ANNUAL REPORT 2010/11

CSIR

our future through science

CONTENTS

INTRODUCTION
Foreword by the Minister of Science and Technology 02
Chairman's overview 04
CEO's introduction 06

PROJECT HIGHLIGHTS **08**
Built environment 10
Defence and security 18
Energy 26
Health 30
Industry: Advanced manufacturing 36
Industry: Mining 48
Natural environment 52
ICT for society 60

KNOWLEDGE DISSEMINATION **74**
Journal articles 76
Books and book chapters 88
Intellectual property portfolio performance
Patents granted 91
Invention disclosures 91
Technology packages 91

CORPORATE GOVERNANCE **93**
Corporate governance 94
Governance structure 98
CSIR Board members 99
CSIR Board committees 102
Report of the Audit and Risk Committee 105

AUDIT REPORT **106**
Report of the Auditor-General 106

EXECUTIVE REPORT **108**
Executive report 108
Priority areas:
Building and transforming human capital 112
Strengthening the SET base and performing relevant R&D 113
Transferring technology and skilled human capital 116
Financial sustainability, good corporate governance and citizenship 117

ANNUAL FINANCIAL STATEMENTS **123**
Statements of comprehensive income 124
Statements of financial position 125
Statements of changes in equity 126
Statements of cash flows 127
Notes to the Annual Financial Statements 128
Addendum A: Interest in subsidiaries 166

DISCLOSURE OF EXPENDITURE RELATING TO THE 2010 FIFA SOCCER WORLD CUP **168**

ABBREVIATIONS **170**

FOREWORD BY THE MINISTER OF SCIENCE AND TECHNOLOGY

It is my privilege to share some thoughts in the CSIR's Annual Report 2010/11.

The Annual Report provides an opportunity to reflect on the significance of science and technology in South African society – and on the contribution that the CSIR makes in assisting South Africa's transformation into a knowledge-based economy.

My department endeavours to create an enabling environment necessary for the respective science, engineering and technology institutes (SETIs) to make an impact on economic growth and sustainable development for the benefit of the people of South Africa.

As I have stated, my department will continue to devote increased resource and policy support to improve quality, particularly in disciplines and sectors that have the potential to make a contribution to improving our development status, expanding economic growth, and changing the quality of life of individuals and communities.

I am proud of the competence and excellence that exist in our sector. The CSIR is an outstanding example of this. Its research and development

contribution to the pursuit of scientific and technological solutions to meet our nation's challenges is impressive.

In the past financial year, the Department of Science and Technology (DST) has focused on four key areas:

- Creating a strong and responsive institutional framework to support the creation of a vibrant national system of innovation;
- Supporting fundamental research and development in all disciplines while also proactively responding to new opportunities;
- Developing our human resources and using these skills to contribute to economic growth and socio-economic change;
- Using our geographic advantage and international partnerships to build on our local strengths while maximising African and global collaboration.

These areas find further expression and impetus in the objectives and focus areas contained in the DST's ten-year Innovation Plan (2008-2018). I am pleased to observe that the CSIR is strengthening its partnerships with universities, public sector entities and industry researchers on all the grand challenge areas of the Innovation Plan.

Government has prioritised twelve outcomes that we hope will help to mobilise all sections of society. Science, technology and innovation have a vital contribution to make to the attainment of all of these outcomes.

The CSIR's work has relevance to high-priority national goals such as speeding up growth and transforming the economy to create decent work and sustainable livelihoods; building economic and social infrastructure; strengthening the skills and human resource base; and advancing sustainable resource management and use.

I know that the CSIR's work supports many of the other priority outcomes that guide the current government. This includes the development of planning tools for municipalities, such as the Toolkit for Integrated Planning, and various information and communications technology-based projects that support enhanced service delivery such as the Wireless Mesh Networking project.

The DST, primarily through the CSIR, also has a key role to play in the 2010 Industrial Policy Action Plan (IPAP). We have included in the current IPAP a focus on R&D-led industrial development.

On an ongoing basis, the IPAP will be improved and refined and it is vital that we strengthen opportunities for R&D-led industrial development across all the focus areas of the CSIR, from the biosciences to ICTs.

I congratulate the CSIR on its sterling work and am pleased to see it responding to my challenge posed during the recent CSIR Real and Relevant conference: for it to play a more strategic and influential role in R&D in South Africa; and to think beyond individual projects – looking at how to play a more catalytic role in the development of industry sectors that will constitute a strong and vibrant 21st century South African economy. These industry sectors include advanced metals such as titanium; advanced manufacturing technologies such as laser; and support to state-owned enterprises.

I would like to thank the CSIR Board and the executive team for their continued support.

Mrs Naledi Pandor

CHAIRMAN'S OVERVIEW

The CSIR's excellent performance in the 2010/11 financial year – despite the challenging global economic situation – again demonstrated a healthy balance between good science and good business.

As a multidisciplinary organisation and in line with its mandate, the CSIR is tasked with generating new knowledge, applying existing knowledge, developing technologies and leveraging these to make a positive socio-economic impact. As such, it continued to respond to the national priorities relating to skills development, improving the quality of life by world-class research, technology and innovation outputs; and contributing to the overall competitiveness of South Africa.

Research focus enhanced

I have indicated in the CSIR's 2009/2010 Annual Report that a major focus for the organisation would be the adoption of an Impact Assessment Strategic Framework as well as the implementation of its Research Impact Areas (RIAs). I am pleased to report that good progress has been made in this regard.

Engagement with stakeholders and thorough assessment of the organisation's competences resulted in the firming up of its six RIA strategies for the built environment, defence and security, energy, health, industry, and the natural environment (see page 8). The RIAs will ensure closer alignment with stakeholders' needs and a better articulation of the CSIR's value proposition.

The development of the RIAs was guided by the Impact Assessment Strategic Framework developed in 2010 to ensure the optimal impact of the CSIR's research and development (R&D) work. A key feature of the framework is the application of a logic model to design and execute research programmes.

A more visible CSIR

The CSIR executive and I have made a concerted effort over the past year to strengthen the relationships with stakeholders in higher education institutions, government and the public and private sectors. We have had key interactions with partners and potential partners within South Africa, but also in the United States, the United Kingdom, Europe and Australia.

We value the positive relationship with our main shareholder, the Department of Science and Technology, and have regular interactions with the Minister of Science and Technology, Mrs Naledi Pandor – these engagements have been immensely valuable. Her contribution has assisted the CSIR in maintaining focus on key national imperatives, specifically with a view to effect socio-economic impact.

Building on success and good governance

The CSIR applies the same rigour to its governance as it does to its R&D. The organisation is well known for its strong governance framework and ethical leadership. It was, therefore, not a surprise that it again received an unqualified audit report, with complimentary remarks from the office of the Auditor-General with respect to the organisation's financial governance.

Looking forward

Despite global predictions that the 2011/12 financial year will also be economically challenging, the CSIR will continue to provide focus to its high impact research and technologies, backed by an imperative to remain committed to human capital development. This will ask for innovative research and skills management, the optimal leveraging of strategic alliances and continuous

engagement with all its stakeholders. The Impact Assessment Strategic Framework will be used to make the organisation's outputs more visible and its value-add better understood and appreciated.

I thank the CSIR executive and staff for their splendid contribution to the success of the organisation and congratulate them on their ethos that is evident in the organisation's R&D work. I would also like to thank the members of the Board for their judicious support.

Professor Francis Petersen

CEO'S INTRODUCTION

Performance against organisational priorities

It pleases me to report an outstanding performance from the CSIR in 2010/11.

Human capital development (HCD) is critical for the development of science, engineering and technology (SET) solutions of the highest calibre to improve the lives of South Africans. The CSIR has several HCD programmes in place and actively supports the attainment of higher qualifications through further studies. Thus, the number of permanent staff studying towards Master or PhD degrees increased to 226 in 2010/11 and the number of staff with PhDs increased to 299.

Over the years there has been consistent improvement in our demographic profile, with our research base reaching 52.6% black and 33.2% female.

Publication equivalents increased significantly; 576 were achieved during the past financial year. The publication process mirrors the work done at the CSIR where quality, rigour and relevance determine success.

