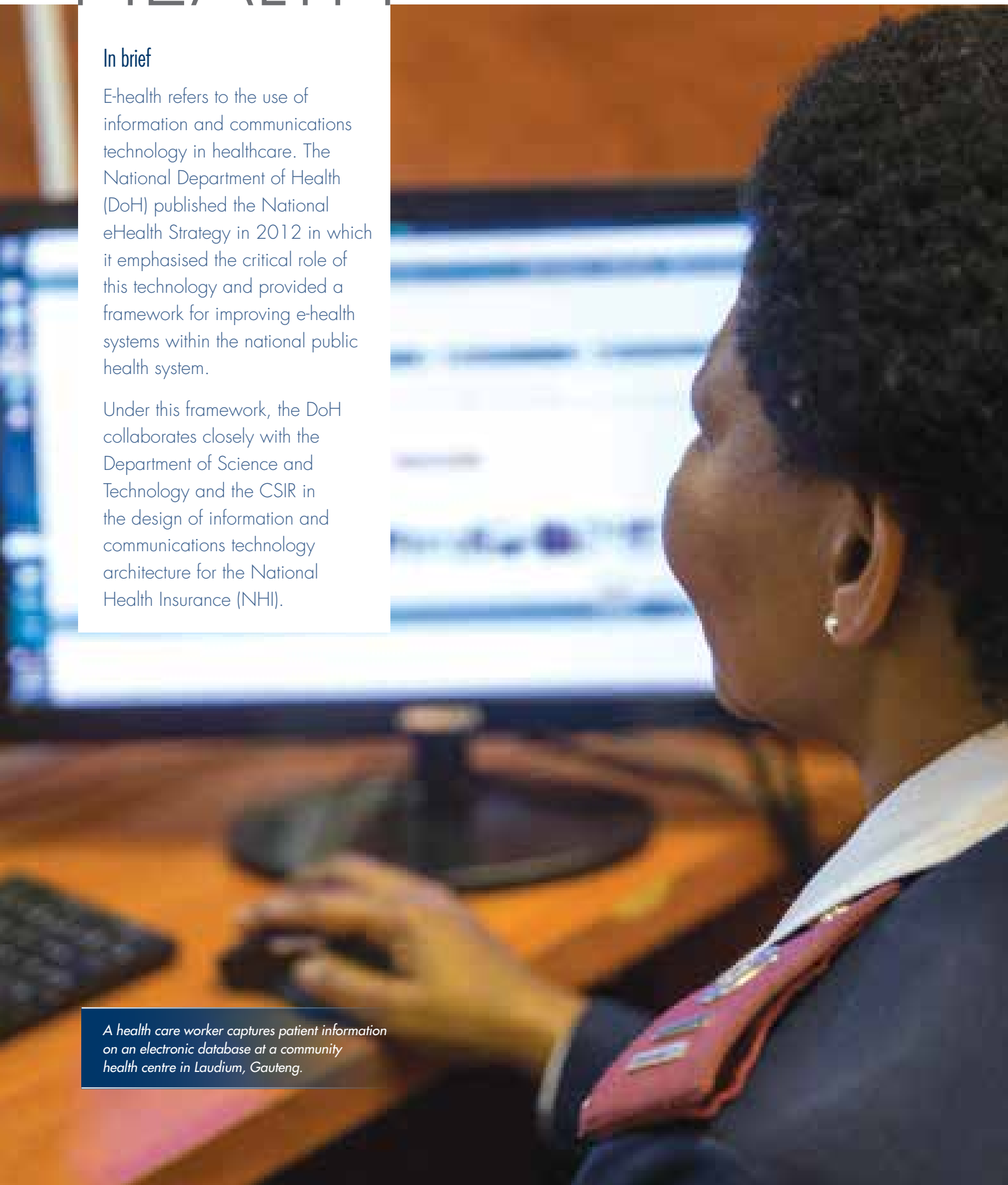
RESEARCH, DEVELOPMENT & IMPLEMENTATION FOR

HEALTH

In brief

E-health refers to the use of information and communications technology in healthcare. The National Department of Health (DoH) published the National eHealth Strategy in 2012 in which it emphasised the critical role of this technology and provided a framework for improving e-health systems within the national public health system.

Under this framework, the DoH collaborates closely with the Department of Science and Technology and the CSIR in the design of information and communications technology architecture for the National Health Insurance (NHI).



A health care worker captures patient information on an electronic database at a community health centre in Laudium, Gauteng.

Supporting the development of health information systems for South Africa

The challenge: Lack of efficient electronic systems

In the e-health strategy for South Africa, Dr Aaron Motsoaledi, Minister of Health, expressed his concern about the prevalence of manual health information systems in the public sector. He was also concerned about the lack of interoperability between existing electronic systems. Efficient health care systems need reliable electronic systems to keep patient records, facilitate fast clinical decision-making and to ensure efficient communication between health care professionals and patients.

Research and development

Norms and standards gazetted

In 2012, the CSIR conducted an analysis of the health information systems deployed in public hospitals and found at least 42 different systems deployed across the country. All of these were essentially stand-alone systems with minimal levels of interoperability, which made it difficult to deliver an integrated health service to patients. For example, when systems are not integrated it can be a challenge to retrieve patient information when the patient visits another health facility and this may result in duplication of prescriptions.

In 2013, the DoH commissioned the CSIR to establish a set of standards for interoperability of e-health systems. The standards would advocate a common 'language' for health systems, thereby ensuring that information could be shared and used effectively across different systems and in different health facilities. In coming up with the standards for South Africa, the CSIR and the DoH considered case studies of e-health standards development internationally and considered South Africa's burden of disease scenarios. The *Health Normative Standards Framework for Interoperability in eHealth* was gazetted on 23 April 2014. It stipulates six categories of standards that all e-health systems deployed in the country should comply with, including standards for the type of content they must contain, terminology used and security features.

Patient registration

Knowledge of patient demographics and a record of their movement through health facilities are fundamental in delivering integrated health care services and are required for planning aspects of the NHI. The CSIR and the DoH have partnered to develop the National Health Patient Registration System, which allows for the registration and identity verification of patients at public health facilities. The system has thus far been deployed in 38 NHI pilot clinics, and has registered more than 400 000 patients. The system is considered the national authoritative source of patient demographic data in the country. The deployment of the system continues.

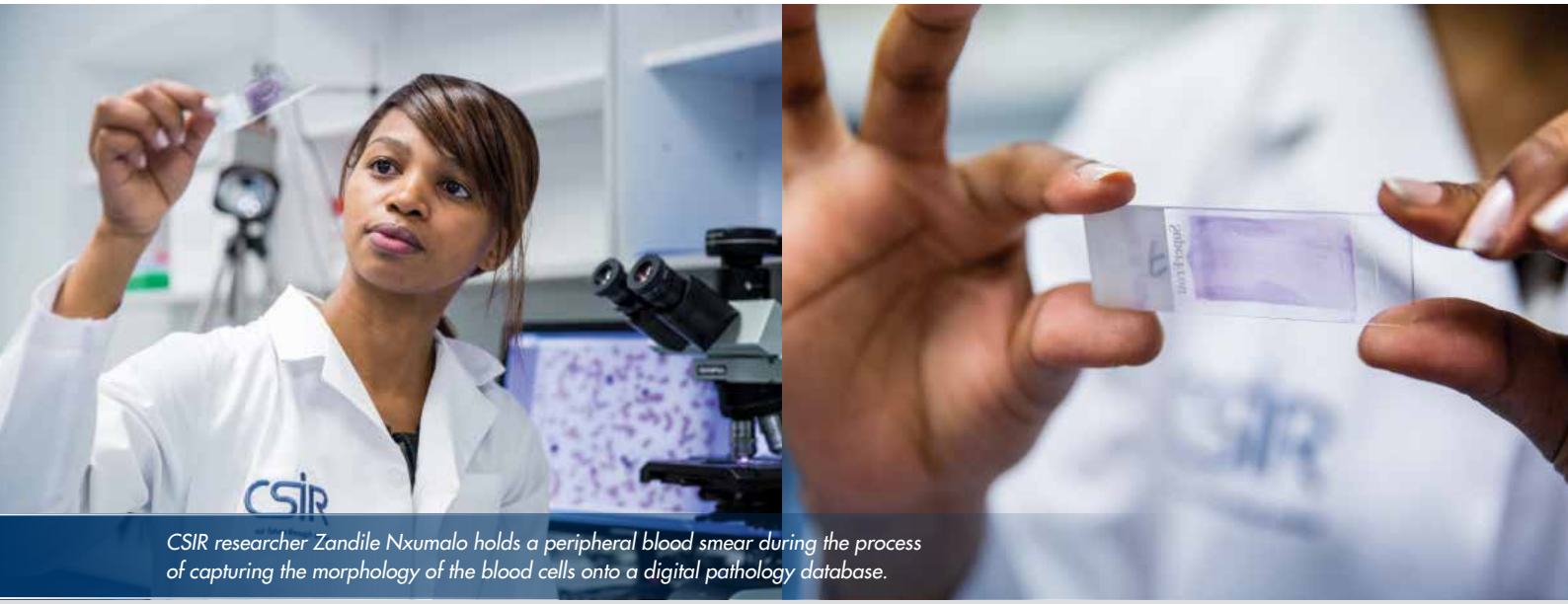
Assessment of patient information systems

The CSIR was commissioned by the DoH to perform an assessment of all patient information systems that are deployed in private and public sector clinics. These contained patients' demographic, clinical and administrative data. The information was voluntarily provided by vendors who provide ICT solutions to clinics and hospitals and assessed against functional requirements and adherence to the *Health Normative Standards Framework*. The CSIR also conducted a costing analysis of these systems and presented the results to the National Health Council, where they were favourably received. The assessment is being extended to hospital information systems. The work will assist provinces to understand the types of primary health care information systems solutions deployed across the country and the important principles on which the procurement decisions of health information systems should be based.

Mobile support for pregnant women

In August of 2014, the Minister of Health launched MomConnect, a mobile phone-based messaging service aimed at providing pregnant women with free antenatal health information. Women who register receive SMSs during their pregnancy and until the baby is one year old. These messages assist pregnant women and new mothers in understanding what they should be experiencing and doing throughout this period.
The messages also encourage women to attend clinics earlier and more often during their pregnancy. The CSIR has provided technical assistance with the design and rollout of MomConnect. To date, more than 300 000 women have registered on MomConnect.

HEALTH



CSIR researcher Zandile Nxumalo holds a peripheral blood smear during the process of capturing the morphology of the blood cells onto a digital pathology database.

New digital pathology database helps train pathologists remotely

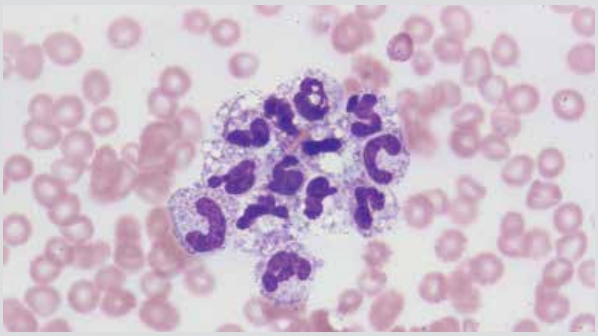
The CSIR and the National Health Laboratory Service (NHLS) have developed a national digital pathology database which is being used to improve the training of pathologists, and to extend expert pathology services to areas outside the major cities where specialists are currently concentrated.

The NHLS provides laboratory and related public health services to over 80% of the population through a national network of laboratories. Every month, its central laboratories receive thousands of blood samples from across the country. However, there is a shortage of diagnostic personnel – specifically highly-skilled pathologists – to deal with the complex cases.

A CSIR-NHLS team constructed a national digital pathology database containing 105 anonymous medical case studies. For each of these case studies, an expert pathologist from the NHLS recorded the clinical features and full blood counts of the sample, capturing digital images of blood samples with detailed annotations that identify specific abnormalities. These database submissions were then reviewed by other experts in order to ensure that the information was accurate.

The database facilitates the training of pathologists to improve the number and accuracy of diagnoses in remote and under-resourced areas and to reduce the need for referrals. It is an up-to-date 'digital textbook' of cellular pathology specifically relevant to South Africa's disease burden, which can be used as a reference database, for example to do comparisons when anomalies are spotted. NHLS staff can also educate themselves to increase the accuracy of their future diagnoses.

The CSIR monitors the activity and usage of the database. The database was used, for a second year, during the annual NHLS morphology training course, during which senior laboratory staff from all over South Africa are trained by the NHLS and the University of the Witwatersrand. Clinicians and NHLS laboratory supervisors at the Tambo Memorial Hospital in Boksburg are also using the database on a weekly basis to facilitate training for laboratory staff.



A digital view of human blood cells (white blood cells in purple and red blood cells in pink) as seen through a microscope.

Active ingredients are being added to the supercritical carbon dioxide reactor. (Above) The final product in capsule format.

Healthier process for micro-encapsulation of probiotics and vitamins

In the manufacturing of pharmaceuticals, encapsulation is a process used to coat active pharmaceutical ingredients, usually with polymers, to improve their stability and absorption in the body. The CSIR has patented an encapsulation technology in which special polymer molecules, which can attach to each other, are mixed with the active ingredients.

The process results in the formation of a tight 'mesh' of polymer molecules around the active ingredients, protecting them from light, moisture and temperature fluctuations during storage. In oral delivery applications, the encapsulation material also protects the active ingredients from harsh acidic conditions in the stomach, and releases the active ingredients only once it reaches the intestinal tract.

The CSIR encapsulation technology does not require the use of high temperatures or organic solvents, which have been associated with safety and health risks, to process the polymers. Instead, only supercritical carbon dioxide is needed. Carbon dioxide reaches a supercritical state beyond a critical pressure and temperature, where it has properties of both liquids and gases. For example, it can dissolve materials like a liquid, but flows like a gas.

The CSIR has applied this technology to address the inherent sensitivity and instability of beta-carotene (Vitamin A) to potentially enhance the efficacy of vitamin supplementation programmes. The research showed that, compared to conventional encapsulation techniques during which more than 50% of beta-carotene activity is lost, the carbon dioxide-based encapsulation technology leads to virtually no activity loss, with encapsulation efficiencies between 90 and 100%. The mesh-like structure of the encapsulation technology also increases the shelf-life of beta-carotene by a factor of at least seven times compared to non-encapsulated beta-carotene.

One of the key concepts in vitamin nutrition is bioaccessibility – the fraction of digested vitamin accessible for intestinal absorption. Due to the hydrophobic nature of beta-carotene, solubility in the intestinal fluids is very low, leading to limited absorption. For instance, only 1–3% of the beta-carotene in raw carrots is accessible for absorption. Through the incorporation of selected compounds in the formulation, it is possible to improve the solubility of beta-carotene in intestinal fluids by a factor of three, which in turn leads to greater absorption in the body.

HEALTH

A pipette is used to spot reagents onto a wax-patterned paper diagnostic device.

An example of printed electronic circuits used for environmental diagnostics.

CSIR creates a low-cost paper-based platform for diagnostics

CSIR researchers are pursuing the development of paper-based sensor technology, which has the potential to become a key component of point-of-care diagnostics for the South African health care system.

The remote location of some health care facilities delays diagnostic test results. Point-of-care technologies could provide immediate results for a variety of health conditions leading to faster diagnoses and more effective treatment.

The World Health Organization states that diagnostic devices in low-resourced settings must be affordable, sensitive, specific, user-friendly, rapid and robust, equipment free, and deliverable to end-users. Many high-end products which come into countries like South Africa do not conform to these criteria. CSIR researchers are working to develop diagnostic devices that meet these specifications.

Paper-based microfluidic diagnostic devices are related to existing lateral flow devices, such as pregnancy tests, but allow for greater control of the fluids and allow for a number of technologies to be incorporated into the device, such as printed electronics for sensing, display of results and provision of power, making the device more intelligent. These devices are produced at a low-cost and are disposable.

The research team has successfully printed microfluidic channels onto paper using wax printing techniques. The use of wax, which is hydrophobic, creates channels on the paper and controls the movement of fluid along the paper device. Biological and chemical reagents have been deposited on the paper substrates using specialised printing equipment. These materials interact with the flowing sample to produce a test result.

With respect to the electronic circuits, a specialised printer is used to print conductive inks onto paper to create electrodes and electronic tracks to allow for the printing of paper-based electronic circuits. The test result can therefore be analysed and displayed on the paper device using light-emitting diodes. In future, these sensors may be used for medical and environmental testing and could play a vital role within South Africa by enabling low-cost diagnostics to be performed at the point of care or need.

THE RESEARCH TEAM HAS SUCCESSFULLY PRINTED MICROFLUIDIC CHANNELS ONTO PAPER USING WAX PRINTING TECHNIQUES.

PROJECT HIGHLIGHTS

RESEARCH, DEVELOPMENT AND IMPLEMENTATION TO

SHAPE SOUTH AFRICA'S DIGITAL FUTURE

The *National Development Plan 2030* defines its vision for 2030 as a dynamic and connected information society, and a vibrant knowledge economy that is more inclusive and prosperous. The CSIR is contributing to the vision of an inclusive information society by assisting in creating a landscape enabled by information and communications technology (ICT), implementing and operating a national integrated cyberinfrastructure; as well as solving ICT science, engineering and technology problems relating to earth observation, health, broadband access, urbanisation and other national priorities that require ICT interventions.

SHAPING SOUTH AFRICA'S DIGITAL FUTURE

A screen on the locally produced eBook. An isiXhosa version has been piloted in the Eastern Cape.

Text-to-speech technology developed for indigenous languages

CSIR researchers have developed text-to-speech (TTS) software specifically for South African indigenous languages and piloted this technology among children in the Western and Eastern Cape.

The technology, called Qfrency TTS, converts text to synthesised speech in several official South African languages and can be used on standard desktop computers, laptops, tablets or mobile phones. Various voice options are available, for example different genders, accents and styles.

In one of the projects related to this work, the CSIR and Stellenbosch University collaborated to develop an eBook on a touch-screen tablet, which is able to read out children's stories using a digital voice.

Forty-two children from a community in the Western Cape where many parents work in the surrounding vineyards, took part in a pilot study with an Afrikaans version of the prototype to find out if the platform makes any difference to the development of their reading and word-recognition skills.

None of the children had any previous experience with computers or even cell phones, yet they quickly grasped the digital functions of the tablet and the interactive intervention programme. Comparisons between the pre-intervention and post-intervention assessments showed that all the children learned new words as a result of the intervention. An isiXhosa version has been piloted in the Eastern Cape.

In addition, the CSIR is trialling this technology in a project aimed at rapidly providing newspaper and magazine content to subscribers of the South African Library for the Blind; and it is available on a CSIR-developed portable computer for the Blind called the SAnote, to synthesise documents into natural sounding speech for playback.

Other potential applications include government service delivery – providing access to information, such as health advice, over the voice or data channel of a cell phone – as well as navigation – correctly pronouncing street names and other words, from different South African languages, in the same sentence.

The research is funded by the Department of Science and Technology, while the Department of Arts and Culture is funding the project for the South African Library for the Blind.

Siveshnee Moonsamy demonstrates technology that enables entrepreneurs to operate their own television stations over the mobile internet.

Mobile Internet Protocol Television platform creates new opportunities in South Africa

The CSIR has developed a platform that will allow entrepreneurs to operate their own television stations over the mobile internet. This innovation, called micro-enterprise media engine or Meme, allows for the streaming of mobile videos without buffering and makes it possible to broadcast scheduled content in both low- and high-bandwidth environments.

Broadcasting over the mobile internet – known as mobile Internet Protocol Television (mIPTV) – is in its infancy in South Africa with no sustainable commercial offerings on the market. Unlike video-on-demand platforms, which only have hosted content, this form of linear television allows for video content to be uploaded, scheduled and broadcasted to a global audience instantaneously.

Traditional television broadcasting is expensive and is dominated by large companies that own the gateway to content delivery mechanisms, including digital satellite TV and terrestrial digital and analogue TV.

The cost to enter this industry is restrictive. Furthermore, content creators have limited avenues to distribute their content. The CSIR-developed technologies open up opportunities for entrepreneurs to operate their own television stations and broadcast to all audiences connected to the mobile internet at very low cost, regardless of their connection speed. The platform creates new opportunities for local content producers to participate in the global media economy.

THE CSIR-DEVELOPED TECHNOLOGIES OPEN UP OPPORTUNITIES FOR ENTREPRENEURS TO OPERATE THEIR OWN TELEVISION STATIONS AND BROADCAST TO ALL AUDIENCES CONNECTED TO THE MOBILE INTERNET AT VERY LOW COST, REGARDLESS OF THEIR CONNECTION SPEED.

SHAPING SOUTH AFRICA'S DIGITAL FUTURE

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

Improved monitoring of large areas through space and ICT convergence

Improving South Africa's capability to monitor its considerable land and sea surfaces requires information and communications technology-related interventions. Two CSIR systems, rooted in the innovative use of space and information and communications technologies, have been developed and taken into industrial use.

The first system is a robust system to systematically detect deformation of land surfaces. In South Africa, large areas are affected by surface deformation associated with underground mining or natural geological processes. It poses a significant threat to the safety of humans and damage to infrastructure. Proving the stability of undermined areas is important for post-mining rehabilitation.

The large-area surface deformation monitoring system uses data captured by earth-orbiting satellites to map surface deformation over large areas (up to 150km^2) at very fine scales (down to 1mm) and to monitor the evolution of areas where deformation occurs over time.

The deformation measurements are provided on a web-accessible platform. The system overcomes the limitations of traditional monitoring, such as labour-intensiveness as well as working in potentially unsafe areas.

The system follows another CSIR-developed Earth observation monitoring and decision-making system, the Advanced Fire Information System (AFIS). The system was developed to help reduce the damage caused by wildfires. Using satellite data, AFIS detects fires in real time and issues automatic warnings to the cell phones or tablets of users, such as farmers, conservationists and those managing electricity transmission lines.

Both of these technologies have been adopted internationally. The large-area surface deformation monitoring system was used in Namibia while the full AFIS solution is operational in Argentina, Portugal and across southern Africa.

USING SATELLITE DATA, AFIS DETECTS FIRES IN REAL TIME AND ISSUES AUTOMATIC WARNINGS TO THE CELL PHONES OR TABLETS OF USERS, SUCH AS FARMERS, CONSERVATIONISTS AND THOSE MANAGING ELECTRICITY TRANSMISSION LINES.

The CHPC registered 130 new private and public sector users this year.

Enhancing industries and building new competencies through high-performance computing

The CSIR implements the National Integrated Cyberinfrastructure on behalf of the Department of Science and Technology. National Integrated Cyberinfrastructure consists of world-class computing, high-speed network and data infrastructure and services to enable new forms of scientific and industrial development. The Centre for High Performance Computing (CHPC) is one of the pillars of this cyberinfrastructure.

The CHPC works closely with private and listed companies (users) on a contract research and development basis to enhance their competitive edge. The CHPC registered 130 new private and public sector users this year.

The demand for use of the centre has led to the installation of a new high-performance computing cluster dedicated to grid computing for two of seven particle detector experiments at the European Organization for Nuclear Research, CERN.

The centre contributes to the implementation of the Square Kilometer Array (SKA) initiative as a member within the Science Data Processing consortium, where the facilities are used for test-bed purpose. Furthermore, the centre drives the initiative of building capacity for the SKA African partner countries, where it has provided high-performance computing equipment and training.

Building human capital in high-performance computing

The centre actively promotes high-performance computing to students to build South Africa's know-how in this field. The quality of training the students receive at the CHPC is renowned – the CHPC has won the International Student Cluster Challenge hosted by the International Supercomputing Conference (ISC), twice. The competition affords countries the opportunity to pit their high-performance computing know-how in a friendly, yet spirited competition. The competition features teams of six students, who build small clusters of their own design on the ISC exhibit floor and race to demonstrate the greatest performance across a series of benchmarks and applications.

In continuing to build expert-level skills, the CHPC enabled the research of 10 PhD and 13 MSc students who graduated through utilisation of the centre's resources. Furthermore, CHPC users produced 95 peer-reviewed publications in the past year.

SHAPING SOUTH AFRICA'S DIGITAL FUTURE

South Africa's Information and Communications Technology Research, Development and Innovation Roadmap will be implemented through the Office of Digital Advantage.

Building traction in the execution of the ICT RDI Roadmap

The South African Cabinet's approval of the Information Communication Technology Research, Development and Innovation (ICT RDI) Roadmap on 30 April 2013 marked the execution phase of the ICT RDI Roadmap.

To enable the successful execution of this roadmap over the course of the next decade, a portfolio management office, the Office of Digital Advantage, will be established. The purpose of the office is to ensure the efficient and transparent coordination, monitoring and active management of the portfolio of RDI investments in ICT. The CSIR constituted an interim implementation office on behalf of the Department of Science and Technology (DST), through which there have been major strides in executing the ICT RDI Roadmap, namely in the signing of two major agreements and building critical scarce skills.

Achievements in executing the ICT RDI Roadmap

In February 2015, a partnership worth R700 million, of which R370 million will be dedicated to ICT research and development (R&D), was concluded between IBM South Africa, the Department of Trade and Industry (**the dti**), the DST, the CSIR, and the University of the Witwatersrand.

The partnership focuses on big data and analytics, mobile technologies and cloud computing in applications such as inclusive health care, agriculture, and water and sanitation. In addition, IBM researchers will work closely with local universities, innovation centres, start-ups and government to strengthen South Africa's emerging innovation ecosystem and to develop the next-generation technology skills. The partnership was made possible through a seven-year equity equivalent investment in ICT by IBM and marks the first time that an R&D investment is recognised as a component of the Equity Equivalent Investment Programme of **the dti**. The CSIR has started an initiative to develop critical skills in data science in South Africa. Fourteen undergraduate students took part in an intensive 11-week advanced data science programme. The programme will be expanded to include 30 students across 12 universities in the next phase.

In March 2015, Cisco South Africa signed a three-year, R50 million investment with Nelson Mandela Metropolitan University in partnership with the CSIR, the DST and the Square Kilometre Array to establish a Centre for Broadband. The centre will focus on advancing research in broadband with the goal to produce research products in optical fibre communications and high-end skills in broadband technologies with opportunities to spin off technology start-ups from the research programme.

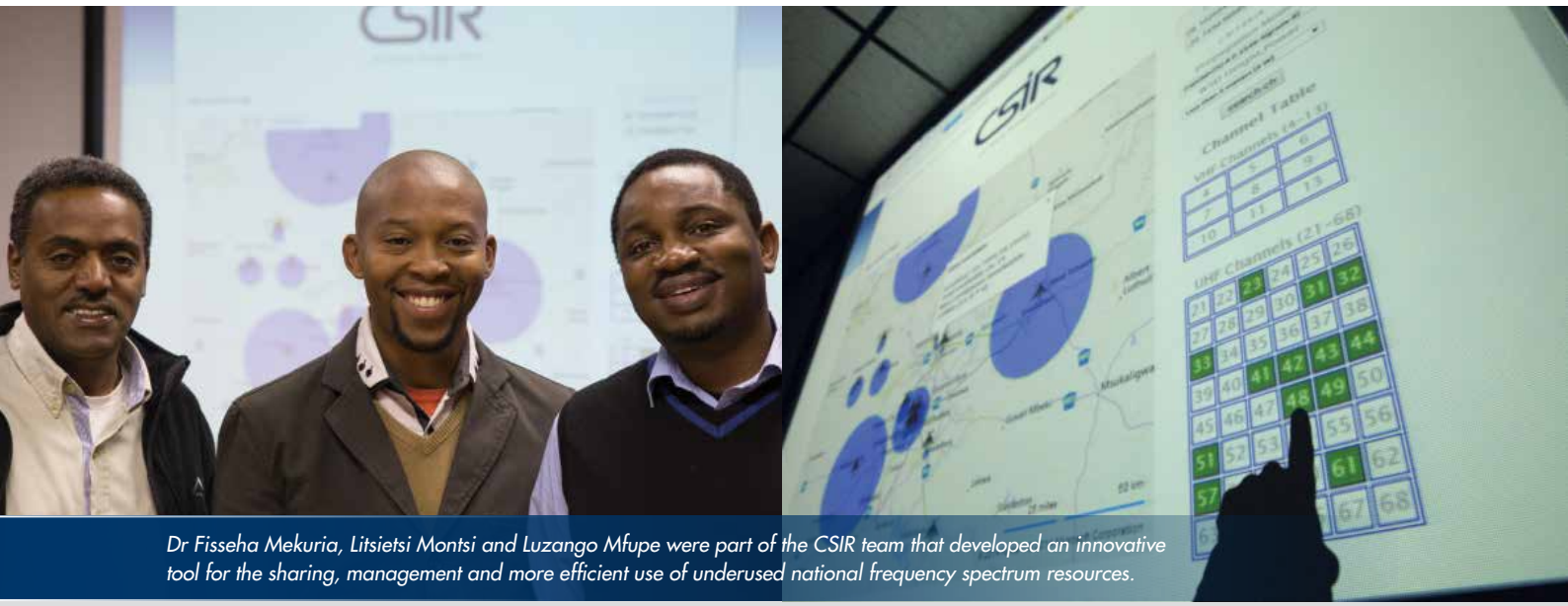
PROJECT HIGHLIGHTS

PARTNERING FOR

AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

South Africa subscribes to the African Union vision of "An integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena." The CSIR is contributing toward this vision by collaborating with African partners on science, engineering and technology solutions.

PARTNERING FOR AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION



Dr Fisseha Mekuria, Litsietsi Montsi and Luzango Mfupe were part of the CSIR team that developed an innovative tool for the sharing, management and more efficient use of underused national frequency spectrum resources.

Sharing experiences in innovative frequency spectrum management

Many African countries need to effectively manage their national spectrum resources to accelerate the implementation of wireless internet services. The CSIR is sharing its knowledge on dynamic spectrum management with other African governments and institutions.

Radio frequency spectrum, the part of the electromagnetic spectrum allocated to radio communication services such as television broadcasts, mobile, radio and WiFi, is an important national resource needed for the increasing service demand from wireless devices used in everyday life, such as smartphones and laptops.

While there seems to be a widespread shortage of usable spectrum, much of the needed spectrum is lying dormant or is currently under-utilised, specifically in the TV broadcasting frequency ranges. To help better manage national spectrum resources, the CSIR has developed a geo-location-based dynamic spectrum system and allocation tool that allows users to identify and access unused frequency spectrum at any location, without interfering with existing spectrum users. This means that South Africa now has the ability to utilise and share available spectrum in the TV broadcasting bands, and provide high-speed broadband internet services to under-served areas.

By using the CSIR tool, secondary spectrum users (like wireless network operators) can make an online enquiry to determine what spectrum frequencies are available for use at a particular location and time and allocate suitable channels for use by these secondary network devices, while actively preventing signal collision or interference with primary users.

The CSIR's involvement in various information and communications technology-related activities with spectrum regulators in Ghana, Botswana and Tanzania is helping to shape the agenda for Africa-wide efficient spectrum management and innovative broadband services.

Most recently, the CSIR has developed a cloud-based national spectrum database hosting framework, for the hosting of national spectrum databases for other African countries.

THE CSIR'S INVOLVEMENT IN VARIOUS INFORMATION AND COMMUNICATIONS TECHNOLOGY-RELATED ACTIVITIES WITH SPECTRUM REGULATORS IS HELPING TO SHAPE THE AGENDA FOR AFRICA-WIDE EFFICIENT SPECTRUM MANAGEMENT AND INNOVATIVE BROADBAND SERVICES.

The CSIR is assisting various African countries in projects to improve road infrastructure and transport research capabilities, including Tanzania.

Supporting Africa's road infrastructure development

The CSIR is providing technical assistance and expertise in the creation of road and transport research centres and platforms across Africa, most notably in Mozambique and Tanzania.

After having played a major role in the establishment of a road research centre in Mozambique, the CSIR is now also providing technical assistance to the government of Tanzania in setting up its own road research centre. This programme is being supported by the Africa Community Access Programme of the United Kingdom's Department for International Development (DFID).

The CSIR drafted a business plan for Tanzania's road research centre at the request of the Tanzanian Prime Minister's office. The centre will support better planning in the development of road infrastructure in Tanzania.

The CSIR also investigated the cause and mechanism of premature rutting – the forming of grooves resulting from wheelpath on a road surface – on national roads in Tanzania, and has begun work on better asphalt mix design guidelines. In addition, DFID tasked the CSIR to develop software for the in-situ assessment of road pavements and the design of low-volume access roads in Tanzania.

Most recently, the CSIR has been involved in the establishment of the first African Road and Transport Research Forum, consisting of 16 African member countries, with other countries expected to become members in the near future.

These 16 countries – Botswana, Democratic Republic of the Congo, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mozambique, Namibia, Nigeria, Sierra Leone, South Africa, South Sudan, Tanzania, Zambia and Zimbabwe – have worked together since early 2015 to explore ways to stimulate cooperation in research and innovation in roads and transport in sub-Saharan Africa.

The aim of the forum is to promote research and innovation activities through networking, coordination, collaboration, knowledge transfer, and providing advice on policies for sustainable development in Africa.

PARTNERING FOR AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

The CSIR has created a mobile test kit for on-site assessment of the suitability of material to be used in the construction of gravel roads. These kits can be used, among other things, to easily determine the mass of a soil sample using a battery operated scale (left), for liquid limit determination using a standard drop cone (right) and to dry linear shrinkage samples in a solar oven (bottom) for analysis.

Gravel road test kit contribute to better roads in Tanzania

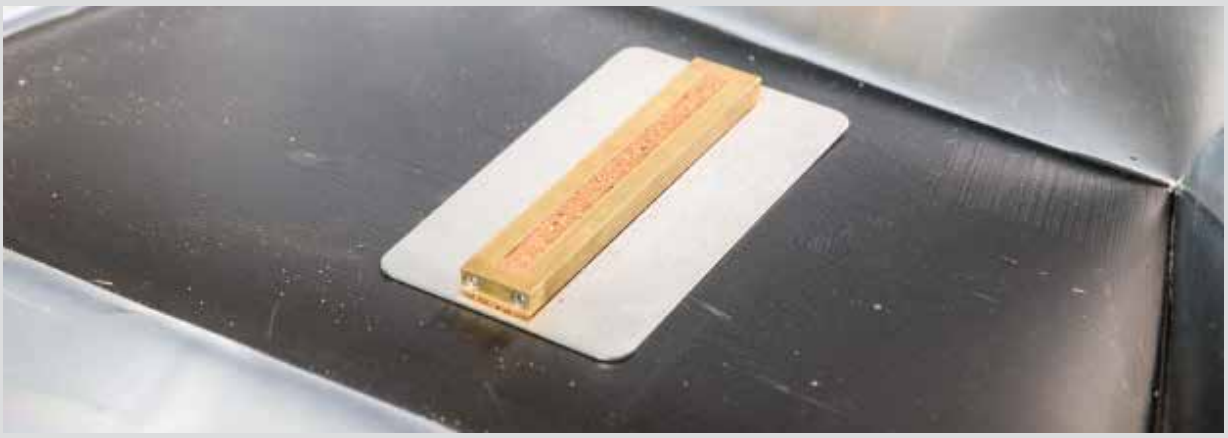
The CSIR has developed a low-cost gravel road test kit for on-site assessment of the suitability of material for use in the construction of gravel roads. The organisation has trained Tanzanian engineers and technicians in the use of the test kits as part of a capacity-building project to improve that country's gravel road infrastructure. The kit was developed in conjunction with the International Labour Organisation.

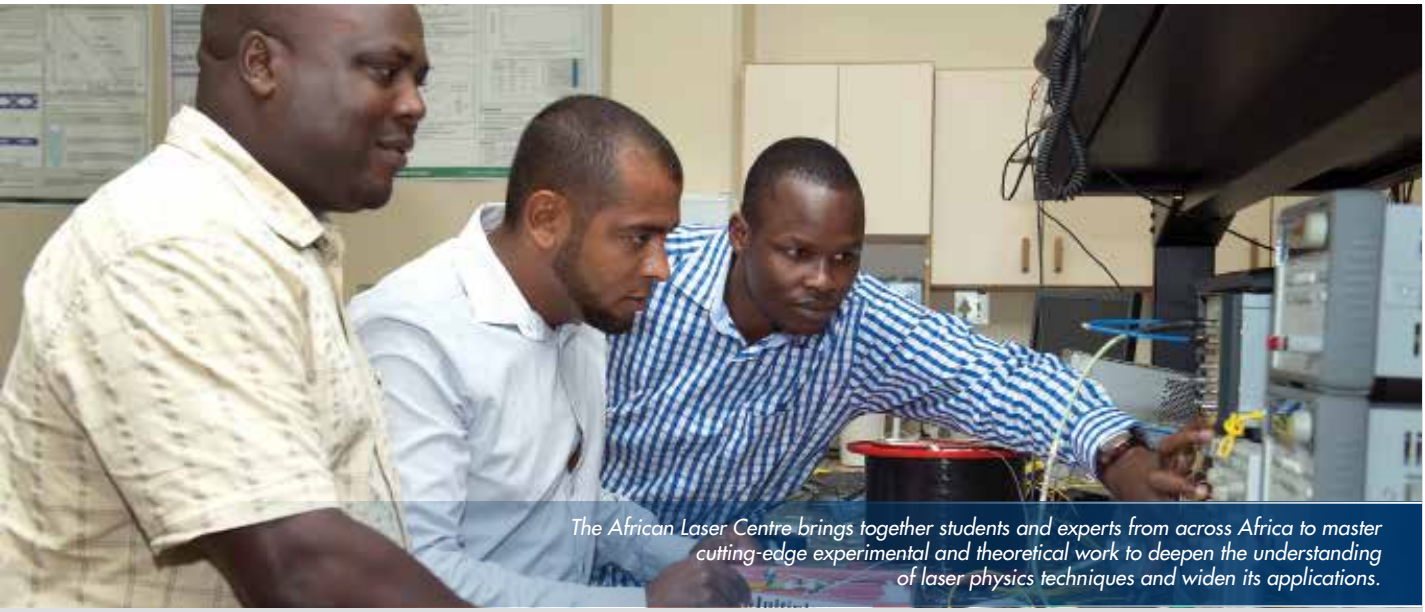
The gravel road test kit allows for field grading, determination of compacted strength and aggregate strength of potential gravel material to be used as road surface cover for unsealed roads. This helps to ensure that the quality of the construction is appropriate.

The test kit does not require electricity as the oven used for heating soil samples only makes use of solar energy.

A total of 21 technicians and 43 engineers from the regional administration and local government, districts and municipalities participated in the training.
The overall objective was to build the capacity of the technicians and engineers to use the test kit to improve quality control of wearing course materials for low-volume, unsealed roads.

The project is funded by the European Union and implemented by UK company, Cardno IT Transport, who contracted the CSIR to provide the training.





The African Laser Centre brings together students and experts from across Africa to master cutting-edge experimental and theoretical work to deepen the understanding of laser physics techniques and widen its applications.

Africa advances its capabilities in laser technology

South African laser scientists have collaborated with their counterparts in Uganda, Algeria, Kenya, Nigeria, Morocco and Tunisia on 11 projects in the field of lasers and laser applications during 2014. Through this collaboration, some 71 postgraduate students in Africa gained exposure to laser-related research.

The research projects varied from laser applications for health, such as studying the anti-cancer and anti-inflammatory activities of medicinal plant extracts, to laser applications for manufacturing, such as a study on the corrosion of titanium-based composite coatings.

The collaboration was made possible through the African Laser Centre (ALC), a flagship programme of the African Union New Partnership for Africa's Development. The ALC is managed by the CSIR on behalf of the Department of Science and Technology.

The ALC has funded 25 scholarships, 21 at doctoral and four at Master's levels during 2014 and hosted training workshops and seminars in South Africa, Morocco, Tunisia and in Egypt, attracting more than 300 researchers from Africa. The ALC was established in 2003 as a mechanism to stimulate African innovation in laser technology.

PARTNERING FOR AFRICAN RESEARCH, DEVELOPMENT AND IMPLEMENTATION

Zambian farmers use Tephrosia vogelii *juice to remove ticks from livestock and to keep away insects in vegetable gardens (right).*

Sharing biosciences expertise in southern Africa

The Southern Africa Network for Biosciences (SANBio) has made progress in developing solutions based on indigenous knowledge to address southern African challenges in health and nutrition. Projects undertaken focused on remedies against HIV infection and livestock diseases, the establishment of fish farms, the production of mushroom products and the development of guidelines for the recording and testing of indigenous products.

SANBio was established in 2005 as one of five regional collaboration networks under the New Partnership for Africa's Development. It is a shared biosciences research, development and innovation platform that provides access to world-class laboratories for African and international scientists conducting biosciences research on African challenges in health, nutrition, agriculture and the environment.

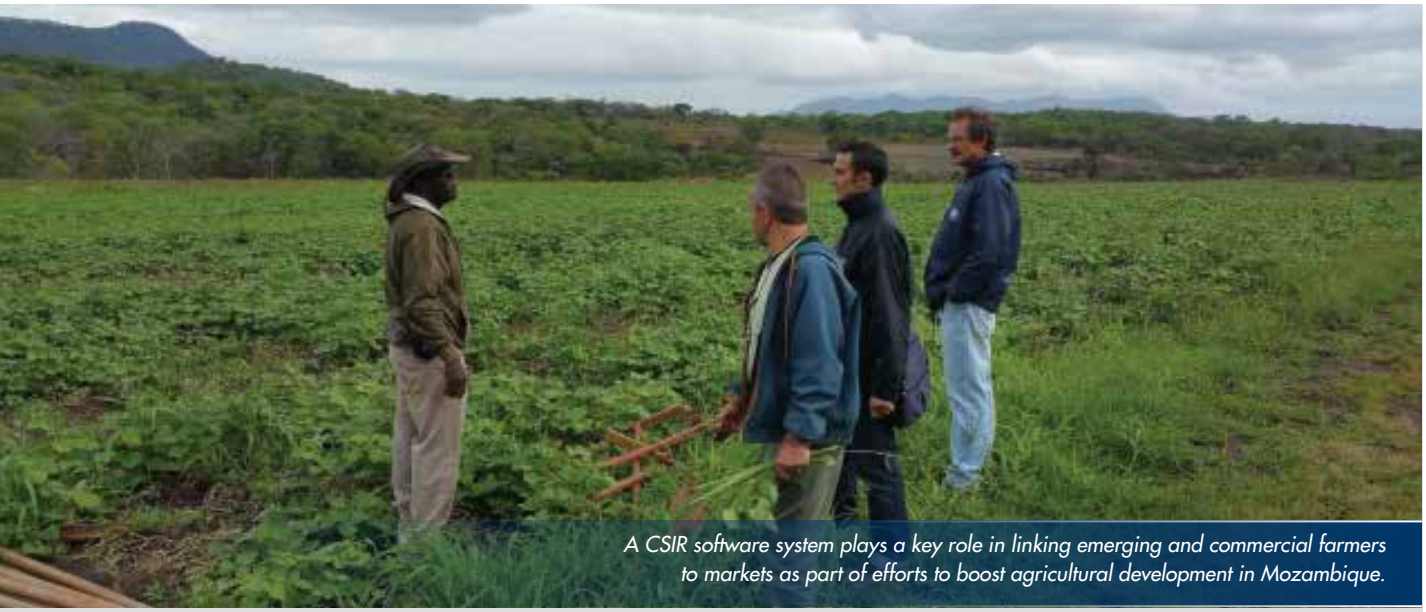
Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, the Seychelles, Zambia and Zimbabwe are members of SANBio. The CSIR is the regional hub providing laboratories, technical support and managing the network on behalf of stakeholders.

As part of this initiative, the CSIR has supported Zambia with pre-clinical testing for the development of a botanical remedy against HIV, which is now ready to be manufactured and tested in clinical trials. In South Africa, the CSIR has also been involved in a project to develop a plant-based platform for the cost-effective expression of proteins from aquatic organisms to be used in microbicides against HIV.