Royalty income reached R8.62 million. The CSIR's research and development (R&D) has created a number of other opportunities for Intellectual Property licensing. Two examples here include a revolutionary technology platform in the biosciences domain, ReSyn™ Biosciences. This offers new miniaturised, high throughput technologies for bio-separation, diagnostics, DNA sequencing and drug discovery, to name a few application areas. The CSIR's laser cladding system, initially developed for Eskom, is a world-first solution for *in situ* sealing of leaks and repairing cracks in vessels under pressure.

Testifying to the relevance and excellence of our work, the value of Contract R&D increased to R1 175.1 million; despite the economic downturn.

The organisation remains one with excellent business processes and governance. We continue our efforts to achieve a B-BBEE Level 2 rating; and after a number of energy saving initiatives, we achieved a 21.4% reduction in energy consumption.

Over the past year, the organisation has also clarified its SET focus and the manner in which this can contribute to some of South Africa's key development challenges – specifically in the areas of job creation and service delivery.

Greater impact with enhanced focus

We are keenly aware that greater impact can be achieved through better focus of the CSIR's R&D portfolio by aligning key areas with South Africa's national priorities.

This enhanced focus has resulted in six research impact areas (RIAs) that are guided by global trends, national challenges, CSIR capabilities and our mandate. The RIAs (*see next section for more information*) include:

- The built environment
- Defence and security
- Energy
- Health
- Industry
- The natural environment.

World-class technology, large scientific infrastructure, scientific computing and the CSIR's cross-cutting competencies support the RIAs.

SET to enable job creation

I endorse Professor Petersen's appreciation of the organisation's commitment to respond to national priorities (*Chairman's overview*). Rather than short-term employment-creation projects, our role is to undertake R&D and technology transfer that will stimulate sustainable industrial activity and job creation in the longer term.

Among others, we work closely with the Department of Trade and Industry (**the dti**) on sector responses to the Industrial Policy Action Plan (IPAP).

The CSIR is also hosting the National Cleaner Production Centre on behalf of **the dti**. The centre contributes to the retention of jobs through improved operational efficiencies and profitability.

The CSIR's implementation unit, Enterprise Creation for Development,

focuses on establishing new developmental enterprises based on CSIR and other technologies.

Further, the CSIR's R&D programmes could lead to the creation of completely new industries; an example here is our R&D in the beneficiation of titanium.

SET to enable service delivery

The CSIR is able to guide and offer solutions to enhance service delivery in the fields of water supply and management; the provision of sanitation, health, education and electricity; the improvement of roads, housing and waste management; and providing access to information.

I am particularly proud of the positive response to our work in the fight against multi-drug- and extensively drug-resistant TB. In this regard, the CSIR has embarked on a project to address the lack of appropriate health infrastructure to prevent cross-infection – a key constraint in the effective treatment and rehabilitation of TB patients and protection of caregivers (read article on page 12).

In another example, to assist authorities and road owners with curbing and preventing the deterioration of road surfaces and repairing potholes, the CSIR compiled technical guidelines on the causes, prevention and repair methods of potholes. These guidelines, made available in December 2010, have been downloaded more than 800 times from December 2010 to March 2011. Training courses on the causes of potholes, their identification and the various repair methods for the different categories of potholes have been held since February 2011 in partnership with the South African Road Federation.

Breaking new ground

Together with our line department, the Department of Science and Technology (**the DST**), the CSIR is braving new research frontiers and amplifying the potential of existing ones. We host the DST's National Centre for Nano-Structured Materials and run DST-funded programmes in synthetic biology. These are emerging areas of research in South Africa.

The CSIR also manages and implements one of the DST's pillars in its cyberinfrastructure strategy, namely the South African National Research Network (SANReN). This high speed and high volume information and communications technology network will greatly benefit researchers and higher education institutions.

In conclusion, let me extend my gratitude for the support and input of our main stakeholder, **the DST** and the Minister of Science and Technology. I would also like to thank my executive and CSIR staff for their contribution to the success of the organisation.

Dr Sibusiso Sibisi

02 PROJECT HIGHLIGHTS

Focused research for increased impact

The CSIR's mandate calls for the improvement of the quality of life of the people of South Africa. Examples of the beneficial effect of CSIR research, development and innovation (RDI) on the economy, society and the environment that we live in, span more than six decades. But, the enormous development challenges facing the country have resulted in a more urgent call than ever before for relevant science to support national priorities.

In a bid to respond to this call and to even further increase the impact of our RDI so that the lives of South Africans can improve sooner – and in greater measures – the organisation set about sharpening its research and development (R&D) focus.

Considerable progress in this regard has been made in the year under review as a result of comprehensive engagement with stakeholders and rigorous assessments of organisational competences. The identified research impact areas (RIAs) and the specific challenges that will be the focus of our research efforts are outlined in the pages that follow.

Without exception, the organisation will continue to combine its multidisciplinary strength in addressing these challenges: a prerequisite for succeeding to conquer the complex challenges of our time.

Nurturing enabling technologies, emerging research areas

To be able to devise the best possible solutions in the RIAs, the CSIR continues to invest in enabling technologies, scientific infrastructure and the competences of people in a multitude of fields.

Nanotechnology, specifically nanostructured materials, is one example of a technology in which the CSIR as well as the Department of Science and Technology, continue to invest. In its first three years, the National Centre for Nano-Structured Materials has made a sizeable contribution to training nanoscientists for the future.

In the same period, a characterisation facility has been established to study nanostructures at an atomic level, which may be used by researchers from around the country. Some of the current work involving nanotechnology includes the development of polymer nanocomposites for smart packaging materials; the development of portable gas sensors for the mining industry; the beneficiation of natural South African nanoclays for use in fire retardant paints to anti-bacterial additives; and the development of specialised nanocomposites for increasing efficiency of photovoltaic cells in solar devices.

Similarly, the CSIR continues to invest in synthetic biology, robotics, photonics and scientific computing.

Improving our planning for impact

In addition to sharpening our research focus, the CSIR also compiled a strategic framework on impact assessment which was approved by the CSIR Board in the year under review. The framework sets out conceptual aspects around defining impact, as well as details on planning, implementing, communicating and assessing impact. In terms of planning for impact, the organisation started using logic models in business plans and in funding decisions during this year.

Featured R&D highlights

R&D projects selected to be featured in this section are at different stages in the innovation cycle: some have already been taken up by the users they were intended for and the 'problem' has been solved, while others are still in the research process, but with a clear vision of the intended impact. We have also attempted to show the scope in the RIAs, from health and the natural environment, to industry and the built environment.

built environment

Infrastructure and associated operations are a prerequisite for economic growth and social development. The built environment is a complex system with numerous elements and a number of external factors influencing it. Factors such as migration and urbanisation – by 2013, 70% of the country's people will be living in cities – contribute to overloaded infrastructure, which in turn demands an increase in service delivery.

In line with the South African government's increased focus on the built environment, the CSIR is putting forward its multidisciplinary capabilities to develop innovations and solutions that will improve the built environment in a sustainable manner. To do this, the organisation will focus on:

- Logistics and infrastructure operations
- Transport infrastructure
- Sustainable human settlements
- Information and communications technology, and sensors
- The built environment as a complex system.

Read about the CSIR's health infrastructure research aimed at reducing the risk of patient-to-patient cross-infection and patient-to-caregiver infection relating to drug-resistant TB. The link between infrastructure and economic welfare is evident in the article on how precise data on waves, tides, currents and winds are needed in the context of safe ports, and how this local skills set has become in demand internationally. A third article summarises other important R&D projects relating to infrastructure – specifically pothole repair; bridge management; immovable asset management; improved road design method; and longer-life roads.

CURBING CROSS-INFECTION OF **DRUG-RESISTANT TB** THROUGH HEALTH INFRASTRUCTURE

In brief

South Africa has insufficient health infrastructure to cope with the growing tuberculosis (TB) epidemic. Extensively drug-resistant (XDR) TB now adds to increasing numbers of multi-drug resistant (MDR) TB patients. The CSIR has set out to address the lack of appropriate infrastructure to address TB infection and cross-infection, a key constraint in the effective treatment and rehabilitation of patients.