SANBio has funded a facility for the development of dietary supplements, teas and soups from mushrooms in Namibia and supported the establishment of fish farming in Malawi. It has also funded the introduction of an indigenous remedy for the control of tick-borne disease in livestock in Zambia.

In Mauritius, 21 researchers from the region have been trained in bio-informatics and the use of information and communications technology in biological research, while the country is also representing the SANBio network in the Human Heredity and Health in Africa Initiative. Local experts at the North-West University have contributed to the development of research methodology for indigenous products and capacity building in indigenous knowledge systems.

SANBio recently signed a new four-year funding contract with the Finnish-Southern Africa Partnership programme, marking the beginning of a second phase of research support in the region. Participating countries co-fund projects.



A CSIR software system plays a key role in linking emerging and commercial farmers to markets as part of efforts to boost agricultural development in Mozambique.

inTouch Africa® system benefits Mozambican agricultural development

The CSIR has contributed an enabling software system at a central hub and in eight districts of Mozambique to promote agricultural development as part of a project involving multiple southern African and international stakeholders.

The CSIR-developed inTouch Africa® software system has been installed in the CepAgri Centre in Chimoio in the Manica province as well as in service centres for economic development and agribusiness located in eight districts of the Manica and Sofala provinces. These district centres are supported by the CepAgri Centre to link emerging and commercial farmers to markets and investors to promote agricultural development.

The service centres are responsible for maintaining datasets on agricultural producers, support entities and possible clients. Through InTouch Africa®, farmers can access these databases for business support and technical support. Fieldworkers collect and add data at the various district offices in the regions, which are then collated in the central database of the CepAgri Centre.

KNOWLEDGE DISSEMINATION

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New international patents granted

Patent title	Patent number	Country
A method of switching from a source encoded video stream to a destination encoded video stream	ZL200880131629.2	China
Biocatalytic preparation of nucleosides	ZL200880131956.8	China
Composition containing arylnaphthalene lignan derivative for preventing and/or treating dementia	2712615	EPO-European Patent Office
Emulsion-derived particles	ZL200880114052.4	China
Gram positive recombinant protein producing bacteria	263715	India
Imidazopyridines and imidazopyrimidines as HIV-1 reverse transcriptase inhibitors	ZL200980145529.9	China
Nanoparticle carriers for drug administration	2008351331	Australia
Nanoparticle carriers for drug administration	AP2966	ARIPO
Nanoparticle carriers for drug administration	1/2010/501865	Philippines
Nanoparticle carriers for drug administration	5575667	Japan
Nanoparticle carriers for drug administration	IDP000035927	Indonesia
Preventative treatment and remission of allergic diseases	AP2893	ARIPO
Production of heterologous extracellular polypeptides in *Yarrowia lipolytica*	8940505	United States
Titanium powder production process	263715	Kazakhstan
Titanium powder production process	8790441	United States
Treatment of erectile dysfunction and libido enhancement	265328	India
Treatment of erectile dysfunction and libido enhancement	ZL200780019206.7	China
Triazine derivatives for use in the treatment of malaria	8940892	United States

CORPORATE GOVERNANCE

Corporate governance

Framework

Corporate governance is formally concerned with the organisational arrangements that have been put in place to provide an appropriate set of checks and balances within which the stewards of the organisation operate. The objective is to ensure that those to whom the stakeholders entrust the direction and success of the organisation act in the best interest of these stakeholders. It is about leadership with integrity, responsibility, accountability and transparency.

The CSIR is committed to principles and practices that provide our stakeholders with the assurance that the organisation is managed soundly and ethically. We have established a management model that governs and provides guidance for the way that all employees interact with our various stakeholder groups.

The underpinning principles of the Group's corporate governance rest on the three cornerstones of an effective and efficient organisation namely: day-to-day management processes; a long-term strategic planning process; and effective change processes. These processes are supported by systems that are used to plan, execute, monitor and control the strategic and operational domains of the organisation. The supporting infrastructure and its evolution are documented in our management model, which is reviewed and updated regularly.

In accordance with the Scientific Research Council Act (No. 46 of 1988), as amended by Act 71 of 1990, the appointment of the CSIR Board is by the Executive Authority. The Board provides strategic direction and leadership; determines goals and objectives of the CSIR and approves key policies. The Board has adopted formal Terms of Reference that are in line with the Scientific Research Council Act and the Public Finance Management Act (PFMA) (No. 1 of 1999), as amended by Act 29 of 1999.

Both the CSIR Board and its Executive Management Committee believe that the organisation has complied with the relevant principles incorporated in the Code of Corporate Practices and Conduct, as set out in the King III Report.

Shareholder's Compact

In terms of Treasury Regulations issued in accordance with the PFMA, the CSIR must, in consultation with the Executive Authority, annually agree on its key performance objectives, measures and indicators. These are included in the shareholder's performance agreement (Shareholder's Compact) concluded between the CSIR Board and the Minister of Science and Technology (Executive Authority).

The compact promotes good governance practices in the CSIR by helping to clarify the roles and responsibilities of the Board and the Executive Authority and ensuring agreement on the CSIR's mandate and key objectives. The chairperson of the Board and the Executive Management Committee hold bilateral meetings with the Executive Authority.

Financial statements

The CSIR Board and the CSIR Executive Management Committee confirm that they are responsible for preparing financial statements that fairly present the state of affairs of the Group as at the end of the financial year and the results and cash flows for that period. The financial statements are prepared in accordance with International Financial Reporting Standards (IFRS). In addition, the CSIR Board is satisfied that adequate accounting records have been maintained.

The external auditor is the Auditor-General, who is responsible for independently auditing and reporting on whether the financial statements are fairly presented in conformity with IFRS. The Auditor-General's Terms of Reference do not allow for any non-audit work to be performed.

Enterprise risk management

The CSIR Board is responsible for ensuring that a comprehensive and effective risk management process is in place.

Enterprise risk management in the CSIR is an ongoing process, focused on identifying, assessing, managing and monitoring all known forms of significant risks across all operations and Group companies. This has been in place for the year under review and up to the date of approval of the annual financial statements.

Corporate governance

A structured process of enterprise risk management has been put in place to ensure that the goals and objectives of the CSIR are attained. This takes cognisance of the fact that the risks identified are often inter-linked, and cannot be managed in isolation. CSIR systems have been put in place to review aspects of economy, efficiency and effectiveness. The management of risk is assigned at appropriate levels to ensure proper responses.

Documented and tested processes are in place which will allow the CSIR to continue its critical business operations, in the event of interruptions impacting on its activities. Based on the work of internal audit, the organisational results achieved, the audit report on the annual financial statements, and the management report of the Auditor-General, the Board is satisfied that the system of risk management has been effective during the year under review.

The CSIR has defined three broad risk categories, namely: systemic risks, strategic risks and operational risks.

Systemic risks

Systemic risks originate from macro-economic and national challenges affecting the National System of Innovation and National Government Business Enterprise space in which the CSIR operates.

Continued evaluation of macro-economic influences, ongoing assessment and engagement with stakeholders remain key in directing research activities towards achieving the CSIR's mandate.

Strategic risks

The organisation has effective mechanisms in place for identifying and monitoring strategic risks that impact the CSIR Group's ability to deliver on its mandate. The procedures for implementing a risk management process include a focus on areas such as: human capital assessment and development; research impact areas; technological development; and business continuity.

Operational risks

The CSIR endeavours to minimise operating risk by ensuring that the appropriate infrastructure, controls, systems and people are in place throughout the Group. Key processes employed in managing operating risk include research ethics and good research practices; segregation of duties; transaction approval frameworks; financial and management reporting; and monitoring of metrics which are designed to highlight positive or negative performance across a broad range of key results areas (KRAs). The Operations Committee, which comprises members of the Executive Management Committee, Operating Unit and Centre Executive Directors, and Group Managers, oversee operational matters.

Sustainability

The CSIR Board has reviewed the Group's financial budgets for the period 1 April 2015 to 31 March 2016 and is satisfied that adequate resources exist to continue as a going concern for the foreseeable future. The CSIR Board confirms that it has assessed key sustainability risks and there is no reason to believe the business will not be a going concern in the year ahead.

The income streams of the CSIR are detailed in the notes to the financial statements.

Internal audit

The Group has an internal audit function that reviews its operations. The Audit and Risk Committee approves the internal audit charter, the annual audit plan and budget of the CSIR internal audit to maintain its independence.

The annual audit plan is based on the key risks to the organisation and outcome of enterprise risk assessment conducted by management, as well as specific areas highlighted by internal audit and the Audit and Risk Committee. In addition, areas highlighted by internal control reviews by the external auditors are incorporated into the internal audit plan.

The annual audit plan is flexible in ensuring it is responsive to changes in the business and emerging risks.

A comprehensive report on internal audit findings is presented to management regularly and to the Audit and Risk Committee quarterly.

Internal control and combined assurance

The CSIR Board has ultimate responsibility for the system of internal control designed to mitigate risks, identify,

Corporate governance

evaluate, manage and provide reasonable assurance against misstatements and losses.

The system comprises self-monitoring mechanisms to allow for actions to be taken to correct deficiencies as they are identified.

A combined assurance approach is in place to assist in addressing key enterprise risks.

Management and the Risk Office identify controls that are necessary to mitigate risks. Internal audit is the third line of defence and provides assurance on the effectiveness of risk management and the system of internal control.

For the year under review, the internal financial controls have been assessed as effective.

Audit

External auditors are responsible for the independent auditing and reporting on the annual financial statements. The statements comply with IFRS.

In line with the requirements of the PFMA and good governance, the internal audit function provides assurance to the Audit and Risk Committee and management on the adequacy and effectiveness of internal controls. Information is derived from an independent evaluation of risk management, governance processes and internal controls. Corrective action is identified and improved controls are recommended.

Approval framework and policies

The CSIR Board has adopted an approval framework that governs the authorisation processes in the CSIR. It deals with, among others, the construction of strategic plans; development of operational plans and budgets; appointment of staff; approval of salaries; intellectual property management and investment in and disposal of property, plant and equipment. It also defines authority levels in relation to organisational positions.

Appropriate controls are in place to ensure compliance with the above framework. A comprehensive set of procedures exists to provide the necessary checks and balances for the economical, efficient and effective use of resources. The essence of this framework is that it is comprehensive, clear and unambiguous, and easy to assimilate and internalise.

All subsidiary companies are under the control of a duly appointed board of directors.

The Board reserves all matters with potential to have material impact on the operations and reputation of the CSIR to itself.

Employee participation

The CSIR strongly encourages effective and modern workplace practices and relationships to foster employee participation and work process involvement as a key practice at all levels in the organisation. Employee participation happens, for example, through PFMA road shows; formal induction programmes; technical and strategic focus groups and task teams.

Code of business ethics and organisational values

The CSIR Board and CSIR Executive Management Committee have approved and adopted a code of ethics which reflects their commitment to a policy of fair dealing and integrity in conducting their operations. The code aligns closely to the CSIR set of values, compliance to laws and regulations and requires all employees to maintain the highest ethical standards, ensuring that business practices are conducted in a manner which is beyond reproach. Monitoring ethical behaviour is devolved to operating unit level and transgressions are addressed by means of procedures detailed in the CSIR Conditions of Service and the PFMA.

Governance structure

The CSIR Board

The responsibilities of the Board are governed by the Scientific Research Council Act and the PFMA. The Board approves the strategy, goals, operating policies and priorities for the organisation and monitors compliance with policies and achievement against objectives.

With the exception of the CEO of the CSIR, all members of the CSIR Board are non-executive. CSIR Board members are actively involved in and bring independent judgement to bear on the Board's deliberations and decisions. All non-executive Board members have been assessed as independent during the year under review.

The CSIR Board, of which the current number of members adheres to the statutory minimum requirements, meets quarterly. For the year under review, the Board met on 26 June 2014, 11 September 2014, 29 and 30 October 2014 for strategy sessions, 6 November 2014 and 26 February 2015. The annual financial statements for the 2014/15 financial year were approved on 25 June 2015.

The CSIR Board has the following sub-committees: the Human Resources and Remuneration Committee; the Audit and Risk Committee; and the Research and Development and Innovation Committee (formerly Strategic Review Committee) (see pages 113 to 114). These committees are selected according to the skills sets required in order for the committees to fulfil their functions. For the 2014/15 year, the committees complied with their respective Terms of Reference.

The CSIR Board has adopted formal Terms of Reference reflected in the Board charter, which are annexed in the Shareholder's Compact.

CSIR Board members (1 April 2014 to 31 March 2015)

The term of the Board appointed on 1 January 2012 came to an end on 31 December 2014.

A new Board was appointed with effect from 1 January 2015 for a four-year term ending 31 December 2018. As with the previous Board, the new Board has a diverse set of skills to effectively discharge its duties.

All Board members were welcomed by the Minister of Science and Technology during an inaugural meeting held on 29 January 2015. The occasion provided the policy context and contribution expected from the Board.

The collective Board was formally inducted on 9 February 2015.

Governance structure

CSIR Board members (1 April 2014 to 31 December 2014)

Prof Francis Petersen

Dean: Faculty of Engineering and the Built Environment, University of Cape Town

Dr Sibusiso Sibisi

Chief Executive Officer: CSIR

Prof Mike Wingfield

Director: Forestry and Agricultural Biotechnology Institute, University of Pretoria

Mr McLean Sibanda

Chief Executive Officer: The Innovation Hub Management Company

Mr Phillip Benadè

Retired from the Department of Education. Independent financial consultant

Mr Ghandi Badela

Advocate: Duma Nokwe Group

Prof Eugene Cloete

Dean: Faculty of Science, University of Stellenbosch

Dr Philip Hugh Goyns

Supply Option Modelling Specialist: Department of Energy

Ms Malebo Mabitje-Thompson

Chief Operations Officer: Department of Trade and Industry

Prof Tebello Nyokong

Professor: Medicinal Chemistry and Nanotechnology, Rhodes University

Ms Swazi Tshabalala

Chief Executive Officer: Industrial Development Group

Schedule of attendance of the CSIR Board and CSIR committee meetings (1 April 2014 to 31 December 2014)

Board member	Board meetings (3)	Audit and Risk Committee (3)	Human Resources and Remuneration Committee (2)	Strategic Review Committee (2)
Petersen	3			2
Badela	3	2		2
Benadè	3	3		2*
Cloete	3			2
Goyns	2		2	1*
Mabitje-Thompson	2		0	0
Nyokong	0			0
Sibanda	2	1	2	1*
Sibisi	3[a]	3[a]	2[a]	2[a]
Tshabalala	3	3		2
Wingfield	3			1

[a] *Attends in capacity as CEO*
* *Attendance by invitation*

Governance structure

CSIR Board members (1 January 2015 to 31 March 2015)

Prof Thokozani Majozi

Chairperson of the CSIR Board NRF/DST Chair: Sustainable Process Engineering, University of the Witwatersrand

Dr Sibusiso Sibisi

Chief Executive Officer, CSIR

Adv. Ghandi Badela

Advocate, Duma Nokwe Group

Dr Philip Hugh Goyns

Senior Climate Change Advisor, Promethium Carbon

Ms Phindile Baleni

Director General, Gauteng Premier's Office

Dr Antonio Llobell

Chief Executive Officer, BioGold International

Dr Ramatsemela Masango

Executive Director, Mzansi Energy Solutions and Innovations (Pty) Ltd

Ms Mokgadi Maseko

Director, Leruo Corporate Consulting

Mr Joel Netshitenzhe

Executive Director and Board Vice-Chairperson, Mapungubwe Institute for Strategic Reflection (MISTRA)

Ms Ayanda Noah

Group Executive: Distribution, Eskom

Prof Mamokgethi Phakeng

Vice Principal of Research and Innovation, Unisa

Schedule of attendance of the CSIR Board and CSIR committee meetings (1 January 2015 to 31 March 2015)

Board member	Board meetings (1)
Majozi	1
Badela	1
Baleni	0
Goyns	1
Llobell	0
Masango	1
Maseko	1
Netshitenzhe	1
Noah	1
Phakeng	0
Sibisi	1[a]

[a] *Attends in capacity as CEO*

Governance structure

Executive Management Committee

The Executive Management Committee has executive responsibility for the CSIR and consists of the following Executive members:

1. Group Executive, Research and Development: Dr Molefi Motuku
2. Chief Financial Officer: Mr Chris Sturdy
3. Chief Executive Officer: Dr Sibusiso Sibisi
4. Group Executive, Shared Services: Mr Raynold Zondo
5. Group Executive, Operations: Mr Laurens Cloete
6. Group Executive, Strategic Alliances and Communication: Dr Rachel Chikwamba

All Executives are employed on a five-year contract basis.

Governance structure

CSIR leadership team

The CSIR management is responsible for strategy implementation and managing the day-to-day affairs of the CSIR and its operating units in accordance with the policies and objectives approved by the CSIR Board.

This leadership team comprises the members of the CSIR Executive Management Committee and Operating Unit Executive Directors and Centre Managers.

Other internal structures that contribute to governance at the CSIR include the Executive, Operations and Strategic Committees, the Strategic Research and the Research Advisory Panels.

Board of directors and Group companies

The CSIR Executive appoints the boards of the various subsidiary companies.

Board and Executive Management remuneration

Details of the CSIR Board are set out on pages 108 to 110 of the Corporate Governance Report. The membership and Terms of Reference of each Board committee are further described on pages 113 to 114.

Remuneration of Board members and the Executive Management is set out in note 18 of the annual financial statements.

Remuneration of Executive Management is in accordance with the remuneration policy which has been approved by the CSIR Board.

General

The CSIR acknowledges that systems of corporate governance should be reviewed continuously to ensure that these are sound and consistent with world-class standards relevant to the operations of the Group.

The CSIR will continue to comply with all major recommendations of the Code of Corporate Practices and Conduct as set out in the King III Report.

Public Finance Management Act (PFMA)

The PFMA came into effect on 1 April 2000 and has had an impact on governance matters in terms of the regulation of financial management in the public sector.

Materiality framework

The materiality framework for reporting losses through criminal conduct and irregular, fruitless and wasteful expenditure, as well as for significant transactions envisaged per section 52 of the PFMA, has been finalised and incorporated into the Shareholder's Compact. No material losses through criminal conduct and fruitless and wasteful expenditure were identified as having been incurred during the year.

CSIR Board committees

Audit and Risk Committee

April 2014 to December 2014

Chairperson Mr P Benadè

Members Mr M Sibanda
Ms BS Tshabalala
Adv G Badela

Meetings 25 June 2014
10 September 2014
6 November 2014

January 2015 to March 2015

Chairperson Ms A Noah

Members Ms M Maseko
Adv G Badela
Ms P Baleni

Purpose

- To deal with all matters prescribed by the regulations issued in terms of the PFMA and the Scientific Research Council Act;
- To perform the final review of the key risk matters affecting the organisation;
- To agree on the scope and review the annual external audit plan and the work of the CSIR internal auditors (including the internal audit charter); and
- To act in an unfettered way to understand the dynamics and performance of the organisation.

The Audit and Risk Committee has adopted formal Terms of Reference and is satisfied that it has complied with its responsibilities as set out in the Terms of Reference.

Human Resources and Remuneration Committee

April 2014 to December 2014

Chairperson Mr M Sibanda

Members Dr PH Goyns
Ms MSM Mabitje-Thompson

Meetings 25 June 2014
10 September 2014

January 2015 to March 2015

Chairperson Adv G Badela

Members Dr PH Goyns
Ms P Baleni
Prof M Phakeng

Purpose

- To influence and advise on human resources and remuneration matters in the organisation; and
- To approve remuneration changes and bonus payments; in addition, it reviews the remuneration of the Executive Management.

The Human Resources and Remuneration Committee has adopted formal Terms of Reference and is satisfied that it has complied with its responsibilities as set out in the Terms of Reference.

CSIR Board committees

Research and Development and Innovation Committee (formerly Strategic Review Committee)

April 2014 to December 2014

Chairperson Prof FW Petersen

Members Prof TE Cloete
Prof TA Nyokong
Prof MJ Wingfield
Ms BS Tshabalala
Mr G Badela

Meetings 26 June 2014
9 October 2014

January 2015 to March 2015

Chairperson Prof M Phakeng

Members Mr J Netshitenzhe
Dr A Llobell
Dr P Goyns
Dr R Masango

Purpose

- To provide guidance and advice on the long-term trajectory and composition of the CSIR's science and technology portfolio in the context of the needs of the country; and
- To ensure that key innovation and research processes are conducted effectively and benchmarked against international best practice, and that research outputs, organisational climate and credibility remain congruent with the role and objectives of the institution.

The Research and Development and Innovation Committee has adopted formal Terms of Reference and is satisfied that it has complied with its responsibilities as set out in the Terms of Reference.

Board and committee meeting attendance

Board meetings (1 April 2014 to 31 December 2014)

Date of meeting	26/06/14	11/09/14	06/11/14
Petersen	Present	Present	Present
Badela	Present	Present	Present
Benadè	Present	Present	Present
Cloete	Present	Present	Present
Goyns	Present	Apology	Present
Mabitje-Thompson	Apology	Present	Present
Nyokong	Apology	Apology	Apology
Sibanda	Present	Present	Apology
Sibisi[a]	Present	Present	Present
Tshabalala	Present	Present	Present
Wingfield	Present	Present	Present

[a] *Attends in capacity as CEO*

Board meetings (1 January 2015 to 31 March 2015)

Date of meeting	26/02/15
Majozi	Present
Badela	Present
Baleni	Apology
Goyns	Present
Llobell	Apology
Masango	Present
Maseko	Present
Netshitenzhe	Present
Noah	Present
Phakeng	Apology
Sibisi[a]	Present

[a] *Attends in capacity as CEO*

Audit and Risk Committee meetings (1 April 2014 to 31 December 2014)

Date of meeting	25/06/14	10/09/14	06/11/14
Benadè	Present	Present	Present
Sibanda	Apology	Present	Apology
Tshabalala	Present	Present	Present
Badela	Present	Apology	Present

Human Resources and Remuneration Committee meetings (1 April 2014 to 31 December 2014)

Date of meeting	25/06/14	10/09/14
Sibanda	Present	Present
Goyns	Present	Present
Mabitje-Thompson	Apology	Apology

Board and committee meeting attendance

Research and Development and Innovation Committee meetings (formerly Strategic Review Committee) (1 April 2014 to 31 December 2014)

Date of meeting	26/06/14	09/10/14
Petersen	Present	Present
Sibisi[a]	Present	Present
Wingfield	Present	Apology
Nyokong	Apology	Apology
Cloete	Present	Present
Badela	Present	Present
Tshabalala	Present	Present
Benade	Present*	Present*
Sibanda	Apology*	Present*
Mabitje-Thompson	Apology*	Apology*
Goyns	Present*	Apology*

[a] *Attends in capacity as CEO*
* *Attendance by invitation*
Meetings are open to all Board members

Report of the Audit and Risk Committee

for the year ended 31 March 2015

The committee is pleased to present its report for the financial year ended on 31 March 2015.

The committee's responsibility

The committee has adopted formal Terms of Reference approved by the Board. Accordingly, the committee has conducted its affairs in compliance with its Terms of Reference, and has discharged its responsibilities contained therein.

Committee members and attendance

The committee consists of the members as stated on page 113 of this report. In accordance with its approved Terms of Reference, the committee met quarterly during the year under review (i.e. 25 June 2014, 10 September 2014, 6 November 2014 and 15 April 2015[1]). Schedule of attendance is shown on page 115 of this report.

The effectiveness of internal control

The system of internal control applied by the CSIR over financial risk management is effective, efficient and transparent. In line with the PFMA and King III, the internal audit provides the committee and management with assurance that the internal controls are appropriate and effective. This is achieved by means of the risk management process, as well as the identification of mitigating measures and on-going assessment thereof.

From the quarterly reports of internal audit, the audit report on the annual financial statements, and the management report of the Auditor-General of South Africa, it was noted that no matters were reported that include any material deficiencies in the system of internal control or any deviations therefrom. Accordingly, the committee can report that the system of risk management and internal control over financial reporting for the period under review was efficient and effective.

Internal audit

The Group has an internal audit function that has a direct line of reporting to the committee. Its charter and audit plans are approved by the committee to ensure it operates independently.

The committee is satisfied that the internal audit function is operating effectively and has addressed the risks pertinent to the CSIR through its audits.

Risk management

The committee is satisfied that the CSIR has a risk management process focused on identifying, assessing, managing and monitoring significant risks across all operations and Group companies. This has been in place for the year under review and up to the date of approval of the annual financial statements.

Evaluation of financial statements

The committee has evaluated the annual financial statements of the CSIR Group for the year ended on 31 March 2015, and based on the information provided, the committee considers that it complies, in all material respects, with the requirements of the various acts governing disclosure and reporting on the annual financial statements.

The committee concurs with the Executive Management that the adoption of the going concern premise in the preparation of the annual financial statements is appropriate. The committee has therefore at its meeting on 24 June 2015, recommended the adoption of the annual financial statements by the CSIR Board.

Ayanda Noah
Chairperson of the Audit and Risk Committee
24 June 2015

[1] *The April 2015 meeting addressed the last quarter of the 2014/15 financial year.*

Report of the Auditor-General

for the year ended 31 March 2015

Report of the Auditor-General to Parliament on the Council for Scientific and Industrial Research

Report on the consolidated and separate financial statements

Introduction

I have audited the consolidated and separate financial statements of the Council for Scientific and Industrial Research (CSIR) and its subsidiaries set out on pages 130 to 175, which comprise the consolidated and separate statements of financial position as at 31 March 2015, the consolidated and separate statements of profit and loss and other comprehensive income, statements of changes in equity and the statements of cash flows for the year then ended, as well as the notes, comprising a summary of significant accounting policies and other explanatory information.

The accounting authority's responsibility for the consolidated and separate financial statements

The accounting authority is responsible for the preparation of and fair presentation of these consolidated and separate financial statements in accordance with International Financial Reporting Standards (IFRS) and the requirements of the Public Finance Management Act of South Africa, 1999 (Act No. 1 of 1999) (PFMA), and for such internal control as the accounting authority determines is necessary to enable the preparation of consolidated and separate financial statements that are free from material misstatement, whether due to fraud or error.

Auditor-General's responsibility

My responsibility is to express an opinion on these consolidated and separate financial statements based on my audit. I conducted my audit in accordance with International Standards on Auditing. Those standards require that I comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the consolidated and separate financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the consolidated and separate financial statements.

The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the consolidated and separate financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation and fair presentation of the consolidated and separate financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by management, as well as evaluating the overall presentation of the consolidated and separate financial statements.

I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion.

Opinion

In my opinion the consolidated and separate financial statements present fairly, in all material respects, the financial position of the Council for Scientific and Industrial Research and its subsidiaries as at 31 March 2015, and their financial performance and cash flows for the year then ended in accordance with IFRS and the requirements of the PFMA.

Report on other legal and regulatory requirements

In accordance with the Public Audit Act of South Africa, 2004 (Act No. 25 of 2004) (PAA) and the general notice issued in terms thereof, I have a responsibility to report on findings on the reported performance information against predetermined objectives for selected objectives presented in the annual performance report, compliance with legislation and internal control. The objective of my test was to identify reportable findings as described under each subheading but not to gather evidence to express assurance on these matters. Accordingly, I do not express an opinion or conclusion on these matters.

Report of the Auditor-General

for the year ended 31 March 2015

Predetermined objectives

I performed procedures to obtain evidence about the usefulness and reliability of the reported performance information for the following selected objectives presented in the annual performance report of the entity for the year ended 31 March 2015:

- **Objective 1:** Scientific and Technical on pages 124 to 125
- **Objective 2:** Learning and Growth on page 125

I evaluated the reported performance information against the overall criteria of usefulness and reliability.

I evaluated the usefulness of the reported performance information to determine whether it was presented in accordance with the National Treasury's annual reporting principles and whether the reported performance was consistent with the planned objectives. I further performed tests to determine whether indicators and targets were well defined, verifiable, specific, measurable, time bound and relevant, as required by the National Treasury's *Framework for managing programme performance information (FMPPI)*.

I assessed the reliability of the reported performance information to determine whether it was valid, accurate and complete.

I did not identify any material findings on the usefulness and reliability of the reported performance information for the following objectives:

- **Objective 1:** Scientific and Technical.
- **Objective 2:** Learning and Growth.

Additional matter

I draw attention to the following matter:

– Achievement of planned targets

Refer to the annual performance report on pages 124 to 125 for information on the achievement of planned targets for the year.

Compliance with legislation

I performed procedures to obtain evidence that the entity had complied with applicable legislation regarding financial matters, financial management and other related matters. I did not identify any instances of material non-compliance with specific matters in key legislation, as set out in the general notice issued in terms of the PAA.

Internal control

I considered internal control relevant to my audit of the financial statements, key performance indicators and performance reporting included in the executive report and compliance with legislation. I did not identify any significant deficiencies in internal control.

Auditor - General

Pretoria
29 July 2015

AUDITOR-GENERAL SOUTH AFRICA

Auditing to build public confidence

EXECUTIVE REPORT

Executive report

Introduction

On behalf of the CSIR Board, we take pleasure in submitting to Parliament, through the Minister of Science and Technology, our Annual Report and the audited annual financial statements of the CSIR Group for the financial year ended 31 March 2015. In the opinion of the CSIR Board, the financial statements fairly present the financial position of the CSIR Group as at 31 March 2015 and the results of its operations for the year then ended.

Statutory basis

As a statutory research council established by government, the CSIR is governed by the Scientific Research Council Act (No. 46 of 1988). The organisation is listed as a Public Business Enterprise in terms of the PFMA (No. 1 of 1999).

The CSIR mandate

The CSIR's mandate is as stipulated in the Scientific Research Council Act (No. 46 of 1988):

"The objects of the CSIR are, through directed and particularly multidisciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act.

– Extract from Scientific Research Council Act (No. 46 of 1988)

The existence of a vibrant economy and a capable state is a pre-requisite for any sustainable solution to South Africa's developmental priorities. The work of the CSIR is therefore aimed both at supporting industrial development as well as enhancing the capabilities of government in the areas of service delivery, policy development and information management.

Scientific Research and Development (R&D) will play a critical role in supporting the short-, medium- and long-term growth of the economy. In the short-term we need to develop and deploy technologies that improve the efficiency and competitiveness of our existing enterprises; while in the medium to long-term we need to develop the industries and sectors (based for example on the use of new technologies or the beneficiation of local resources) that will grow the economy, as well as understanding and mitigating the risks to long-term growth due to climate change and the mismanagement of our natural resources.

While sustained economic growth will almost certainly address the issues of unemployment and poverty, dealing with the threat of inequality will require a strong and capable state. The CSIR sees its role as providing the scientific and technological innovations that will improve the ability of the state to efficiently deliver basic services (such as health, education, social security, access to energy and shelter) to all South Africans, hence combating both material inequality as well as inequality of access to basic services remains critical.

Income sources

The CSIR is funded through a combination of baseline and ring-fenced grants from the Department of Science and Technology (DST) (our Parliamentary Grant), and earns contract research and development income from the public and private sectors; locally and internationally.

Grant funding is invested in research programmes, research infrastructure as well as in R&D skills development. There are a number of policies and guidelines that underpin the effective utilisation of grant funding.

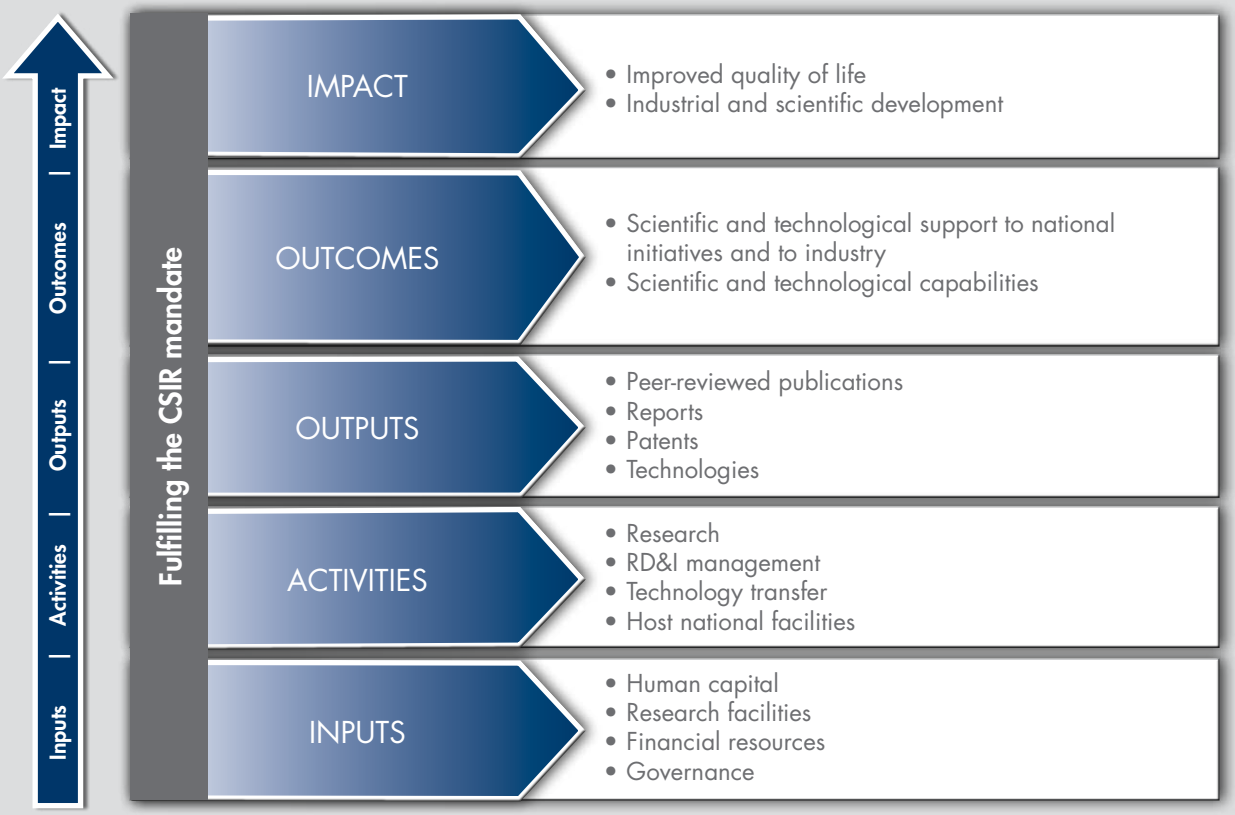
Strategic overview

The CSIR is mandated to contribute to the improved quality of life of all South Africans. Meeting this mandate requires that the CSIR responds to the triple challenge of unemployment, inequality and poverty that faces South Africa. The national government intends to address these challenges through a broad range of programmes, guided by the **National Development Plan (NDP)** and further articulated through government's Programme of Action and sector-specific initiatives. The CSIR's research agenda is also influenced by the DST national R&D strategy and its Ten-Year Innovation Plan.

The CSIR's strategy is structured around a framework aligning organisational inputs, activities and outputs with

Executive report

Figure 1: *The CSIR framework for fulfilling the mandate*



this role and the mandate (Figure 1). The CSIR's role is further defined by organisational competences and capabilities, reinforced through an effective network of local and international research partnerships.

In order to contribute to the programme of national development the CSIR has organised its R&D activities around the concept of a Research Impact Area (RIA). There are six RIAs – Health, Defence and Security, Built Environment, Natural Environment, Industry, and Energy, and these are supported by a set of core technologies (materials, sensors, photonics, robotics, Information and Communication Technology (ICT) and modelling). The immediate impact of this R&D work is further sharpened by four cross-cutting Flagship Programmes (Water Sustainability, Health, Safety and Security, and Transnet Capability Development). The flagships are derived from the R&D outputs generated over time from the RIAs and focus on short-term interventions that transfer technological solutions to external stakeholders.

The six RIAs and four Flagship Programmes have been chosen in order to provide a coherent and organised response to key national development questions.

The **Natural Environment RIA** will support long-term economic growth and the transition to a low-carbon economy by:

1. Developing models to improve our understanding of the scale and impact of climate change;
2. Developing and implementing interventions to facilitate the growth of the green economy;
3. Developing and implementing the tools and methods that improve our ability to understand, measure and sustainably manage our natural resources.

Executive report

The **Defence and Security RIA** contributes to a safe future for South Africa by supporting the building of a capable state and developing technology solutions to ensure safer communities.

The main focus areas of the RIA are:

1. Information security: Promote the adoption and use of trusted technologies, and the development of secure systems;
2. Tactical and strategic situation awareness: Enhance SA's ability to meet its safety and security needs and obligations;
3. Command control and coordination: Develop all-inclusive command, coordination, and control solutions for multi-agency operations; and
4. Developing solutions for inter-operability and standardisation of systems across organs of state tasked with defence and security.

The **Industry RIA** supports long-term economic growth (and thereby helps to grow the economy, create jobs and improve quality of life) by developing and transferring manufacturing technologies that improve the competitiveness of existing South African industry, and by creating new manufacturing opportunities. The main focus areas are:

1. Beneficiation of South African minerals across the value-chain, focusing on titanium, aluminium, and South African clays;
2. Biomanufacturing: Supporting bio- and agro-manufacturing product and process development to generate commercialisable products;
3. The development of new manufacturing processes for the aerospace and automotive industries;
4. Developing advanced materials and composites for industrial-scale manufacture;
5. Enhancing industrial competitiveness through the management of industry support programmes for the aerospace, biomanufacturing, and foundry-sectors, as well as technology localisation;
6. Improving industrial efficiency through fostering the optimal utilisation of resources; and
7. Utilising our information technology (IT) capabilities and infrastructure to create economic opportunities in wireless applications and the commercialisation of software technologies.

The **Energy RIA** promotes achievement of the national vision of an energy-secure and low-carbon national economy through the development and implementation of renewable and alternative energy technologies, focusing in particular on:

1. Energy storage;
2. The development and demonstration of renewable energy technologies;
3. Building an enabling energy environment;
4. Energy system integration; and
5. Market design and policy-making.

The **Health RIA** contributes to improving the health of all South Africans. The main focus areas of the RIA are:

1. Combating the high burden of disease through the development of cost-effective bio-therapeutic technologies;
2. A seamless, secure and trustworthy health information system;
3. The development of medical devices, sensors and information systems to provide point-of-care assistance; and
4. Contribute towards greater food security and combat malnutrition by exploiting indigenous and naturalised plants.

The **Built Environment RIA** will contribute to the development and maintenance of our economic infrastructure and the transformation of human settlements. The main focus areas of the RIA are:

1. The collection, analysis and integration of data in decision-support systems for the planning, monitoring and maintenance of settlements;
2. Improving the design, maintenance and efficiency of buildings;
3. The development of appropriate design methods and maintenance procedures for road, port and railway infrastructure; and
4. Models and methods to support the development of a more efficient public and freight transport system.

Executive report

Overview of 2014/15 performance

Key performance indicators and performance reporting

The CSIR enters into a Shareholder's Compact Agreement with the DST annually. The compact contains both a long-term strategic plan and a detailed operational plan with specific Key Performance Indicators (KPIs). Setting of KPI targets is supported by ongoing benchmarking against similar research organisations and trend analysis. Quarterly reports and the annual Science, Engineering and Technology Institution (SETI) scorecard report to the DST are the main forms by which the performance against these indicators is monitored.

The CSIR's KPIs provide a high-level basket of measures that reflect the strategic objectives of the organisation. These strategic objectives can be summarised as follows:

1. **Scientific and technical:** These KPIs are a measure of the extent to which we conduct research and technological innovation to foster industrial and scientific development. The KPIs that are linked to this strategic objective measure the annual aggregated outputs that are produced by these research programmes. These are academic publications, patents, technology demonstrators, the income earned from R&D performed on behalf of other parties, and the income earned from royalties or the licensing of CSIR technologies.

2. **Learning and growth:** These KPIs measure the extent to which we are able to build and transform human capital. The CSIR's scientific and technical contributions are only possible through the skills and capabilities of our scientific staff (our Science, Engineering and Technology (SET) base). The ongoing development, renewal and transformation of the SET base is therefore of critical importance for the organisation. The KPIs that are linked to this strategic objective include the overall size of the SET base, the number and percentage of that base with doctoral level qualifications, and the number and percentage of the SET base that are black and female South Africans respectively.

3. **Finance and governance:** Without a well-run and financially sustainable organisation our ability to contribute to national development through our scientific and technological work would be severely compromised. The KPIs linked to this strategic objective include the total income obtained by the organisation and the net profit that we are able to generate, the level of investment we make in order to maintain our infrastructure, our Broad-Based Black Economic Empowerment (B-BBEE) status and our safety record.

The CSIR has met or exceeded all the objectives set in the 2014/15 Shareholder's Compact. Once again, the organisation has delivered high quality scientific outputs while growing and transforming our scientific base, and maintaining our already high standards with respect to financial and corporate governance.

Scientific and technical

The CSIR has met or exceeded the annual targets for all six indicators in this category.

Table 1: *CSIR performance: scientific and technical*

Indicator	2014/15 Target	2014/15 Actual
Journal articles	≥ 275	311
Conference papers	≥ 280	294
New technology demonstrators	≥ 25	45
New patents granted	≥ 15	18
Contract R&D income	≥ R1 630m	R1 679m
Royalty and licence income	≥ R5.8m	R8.7m

Executive report

The CSIR continues to place emphasis on the quality and quantity of our research outputs in the form of peer-reviewed publications (journal articles and conference papers), technology demonstrators and patents. Technology demonstrators are a lead indicator of technology transfer and the excellent performance in exceeding this target further illustrates the greater efforts the CSIR is making in this area. R&D contract income amounting to R1.68 billion, exceeded the budget by R49 million, while income from royalties and licensing amounted to R8.7 million, exceeding the target figure by R2.9 million.

Learning and growth

The CSIR has met or exceeded the annual targets for all 7 indicators in this category.

The better than expected growth in SET staff is a very positive indication of growth and was enabled by the sound financial performance. The transformation of SET staff also continues to improve. This good performance is a reflection of the ongoing commitment of the CSIR to the positive transformation of the SET base.

The SET base consists of staff who primarily work on or manage research and development projects. At the end of the financial year the SET base consisted of 1 869 employees, 116 greater than the target of 1 753. The CSIR also comfortably exceeded the targets for the number and percentage of SET staff who are black South Africans and female South Africans respectively.

At the end of the financial year 335 members of the SET base had a doctoral qualification, 15 greater than the target of 320. This equates to 17.9% of the SET base which is lower than the target of 18.2%, but within the variation allowed for in the definition of the indicator.

Table 2: *CSIR performance: learning and growth*

Indicator	2014/15 Target	2014/15 Actual
Total size of SET base	1 753	1 869
No. of black South Africans in SET base	912	1 042
% of SET base who are black South Africans	≥ 52	55.8
No. of female South Africans in SET base	561	628
% of SET base who are female South Africans	≥ 32	33.6
No. of SET base with Doctorates	320	335
% of SET base with Doctorates	≥ 18.2	17.9

Financial and governance

The CSIR has met or exceeded its target for all five indicators in this category.

Table 3: *CSIR performance: financial and governance*

Indicator	2014/15 Target	2014/15 Actual
Investment in property, plant and equipment	≥ R95.7m	R209.7m
Total income	≥ R2 360m	R2 385m
Net profit	≥ R49.1m	R52.4m
B-BBEE rating	Level 2 contributor	Level 2 contributor
Disabling injury frequency rate	<0.3	0.04

The CSIR continued to demonstrate its financial sustainability despite the current difficult economic climate. The solid performance in achieving corporate governance and citizenship targets was maintained, with the B-BBEE contributor level target and the excellent safety record maintained. The value of investment in property, plant and equipment exceeded the target, reflecting focused CSIR investment and success in securing additional funding.

Executive report

Financial performance overview

The CSIR remains financially sustainable and has exceeded its financial targets. The total operating income of the CSIR increased by 10.7% to R2.38 billion (2013/14: R2.15 billion).

The Parliamentary Grant recognised as income in 2014/15 amounted to R675.3 million, an increase of 9.1% from the prior year amount of R618.8 million.