The challenge

The sheer number of TB cases in South Africa is a stark reality. The country has the highest incidence rate for TB infection in the world and over 70% of TB patients are co-infected with HIV/Aids. South Africa does not have sufficient health infrastructure to cope with the TB epidemic. This is compounded by the fact that the layout of many of the facilities increases infection with TB.

Drug-resistant TB is a very serious problem in South Africa. MDR-TB can be treated with medication, but at very high costs, while the recovery rate from XDR-TB is very low.

CSIR research

In the country's fight against TB, the CSIR has been instrumental in supporting the design, development and construction of dedicated, long-term accommodation units for drug-resistant TB patients. A key requirement is to reduce the risk of patient-to-patient cross-infection and patient-to-caregiver infection.

This project has received at least R92 million from The Global Fund and more than R115 million from seven provincial Departments of Health with a total of nine newly-designed TB facilities being constructed. In addition to guidelines for design, development and construction, the CSIR also provides technical advice and training to the teams at the hospitals to ensure the successful roll-out of the TB units.

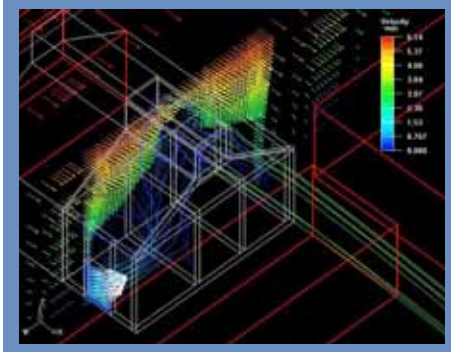
For improved quality of life of long-term drug-resistant TB patients, the CSIR guidelines recommend provision of recreational spaces for sports, visitor areas, physiotherapy facilities, a business hub for patients, and classrooms for younger patients.

CSIR architects and mechanical engineers used computational fluid dynamics (CFD) to study and model the airflow in buildings to improve the design for natural ventilation. For improved TB units at hospitals, the CSIR focused on developing low-cost and low-maintenance, yet fully functional, facilities that will contribute to the prevention and control of airborne TB infection.

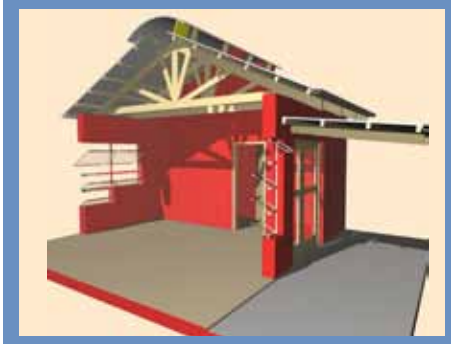
As the implementing agent on behalf of the national Department of Health, the CSIR also provides technical and financial management. Researchers work with the provincial teams, firstly by teaching them about airborne infection control and recommending design ideas. This is followed by a number of working sessions to fine-tune their designs. The CSIR's research includes CFD modelling to test the designs. In this way, the CSIR aims to empower the teams by giving them an understanding of the dynamics of designing to reduce the risk of airborne disease transmission.

Outcomes

An operational TB unit was inaugurated in April 2011 by Deputy President Kgalema Motlanthe. This is a dedicated, long-term accommodation unit for drug-resistant TB-infected patients at the Catherine Booth Hospital in rural KwaZulu-Natal (KZN). Other units are already in use at Manguzi Hospital (also in KZN), Kopano Hospital (Welkom, Free State) and Tshepong Hospital (Klerksdorp, North West).



Computational fluid dynamics modelling by the CSIR, with the image illustrating a typical TB unit ward block showing air flow patterns and velocity vectors.



An exploded view of a typical TB ward block showing materials, construction technology and natural ventilation principles that have been applied.

The other five TB units will be ready to accommodate patients with drug-resistant TB before the end of 2011. These units are at Jose Pearson Hospital (Port Elizabeth, Eastern Cape), Nkqubela Hospital (East London, Eastern Cape), Modimolle Hospital (Limpopo), West End Hospital (Kimberley, Northern Cape), and at Bongani Hospital (Hazyview, Mpumalanga). The KZN Department of Health is building additional long-term accommodation units on other sites, based on the Catherine Booth TB unit.

Getting to grips

Incidence and incidence rate: Terms used with disease and TB are incidence (case load) and incidence rate (rate of spread). Incidence refers to the total number of infections in a population, whereas incidence rate refers to the number of new cases occurring in a population per year, usually expressed as cases per 100 000 per year. South Africa, with an incidence rate of 980/100 000 (WHO 2008), has the highest rate of growth of TB in the world. This is far higher than the average for Africa (about 350/100 000) or incidence rates in other high-burden countries such as China or India. Reducing the number of new TB infections through safer health facilities (as it is an airborne disease) can have a major positive impact.

The Western Cape Department of Health recently contracted the CSIR for support with the development of new MDR-TB accommodation at Brooklyn Chest Hospital.

Based on the R&D of this project, CSIR researchers have delivered numerous invited presentations at national and international conferences, and a number of research articles and reports have been published.

In terms of human capital development, the CSIR conducted awareness and training sessions for the professional teams at each of the nine TB units that form part of The Global Fund project, as well as for the new Brooklyn Chest Hospital project. The professional teams consisted of about 20 people per TB unit. Some provincial training sessions had up to 50 participants per session.

A typical MDR-TB block at Modimolle Hospital.

South Africa has 0.6% of the world's population, while it has 17% of the world's HIV infections and 11% of the world's TB cases.

Deputy President Kgalema Motlanthe opening the dedicated TB ward unit at Catherine Booth Hospital in KwaZulu-Natal. With him is Dr Aaron Motswaledi, Minister of Health.

CSIR ENSURES **SAFER PORTS** LOCALLY AND INTERNATIONALLY

In brief

Safe ports, able to handle increasing volumes of cargo tonnage, require precise data on how infrastructure and vessels are affected by waves, tides, currents and winds in harbour areas. Accurate measurements of these influencing factors and modelling of concomitant infrastructure are vital.

The CSIR's coastal engineering and port infrastructure facilities have gained national and international acclaim due to its track record and excellent results, including precise measurements, especially of waves and ship motions.

The challenge

More than three-quarters of the world's cargo is transported by sea, with ports acting as economic gateways. Ports not only play a vital role in facilitating global trade, they also support the competitiveness of national and regional economies. Port owners must be able not only to meet the immediate demands of their customers, but also invest, both in new facilities for future growth, and in safety measures to safeguard expensive vessels and cargo, communities and the environment.

Eight of the 13 southern African commercial ports are located in South Africa, and handle over 90% of South African international trade. The Transnet National Ports Authority (TNPA) owns and manages the infrastructure of South Africa's commercial ports. Annually, there is an increasing demand for these ports to handle ever greater volumes of cargo, thus requiring constant upgrading and extensions.

CSIR research

In the field of port design and maintenance, the CSIR has developed enhanced methods to track breakwater damage linked to storm events by simulating port designs using small-scale physical models. This leads to optimised maintenance programmes. Data obtained are compared to year-on-year recorded wave information, which is especially important in light of global warming and the increased threat of storms.

Over many years, the CSIR has assisted TNPA port engineers and harbour masters with 48-hour wave forecasts for ports and harbours. The real-time service provided by the CSIR to Transnet includes the monitoring of waves, tides, currents and winds. This is achieved through the WaveNet monitoring system **(http://wavenet.csir.co.za)**, a network of wave stations. The real-time data lead to improvements in the efficient functioning and safety of South African ports.

WaveNet obtains data from, among other sources, 'waverider' buoys, which provide environmental data crucial for forecast purposes. An access link was also established for the South African Weather Service, with data available for its daily forecasts.

In addition to the 'waverider' buoys, WaveNet includes base stations on shore for receiving the incoming wave data, displaying the necessary wave information, and transmitting the relevant data to the central server located at the CSIR Stellenbosch offices.

Physical modelling of infrastructure

In its huge model hall, the CSIR's coastal engineering and port infrastructure group regularly builds 2D and 3D physical scale models of actual or planned harbour breakwaters, entrance channels and ports. Physical scale models offer the best way for researching specific harbour elements. The dynamic processes involved can thus be studied, saving costs by identifying solutions to possible problems before actual construction starts. Numerical model studies can also be calibrated by the use of physical models.