The CSIR's total contract R&D income increased by 12% to R1.68 billion (2013/14: R1.50 billion). This includes a R94 million (2013/14: R65 million) ring-fenced allocation from the DST.

The CSIR's continued alignment with national strategic priorities ensured that a significant part of the contract income was received from the South African public sector. Public sector income amounted to R1.33 billion (2013/14: R1.13 billion).

The continued investment in scientific infrastructure and equipment remains a priority to ensure that world-class facilities and equipment are acquired and maintained. Over the past five financial years R777.5 million has been invested in property, plant and equipment with R209.7 million invested in the 2014/15 financial year.

Five-year review of income and expense indicators

	2015 R'000	2014 R'000	2013 R'000	2012 R'000	2011 R'000
Total income	**2 442 590**	**2 202 595**	**2 069 221**	**1 919 381**	**1 776 827**
Parliamentary Grant recognised as income	675 340	618 849	594 478	556 837	535 357
Contract income, royalty income, other income and net finance income	**1 767 250**	**1 583 746**	**1 474 743**	**1 362 544**	**1 241 470**
Local private and international sectors	348 388	361 353	361 018	320 491	354 389
Local public sector	1 331 042	1 134 470	1 027 998	952 909	820 705
Royalties and other income	30 202	38 766	39 351	50 771	13 197
Net finance income	57 618	49 157	46 376	38 373	53 179
Total expenditure	**2 390 203**	**2 151 664**	**2 020 769**	**1 850 383**	**1 741 317**
Employees' remuneration	1 339 345	1 229 566	1 108 202	1 014 879	940 776
Operating expenses	1 002 234	874 885	867 680	793 680	759 048
Depreciation	48 624	47 213	44 887	41 824	41 493

Net profit and cash flow

The net profit of the CSIR amounts to R52.4 million (2013/14: R52.3 million). The net profit for the CSIR Group is R52.8 million (2013/14: R54.1 million). The cash and cash equivalent holdings of the CSIR stood at R975.9 million (2013/14: R1 043.4 million). The current ratio is comparable to the previous financial year at 1.1.

Executive report

Five-year ratio analysis

	2015	2014	2013	2012	2011
Operating expenses					
Remuneration as a percentage of total income (excluding finance income)	**56.2%**	57.1%	54.8%	54.0%	54.6%
Remuneration as a percentage of total operating expenditure	**56.0%**	57.1%	54.8%	54.8%	54.0%
Asset management					
Investment in property, plant and equipment (Rm)	**209.7**	134.7	130.1	184.2	118.8
Investment in property, plant and equipment as a percentage of revenue	**8.9%**	6.3%	6.5%	10.0%	6.9%
Net asset turn	**2.8**	2.7	3.2	3.3	3.3
Current ratio	**1.1**	1.1	1.1	1.1	1.1
Cash flow					
Net cash from operating activities (R'000)	**41 407**	137 626	130 385	78 562	299 171
Cash and cash equivalents at end of year (including long-term fixed deposits) (R'000)	**975 952**	1 043 427	983 511	949 360	975 755

Definitions

Net asset turn: Total revenue (including finance income) divided by net assets

Current ratio: Current assets divided by current liabilities

The post-retirement medical benefit expense and liability and the effects of the adoption of IFRS, IAS39: Financial instruments – recognition and measurement have been excluded for the comparison of financial indicators.

ANNUAL FINANCIAL STATEMENTS

STATEMENTS OF

Profit or loss and other comprehensive income

for the year ended 31 March 2015

	Notes	GROUP 2015 R'000	GROUP 2014 R'000	CSIR 2015 R'000	CSIR 2014 R'000
Revenue	2	**2 362 176**	2 128 154	**2 363 444**	2 128 351
Other income		**21 605**	25 193	**21 528**	25 087
Total operating income		**2 383 781**	2 153 347	**2 384 972**	2 153 438
Expenditure					
Employees' remuneration		**1 341 617**	1 231 173	**1 339 345**	1 229 566
Depreciation and amortisation	6 & 7	**48 652**	47 240	**48 624**	47 213
Operating expenses		**1 001 862**	873 419	**1 002 234**	874 885
Total operating expenditure		**2 392 131**	2 151 832	**2 390 203**	2 151 664
Finance income	4	**65 688**	54 860	**64 570**	53 792
Finance expense	4	**(6 952)**	(4 635)	**(6 952)**	(4 635)
Share of profit of joint ventures and associates	8	**2 426**	997	**–**	–
Profit before income tax	3	**52 812**	52 737	**52 387**	50 931
Income tax expense	5	**–**	–	**–**	–
Profit for the year		**52 812**	52 737	**52 387**	50 931
Other comprehensive income					
Not subsequently reclassified to profit or loss:					
Remeasurement of post-retirement medical benefit obligation	17.4	**8**	1 402	**8**	1 402
Other comprehensive income for the year		**8**	1 402	**8**	1 402
Total comprehensive income for the year		**52 820**	54 139	**52 395**	52 333
Profit attributable to:					
Stakeholders of the parent		**52 812**	52 737	**52 387**	50 931
Total comprehensive income attributable to:					
Stakeholders of the parent		**52 820**	54 139	**52 395**	52 333

STATEMENTS OF

Financial position

as at 31 March 2015

	Notes	GROUP 2015 R'000	GROUP 2014 R'000	CSIR 2015 R'000	CSIR 2014 R'000
ASSETS					
Non-current assets		**751 915**	663 851	**750 431**	676 622
Property, plant and equipment	6	**736 032**	654 676	**736 009**	654 646
Intangible assets	7	**–**	–	**–**	–
Interest in joint ventures and associates	8	**10 474**	9 175	**1 364**	1 315
Interest in subsidiaries	9	**–**	–	**7 649**	20 661
Other investments	10	**5 409**	–	**5 409**	–
Current assets		**1 351 141**	1 474 858	**1 343 040**	1 452 154
Trade and other receivables	11	**264 325**	323 745	**264 187**	323 696
Inventory and contracts in progress	12	**102 901**	85 031	**102 901**	85 031
Cash and cash equivalents	23	**983 915**	1 066 082	**975 952**	1 043 427
TOTAL ASSETS		**2 103 056**	2 138 709	**2 093 471**	2 128 776
EQUITY AND LIABILITIES					
Reserves		**879 147**	826 327	**869 472**	817 077
Retained earnings		**879 147**	826 327	**869 472**	817 077
Non-current liabilities		**10 614**	9 772	**10 614**	9 772
Post-retirement medical benefits	17.4	**10 614**	9 772	**10 614**	9 772
Current liabilities		**1 213 295**	1 302 610	**1 213 385**	1 301 927
Advances received	14	**767 209**	778 851	**767 209**	778 851
Trade and other payables	15	**446 086**	523 759	**446 176**	523 076
TOTAL EQUITY AND LIABILITIES		**2 103 056**	2 138 709	**2 093 471**	2 128 776

STATEMENTS OF

Changes in equity

for the year ended 31 March 2015

	Retained earnings R'000	Total R'000
GROUP		
Balance at 31 March 2013 (restated)	772 188	**772 188**
Total comprehensive income	54 139	**54 139**
Profit for the year	52 737	**52 737**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	1 402	**1 402**
Balance at 31 March 2014	826 327	**826 327**
Total comprehensive income	52 820	**52 820**
Profit for the year	52 812	**52 812**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	8	**8**
Balance at 31 March 2015	**879 147**	**879 147**
CSIR		
Balance at 31 March 2013 (restated)	764 744	**764 744**
Total comprehensive income	52 333	**52 333**
Profit for the year	50 931	**50 931**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	1 402	**1 402**
Balance at 31 March 2014	817 077	**817 077**
Total comprehensive income	52 395	**52 395**
Profit for the year	52 387	**52 387**
Other comprehensive income for the year:		
Remeasurement of post-retirement medical benefit obligation	8	**8**
Balance at 31 March 2015	**869 472**	**869 472**

STATEMENTS OF

Cash flows

for the year ended 31 March 2015

	Notes	GROUP 2015 R'000	GROUP 2014 R'000	CSIR 2015 R'000	CSIR 2014 R'000
Cash flows from operating activities					
Cash receipts from external customers		**1 765 929**	1 528 844	**1 767 088**	1 523 632
Parliamentary Grant received		**657 819**	633 678	**657 819**	633 678
Cash paid to suppliers and employees		**(2 443 881)**	(2 070 017)	**(2 441 383)**	(2 067 279)
Cash (utilised)/generated from operating activities	22	**(20 133)**	92 505	**(16 476)**	90 031
Finance income received	4	**65 953**	53 298	**64 835**	52 230
Finance expense paid	4	**(6 952)**	(4 635)	**(6 952)**	(4 635)
Net cash from operating activities		**38 868**	141 168	**41 407**	137 626
Cash flows from investing activities					
Acquisition of property, plant and equipment	6	**(130 512)**	(81 981)	**(130 482)**	(81 981)
Proceeds on disposal of property, plant and equipment		**825**	4 750	**825**	4 750
Decrease in subsidiary loans		**–**	–	**13 000**	–
Decrease in interest in joint ventures and associates		**7 000**	750	**6 000**	–
Increase in investments		**(1 705)**	–	**(1 705)**	–
Acquisition of intangible assets	7	**(123)**	–	**–**	–
Net cash utilised in investing activities		**(124 515)**	(76 481)	**(112 362)**	(77 231)
Cash flows from financing activities					
Net cash utilised in financing activities		**–**	–	**–**	–
Unrealised exchange gains/(losses) on foreign cash balances		**3 480**	(479)	**3 480**	(479)
Net (decrease)/increase in cash and cash equivalents		**(82 167)**	64 208	**(67 475)**	59 916
Cash and cash equivalents at beginning of the year		**1 066 082**	1 001 874	**1 043 427**	983 511
Cash and cash equivalents at end of the year	23	**983 915**	1 066 082	**975 952**	1 043 427

NOTES TO THE

Annual financial statements

for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES

The CSIR is a national government business enterprise (enacted by The Scientific Research Council Act, Act 46 of 1988) domiciled in the Republic of South Africa. The address of the CSIR's principal place of business is Meiring Naudé Road, Brummeria, Pretoria. The CSIR undertakes directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic.

The consolidated annual financial statements of the Group as at and for the year ended 31 March 2015 comprise the company and its subsidiaries (together referred to as the Group) and the Group's interest in associates and jointly controlled entities.

1.1 Basis of presentation

The consolidated annual financial statements have been prepared in accordance with International Financial Reporting Standards (IFRS) as issued by the International Accounting Standards Board (IASB) and the Public Finance Management Act, Act 1 of 1999 as amended by Act 29 of 1999.

The policies set out as follows have been consistently applied to all the years presented. The consolidated financial statements of the Group until 31 March 2013 had been prepared in accordance with South African Statements of Generally Accepted Accounting Practice (SA GAAP).

The preparation of financial statements requires management to make judgements, estimates and assumptions that affect the application of policies and reported amounts of assets and liabilities, income and expenses. The estimates and associated assumptions are based on historical experience and various other factors that are believed to be reasonable under the circumstances, the result of which forms the basis of making judgements about carrying values of assets and liabilities that are not readily apparent from other sources. Actual results may differ from these estimates.

Estimates and underlying assumptions are reviewed on an ongoing basis. Revisions to accounting estimates are recognised in the period in which the estimate is revised and in any future periods affected.

The consolidated annual financial statements are presented in South African rand (R), which is the CSIR's functional currency, and are rounded off to the nearest thousand.

1.2 Basis of consolidation

Subsidiaries

Subsidiaries are all entities (including structured entities) over which the Group has control. The Group controls an entity when the Group is exposed to, or has rights to, variable returns from its involvement with the entity and has the ability to affect those returns through its power over the entity. Subsidiaries are fully consolidated from the date on which control is transferred to the Group. They are deconsolidated from the date that control ceases.

The Group applies the acquisition method to account for business combinations. The consideration transferred for the acquisition of a subsidiary is the fair values of the assets transferred, the liabilities incurred to the former owners of the acquiree and the equity interests issued by the Group. The consideration transferred includes the fair value of any asset or liability resulting from a contingent consideration arrangement. Identifiable assets acquired and liabilities and contingent liabilities assumed in a business combination are measured initially at their fair values at the acquisition date. The Group recognises any non-controlling interest in the acquiree on an acquisition-by-acquisition basis, either at fair value or at the non-controlling interest's proportionate share of the recognised amounts of the acquiree's identifiable net assets.

Acquisition-related costs are expensed as incurred.

If the business combination is achieved in stages, the acquisition date carrying value of the acquirer's previously held equity interest in the acquiree is re-measured to fair value at the acquisition date; any gains or losses arising from such re-measurement are recognised in profit or loss.

Any contingent consideration to be transferred by the Group is recognised at fair value at the acquisition date. Subsequent changes to the fair value of the contingent consideration that is deemed to be an

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

Subsidiaries (continued)

asset or liability is recognised in accordance with IAS 39 either in profit or loss or as a change to other comprehensive income. Contingent consideration that is classified as equity is not re-measured, and its subsequent settlement is accounted for within equity.

The excess of the consideration transferred, the amount of any non-controlling interest in the acquiree and the acquisition-date fair value of any previous equity interest in the acquiree over the fair value of the identifiable net assets acquired is recorded as goodwill. If the total of consideration transferred, non-controlling interest recognised and previously held interest measured is less than the fair value of the net assets of the subsidiary acquired in the case of a bargain purchase, the difference is recognised directly in profit or loss.

Inter-company transactions, balances and unrealised gains on transactions between group companies are eliminated. Unrealised losses are also eliminated. When necessary, amounts reported by subsidiaries have been adjusted to conform with the Group's accounting policies.

Investments in subsidiaries are measured at cost less accumulated impairment losses in the CSIR's annual financial statements.

Changes in ownership interests in subsidiaries without change of control

Transactions with non-controlling interests that do not result in loss of control are accounted for as equity transactions – that is, as transactions with the owners in their capacity as owners. The difference between fair value of any consideration paid and the relevant share acquired of the carrying value of net assets of the subsidiary is recorded in equity. Gains or losses on disposals to non-controlling interests are also recorded in equity.

Disposal of subsidiaries

When the Group ceases to have control, any retained interest in the entity is remeasured to its fair value at the date when control is lost, with the change in carrying amount recognised in profit or loss. The fair value is the initial carrying amount for the purposes of subsequently accounting for the retained interest as an associate, joint venture or financial asset. In addition, any amounts previously recognised in other comprehensive income in respect of that entity are accounted for as if the Group had directly disposed of the related assets or liabilities. This may mean that amounts previously recognised in other comprehensive income are reclassified to profit or loss.

Associates

Associates are all entities over which the Group has significant influence but not control, generally accompanying a shareholding of between 20% and 50% of the voting rights. Investments in associates are accounted for using the equity method of accounting. Under the equity method, the investment is initially recognised at cost, and the carrying amount is increased or decreased to recognise the investor's share of the profit or loss of the investee after the date of acquisition. The Group's investment in associates includes goodwill identified on acquisition.

If the ownership interest in an associate is reduced but significant influence is retained, only a proportionate share of the amounts previously recognised in other comprehensive income is reclassified to profit or loss where appropriate.

The Group's share of post-acquisition profit or loss is recognised in profit or loss, and its share of post-acquisition movements in other comprehensive income is recognised in other comprehensive income with a corresponding adjustment to the carrying amount of the investment. When the Group's share of losses in an associate equals or exceeds its interest in the associate, including any other unsecured receivables, the Group does not recognise further losses, unless it has incurred legal or constructive obligations or made payments on behalf of the associate.

The Group determines at each reporting date whether there is any objective evidence that the investment in the associate is impaired. If this is the case, the Group calculates the amount of impairment as the difference between the recoverable amount of the associate and its carrying value and recognises the amount adjacent to share of profit/(loss) of associates in profit or loss.

Profits and losses resulting from upstream and downstream transactions between the Group and its associate are recognised in the Group's financial

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

Associates (continued)

statements only to the extent of unrelated investor's interests in the associates. Unrealised losses are eliminated unless the transaction provides evidence of an impairment of the asset transferred. Accounting policies of associates have been changed where necessary to ensure consistency with the policies adopted by the Group.

Dilution gains and losses arising in investments in associates are recognised in profit or loss.

Investments in associates are measured at cost less accumulated impairment losses in the CSIR's annual financial statements.

Joint arrangements

Under IFRS 11 investments in joint arrangements are classified as either joint operations or joint ventures depending on the contractual rights and obligations of each investor. The CSIR Group has assessed the nature of its joint arrangements and determined them to be joint ventures. Joint ventures are accounted for using the equity method.

Under the equity method of accounting, interests in joint ventures are initially recognised at cost and adjusted thereafter to recognise the Group's share of the post-acquisition profits or losses and movements in other comprehensive income. When the Group's share of losses in a joint venture equals or exceeds its interests in the joint ventures (which includes any long-term interests that, in substance, form part of the Group's net investment in the joint ventures), the Group does not recognise further losses, unless it has incurred obligations or made payments on behalf of the joint ventures.

Unrealised gains on transactions between the Group and its joint ventures are eliminated to the extent of the Group's interest in the joint ventures. Unrealised losses are also eliminated unless the transaction provides evidence of an impairment of the asset transferred. Accounting policies of the joint ventures have been changed where necessary to ensure consistency with the policies adopted by the Group.

Investments in joint ventures are measured at cost less accumulated impairment losses in the CSIR's annual financial statements.

1.3 Foreign currencies

Foreign operations

All foreign subsidiaries of the CSIR are foreign operations. There are no foreign subsidiaries in the period covered by this set of annual financial statements.

The financial statements of foreign subsidiaries are translated into South African rand as follows:

- Assets and liabilities, including goodwill and fair value adjustments on acquisition, at rates of exchange ruling at the reporting date.
- Revenue, expenditure and cash flow items at the average rates of exchange during the relevant financial year (the average rates approximate exchange rates at the various dates).

Differences arising on translation are recognised in other comprehensive income and presented in equity as non-distributable reserves called a foreign currency translation reserve (FCTR). When a foreign operation is disposed of, in part or in full, the relevant amount in the FCTR is transferred to profit or loss.

Foreign exchange gains and losses arising from a monetary item receivable from or payable to a foreign operation, the settlement of which is neither planned nor likely in the foreseeable future, are considered to form part of a net investment in a foreign operation and are recognised directly in other comprehensive income and presented in equity in the FCTR.

Foreign currency transactions and balances

Transactions in foreign currencies are converted to South African rand at the rate of exchange ruling at the date of the transactions. Monetary assets and liabilities denominated in foreign currencies are translated into South African rand using the rates of exchange ruling at the reporting date. The resulting exchange differences are recognised in profit or loss. Non-monetary assets and liabilities measured at fair value are translated at foreign exchange rates ruling at the date the fair value was determined.

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.4 Property, plant and equipment

Owned assets

Land is stated at cost less accumulated impairment losses. Buildings, equipment and vehicles are stated at cost less accumulated depreciation and accumulated impairment losses. Cost includes expenditure directly attributable to acquisition.

The cost of self-constructed assets includes the cost of materials, direct labour, the initial estimate, where relevant, of the costs of dismantling and removing the items and restoring the site on which these are located and an appropriate proportion of production overheads.

Where parts of an item of property, plant and equipment have different useful lives, these are accounted for as separate items (major components) of property, plant and equipment.

Gains and losses on disposal of an item of property, plant and equipment are determined by comparing proceeds from disposal with the carrying amount of property, plant and equipment and are recognised in profit or loss.

Subsequent costs

The Group recognises in the carrying amount of an item of property, plant and equipment, the cost of replacing a part of such an item when that cost is incurred, if it is probable that the future economic benefits embodied in the item will flow to the Group and the cost of the item can be measured reliably. The carrying amount of the replaced part is derecognised. The costs of the day-to-day servicing of property, plant and equipment are recognised in profit or loss as incurred.

Depreciation

Depreciation is based on cost less residual value and is calculated on the straight-line method from the day the assets are available for use, at rates considered appropriate to write off carrying values over the estimated useful lives of the assets, except for assets specifically acquired for a contract, which are depreciated over the life of the contract. Land is not depreciated.

The estimated lives of the main categories of property, plant and equipment for the current and comparative period are as follows:

- Land: Indefinite
- Buildings: 40 years
- Equipment: 3 to 10 years
- Vehicles: 10 years

Depreciation methods, useful lives and current residual values, if not insignificant, are reassessed annually.

1.5 Intangible assets

Research and development

Expenditure on research activities, undertaken with the prospect of gaining new scientific or technical knowledge and understanding, is recognised in profit or loss when incurred.

Development activities involve a plan or design for the production of new or substantially improved products and processes. Development expenditure is capitalised only if development costs can be measured reliably, the product or process is technically and commercially feasible, future economic benefits are probable, and the Group intends to and has sufficient resources to complete development and to use or sell the asset. The expenditure capitalised includes the cost of materials, direct labour and overhead costs that are directly attributable to preparing the asset for its intended use. Other development expenditure is recognised in profit or loss when incurred.

Capitalised development expenditure is measured at cost less accumulated amortisation and accumulated impairment losses.

Subsequent costs

Subsequent expenditure on capitalised intangible assets is capitalised only when it increases the future economic benefits embodied in the specific asset to which it relates. All other expenditure, including expenditure on internally generated goodwill and brands, is expensed as incurred.

Amortisation

Amortisation is based on cost and calculated on the straight-line method at rates considered appropriate to write off carrying values over the estimated useful lives of the intangible assets with definite useful lives.

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

Amortisation (continued)

Intangible assets are amortised from the day they are available for use.

The estimated lives of intangible assets with definite useful lives are as follows:

– Investment in technology: 3 to 10 years

Amortisation methods, useful lives and residual values are reviewed at each reporting date and adjusted if appropriate.

1.6 Impairment

Financial assets

A financial asset not classified at fair value through profit or loss is assessed at each reporting date to determine whether there is any objective evidence that it is impaired. A financial asset is considered to be impaired if objective evidence indicates that one or more events have had a negative effect on the estimated future cash flows of that asset.

An impairment loss in respect of a financial asset measured at amortised cost is calculated as the difference between its carrying amount, and the present value of the estimated future cash flows discounted at the original effective interest rate.