The CSIR team deploying an anti-trawl mooring in the ocean.

The CSIR is regularly commissioned for local projects, such as studies associated with the deepening of the entrance channel at Durban harbour, and extensions to the Port of Cape Town.

International projects

Large projects undertaken for international port authorities account for more than half of this CSIR group's research and development (R&D) contract income. When large R&D projects require physical modelling, the CSIR builds small-scale models to test wave agitation, safety of structures and best efficiencies for safe port operations. Recent initiatives included projects for Abu Dhabi; Qatar; and Australia.

During the past financial year, Australia's Port Hedland project was the most technically challenging one undertaken by the CSIR. The proposed extensions to Port Hedland included an off-shore loading wharf, built in the open ocean. The CSIR undertook numerical and physical modelling, including wave agitation, moored-ship motion and the influence of passing ships.

The Port of Doha, Qatar, was the second biggest project for the CSIR team during 2010. Doha is an inland port, dredged from dry land. Physical modelling conducted for the Port of Doha included studies of wave agitation and breakwater stability.

Following the successes of the CSIR's team with these two international ports, negotiations are already underway between the CSIR and the port authorities of Port Hedland and Doha for further R&D. The proposed expansion of inner harbour facilities for Port Hedland is being discussed. The Port of Doha is looking at commissioning the CSIR to undertake studies relating to a proposed industrial canal to the north of the port.

The CSIR model hall is reckoned to be the fourth biggest facility of its kind in the world. The CSIR has seen significant growth in the specialised field of modelling moored-ship motions, where new software has been developed as well as new measuring techniques. New innovative techniques, using digital imagery, and the size and capability of facilities have helped to keep the CSIR ahead of international competition.
In terms of human capital development, students from Stellenbosch University, which is adjacent to the CSIR's facilities, annually do their practical work and obtain mentoring in the CSIR's coastal engineering and port infrastructure group. These include undergraduate and postgraduate engineering students.

Moored model ships set up in the CSIR's physical model hall in Stellenbosch for studying conditions using the Australian Port Hedland model.

CSIR ASSISTS WITH **IMPROVING INFRASTRUCTURE** FROM PLANNING THROUGH TO MANAGEMENT

In brief

Expanding and improving infrastructure such as roads, rail networks, bridges, ports, airports, buildings and other facilities are a national priority to be achieved without forfeiting environmental sustainability. In addition, the effective operation of infrastructure through proper management is crucial for economic welfare.

The provision of infrastructure and associated operations also stimulate growth by increasing the productive capacity of the economy. Social development can take place only with proper provision of basic amenities such as hospitals, schools and housing, together with infrastructure for electricity supply, water and sanitation.

The CSIR conducts relevant research, development and implementation to maintain, improve and manage existing infrastructure, while also assisting with developing cost-effective new infrastructure with a long design life.

R&D solutions for pothole repair

The increasing occurrence and size of potholes pose a serious danger to road users and result in huge costs incurred for vehicle repair. This is compounded by the lack of proactive, routine road maintenance, combined with rainfall seasons and an increase of heavy vehicles on the country's roads. Further, incorrect 'patching' techniques lead to the repeated repair of potholes and their recurrence in the same areas.

In response to the increasing problem of potholes on South Africa's roads, the CSIR set out to use its R&D expertise to find solutions in this area. Researchers undertook literature studies, combined their expertise in infrastructure engineering and the management of roads, and then conducted field investigations of pothole problems in real-life situations. This led to South Africa's first technical guide on potholes, their causes, identification and repair, being published by the CSIR in December 2010.

The guidelines are aimed at road owners and provincial, municipal and consulting engineers, as well as road maintenance supervisors. The CSIR also produced a short, non-technical publication, aimed at decision makers, on the main causes of typical potholes and ways of limiting their formation.

Training courses based on the technical guide and aimed at provincial, municipal and consulting engineers as well as road owners started in February 2011. More than 800 participants attended the training course during the first five months of it being presented. **(http://www.csir.co.za/pothole_guides)**

Longer-life roads on the cards

In search of longer-life roads, the CSIR and the Southern African Bitumen Association (SABITA) are investigating a cost-effective road materials technology with improved performance. The technology, known as HiMA – high-modulus asphalt – was originally developed by France in the '90s and is used extensively in that country for roads carrying heavy traffic loads.

The use of HiMA for road construction results in roads that last longer and need less maintenance, thus leading to fewer delays for road users. HiMA also decreases the life-cycle costs of roads.

Researchers are developing the technology to suit South African circumstances for use on roads that carry high volumes of traffic. Following extensive research, the CSIR and SABITA have developed preliminary guidelines for the design of South African HiMA mixes and roads containing HiMA layers.

Shear testing of asphalt samples in the CSIR laboratory. Asphalt is a composite material, consisting of graded mineral aggregate (crushed rock) blended with a bituminous binder. It is commonly used in the construction of road surfaces, airport runways and parking lots.

CSIR system leads to well-maintained bridge infrastructure

Bridges are a major infrastructural asset and need to be maintained regularly. The CSIR recommends inspections every five years and a maintenance strategy over a five-year period, based on a priority list of bridges in need of repair.

The CSIR developed the Struman bridge management system (BMS) in collaboration with a local consulting engineering firm. The system comprises customised and regularly updated software, manuals and training programmes for clients, ensuring that qualified engineers who act as bridge inspectors have a consistent approach in rating the condition of bridges.
The advantages of the Struman BMS include that it focuses on actual defects rather than on the overall condition of all bridge elements. Bridges in need of repair are thus prioritised in order of importance.

Locally, the South African National Roads Agency Ltd (SANRAL) has implemented the Struman BMS and the system is used in most provinces. It is also used in Namibia, Botswana, Swaziland, Taiwan and Dubai.

CSIR contributes to better infrastructure management through immovable asset management

With its immovable asset management (IAM) programme, the CSIR provides routine decision-support to infrastructure delivery departments. The aim is to support departments to improve the efficient management of their immovable assets as required by legislation, including the Government Immovable Asset Management Act (GIAMA), 2007 (No 19 of 2007), the Public Finance Management Act, 1999 (No1 of 1999, as amended) and related policy and legislation.

Immovable assets are described as land and any immovable improvement on that land, which have enduring value and consist of various types of assets. These include installed machinery and equipment that are integral parts of immovable assets and cover all state-owned and leased assets.

Recent immovable asset management projects include:

- Performance assessment of all immovable assets for the Department of Arts and Culture (2009 - 2010), Department of Defence (2008 - 2011), Limpopo Department of Health and Social Development (2005 - 2007), Limpopo Department of Education (2007 - 2008), Mpumalanga Department of Health (2008 - 2010)
- Compilation of user asset management plans for various national and provincial departments (2008 - 2011)
- Immovable asset management policy development and valuation of immovable assets for the Free State Department of Public Works (2009)
- Immovable asset management policy development and strategic maintenance planning for the Mpumalanga Department of Public Works, Roads and Transport (2010 - 2011)
- On-going system support and maintenance on the computerised immovable asset management system for the KwaZulu-Natal Department of Public Works.

Improved design and quality of SA roads

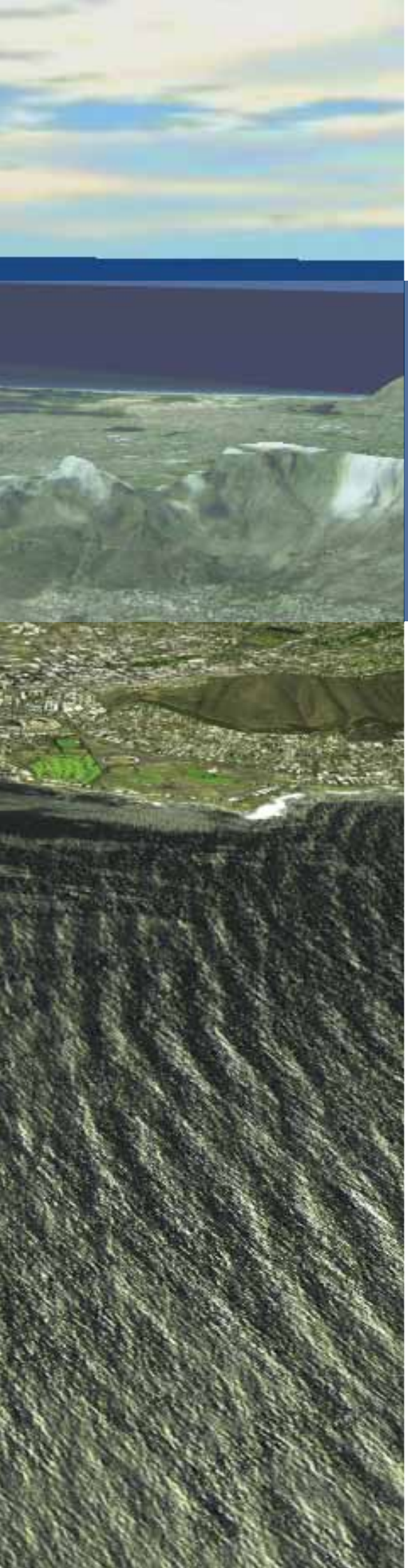
SANRAL has commissioned the CSIR to conduct a comprehensive study to evaluate and update the current South African road pavement design method. Due to increased premature road failures and associated traffic congestion, comprehensive work was required, with a substantial financial investment by both SANRAL and the CSIR.

Important parts of the current road design method were obsolete, needing serious revision and updating. Guideline documents, test protocols and equipment for new design and rehabilitation investigation are being modified based on new information generated through this project.

The new road design method will protect the multibillion-rand investment in the South African transport infrastructure through improving the quality of road design by the local road industry. The new method will facilitate the analysis of the current road network condition and the maintenance process. Roads approaching the end of their design lives can thus be identified timeously, allowing for early, light rehabilitation instead of total (and more costly) reconstruction.

The new method encompasses a web-based software application through membership registration, managed by SANRAL, with technical support from the CSIR. It caters for different levels of expertise and design complexity, covering a broad spectrum of roads ranging from national roads to light structures for rural access and urban mobility.


defence
&
security
(72.87sec)



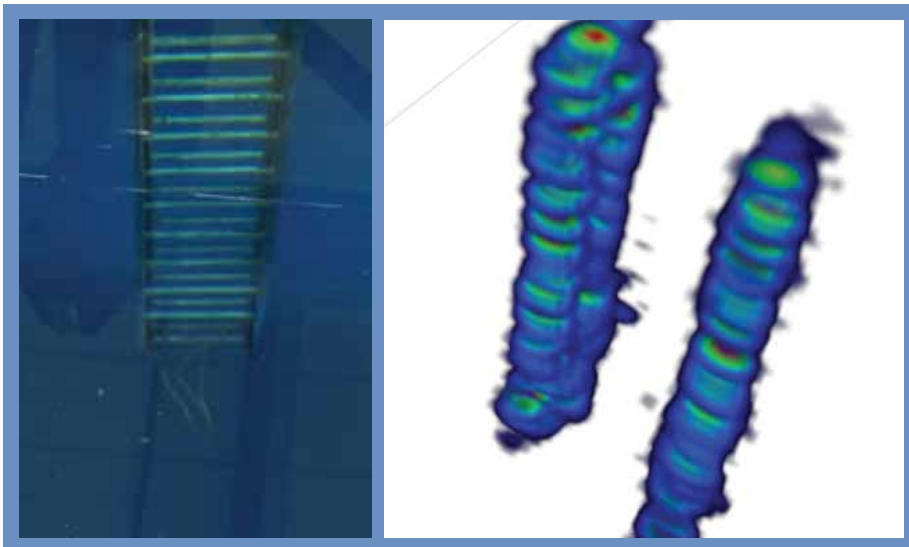
The changing security environment poses significant challenges to R&D. These changes relate to asymmetric warfare, where opponents have completely different capabilities, and to systems warfare, where nodal points in national infrastructure are destroyed. The CSIR believes that it can contribute significantly to the security of South Africa, the region and continent through its science and technology, specifically by focusing on:

- Tactical and strategic situation awareness
- Information security
- Interoperability and standardisation across government departments
- Command, control and coordination

In one example of work in this field, a detection system has been developed to identify threats in South African waters. An example of what is possible in terms of integrating systems is also outlined in the next pages. Also read about CSIR endeavours to merge card readers and biometric fingerprint readers to guarantee secure information and to counter identity theft.

UNDERWATER 3D IMAGING SONAR
FOR PROTECTION OF SOUTH AFRICA'S SHIPPING CORRIDORS

In brief
The CSIR has developed technology that aims to protect the shipping corridors around South African ports, harbours and the coastline for both commercial and naval vessels. The underwater sonar produces world-first images showing detailed feature information, at a level not previously achieved with so few sensor elements.



The ladder (left) in the underwater test facility was scanned by the sonar and resulted in a detailed image (right).

The challenge
Approximately 90% of goods imported into South Africa come by ship. Therefore keeping the shipping corridors and harbours around the country safe from threats is an economical imperative. These threats can take many forms, ranging from the pirates who now roam the coastline of neighbouring Mozambique, to illegal cargo being smuggled underneath the hulls of ships.

Having a comprehensive threat detection system, which is also relatively lightweight and easy to handle, considerably aids the effort of those defending our harbours and ports.

CSIR research
CSIR researchers developed the world's first low element-count three-dimensional (3D) underwater imaging system and built a technology demonstrator that was successfully tested at the underwater test facility of the Institute for Maritime Technology. It is a comprehensive threat detection system that can locate underwater objects in planar imaging (two dimensional), and 3D imaging, as well as detect moving targets.

The system has been shown to produce world-first images with detailed feature information, at a level not previously achieved with so few sensor elements. Conventional imaging systems make use of a two-dimensional planar array of sensors to produce an image of a scene. In the underwater domain the discrete nature of these sensors leads to an extremely high level of complexity and cost.

In a novel approach for the underwater field, the CSIR team developed, over a period of three years, a range of technology building blocks which can achieve the same image using a fraction of the sensors normally required. This should make the system much cheaper than 3D underwater imaging systems currently available and, due to its acoustic properties, of a much higher resolution.

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

The team moved up the system hierarchy levels to develop a set of transducer arrays that exhibit high levels of acoustic performance. Most notable is the achievement of very broad frequency bandwidth transmission levels and specialised signal processing techniques for both the transmit and receive arrays. These aspects alone opened the door for the concept to be developed to its current state of technology readiness. Whereas conventional acoustic transducers have bandwidths close to 20-30 kHz, the team succeeded in realising a ten-fold improvement in bandwidth, producing transmitting transducers with 200 kHz bandwidths.

These broad band transducers were made, not just as single element devices but also as multi-element arrays, making use of the composite sensor material properties to be able to pattern electrodes directly to a monolithic structure. This achieves a reduction in device assembly complexity and greatly improves reliability.

Outputs
The system has been successfully tested in the South African Navy's facilities in Simon's Town under the watchful eye of Armscor and Naval personnel. The achievement of images showing object feature details and the resolving of objects

placed close together far exceed any system currently available internationally and represent an achievement of significant value to the Navy and other entities concerned with viewing the underwater surrounds of important facilities.

The unique outputs have also attracted the attention of several players in the field of underwater security systems, both locally and internationally.

To take the technology from its current demonstrator phase to commercialisation (and personalised adaptation), several different skills and knowledge sets will be working together, which will further increase capacity-building from a human resources point of view.

Further outputs include:

- Two of the researchers on the team will soon be completing their Master's studies based on the system.
- Two papers on the system have been delivered at the Waterside Security Conference in Denmark (2008) and Italy (2010) respectively, with a further three papers based on the technology used in the system also published at international conferences.

Funding and collaboration

The South African Navy acted as both the main funder and collaborator on the development of the technology, with investment also by the CSIR. The research group collaborated with the University of Cape Town's Professor Andrew Wilkinson to develop the concept for a 3D imaging sonar that could be realised with a low sensor element count.