Individually-significant financial assets and those that have been identified as impaired are tested for impairment on an individual basis. The remaining financial assets are assessed collectively in groups that share similar credit risk characteristics.

All impairment losses are recognised in profit or loss.

An impairment loss is reversed if the reversal can be related objectively to an event occurring after the impairment loss was recognised. For financial assets measured at amortised cost the reversal is recognised in profit or loss.

Non-financial assets

The carrying amounts of the Group's non-financial assets, other than inventories and deferred tax assets, are reviewed at each reporting date to determine whether there is any indication of impairment. If any such indication exists then the asset's recoverable amount is estimated. For goodwill arising from the acquisition of subsidiaries and intangible assets that have indefinite lives or that are not yet available for use, the recoverable amount is estimated at each reporting date.

An impairment loss is recognised if the carrying amount of an asset or its cash-generating unit exceeds its recoverable amount. A cash-generating unit is the smallest identifiable asset group that generates cash flows that are largely independent from other assets and groups. Impairment losses are recognised in profit or loss. Impairment losses recognised in respect of cash-generating units are allocated first to reduce the carrying amount of any goodwill allocated to the units and then to reduce the carrying amount of the other assets in the unit (group of units) on a pro rata basis.

The recoverable amount of an asset or cash-generating unit is the greater of its value in use and its fair value less costs of disposal. In assessing value in use, the estimated future cash flows are discounted to their present value using a pre-tax discount rate that reflects current market assessments of the time value of money and the risks specific to the asset.

An impairment loss in respect of goodwill is not reversed. In respect of other assets, impairment losses recognised in prior periods are assessed at each reporting date for any indications that the loss has decreased or no longer exists. An impairment loss is reversed if there has been a change in the estimates used to determine the recoverable amount. An impairment loss is reversed only to the extent that the asset's carrying amount does not exceed the carrying amount that would have been determined, net of depreciation or amortisation, if no impairment loss had been recognised.

1.7 Short-term employee benefits

Short-term employee benefit obligations are measured on an undiscounted basis and are expensed as the related service is provided. A liability is recognised for the amount expected to be paid under short-term cash bonus if the Group has a present legal or constructive obligation to pay this amount as a result of past service provided by the employee, and the obligation can be estimated reliably.

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.8 Retirement benefits

Pension fund

The Group operates a defined contribution plan, the assets of which are held in a separate trustee-administered fund. The benefits payable by the fund in the future, due to retirements and withdrawals from the fund, are contributions to the fund together with fund interest at a rate determined by the valuator with the consent of the trustees. The rate is so determined that the value of the total of the fund shall not exceed the value of the total assets of the fund. The Group's contribution to the plan is charged to profit or loss when due.

Post-retirement benefits other than pensions

The Group provides post-retirement medical benefits to qualifying employees, which is deemed to be a defined benefit plan. The expected costs of these benefits are determined using the projected unit credit method, with actuarial valuations being carried out at each reporting date. Contributions are made to the relevant funds over the expected service lives of the employees entitled to those funds. The estimated cost of providing such benefits is charged to profit or loss on a systematic basis over the employees' working lives within the Group.

Actuarial gains and losses are recognised in other comprehensive income in the year when actuarially determined. The amount recognised in the statement of financial position represents the present value of the post-retirement medical fund benefit obligation. Any asset resulting from this calculation is limited to actuarial losses and the present value of available refunds and reductions in future contributions to the plan.

1.9 Inventory and contracts in progress

Inventory is measured at the lower of cost and net realisable value. Cost of inventory is determined by the weighted average method. In the case of work in progress, cost includes an appropriate share of production overheads based on normal operating capacity. Net realisable value represents the estimated selling price less all estimated costs to completion and costs to be incurred in selling.

Contracts in progress are stated as a percentage of the sales value of work completed, after provision for losses relating to the stage of completion and any foreseeable losses to completion of the contract, less progress billings.

1.10 Income tax

The CSIR is exempt from South African income tax. The income tax expense of subsidiary companies is reflected on Group level.

Income tax expense comprises current and deferred tax. The current tax charge is based on the profit or loss for the year as adjusted for items that are non-taxable or disallowed. It is calculated using tax rates that have been enacted or substantially enacted at the reporting date. Income tax expense is recognised in profit or loss except to the extent that it relates to items recognised directly in other comprehensive income or equity, in which case it is recognised in other comprehensive income or equity.

Deferred tax is recognised in respect of temporary differences arising from differences between the carrying amounts of assets and liabilities in the financial statements and the corresponding tax basis used in the computation of the taxable profit.

Where the tax effects of temporary differences, including those arising from tax losses, give rise to a deferred tax asset, the asset is recognised only if it is probable that future taxable profits will be sufficient to allow the tax benefit of the loss to be realised. Deferred tax assets are reviewed at each reporting date and are reduced to the extent that it is no longer probable that the related tax benefit will be realised. Deferred tax is not recognised for the following temporary differences: the initial recognition of assets or liabilities in a transaction that is not a business combination and that affects neither profit or loss, and differences relating to investments in subsidiaries, associates and jointly controlled entities to the extent that it is probable that they will not reverse in the foreseeable future.

Deferred tax assets and liabilities are offset when there is a legally enforceable right and when these relate to income taxes levied by the same taxation authority and the Group intends to settle its current tax assets and liabilities on a net basis.

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.11 Provisions

Provisions are recognised when the Group has a present legal or constructive obligation as a result of past events, for which it is probable that an outflow of economic benefits will be required to settle the obligation, and a reliable estimate can be made of the amount of the obligation. Provisions are measured at the present value of the expenditures expected to be required to settle the obligation using a pre-tax rate that reflects current market assessments of the time value of money and the risks specific to the obligation. The increase in the provision due to passage of time is recognised as interest expense.

A provision for onerous contracts is recognised when the expected benefits to be derived by the Group from a contract are lower than the unavoidable cost of meeting its obligations under the contract. The provision is measured at the present value of the lower of the expected cost of terminating the contract and the expected net cost of continuing with the contract. Before a provision is established, the Group recognises any impairment loss on the assets associated with that contract.

1.12 Government grants

Government grants that compensate the Group for expenses incurred are recognised as income on a systematic basis over periods necessary to match the assistance with the related expenses it is intended to compensate.

Grants that compensate the Group for the cost of an asset are deducted in arriving at the carrying amount of the acquired asset.

1.13 Revenue recognition

Revenue from the sale of goods is measured at the fair value of the consideration received or receivable, net of returns and allowances, trade discounts and volume rebates. Revenue is recognised when the significant risks and rewards of ownership have been transferred to the buyer, recovery of the consideration is probable, the associated costs and possible return of goods can be estimated reliably and there is no continuing management involvement with the goods, and the amount of revenue can be measured reliably.

Revenue from services rendered is recognised in profit or loss in proportion to the stage of completion of the transaction at the reporting date. The stage of completion is assessed by reference to work performed as at the reporting date.

Contract revenue includes the initial amount agreed in the contract plus any variations in contract work, claims and incentive payments to the extent that it is probable that these will result in revenue and can be measured reliably. As soon as the outcome of a contract can be estimated reliably, contract revenue and expenses are recognised in profit or loss in proportion to the stage of completion of the contract.

The stage of completion is assessed by reference to work performed as at reporting date. When the outcome of a contract cannot be estimated reliably, contract revenue is recognised only to the extent of contract costs incurred that are likely to be recoverable. An expected loss on a contract is recognised immediately in profit or loss.

Royalties are accrued based on the stipulations of the applicable contracts.

1.14 Finance income/expense

Finance income/expense comprises interest receivable on funds invested, dividend income, fair value adjustments on investments and interest payable on borrowings. Interest income is recognised in profit or loss as it accrues, using the effective interest rate method. Dividend income is recognised in profit or loss on the date that the entity's right to receive payments is established (which is when the dividend is declared). Interest payable on borrowings is calculated using the effective interest rate method.

1.15 Expenses

Operating lease payments

Leases in which a significant portion of the risks and rewards of ownership are retained by the lessor are classified as operating leases. Payments made under operating leases are recognised in profit or loss on a straight-line basis over the term of the lease. Lease incentives received are recognised in profit or loss as an integral part of the total lease expense, over the term of the lease.

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.15 Expenses (continued)

Finance lease payments

Leases of property, plant and equipment where the Group has substantially all the risks and rewards of ownership are classified as finance leases. Minimum lease payments are apportioned between the finance charge and the reduction of the outstanding liability. The finance charge is allocated to each period during the lease term so as to produce a constant periodic rate of interest on the remaining balance of the liability.

1.16 Financial instruments

Financial instruments are initially measured at fair value plus, for instruments not at fair value through profit or loss, any directly attributable transaction costs, when the Group has become a party to contractual provision of the instrument. Subsequent to initial recognition, these instruments are measured as set out as follows:

Loans and receivables

Trade and other receivables

Trade receivables are subsequently measured at amortised cost using the effective interest method less any impairment losses, which approximate the fair value of these due to the short-term nature thereof.

Loans

Loans are measured at amortised cost using the effective interest method less any impairment losses if they have a fixed maturity, or at cost if there is no fixed maturity.

Cash and cash equivalents

Cash and cash equivalents are measured at amortised cost, which is their fair value. Cash and cash equivalents comprise fixed deposits, call deposits, bank balances, cash on hand and cash deposits.

Financial assets at fair value through profit or loss

Forward exchange contracts

Forward exchange contracts are fair valued and gains and losses are recognised in profit or loss. Hedge accounting is not applied.

Financial liabilities at amortised cost

Trade and other payables and advances received

Trade and other payables and advances received are stated at amortised cost, which approximates the fair value of these due to the short-term nature thereof.

De-recognition

Financial assets (or a portion thereof) are de-recognised when the Group realises the rights to the benefits specified in the contract, the rights expire or the Group surrenders or otherwise loses control and does not retain substantially all risks and rewards of the asset. On de-recognition, the difference between the carrying amount of the financial asset and proceeds receivable is included in profit or loss.

Financial liabilities (or a portion thereof) are de-recognised when the obligation specified in the contract is discharged, cancelled or expires. On de-recognition, the difference between the carrying amount of the financial liability and the amount paid for it is included in profit or loss.

1.17 Related parties

The Group operates in an economic environment currently dominated by entities directly or indirectly owned by the South African government. As a result of the constitutional independence of all three spheres of government in South Africa, only parties within the national sphere of government will be considered to be related parties.

Key management is defined as being individuals with the authority and responsibility for planning, directing and controlling the activities of the entity. All individuals from the level of Group Executive up to the Board of Directors are regarded as key management.

Close family members of key management are considered to be those family members who may be expected to influence, or be influenced by key management individuals or other parties related to the entity.

NOTES TO THE
Annual financial statements
for the year ended 31 March 2015

1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.18 Standards and interpretations issued, not yet effective

At the date of authorisation of the financial statements of the Group for the year ended 31 March 2015, the following standards and interpretations were in issue but not yet effective:

Standard/Interpretation	Description	Effective date
Amendment to IAS 19, 'Employee benefits', on defined benefit plans	These narrow scope amendments apply to contributions from employees or third parties to defined benefit plans. The objective of the amendments is to simplify the accounting for contributions that are independent of the number of years of employee service, for example, employee contributions that are calculated according to a fixed percentage of salary. These amendments will not affect the Group's results.	Annual periods beginning on or after 1 July 2014
Amendments to IFRS 10, 'Consolidated financial statements' and IAS 28, 'Investments in associates and joint ventures' on sale or contribution of assets	This amendment was issued to eliminate the inconsistency between IFRS 10 and IAS 28. If the non-monetary assets sold or contributed to an associate or joint venture constitute a 'business', then the full gain or loss will be recognised by the investor. A partial gain or loss is recognised when a transaction involves assets that do not constitute a business, even if these assets are housed in a subsidiary. This amendment is not expected to affect the Group's results.	Annual periods beginning on or after 1 January 2016
Amendments to IFRS 10, 'Consolidated financial statements' and IAS 28, 'Investments in associates and joint ventures' on applying the consolidation exemption	The amendments clarify the application of the consolidation exception for investment entities and their subsidiaries. These amendments will not affect the Group's results.	Annual periods beginning on or after 1 January 2016
Amendment to IFRS 11, 'Joint arrangements' on acquisition of an interest in a joint operation	This amendment adds new guidance on how to account for the acquisition of an interest in a joint operation that constitutes a business. The amendments specify the appropriate accounting treatment for such acquisitions. The impact of this amendment on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2016

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1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.18 Standards and interpretations issued, not yet effective (continued)

Standard/Interpretation	Description	Effective date
IFRS 14 – Regulatory deferral accounts	IFRS 14, 'Regulatory deferral accounts' was issued specific to first time adopters as an interim standard on the accounting for certain balances that arise from rate-regulated activities (regulatory deferral accounts). Rate regulation is a framework where the price that an entity charges to its customers for goods and services is subject to oversight and/or approval by an authorised body. This standard will not affect the Group's results.	Annual periods beginning on or after 1 January 2016
Amendments to IAS 1, 'Presentation of financial statements' disclosure initiative	These amendments were issued to clarify guidance in IAS 1 on materiality and aggregation, the presentation of subtotals, the structure of financial statements and the disclosure of accounting policies. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2016
Amendment to IAS 16, 'Property, plant and equipment' and IAS 38, 'Intangible assets', on depreciation and amortisation	This amendment clarifies that the use of revenue based methods to calculate the depreciation of an asset is not appropriate because revenue generated by an activity that includes the use of an asset generally reflects factors other than the consumption of the economic benefits embodied in the asset. It has also clarified that revenue is generally presumed to be an inappropriate basis for measuring the consumption of the economic benefits embodied in an intangible asset. This amendment will not affect the Group's results.	Annual periods beginning on or after 1 January 2016

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1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.18 Standards and interpretations issued, not yet effective (continued)

Standard/Interpretation	Description	Effective date
Amendments to IAS 16, 'Property, plant and equipment' and IAS 41, 'Agriculture' on bearer plants	In this amendment to IAS 16 bearer plants have been scoped in, but the produce on bearer plants have not been scoped in. It explains that a bearer plant not yet in the location and condition necessary to bear produce is treated as a self-constructed asset. In this amendment to IAS 41, the definition of a bearer plant has been adjusted to include examples of non-bearer plants and to remove current examples of bearer plants from IAS 41. This amendment will not affect the Group's results.	Annual periods beginning on or after 1 January 2016
Amendments to IAS 27, 'Separate financial statements' on equity accounting	In this amendment the option to use the equity method to account for investments in subsidiaries, joint ventures and associates in an entity's separate financial statements has been restored. This amendment will not affect the Group's results.	Annual periods beginning on or after 1 January 2016
IFRS 15 – Revenue from contracts with customers	The converged standard on revenue recognition has been issued. It is a single, comprehensive revenue recognition model for all contracts with customers to achieve greater consistency in the recognition and presentation of revenue. Revenue is recognised based on the satisfaction of performance obligations, which occurs when control of goods or services transfers to a customer. The impact of this standard on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2017

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1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.18 Standards and interpretations issued, not yet effective (continued)

Standard/Interpretation	Description	Effective date
IFRS 9 – Financial instruments (2009 & 2010) • **Financial liabilities** • **Derecognition of financial instruments** • **Financial assets** • **General hedge accounting**	IFRS 9 addresses classification and measurement of financial assets and replaces the multiple classification and measurement models in IAS 39 with a single model that has only two classification categories: amortised cost and fair value. IFRS 9, 'Financial instruments' has been updated to include guidance on financial liabilities and derecognition of financial instruments. The accounting and presentation for financial liabilities and for derecognising financial instruments has been relocated from IAS 39, 'Financial instruments: Recognition and measurement', without change, except for financial liabilities that are designated at fair value through profit or loss. The impact of this standard on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2018
Amendment to IFRS 9 – 'Financial instruments', on general hedge accounting	IFRS 9 has been amended to align hedge accounting more closely with an entity's risk management. The revised standard also establishes a more principles-based approach to hedge accounting and addresses inconsistencies and weaknesses in the current model in IAS 39. This amendment will not affect the Group's results.	Annual periods beginning on or after 1 January 2018
Annual improvements 2012	Improvements to IFRSs (issued December 2013) was issued as part of the 'annual improvements process' resulting in the following amendments to standards issued, but not effective for the first time for 31 March 2015 year-ends: • IFRS 8, 'Operating segments' • IFRS 13, 'Fair value measurement' • IAS 16, 'Property, plant and equipment' and IAS 38, 'Intangible assets' and • IAS 24, 'Related party disclosures'. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 July 2014

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1 PRINCIPAL ACCOUNTING POLICIES (CONTINUED)

1.18 Standards and interpretations issued, not yet effective (continued)

Standard/Interpretation	Description	Effective date
Annual improvements 2013	The final standard was published for the 2011 to 2013 cycle of the annual improvements, with amendments that affected four standards issued, but not effective for the first time for 31 March 2015 year-ends: • IFRS 1, 'First time adoption of International Financial Reporting Standards' • IFRS 3, 'Business combinations' • IFRS 13, 'Fair value measurement' and • IAS 40, 'Investment property'. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 July 2014
Annual improvements 2014	In September 2014 the annual improvements for the 2012 to 2014 cycle was issued, which contains five amendments to four standards, excluding consequential amendments: • IFRS 5, 'Non-current assets held for sale and discontinued operations' • IFRS 7, 'Financial instruments; Disclosures' • IAS 19, 'Employee benefits' and • IAS 34, 'Interim financial reporting'. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods beginning on or after 1 January 2016

The Group has not early-adopted any of the above guidance.

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2 REVENUE

	GROUP				CSIR			
	2015		2014		**2015**		2014	
	R'000	**%**	R'000	%	**R'000**	**%**	R'000	%
Parliamentary Grant	**675 340**	**29**	618 849	30	**675 340**	**29**	618 849	30
Parliamentary Grant received	**657 819**	**28**	633 678	30	**657 819**	**28**	633 678	30
Less:								
Grant received for projects started before year-end but not completed	**(54 307)**	**(2)**	(71 828)	(3)	**(54 307)**	**(2)**	(71 828)	(3)
Add:								
Grant received in prior year for projects completed in this year	**71 828**	**3**	56 999	3	**71 828**	**3**	56 999	3
Contract R&D income	**1 677 766**	**71**	1 495 626	69	**1 679 430**	**71**	1 495 823	69
Local private sector	**161 604**	**7**	157 995	7	**161 265**	**7**	158 223	7
Local public sector	**1 329 039**	**56**	1 134 501	52	**1 331 042**	**56**	1 134 470	52
International sector (including Africa)	**187 123**	**8**	203 130	10	**187 123**	**8**	203 130	10
Royalties	**9 070**	**–**	13 679	1	**8 674**	**–**	13 679	1
	2 362 176	**100**	2 128 154	100	**2 363 444**	**100**	2 128 351	100

Contract R&D income is disclosed after taking into account the effect of the time value of money (the value of discounting) in terms of SAICA's Circular 9 of 2006: Transactions giving rise to adjustments to revenue/purchases. The value is R13,01 million (2014: R14,82 million) and is included in finance income (note 4).

Included in public sector contract R&D income is R93,93 million (2014: R65,04 million) ring-fenced allocation from the Department of Science and Technology for specific initiatives managed through memorandums of agreement.

Included in contract R&D income is rental income amounting to R35,56 million (2014: R33,26 million).

Estimates on Parliamentary Grant recognition are based on cost to completion, budgets and percentage of completion.

NOTES TO THE
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3 PROFIT BEFORE INCOME TAX

Profit before income tax is arrived at after taking the following items into account:

	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
Audit fees	**6 251**	4 910	**6 251**	4 910
Fees for services	**6 224**	7 433	**6 127**	7 284
Patent costs	**4 813**	6 171	**4 716**	6 022
Legal costs	**1 411**	1 262	**1 411**	1 262
Operating leases	**5 240**	5 844	**5 150**	5 762
Buildings	**1 287**	1 263	**1 197**	1 181
Equipment	**2 259**	3 022	**2 259**	3 022
Vehicles	**1 694**	1 559	**1 694**	1 559
Net realised foreign exchange gain	**(14 322)**	(28 275)	**(14 322)**	(28 275)
Net unrealised foreign exchange (gain)/loss	**(5 097)**	8 144	**(5 097)**	8 144
Board members' and Executive Management's remuneration (note 18)	**23 850**	20 809	**21 698**	18 758
(Reversals of impairments)/impairments	**(10 064)**	672	**(10 351)**	2 611
Reversal of impairment on subsidiaries, joint ventures and associates	**(5 873)**	(1 988)	**(6 037)**	(49)
(Reversal of impairment)/impairment on trade receivables	**(4 314)**	2 660	**(4 314)**	2 660
Impairment on intangible assets	**123**	–	**–**	–
Bad debt written off	**302**	3 186	**302**	3 186
Profit on disposal and write-off of property, plant and equipment	**(321)**	(3 912)	**(330)**	(3 912)
Lost and/or stolen equipment and vehicles*	**488**	655	**488**	655
Losses incurred	**488**	1 283	**488**	1 283
Losses recovered	**–**	(628)	**–**	(628)

* These are losses incurred in the normal course of the CSIR's business and are covered by the CSIR's insurance policy. The net losses incurred on these are included in the profit on disposal and write-off of property, plant and equipment amounts.

NOTES TO THE
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4 FINANCE INCOME/EXPENSE

	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
Finance income	**65 688**	54 860	**64 570**	53 792
Interest on bank balances and investments	**52 613**	40 042	**51 495**	38 974
Adjustment on initial recognition of contract R&D income*	**13 075**	14 818	**13 075**	14 818
Finance expense	**(6 952)**	(4 635)	**(6 952)**	(4 635)
Adjustment on initial recognition of operating expenses*	**(6 952)**	(4 635)	**(6 952)**	(4 635)
	58 736	50 225	**57 618**	49 157

* These adjustments are due to the effect of the time value of money (the value of discounting) in terms of SAICA's Circular 9 of 2006: Transactions giving rise to adjustments to revenue/purchases.

5 INCOME TAX EXPENSE

The CSIR is exempt from South African income tax in terms of section 10 (1) (t) (i) of the Income Tax Act, Act No 58 of 1962.