Several international sonar companies in Europe and Asia have shown interest in funding the further development of the system to a commercialisation phase.

Prototype 3D imaging array showing the high acoustic bandwidth transmitter (vertical) and receiver (horizontal) arrays for producing 3D underwater images.

SYSTEMS OF **SYSTEMS INTEGRATION** FOR REAL WORLD, REAL-TIME BATTLEFIELD SCENARIOS

In brief

To demonstrate its ability to integrate complex systems, the CSIR has integrated the Sensors for Electronic Warfare Engagement Simulation (SEWES) with its Digital Radio Frequency Memory (DRFM) and SigmaHat, the organisation's new Radar Cross Section (RCS) prediction tool. Each of these have been in development for some years. Progress over the past year has demonstrated that complex systems can be successfully integrated at minimal cost.

The challenge

To simulate target tracking, real radars are 'tricked' into tracking simulated targets. However, modern radar systems are developed in such a way that they reject non-realistic target representations. Thus the CSIR had the challenge of increasing the realism of the target that is emitted by the hardware-in-the-loop (HWIL) simulator. This can only be achieved by integrating a high fidelity target response (SigmaHat), a proper scenario controller with realistic scenario dynamics (SEWES) and the hardware that can generate such a realistic target return in real time (DRFM), thus drastically improving the accuracy of the simulation

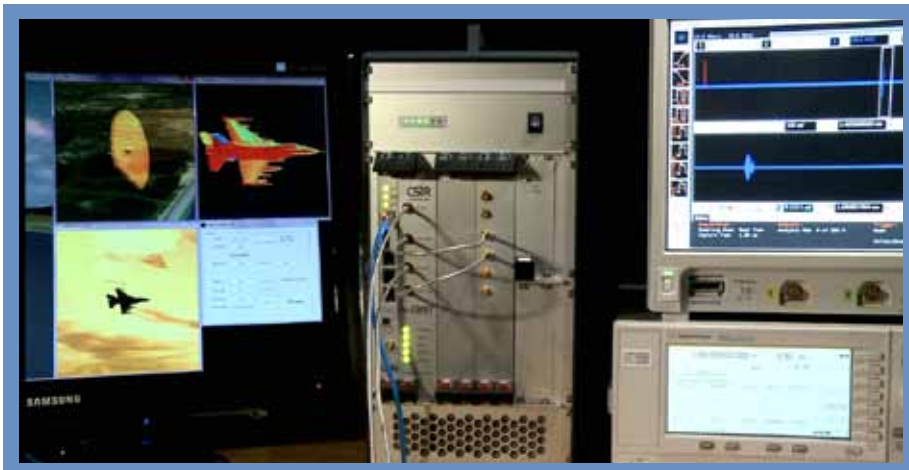
The more realistic scenarios that can be run, the better prepared the armed forces are for any eventuality.

An integrated system can also assist with personnel training as it provides a virtual environment that allows scenarios to be played out in the real world in real time.

CSIR research

During the past financial year, the CSIR completed its integration of SEWES with the DRFM and SigmaHat.

SEWES is a few-on-few electronic warfare simulation environment with the capability



SEWES DRFM- SigmaHat system

of creating, performing and analysing scenarios. This facilitates trade-off studies ranging from algorithm level research to doctrine development and evaluation. It is a scalable simulation that allows for a wide range of platforms and entities, consisting of various sensors or effectors, to engage each other in a simulated realistic virtual environment. Simulated 'what if' scenarios can be displayed, stored and evaluated while the engagement is visualised in 3D. SEWES' innovative architecture allows it to adapt itself to each scenario's unique requirements and to interoperate with other simulators. Naval, air or ground platforms can be selected; each having its own command and control, and from where all interactions between systems are controlled and time-line behaviour observed. It also allows for faster than real-time simulations, making HWIL testing possible. Models can be modified or added as and when new scenarios present themselves.

The user is offered the freedom to import validated real world parameters, be it positional data, RCS, infrared signature or measured antenna patterns. Generated outputs are export-ready and compatible with other applications, such as 3D display and visualisation tools.

SigmaHat is a radar scattering prediction tool for large complex objects. It can provide estimates of the RCS of naval, air or ground platforms. In the integrated setup, platform-profile information from SEWES can be used by SigmaHat to calculate the RCS for all target aspect angles in a profile.

The RCS data are then used to extract dominant scattering points of the platform for each frame in the profile. The parameters of these scattering points are exported to SEWES, which integrates the data into the scenario simulation. SigmaHat's real beam image shows the distribution of the platform's scattered field intensity, indicated as varying colour profiles. SigmaHat is based on innovative calculation techniques, which provide a blend of scale, speed and accuracy, perfectly suited to radar and electronic warfare (EW) applications. The DRFM is the hardware closing the loop with the radar under test that responds in real-time to radar signals. The DRFM records pulses received from the radar system, and then recalls the recorded pulses back towards the radar, which now perceives these pulses as reflections from a target.

Traditionally, DRFMs simulate targets as single point reflections with only one pulse

recalled per target. The latest module simulates targets as a collection of point scatterers. It is essentially multiple DRFMs in one. This DRFM illustrates the depth of the CSIR's expertise in high-speed mixed signal hardware, and firmware and digital signal processing. The integration of the DRFM with two software simulators – SEWES and SigmaHat – provides a high-fidelity HWIL environment for radar and EW research and development, such as target classification and deception jamming.

Outputs

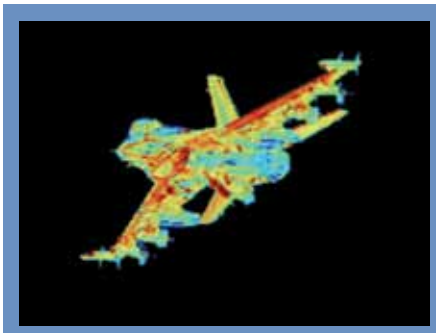
The outputs were:

- A successful demonstration of the integrated hardware and software, which was mobile and could be shown locally and internationally.
- A video to capture the integrative effort, as well as to showcase the three simulators in separation and how they can be combined to form a superior simulator.
- Software and firmware generated to enable integration, both currently and in the future.

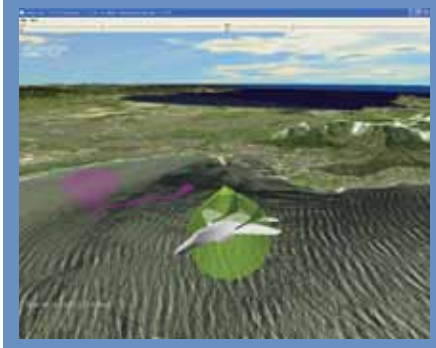
Apart from the knowledge generated, the CSIR team realised that integrating complex systems is possible with minimal resources; the result of such an integration can be a marketable offering.

Getting to grips

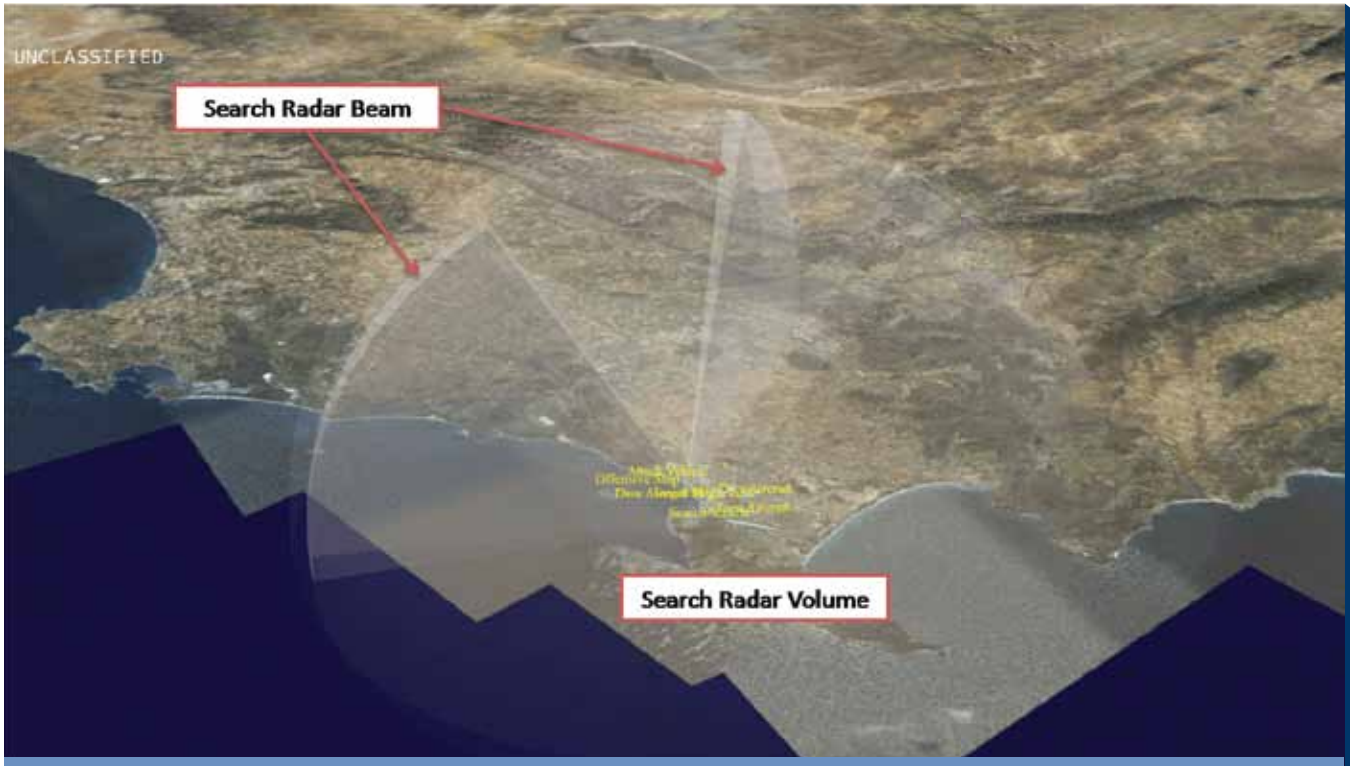
System of systems integration: A method to pursue development, integration, interoperability, and optimisation of systems to enhance performance in future battlefield scenarios *-Pei, R.S., "Systems of Systems Integration (SoSI) - A Smart Way of Acquiring Army C4I2WS Systems," Proceedings of the Summer Computer Simulation Conference, (2000), pp. 574-579.*



SigmaHat real-beam image



SEWES scenario simulation



SEWES scenario simulation

SINGLE DEVICE COMBINES **SMART CARD AND BIOMETRIC CAPABILITIES** FOR SECURE USER AUTHENTICATION

In brief

As piracy and identity theft are committed more frequently, smart card readers have provided enhanced security for businesses and consumers. Manufacturers are developing smart card readers that are highly reliable, compact and provide piracy protection in numerous applications including banking, metering/vending and health. Combined with a fingerprint reader, these gadgets can be used in any form of application requiring high level of trust and security.

The CSIR is looking at intelligent ways of merging both the card reader as well as the biometric fingerprint reader into a single device to provide for unmatched security.

The challenge

In today's complex and ever-changing world, the need for security is paramount. This is especially true when securing and accessing users' personal information, to ensure that only authorised personnel can view or modify private and confidential information.

Therefore, the challenge is to provide a secure smart card reader to enable end-users to address concerns of fraud and identity theft. Currently most smart card readers on the market use Personal Identification Number (PIN) as a means of authenticating users. Although reliable, this technique is no longer considered reliable enough to satisfy security requirements of electronic transactions.

Biometrics is a science which is used to authenticate users based on their unique physiological or behavioural characteristics. No equivalent exists when integrated to a smart card reader as a means of authenticating users.
Another challenge of introducing biometrics into smart card readers revolves around performance issues. The required speed for processing pins is much slower than the speed required for processing biometrics. CSIR researchers are looking into ways of significantly reducing that disparity for the acceptability and competitiveness of the device in the market.

CSIR research

Respectively, smart card and biometric readers are increasingly becoming popular security features for laptop PCs, enabling user authentication, and protecting sensitive information in health care, banking, government and other areas. In this case, the CSIR is looking at intelligent ways of merging both the card reader as well as the biometric fingerprint reader into a single device to provide for unmatched security and authentication for security critical applications.
To meet reliability and security demands, a system of this nature must comply with international standards including Europay MasterCard VISA peripheral component interconnect (PCI) pin entry device (PED). This additional protection eliminates the capability for a hacker to insert a bug on the connector and extract the secret information.

Outputs

Half way through the development of this device, CSIR researchers already have a prototype that can be used for demonstration purposes.

The prototype consists of an electronic circuit board that has been built to demonstrate a communication between a smart card and a host system (a PC in this instance) through a USB or RS232 link. The prototype also features an LCD display and GSM/GPRS/3G communication link that can be used for

communication and data exchange with remote hosts. The security mechanism implemented at this stage comprises a mutual authentication between the reader and the card which removes any possibility of a hacker fooling the system by using counterfeited or manipulated cards.

The group is currently integrating the fingerprint reader solution into the prototype to get the block working as a unit; and the results so far are very promising.

This future technology has huge potential for economic growth. CSIR researchers are set to become the first South Africans to demonstrate a system that incorporate both a smart card and a biometric fingerprint reader.

CSIR researchers Hippolyte Djonon Tsague (left) and Terrence Moabalobelo fine-tuning the smart card reader.


energy

The demand for energy in South Africa is still on the rise; every new home and every new factory need electricity. The challenge of supply is further compounded by the need to drastically reduce the carbon footprint while also reducing the impact on our water resources, as South Africa is a water-scarce country that faces a growing water demand. The CSIR's vision in this respect speaks directly to the challenge of providing technology that will ensure an energy-secure, low-carbon, national economy with a reduced negative impact on water resources. To achieve this, the organisation focuses on:

- High-temperature, concentrating solar power
- Clean coal technology
- Bio-energy
- Batteries and fuel cells
- Decision-support tools

The next two pages feature a project which speaks to the CSIR's vision for the future of energy. Researchers are creating a concentrating solar thermal power station as a small scale research facility. They hope to demonstrate pressurised thermal storage that will allow a gas turbine generator to function when the sun is not shining, and consuming no water in the power cycle.

SOLAR THERMAL RESEARCH FACILITY:
FROM DESIGN TO MODELLING AND EXPERIMENTATION

In brief

The CSIR is in the process of creating a concentrating solar thermal power station as a small scale research facility. Successful, timely completion may result in a world first: pressurised thermal storage that will allow the gas turbine generator to run when the sun is not shining. Further, unlike competing concentrating solar technologies, this plant will consume no water in the power cycle. For some of the components of the solar thermal research facility, existing technologies are customised, while some components have to be designed and built at the CSIR. The systems and their integration are modelled to ensure optimal functioning before verifying results through experiments.

The challenge

South Africa faces numerous energy-related challenges. These challenges are about providing access to electricity to all; securing energy supply in the short and the long term; reducing carbon dioxide emissions; and ensuring that current and future electricity and fuel production does not aggravate water security or availability of arable land. This has led the CSIR to investigate concentrating solar power (CSP). In CSP, sunlight collected over a large area is focused onto a much reduced area using mirror assemblies that move to track the sun. Electrical power is produced when the concentrated light is converted to heat, which drives a heat engine that is connected to an electrical power generator.

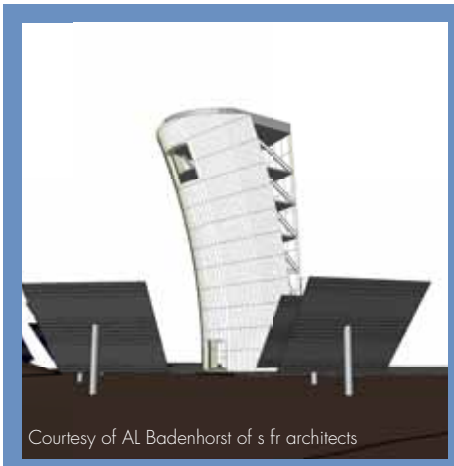
The use of a CSP will mean that South Africa's abundance of sunshine is used, greatly reducing carbon dioxide emissions. The choice of a gas turbine-driven system means no water is used either for cooling or for the power cycle; and that both the infrastructure costs and the cost of the electricity generated is lower than competing steam-turbine driven systems. In addition, the power can be generated from distributed plants, which can be built faster and closer to municipal centres than large centralised power stations. The use of thermal storage allows excess solar heat to be harvested and stored for later use when the sun is not shining (it is cheaper to store heat than it is to store electricity).