	%	%
South African normal rate of taxation	**28%**	28%
Profit attributable to tax exempt entities	**(28%)**	(27%)
Assessed loss (refer note 13)	**1%**	1%
Share of profit of associate	**(1%)**	(2%)
Current and deferred taxation – effective rate	**0%**	0%

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6 PROPERTY, PLANT AND EQUIPMENT

	2015			2014		
	Cost R'000	**Accumulated depreciation R'000**	**Carrying value R'000**	Cost R'000	Accumulated depreciation R'000	Carrying value R'000
Group						
Land	**143 587**	**–**	**143 587**	143 587	–	143 587
Buildings	**442 570**	**68 480**	**374 090**	407 078	68 262	338 816
Equipment	**576 828**	**360 388**	**216 440**	462 654	292 261	170 393
Vehicles	**7 318**	**5 403**	**1 915**	6 823	4 943	1 880
	1 170 303	**434 271**	**736 032**	1 020 142	365 466	654 676
CSIR						
Land	**143 587**	**–**	**143 587**	143 587	–	143 587
Buildings	**442 570**	**68 480**	**374 090**	407 078	68 262	338 816
Equipment	**576 781**	**360 364**	**216 417**	462 560	292 197	170 363
Vehicles	**7 318**	**5 403**	**1 915**	6 823	4 943	1 880
	1 170 256	**434 247**	**736 009**	1 020 048	365 402	654 646

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6 PROPERTY, PLANT AND EQUIPMENT (CONTINUED)

	Land R'000	Buildings R'000	Equipment R'000	Vehicles R'000	Total R'000
Group					
Carrying value 31 March 2013 (restated)	143 587	315 190	159 716	2 280	**620 773**
Additions	–	23 828	58 060	93	**81 981**
Disposals and write-offs	–	–	(838)	–	**(838)**
Depreciation	–	(202)	(46 545)	(493)	**(47 240)**
Carrying value 31 March 2014	143 587	338 816	170 393	1 880	**654 676**
Additions	–	35 492	94 413	607	**130 512**
Disposals and write-offs	–	–	(504)	–	**(504)**
Depreciation	–	(218)	(47 862)	(572)	**(48 652)**
Carrying value 31 March 2015	**143 587**	**374 090**	**216 440**	**1 915**	**736 032**
CSIR					
Carrying value 31 March 2013 (restated)	143 587	315 190	159 659	2 280	**620 716**
Additions	–	23 828	58 060	93	**81 981**
Disposals and write-offs	–	–	(838)	–	**(838)**
Depreciation	–	(202)	(46 518)	(493)	**(47 213)**
Carrying value 31 March 2014	143 587	338 816	170 363	1 880	**654 646**
Additions	–	35 492	94 383	607	**130 482**
Disposals and write-offs	–	–	(495)	–	**(495)**
Depreciation	–	(218)	(47 834)	(572)	**(48 624)**
Carrying value 31 March 2015	**143 587**	**374 090**	**216 417**	**1 915**	**736 009**

Land and buildings are unencumbered and full details of the titles are available at the registered office of the CSIR.

A change in the depreciation estimate due to a change in the useful lives of equipment resulted in a R2,2 million (2014: R2,5 million) decrease in the depreciation amount for the current financial year.

During the current financial year, assets to the value of R79,2 million (2014: R52,7 million) were purchased with Government grant funds. At year-end the cumulative value of assets purchased with Government grant funds and shown at a nil cost is R469,1 million (2014: R393,2 million).

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7 INTANGIBLE ASSETS

	2015			2014		
	Cost	**Accumulated amortisation & impairment**	**Carrying value**	Cost	Accumulated amortisation & impairment	Carrying value
	R'000	**R'000**	**R'000**	R'000	R'000	R'000
Group						
Investments in technology	**10 862**	**10 862**	**–**	10 739	10 739	–

	GROUP
	R'000
Carrying value 31 March 2013 (restated)	–
Carrying value 31 March 2014	–
Additions	123
Impairment*	(123)
Carrying value 31 March 2015	**–**

* There are no guarantees of future cash flows and therefore the intangible assets have been impaired. This impairment is not material for the Group.

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
8 INTEREST IN JOINT VENTURES AND ASSOCIATES				
Cost of investments less impairment losses	**1**	1	**1**	1
Loans to joint ventures and associates	**29 187**	36 187	**27 937**	33 937
Share of post-acquisition losses of joint ventures	**(23 554)**	(23 735)	**–**	–
Share of post-acquisition gains of associates	**7 694**	5 449	**–**	–
Share of pre-acquisition gains of associates	**151**	151	**–**	–
	13 479	18 053	**27 938**	33 938
Impairment of joint ventures and associates	**(3 005)**	(8 878)	**(26 574)**	(32 623)
	10 474	9 175	**1 364**	1 315

The loans to joint ventures and associates are interest free, unsecured and have no fixed terms of repayment. In substance, they form part of the Group's net investment in joint ventures and associates.

Agreements have been entered into between the CSIR and certain joint ventures and associates to subordinate the loans made to those joint ventures and associates. The subordination agreements will remain in force for as long as the liabilities of the relevant joint ventures or associates exceed their assets, fairly valued.

Details of the joint ventures and associates at 31 March 2015 are as follows:

Name of joint venture/associate	Place of incorporation	Portion of ownership interest	Portion of voting power held	Principal activity	Carrying value 2015 R'000	Carrying value 2014 R'000	Financial year-end
Joint ventures							
Sera (Pty) Ltd	South Africa	50%	50%	Commercialisation and licensing of patents	**3 005**	8 878	31 March
Ellipsoid Technology (Pty) Ltd	South Africa	50%	50%	Development of encapsulation technology	**1 378**	1 325	31 March
Associates							
Uvirco Technologies (Pty) Ltd	South Africa	45%	45%	Manufacturing of high technology cameras	**9 096**	7 850	31 March
					13 479	18 053	

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8 INTEREST IN JOINT VENTURES AND ASSOCIATES (CONTINUED)

The following are details of the significant joint ventures' and associates' assets, liabilities, income and expenses:

	JOINT VENTURES GROUP		ASSOCIATES GROUP	
	2015 R'000	2014 R'000	**2015 R'000**	2014 R'000
Current assets	**7 321**	19 660	**24 945**	21 922
Non-current assets	**33 665**	33 056	**2 759**	3 450
Current liabilities	**53 518**	53 610	**10 068**	11 475
Non-current liabilities	**36 232**	48 232	**–**	1 250
Income	**972**	1 132	**35 078**	37 690
Expenses	**611**	5 019	**30 088**	31 156

9 INTEREST IN SUBSIDIARIES

	CSIR	
	2015 R'000	2014 R'000
Shares at cost less impairment losses	**4 650**	4 650
Indebtedness	**2 999**	16 011
– by subsidiaries	**19 500**	32 500
– impairment of loans	**(16 501)**	(16 489)
	7 649	20 661

Details disclosed in Addendum A.

The loans to subsidiaries are interest free, unsecured and have no fixed terms of repayment.

Agreements have been entered into between the CSIR and certain subsidiaries to subordinate the loans made to those subsidiaries. The subordination agreements will remain in force for as long as the liabilities of the relevant subsidiaries exceed their assets, fairly valued.

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10 OTHER INVESTMENTS

	% held	Number of shares held 2015	Number of shares held 2014	Class of shares	GROUP 2015 R'000	GROUP 2014 R'000	CSIR 2015 R'000	CSIR 2014 R'000
Unlisted shares								
Persomics	12.31%	7 250	–	Ordinary	5 409	–	5 409	–
					5 409	–	5 409	–

11 TRADE AND OTHER RECEIVABLES

	GROUP 2015 R'000	GROUP 2014 R'000	CSIR 2015 R'000	CSIR 2014 R'000
Trade receivables	226 752	288 754	226 740	288 728
Prepaid expenditure	36 870	25 696	36 870	25 696
Other receivables	703	9 295	577	9 272
	264 325	323 745	264 187	323 696

Trade receivables are shown net of impairment losses. Refer to note 21 for more detail on trade receivables.

12 INVENTORY AND CONTRACTS IN PROGRESS

	GROUP 2015 R'000	GROUP 2014 R'000	CSIR 2015 R'000	CSIR 2014 R'000
Contracts in progress less provision for losses	101 409	83 655	101 409	83 655
Raw materials and consumables	1 492	1 376	1 492	1 376
	102 901	85 031	102 901	85 031

Estimates on contract in progress recognition are based on cost to completion, budgets and percentage of completion.

13 DEFERRED TAX

Two subsidiaries in the Group are in assessed loss positions and no deferred tax assets were raised for these assessed losses due to the uncertainty of the recoverability in future periods in respect of the carry forward of unused tax losses.

	2015	2014
Opening balance	6 131	5 004
Assessed tax loss generated for the year	1 835	1 127
Assessed tax loss carried forward	7 966	6 131

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
14 ADVANCES RECEIVED				
Advances on contracts received from clients and stakeholders	**767 209**	778 851	**767 209**	778 851
15 TRADE AND OTHER PAYABLES				
Accounts payable and accruals	**288 368**	371 528	**288 458**	370 845
Salary related accruals	**157 718**	152 079	**157 718**	152 079
Forward exchange contracts	**–**	152	**–**	152
	446 086	523 759	**446 176**	523 076

16 OPERATING LEASE COMMITMENTS

Financial commitments under non-cancellable operating leases will result in the following payments falling due:

Within one year:	**1 972**	1 391	**1 957**	1 312
Land and buildings	**1 051**	199	**1 036**	120
Vehicles	**921**	1 192	**921**	1 192
Within two to five years:	**850**	1 379	**850**	1 379
Land and buildings	**236**	–	**236**	–
Vehicles	**614**	1 379	**614**	1 379

Agreements relating to operating lease payments for vehicles vary from 12 to 48 months and payments are fixed for the term of the agreements.

The CSIR leases buildings under operating leases. The lease periods vary from 12 to 60 months. Lease payments are increased with a fixed annual escalation percentage to reflect market rentals. None of the leases include contingent rentals.

The CSIR leases a number of properties at nominal rental amounts. The lease periods vary from 25 to 99 years.

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17 RETIREMENT BENEFITS OF EMPLOYEES

17.1 CSIR Pension Fund

The fund is registered in terms of the Pension Funds Act, 1956, and is a defined contribution plan. The CSIR's liability to the fund is limited to paying the employer contributions. Life cover and dependants' pensions are fully secured by a continued income and life insurance policy. All the CSIR's permanent employees are members of the fund.

Employer contributions of R91,1 million (2014: R82,7 million) and employee contributions of R53,4 million (2014: R48,3 million) were expensed during the year.

17.2 Mine Officials Pension Fund and Sentinel

At the time of the merger with the Chamber of Mines Research Organisation (COMRO) in 1993, certain COMRO (Sentinel Mining) employees elected to remain members of the Mine Officials Pension Fund and Sentinel (previously Chamber of Mines Pension Fund). In terms of the agreement with the Chamber of Mines, this election held no liability for the CSIR other than paying the monthly employee contributions. The funds were defined benefit plans.

On 1 March 2001 the members of the Chamber of Mines Pension Fund moved to Sentinel.

In 2014 there was one employee remaining who had formally converted his secondment to a CSIR appointment. Employer contributions of R1 512 and employee contributions of R936 were expensed for the prior year. Employer contributions were charged against income when incurred. During the 2014 financial year the member transferred to the CSIR Pension Fund.

17.3 Associated Institutions Pension Fund (AIPF)

The fund is a defined benefit plan. The formula used to determine pensions is based on the pensionable earnings of the final year, and the aggregate period of uninterrupted membership.

The CSIR has one employee (2014: one employee) who is a member of the AIPF as at 31 March 2015. The fund is controlled by the state, which has assumed responsibility for the unfunded portions of these funds.

Employer contributions of R6 506 (2014: R5 951) and employee contributions of R4 066 (2014: R3 719) were expensed during the year.

17.4 Post-retirement medical benefits

The CSIR has a post-retirement medical benefit obligation to certain qualifying retired CSIR employees (pensioners) that joined the CSIR prior to 30 September 1996. An offer was made to qualifying pensioners in December 2005 to accept an annuity, payable from an independent source, equivalent to the value of their medical subsidy. The pensioners who accepted the offer are no longer entitled to a subsidy from the CSIR.

The accumulated benefit obligation and the annual cost of accrual of benefits are assessed by independent, qualified actuaries using the projected unit credit method. The estimated present value of the anticipated expenditure for the remaining 18 continuation members (2014: 18 continuation members) was recalculated by the actuaries as at 31 March 2015 and will be funded through cash and cash equivalents. These cash and cash equivalents have not been set aside specifically for this benefit.

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000

17 RETIREMENT BENEFITS OF EMPLOYEES (CONTINUED)

17.4 Post-retirement medical benefits (continued)

The amount included in the statement of financial position arising from the CSIR's obligation in respect of post-retirement medical benefits is as follows:

Present value of obligations	**10 614**	9 772	**10 614**	9 772
Net liability on statement of financial position	**10 614**	9 772	**10 614**	9 772

Amounts recognised in the statement of comprehensive income in respect of the scheme are as follows:

Interest cost	**850**	827	**850**	827
Actuarial gain recognised during the year	**(8)**	(1 402)	**(8)**	(1 402)
	842	(575)	**842**	(575)

Movement in the net liability recognised in the statement of financial position is as follows:

Net liability at the beginning of the year	**9 772**	10 347	**9 772**	10 347
Movement for the year	**842**	(575)	**842**	(575)
Net expense/(income) recognised in the statement of comprehensive income	**842**	(575)	**842**	(575)
Net liability at the end of the year	**10 614**	9 772	**10 614**	9 772

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000

17 RETIREMENT BENEFITS OF EMPLOYEES (CONTINUED)

17.4 Post-retirement medical benefits (continued)

Principal actuarial assumptions at the reporting date:

Discount rate at 31 March	**7.40%**	8.70%	**7.40%**	8.70%
Medical inflation costs	**6.40%**	6.40%	**6.40%**	6.40%

The above results are sensitive to changes in the assumed future rate of medical inflation.

The effect of a one percent increase in the assumed future rate of medical inflation would have the following effects:

Effect on defined benefit obligation	**722**	655	**722**	655

The effect of a one percent decrease in the assumed future rate of medical inflation would have the following effects:

Effect on defined benefit obligation	**(653)**	(593)	**(653)**	(593)

The above sensitivity analyses are based on a change in an assumption while all other assumptions are assumed to remain unchanged. This may not always be realistic as some of the assumptions tend to be correlated. When calculating the sensitivity of the defined benefit obligation to significant actuarial assumptions the same method (present value of the defined benefit obligation calculated with the projected unit credit method at the end of the reporting period) has been applied as when calculating the liability recognised within the statement of financial position.

Historical information	**2015**	2014	2013	2012	2011
Present value of the defined benefit obligation	**10 614**	9 772	10 347	8 260	10 142
Deficit in the plan	**10 614**	9 772	10 347	8 260	10 142

The average term (undiscounted) of the defined benefit obligation is 10.1 years (2014: 10.6 years) and the average duration (discounted) of the defined benefit obligation is 7.1 years (2014: 7.0 years).

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18 BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT'S REMUNERATION

2015

	Entity	Fees for services as director	Managerial Services				Total
			Basic salary	Bonuses and performance-related payments	Retirement fund and medical aid contributions	Sale of accrued leave*	
		R'000	R'000	R'000	R'000	R'000	R'000
Board members and Executive Directors							
Dr SP Sibisi	CSIR	–	3 594	1 791	597	–	**5 982**
Non-executive Board members							
Mr P Benadè (until Dec 2014)	CSIR	107	–	–	–	–	**107**
Professor TE Cloete (until Dec 2014)	CSIR	78	–	–	–	–	**78**
Ms M Mabitje-Thompson (until Dec 2014)	CSIR	–	–	–	–	–	**–**
Professor TA Nyokong (until Dec 2014)	CSIR	–	–	–	–	–	**–**
Professor FW Petersen (until Dec 2014)	CSIR	104	–	–	–	–	**104**
Mr M Sibanda (until Dec 2014)	CSIR	84	–	–	–	–	**84**
Ms BS Tshabalala (until Dec 2014)	CSIR	107	–	–	–	–	**107**
Professor MJ Wingfield (until Dec 2014)	CSIR	68	–	–	–	–	**68**
Adv G Badela	CSIR	107	–	–	–	–	**107**
Ms P Baleni (from Jan 2015)	CSIR	–	–	–	–	–	**–**
Dr PH Goyns	CSIR	–	–	–	–	–	**–**
Dr A Llobell (from Jan 2015)	CSIR	–	–	–	–	–	**–**
Professor T Majozi (from Jan 2015)	CSIR	33	–	–	–	–	**33**
Dr R Masango (from Jan 2015)	CSIR	19	–	–	–	–	**19**
Ms M Maseko (from Jan 2015)	CSIR	19	–	–	–	–	**19**
Mr J Netshitenzhe (from Jan 2015)	CSIR	19	–	–	–	–	**19**
Ms A Noah (from Jan 2015)	CSIR	19	–	–	–	–	**19**
Professor M Phakeng (from Jan 2015)	CSIR	10	–	–	–	–	**10**
Executive Management							
Dr RK Chikwamba	CSIR	–	1 803	630	132	–	**2 565**
Mr JPL Cloete (from Nov 2014)	CSIR	–	2 018	622	155	–	**2 795**
Dr M Motuku	CSIR	–	2 124	853	189	–	**3 166**
Mr CR Sturdy	CSIR	–	2 081	886	369	–	**3 336**
Mr RM Zondo	CSIR	–	2 061	813	206	–	**3 080**
Subsidiaries							
Non-executive Board member							
Mr M Sibanda	Technifin SOC Ltd	51	–	–	–	–	**51**
Executive Management							
Mr JG Hattingh (until Feb 2015)**	Technifin SOC Ltd	–	2 101	–	–	–	**2 101**
2015		**825**	**15 782**	**5 595**	**1 648**	**–**	**23 850**

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18 BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT'S REMUNERATION (CONTINUED)

2014

	Entity	Fees for services as director	Managerial Services				Total
			Basic salary	Bonuses and performance-related payments	Retirement fund and medical aid contributions	Sale of accrued leave*	
		R'000	R'000	R'000	R'000	R'000	R'000
Board members and Executive Directors							
Dr SP Sibisi	CSIR	–	3 330	1 622	558	1 236	**6 746**
Non-executive Board members							
Adv G Badela	CSIR	110	–	–	–	–	**110**
Mr P Benadè	CSIR	123	–	–	–	–	**123**
Professor TE Cloete	CSIR	92	–	–	–	–	**92**
Dr PH Goyns	CSIR	–	–	–	–	–	**–**
Ms MSM Mabitje-Thompson	CSIR	–	–	–	–	–	**–**
Professor TA Nyokong	CSIR	37	–	–	–	–	**37**
Professor FW Petersen	CSIR	120	–	–	–	–	**120**
Mr M Sibanda	CSIR	138	–	–	–	–	**138**
Ms BS Tshabalala	CSIR	110	–	–	–	–	**110**
Professor MJ Wingfield	CSIR	46	–	–	–	–	**46**
Executive Management							
Dr RK Chikwamba	CSIR	–	1 684	571	123	87	**2 465**
Dr M Motuku	CSIR	–	2 028	579	176	42	**2 825**
Mr CR Sturdy	CSIR	–	1 944	803	345	–	**3 092**
Mr RM Zondo	CSIR	–	1 925	736	193	–	**2 854**
Subsidiaries							
Non-executive Board member							
Mr M Sibanda	Technifin (Pty) Ltd	56	–	–	–	–	**56**
Executive Management							
Mr JG Hattingh	Technifin (Pty) Ltd	–	1 546	449	–	–	**1 995**
2014		**832**	**12 457**	**4 760**	**1 395**	**1 365**	**20 809**

* The approved changes to the CSIR conditions of service, effective 1 April 2013, resulted in amendments to leave days and the accumulation of leave. Leave accrued as at 1 April 2013 had to be utilised or sold within 2 years.

** Including severance

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
19 CONTINGENT LIABILITIES AND FACILITIES				
Local and foreign payment and performance guarantees issued as at 31 March	**7 984**	10 785	**7 984**	10 785

The CSIR has a borrowing plan approved by the Minister of Finance to issue performance bonds, local and foreign advance payment guarantees and carnets.

Legal costs and litigation
In the nature of the CSIR's business, agreements with complex deliverables may be entered into. All necessary steps are taken to manage the risks inherent to these transactions. If and when it is evident that there is a reasonable probability that a dispute on a transaction could lead to costs against the CSIR, such costs will be disclosed.

20 CAPITAL COMMITMENTS				
Property, plant and equipment	**70 720**	82 036	**70 720**	82 036

This capital expenditure is to be financed from internal sources.

21 FINANCIAL INSTRUMENTS

The Group has exposure to the following risks from its use of financial instruments:
- market risk
- credit risk
- liquidity risk.

This note presents information about the Group's exposure to each of the above risks and the Group's objectives, policies and processes for measuring and managing risk. Further quantitative disclosures are included throughout these consolidated financial statements.

The Board has overall responsibility for the establishment and oversight of the Group's risk management framework.

The Group's risk management policies are established to identify and analyse the risks faced by the Group, to set appropriate risk limits and controls, and to monitor risks and adherence to limits. Risk management policies and systems are reviewed regularly to reflect changes in market conditions and the Group's activities. The Group, through its training and management standards and procedures, aims to develop a disciplined and constructive control environment in which all employees understand their roles and obligations.

The Audit and Risk Committee oversees how management monitors compliance with the Group's risk management policies and procedures and reviews the adequacy of the risk management framework in relation to the risks faced by the Group. The Group Audit and Risk Committee is assisted in its oversight role by internal audit. Internal audit undertakes both regular and ad hoc reviews of risk management controls and procedures, the results of which are reported to the Audit and Risk Committee.

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21 FINANCIAL INSTRUMENTS (CONTINUED)

21.1 Market risk

Market risk is the risk that changes in market prices, such as foreign exchange rates and interest rates will affect the Group's income or the value of its holdings of financial instruments. The objective of market risk management is to manage and control market risk exposures within acceptable parameters, while optimising the return.

Foreign currency risk

The Group is exposed to currency risk on sales and purchases that are denominated in a currency other than the respective functional currency of the Group entities.

The Group enters into forward exchange contracts to buy specified amounts of foreign currencies in the future at a predetermined exchange rate.

Forward exchange contracts are entered into mainly to cover import orders. The Group has no policy to enter into forward exchange contracts for anticipated foreign receipts. The Group does not use derivative financial instruments for speculative purposes.

The Group's exposure to foreign currency risk was as follows:

	31 MARCH 2015					
	Total R'000	ZAR R'000	EURO R'000	USD R'000	GBP R'000	Other R'000
Trade receivables	**226 752**	179 926	354	44 311	2 161	–
Bank accounts	**167 829**	96 213	5 750	55 390	4 939	5 537
Trade and other payables	**(446 086)**	(443 224)	(1 672)	(988)	(202)	–
Gross statement of financial position exposure	**(51 505)**	(167 085)	4 432	98 713	6 898	5 537
Forward exchange contracts	**–**	–	–	–	–	–
Net exposure	**(51 505)**	**(167 085)**	**4 432**	**98 713**	**6 898**	**5 537**

	31 MARCH 2014					
	Total R'000	ZAR R'000	EURO R'000	USD R'000	GBP R'000	Other R'000
Trade receivables	**288 754**	262 806	1 139	23 120	689	1 000
Bank accounts	**149 743**	77 469	2 324	64 572	4 451	927
Trade and other payables	**(523 759)**	(470 425)	(50 340)	(2 994)	–	–
Gross statement of financial position exposure	**(85 262)**	(130 150)	(46 877)	84 698	5 140	1 927
Forward exchange contracts	**(5 478)**	–	(5 478)	–	–	–
Net exposure	**(90 740)**	**(130 150)**	**(52 355)**	**84 698**	**5 140**	**1 927**

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	GROUP	
	2015	2014

21 FINANCIAL INSTRUMENTS (CONTINUED)
21.1 Market risk (continued)

Foreign currency risk (continued)

The following significant exchange rates applied during the year:

	R	R
Average rate of forward exchange contracts: Euro	**–**	14.7727
Year-end spot rate:		
Euro	**13.1191**	14.5514
USD	**12.0907**	10.5761
GBP	**17.9367**	17.5980

Sensitivity analysis

A 10% strengthening of the rand against the following currencies at 31 March would have (decreased)/increased profit or loss by the amounts shown below. This analysis assumes that all other variables remain constant. The analysis is performed on the same basis for 2014.

	R'000	R'000
Euro	**(443)**	5 236
USD	**(9 871)**	(8 470)
GBP	**(690)**	(514)
Other	**(554)**	(193)

A 10% weakening of the rand against the above currencies at 31 March would have had the equal but opposite effect on the above currencies to the amounts shown above, on the basis that all other variables remain constant.

Interest rate risk

Interest rate exposure and investment strategies are evaluated by management on a regular basis. Interest-bearing investments are held with several reputable banks in order to minimise exposure.

At the reporting date the interest rate profile of the Group's interest-bearing financial instruments was as follows:

Fixed rate instruments: carrying amount	**R'000**	R'000
Financial assets: Fixed deposits	**750 032**	860 713

The Group does not account for any fixed rate financial assets and liabilities at fair value through profit or loss, and the Group does not designate derivatives as hedging instruments under a fair value hedge accounting model. Therefore, a change in interest rates at the reporting date would not affect profit or loss.

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	GROUP	
	2015	2014
	R'000	R'000

21 FINANCIAL INSTRUMENTS (CONTINUED)

21.1 Market risk (continued)

Interest rate risk (continued)

Variable rate instruments: carrying amount

Financial assets: Call deposits	**63 000**	55 000
Financial assets: Bank balances	**167 829**	149 743
	230 829	204 743

Sensitivity analysis

An increase of 100 basis points in interest rates at the reporting date would have increased equity and profit and loss by the amounts shown below. This analysis assumes that all other variables, in particular foreign currency rates, remain constant. The analysis is performed on the same basis for 2014.

Variable rate instruments	**2 308**	2 047

A decrease of 100 basis points would have had the equal but opposite effect to the amounts shown above.

21.2 Credit risk

Credit risk is the risk of financial loss to the Group if a customer or counterparty to a financial instrument fails to meet its contractual obligations, and arises principally from the Group's bank balances and deposits, trade and other receivables and loans to joint ventures, associates and subsidiaries.

Trade and other receivables and loans to joint ventures, associates and subsidiaries

Trade and other receivables and loans to joint ventures, associates and subsidiaries are presented net of impairment losses. Credit risk with respect to trade receivables is limited due to the large number of customers comprising the Group's customer base and their dispersion across different industries and geographical areas.

Bank balances and deposits

The Group's bank balances and cash are placed with high credit, quality financial institutions with no significant exposure to any one financial institution.

Guarantees

Refer to note 19 for details on bank guarantees issued with respect to facilities.

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21 FINANCIAL INSTRUMENTS (CONTINUED)
21.2 Credit risk (continued)

	GROUP	
	2015	2014
	R'000	R'000
Exposure to credit risk		
The carrying amount of financial assets represents the maximum credit exposure.		
The maximum exposure to credit risk at the reporting date was:		
Current fixed deposits	**750 032**	860 713
Call deposits	**63 000**	55 000
Bank balances	**167 829**	149 743
Cash on hand and cash deposits	**3 054**	626
Trade and other receivables	**264 325**	323 745
Contracts in progress less provision for losses	**101 409**	83 655
	1 349 649	1 473 482

The maximum exposure to credit risk for trade receivables at the reporting date by type of customer was:		
Local public sector	**139 419**	223 494
Local private sector	**39 852**	38 625
International sector	**47 481**	26 635
	226 752	288 754

The Group's most significant customers are various local public sector customers.

The aging of the Group's trade receivables at the reporting date was:

	2015		2014	
	Gross	**Impairment**	Gross	Impairment
	R'000	**R'000**	R'000	R'000
Not past due	**162 352**	**1 040**	228 040	210
Past due 0 – 30 days	**28 555**	**77**	29 550	95
Past due 31 – 120 days	**28 016**	**648**	31 634	2 944
Past due more than 120 days	**23 334**	**13 740**	19 349	16 570
	242 257	**15 505**	308 573	19 819

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21 FINANCIAL INSTRUMENTS (CONTINUED)

21.2 Credit risk (continued)

Exposure to credit risk (continued)

The movement in the allowance for impairment in respect of trade receivables during the year was as follows:

	GROUP	
	2015	2014
	R'000	R'000
Balance at 1 April	**19 819**	17 159
Movement for the year	**(4 314)**	2 660
Recoveries	**(6 332)**	(6 188)
Utilisation	**(8 826)**	(6 090)
New impairment allowances	**10 844**	14 938
Balance at 31 March	**15 505**	19 819

The allowance account in respect of trade receivables is used to record impairment losses unless the Group is satisfied that no recovery of the amount owing is possible; at that point the amount considered irrecoverable is written off against the financial asset directly.

The fully performing trade receivables are considered to be of high credit quality.

21.3 Liquidity risk

Liquidity risk is the risk that the Group will not be able to meet its financial obligations as these fall due. The Group's approach to managing liquidity is to ensure, as far as possible, that it will always have sufficient liquidity to meet its liabilities when due, under both normal and stressed conditions, without incurring unacceptable losses or risking damage to the Group's reputation.

The Group monitors its cash flow on a daily basis. Typically, the Group ensures that it has sufficient cash on demand to meet expected operational expenses for a period of 60 days, including the servicing of financial obligations; this excludes the potential impact of extreme circumstances that cannot be predicted reasonably, such as natural disasters.

The following are the contractual maturities of financial liabilities, including interest payments and excluding the impact of netting agreements for the Group:

	2015			2014		
	Carrying amount	**Contractual cash flows**		Carrying amount	Contractual cash flows	
		6 months or less	**6–12 months**		6 months or less	6–12 months
	R'000	**R'000**	**R'000**	R'000	R'000	R'000
Non-derivative financial liabilities						
Trade and other payables	**(446 086)**	**(446 086)**	**–**	(523 759)	(523 759)	–
Derivative financial liabilities						
Forward exchange contracts	**–**	**–**	**–**	(152)	(5 582)	–
	(446 086)	**(446 086)**	**–**	(523 911)	(529 341)	–

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21 FINANCIAL INSTRUMENTS (CONTINUED)
21.3 Liquidity risk (continued)

	2015 R	2014 R
Rate of forward exchange contracts:		
Euro	–	15.0550

21.4 Fair values

At 31 March 2015 the carrying amount of bank balances and cash, deposits, trade and other receivables, contracts in progress and trade and other payables approximated their fair values due to the short-term maturities of these assets and liabilities.

Basis for determining fair values

Interest free employee loans

The fair value of interest free employee loans is calculated based on the present value of future cash flows, discounted at the market rate of interest at the reporting date.

Trade and other receivables and trade and other payables

The fair value of trade and other receivables and trade and other payables is calculated based on the present value of future cash flows, discounted at the average return on investment rate at the reporting date.

Forward exchange contracts

The fair value of forward exchange contracts is determined using forward exchange rates at the Statement of Financial Position date, with the resulting value discounted back to present value.

21.5 Fair value hierarchy

The table below analyses financial instruments carried at fair value, by valuation method. The different levels have been defined as follows:

Level 1: quoted prices (unadjusted) in active markets for identical assets or liabilities.

Level 2: inputs other than quoted prices included within Level 1 that are observable for the asset or liability, either directly (as prices) or indirectly (derived from prices).

Level 3: inputs for the asset or liability that are not based on observable market data (unobservable inputs).

	Level 1	Level 2	Level 3	Total
31 March 2015				
Forward exchange contracts	–	–	–	–
31 March 2014				
Forward exchange contracts	–	(152)	–	(152)

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22 RECONCILIATION OF OPERATING PROFIT TO CASH GENERATED FROM OPERATING ACTIVITIES

	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
Operating profit for the year before taxation	**52 812**	52 737	**52 387**	50 931
Adjusted for:				
Depreciation and amortisation	**48 652**	47 240	**48 624**	47 213
Net unrealised foreign exchange (gain)/loss	**(5 097)**	8 144	**(5 097)**	8 144
Net finance income	**(58 736)**	(50 225)	**(57 618)**	(49 157)
Post-retirement medical benefits	**850**	827	**850**	827
Straight-lining adjustment of operating leases	**25**	5	**25**	5
Leave accrual and warranty provision	**8 617**	16 140	**8 617**	16 140
Impairments	**(10 064)**	672	**(10 351)**	2 611
Profit on disposal and write-off of property, plant and equipment	**(321)**	(3 912)	**(330)**	(3 912)
Share of profit of joint ventures and associates	**(2 426)**	(997)	**–**	–
Bad debt written off	**677**	3 186	**677**	3 186
Other investments	**(3 704)**	–	**(3 704)**	–
Operating profit before changes in working capital	**31 285**	73 817	**34 080**	75 988
Decrease/(increase) in trade and other receivables	**65 456**	(25 096)	**65 545**	(30 460)
(Increase)/decrease in inventory and contracts in progress	**(18 917)**	19 937	**(18 917)**	19 937
(Decrease)/increase in advances received	**(11 642)**	21 964	**(11 642)**	21 964
(Decrease)/increase in trade and other payables	**(86 315)**	1 883	**(85 542)**	2 602
Net working capital changes	**(51 418)**	18 688	**(50 556)**	14 043
Cash (utilised)/generated from operating activities	**(20 133)**	92 505	**(16 476)**	90 031

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000
23 CASH AND CASH EQUIVALENTS				
Fixed deposits	**750 032**	860 713	**745 000**	842 000
Call deposits	**63 000**	55 000	**61 000**	53 000
Bank balances	**167 829**	149 743	**166 898**	147 801
Cash on hand and cash deposits	**3 054**	626	**3 054**	626
	983 915	1 066 082	**975 952**	1 043 427

24 RELATED PARTY TRANSACTIONS

The CSIR is a schedule 3B National Government Business Enterprise in terms of the Public Finance Management Act, Act 1 of 1999 as amended by Act 29 of 1999, and therefore falls within the national sphere of government. As a consequence, the CSIR has a significant number of related parties, being entities that fall within the national and provincial sphere of government. Amounts due from/to these entities are subject to the same terms and conditions as normal trade receivables and trade payables. For detail on individually significant transactions refer to notes 2 and 3.

In addition, the CSIR has a related party relationship with its subsidiaries (see Addendum A) and joint ventures and associates (see note 8). Unless specifically disclosed, these transactions are concluded at arm's length and the Group is able to transact with any entity.

24.1 Transactions with related parties

The following is a summary of transactions with related parties during the year and balances due at year-end:

Constitutional institutions				
Services rendered	**–**	682	**–**	682
Amount due from	**–**	323	**–**	323
Major public entities				
Services rendered	**335 898**	309 629	**335 898**	309 629
Services received	**162 202**	291 348	**162 202**	291 348
Amount due from	**39 134**	46 333	**39 134**	46 333
National public entities				
Services rendered	**102 347**	94 629	**102 347**	94 629
Services received	**13 479**	16 468	**13 479**	16 468
Amount due from	**6 010**	8 484	**6 010**	8 484

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	GROUP		CSIR	
	2015	2014	**2015**	2014
	R'000	R'000	**R'000**	R'000

24 RELATED PARTY TRANSACTIONS (CONTINUED)

24.1 Transactions with related parties (continued)

National government business enterprises				
Services rendered	**4 944**	4 690	**4 944**	4 690
Services received	**5 043**	4 161	**5 043**	4 161
Amount due from/(to)	**684**	(2 739)	**684**	(2 739)
Provincial public entities				
Services rendered	**528**	25	**528**	25
Amount due from	**500**	–	**500**	–
Provincial government business enterprises				
Services rendered	**7 408**	10 240	**7 408**	10 240
Services received	**28**	–	**28**	–
Amount due from	**3 427**	1 366	**3 427**	1 366
Government departments				
Services rendered	**1 505 593**	1 239 420	**1 505 593**	1 239 420
Services received	**404**	10 799	**404**	10 799
Amount due from	**66 673**	155 145	**66 673**	155 145
Subsidiaries				
Services rendered	**–**	–	**2 033**	533
Services received	**–**	–	**218**	53
Amount due (to)/from	**–**	–	**(8)**	5
Joint ventures and associates				
Services rendered	**2 393**	2 426	**2 046**	2 117
Services received	**563**	34	**477**	34
Amount due to	**(395)**	(16)	**(332)**	(16)

24.2 Transactions with key management

Total remuneration of key management is included in employees' remuneration (refer to note 18 for Executive Management's remuneration).

25 IRREGULAR EXPENDITURE

Irregular expenditure relating to the current year:				
– Administrative error in assessing supplier	**117**	–	**117**	–
Irregular expenditure awaiting condonation	**117**	–	**117**	–

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26 TRANSITION TO IFRS

The 2013/14 consolidated annual financial statements were prepared and published in the 2013/14 CSIR Annual Report in accordance with statements of South African Generally Accepted Accounting Practice (SA GAAP). Subsequent to the publishing of the 2013/14 Annual Report, the 2013/14 consolidated annual financial statements were prepared in accordance with International Financial Reporting Standards (IFRS) and were audited and signed off by the Auditor-General.

The comparitive figures in this set of annual financial statements thus includes the figures as per the 2013/14 IFRS financial statements.

IFRS 1, First-time Adoption of International Financial Reporting Standards (IFRS 1), was applied in preparing the 2013/14 consolidated financial statements and these were the Group's first consolidated financial statements to be prepared in accordance with IFRS.

IFRS 1 requires full retrospective application of IFRS. However, the standard allows for exceptions and exemptions from full retrospective application of IFRS. The Group applied the following transition exceptions and exemptions to retrospective application of IFRS when preparing the 2013/14 IFRS consolidated financial statements:

Exception to restating non-controlling interest
The Group elected not to apply *IFRS 3 Business Combinations* retrospectively and therefore also did not restate non-controlling interests.

Exception to restating estimates
No changes were made to estimates recorded under SA GAAP.

Exemption for investment in subsidiaries, joint ventures and associates (*CSIR separate financial statements*)
The CSIR chose to make use of the exemption allowing the CSIR to measure investments in subsidiaries at the carrying amount under SA GAAP.

Exemption for business combinations (*Group only*)
The Group chose to make use of the exemption allowing it to only apply *IFRS 3 Business Combinations* prospectively from the date of transition.

Exemption to apply fair value as deemed cost
The Group elected to apply the exemption to revalue certain items of property, plant and equipment to its fair value at 1 April 2012.

Exemption for arrangements containing a lease
The Group elected the exemption to apply *IFRIC 4 Determining whether an arrangement contains a lease* prospectively to all arrangements in existence at transition date.

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26 TRANSITION TO IFRS (CONTINUED)

Exemption for employee benefit disclosures

The Group elected the exemption to prospectively apply the disclosure requirements of *IAS 19R Employee Benefits* relating to the sensitivity analysis. The Group therefore did not need to provide comparative information relating to the sensitivity of the defined benefit obligation to actuarial assumptions.

Reconciliation of equity and comprehensive income as previously reported under SA GAAP to IFRS

The Group elected to apply the exemption to revalue certain items of property, plant and equipment to its fair value of R143,6 million at 1 April 2012. There was no resulting increase in depreciation expense for the year ended 31 March 2013 as the revaluation related mainly to land. The adjustment to the consolidated statement of financial position at 31 March 2013 was therefore the same as at 1 April 2012.

Under IFRS, the Group recognises re-measurements of actuarial gains and losses in other comprehensive income. Under SA GAAP, the Group recognised actuarial gains and losses in profit or loss. There was no impact on the carrying value of the post-retirement medical benefit scheme, nor on total equity recognised and presented.

The effect of the IFRS 1 exemption elected, together with the change in accounting policy, on equity and comprehensive income was as follows:

	GROUP		CSIR	
	31 March 2013	1 April 2012	31 March 2013	1 April 2012
	R'000	R'000	R'000	R'000
Equity				
Equity reported under SA GAAP	633 422	580 158	625 978	577 526
IFRS adjustments increase:				
Revaluation of property, plant and equipment	138 766	138 766	138 766	138 766
Equity as reported under IFRS	772 188	718 924	764 744	716 292

ADDENDUM A:

Interest in subsidiaries

31 March 2015

Consolidated subsidiaries	Country of incorporation	Issued capital	Effective holding		Financial year-end	Interests of the CSIR: Shares at cost less accumulated impairment losses	
		R'000	2015 %	2014 %		2015 R'000	2014 R'000
Direct investments							
Technology Finance Corporation SOC Ltd (Technifin)	South Africa	**5 200**	**100**	100	31 March	**4 650**	4 650
Technovent SOC Ltd	South Africa	**5 000**	**100**	100	31 March	**–**	–
						4 650	4 650

The Group has interests in three dormant companies. Details of these interests are available at the CSIR's registered office.

ADDENDUM A:

Interest in subsidiaries

31 March 2015

Interests of the CSIR				
Net indebtedness less accumulated impairment losses by subsidiaries		Net investment		General nature of business
2015 R'000	2014 R'000	**2015 R'000**	2014 R'000	
–	12 000	**4 650**	16 650	The acquisition and transfer of technology to industry by licensing new inventions, providing finance to develop technology and venture capital for the exploitation thereof.
2 999	4 011	**2 999**	4 011	The company sources technologies and entrepreneurs from the CSIR, other S&T institutions, universities or any developer of technology and develops these into viable businesses with the aim of spinning them off for capital gain and/or public good.
2 999	16 011	**7 649**	20 661	

Abbreviations

2D	Two-dimensional
3D	Three-dimensional
AFIS	Advanced Fire Information System
AIPF	Associated Institutions Pension Fund
AISI	Aerospace Industry Support Initiative
ALC	African Laser Centre
AMD	Acid mine drainage
ARC	Agricultural Research Council
B-BBEE	Broad-based Black Economic Empowerment
CERN	European Organization for Nuclear Research
CHPC	Centre for High Performance Computing
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DFID	Department for International Development
DMR	Department of Mineral Resources
DoH	Department of Health
DST	Department of Science and Technology
EPO	European Patent Office
FCTR	Foreign currency translation reserve
FMPPI	Framework for managing programme performance information
GBP	Great British Pound
GWh	Gigawatt hour
HIV	Human Immunodeficiency Virus
IAS	International Accounting Standards
IASB	International Accounting Standards Board
ICT	Information and Communications Technology
IEE	Industrial Energy Efficiency
IFRIC	International Financial Reporting Interpretations Committee
IFRS	International Financial Reporting Standards
ISC	International Supercomputing Conference
ISO	International Standards Organisation
KRA	Key results area
kWh	Kilowatt-hour
LIDAR	Light Detection and Ranging
mIPTV	Mobile Internet Protocol Television
MMV	Medicines for Malaria Venture
MSc	Master of Science
NCPC-SA	National Cleaner Production Centre of South Africa
NDP	National Development Plan
NERSA	National Energy Regulator of South Africa
NHI	National Health Insurance
NHLS	National Health Laboratory Service
PAA	Public Audit Act
PFMA	Public Finance Management Act
PhD	Doctor of Philosophy
PV	Photovoltaic
PVC	Polyvinyl chloride
R&D	Research and Development
RDI (also RD&I)	Research, Development and Innovation
RIA	Research Impact Area
SA GAAP	South African Statements of Generally Accepted Accounting Practice
SAICA	South African Institute of Chartered Accountants
SAN	South African Navy
SANBio	Southern Africa Network for Biosciences
SANDF	South African National Defence Force
SANParks	South African National Parks
SAR	Synthetic Aperture Radar
SDP	Science Data Processing
SET	Science, engineering and technology
SETI	Science, Engineering and Technology Institution
SKA	Square Kilometre Array
SMME	Small, Medium and Micro Enterprise
SMS	Short message service
SOC	State-owned company
the dti	Department of Trade and Industry
TTS	Text-to-speech
TV	Television
UAV	Unmanned aerial vehicle
UK	United Kingdom
UNIDO	United Nations Industrial Development Organization
USA	United States of America
USD	United States Dollar
UV	Ultraviolet

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