In this project the CSIR aims to design and build a solar thermal power station to show how a variable or non-guaranteed resource such as the sun, can provide constant, guaranteed power. Successful, timely completion may result in a world first: pressurised thermal storage that will allow a gas turbine generator to run when the sun is not shining. Thermal storage options exist for steam turbine generators but not for gas turbines.

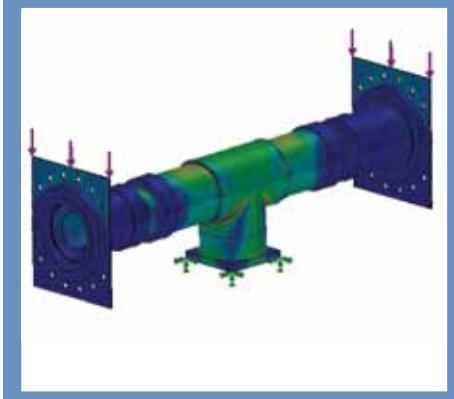
CSIR research

The construction of a solar thermal research facility requires the design and integration of numerous components. A heliostat 'collects' solar radiation, and a heliostat field with numerous heliostats replicates this effect – concentrating it through angling to a single, common receiver. This solar receiver uses concentrated solar flux to raise the gas turbine compressor delivery temperature to 800 - 1000°C. The other components are a gas turbine, modified for solar operation; a tower for the receiver and the turbine; and a high temperature pressurised thermal storage system.

The complexity of multiple systems operating concurrently is the biggest challenge in the execution of the project, and the appropriate application of systems engineering will manage this complexity and will in the end determine whether the system operates optimally and cost-effectively. The team relies heavily on techniques such as sophisticated mathematical modelling and optical ray tracing to ensure that every heliostat is angled and positioned perfectly for every changing moment during the day, and to prevent what is referred to as 'spillage', in other words, the maximum radiation in the focal spot not being 'captured' by the receiver.



A visualisation of the tower of the CSIR concentrating solar research facility.



Predicted load distribution during development of the CSIR heliostat.

It also had to be tested for environmental durability, ensuring that it can withstand hailstones and strong winds. In addition to writing an algorithm to predict wind load for every one of the many positions of the heliostats, another algorithm predicts the sun's positions and the range of movement

required by the heliostat to be optimally positioned at all times. The heliostat design specifies low-cost components and simple systems.

To capitalise on existing knowledge, the German Aerospace Centre, DLR, was called upon to design the layout of the heliostat field. This requires the optimisation of the tower height and the individual positions of the many heliostats in the field to minimise mutual shading and blocking, maximising heat collected throughout the year and minimising the combined heliostat and tower infrastructure costs. Shading of a heliostat occurs when another heliostat, moving to track the sun, obstructs incoming sunlight at some time of the day; by contrast blocking occurs when sunlight reflected by the heliostat is obstructed from reaching the target. The site's contours add another level of complexity. Furthermore, the design must guarantee enough power during sunshine hours to simultaneously drive the gas turbine and to build sufficient heat reserve in the storage system.

A gas turbine capable of running on natural gas (which is used commercially in other parts of the world) was commissioned. Rated at 100kW, the turbine is large enough to behave in a manner representative of much larger gas turbine plants and so prove the concept, yet small enough to greatly reduce the capital outlay for the plant. While the turbine can run on solar and diesel in a hybrid model, CSIR researchers hope to operate the system on solar and biogas from sewage, replacing the diesel. The design of the tower, which houses the thermal storage system and the receiver, is in progress. This design has to heed aspects such as the weight of storage to enable running for several hours when the sun is not shining.

Outputs

While the research is ongoing and the facility is in the design phase, good progress has been made in building expertise required for solar power research, with researchers undergoing training in gas turbine combustion and modelling different solar power technologies. In turn the CSIR shared the knowledge it has generated to date at the SolarPaces 2010 conference, by presenting two papers. Four mechanical engineering Master's students – studying the country's only postgraduate course in Concentrating Solar Power at the University of Stellenbosch – spent time working at the CSIR on CSP topics, gaining experience and helping the CSIR achieve research deliverables.

Funding

All work undertaken to date has been funded through the CSIR's parliamentary grant.

Getting to grips

Heliostat: (from *helios*, the Greek word for sun, and *stat*, as in stationary) is a device that includes a mirror, which turns so as to keep reflecting sunlight toward a predetermined target, compensating for the sun's apparent motions in the sky.

A mini-heliostat was installed to check the tracking and control system. Pointing to where the focal beam that is reflected from this single heliostat is concentrated, is Thomas Roos with students from the universities of Stellenbosch and Johannesburg.


health

For many South Africans, limited access to health care services and suffering caused by diseases such as HIV/Aids and TB are the harsh realities of everyday life. The CSIR is committed to contribute towards changing this dire situation. The organisation's vision is to provide innovative technologies and solutions supporting the reduction of the burden of disease and the transformation of South Africa's health care delivery system in partnership with key stakeholders. The CSIR focuses on the following areas to maximise its impact:

- Prevention of HIV, TB and malaria
- Diagnostics for HIV, TB and malaria
- Treatment of HIV, TB and malaria
- Improvement of the health care delivery system

Aptamer technology is regarded by many as an emerging technology that may play a deciding role in overcoming these diseases. Read about the accumulation of skills and equipment in this domain. Another article focuses on the CSIR's high throughput biology laboratory and its advances in miniaturisation which have led to a powerful tool in the quest for treatment of priority diseases.

APTAMER RESEARCH
TACKLES CONTINENT'S WORST DISEASES

In brief

The CSIR's research in the development of aptamer-based products for the diagnosis, prevention, target drug delivery and treatment of dreaded diseases facing South Africa and the entire continent endorses the maxim that 'the first wealth is health', (Ralph Waldo Emerson). This research is also positioning South Africa to compete successfully within the dynamic knowledge economy and the burgeoning bio-economy.

The challenge

HIV and TB are two major public health challenges facing South Africa. HIV exacerbates the TB epidemic and vice versa. A need therefore exists to interface HIV and TB research programmes and to develop new tools for prevention, diagnosis and treatment of these infectious diseases.

The Department of Science and Technology (DST) has identified the aptamer (synthetic nucleic acid molecules) technology field as one of the emerging research areas in South Africa, which could play a role in expanding the base knowledge creation and develop commercial opportunities. To drive this, the DST has formed a steering committee with members from relevant government departments, science councils, universities, health care and pharmaceutical industries. The steering committee will develop a strategic research agenda for the National Aptamer Technology Platform as well as devise a strategic approach that the DST could follow for developing this area for South Africa.

CSIR research

In response to these health challenges, the CSIR has established a world-class containment level-3 facility with state-of-the-art equipment for HIV and TB research. Furthermore, the CSIR is exploiting aptamers to help solve the HIV and TB health problems facing our nation and the world.

The researcher is incubating *Mycobacterium tuberculosis* solid cultures in a containment level-3 laboratory.

Samples are loaded on a Biacore instrument to measure binding kinetics between HIV-1 gp120 and the aptamer ligand in real time.

Aptamers rival antibodies in function and their applications range from diagnostics; target validation; and targeted drug delivery to therapeutics. In particular, the CSIR is currently exploiting aptamers for targeted delivery of TB and HIV first line drugs; development of novel entry inhibitor drugs against HIV; eradication of cells latently infected with HIV; prevention of mother-to-child transmission of HIV through breast feeding; development of aptamer-based point-of-care TB diagnostics; development of aptamer-based multiplex point-of-care diagnostic kits for HIV and TB; and studying and understanding the pathogenesis of HIV and TB co-infection.

Outputs

Solid skills have been developed in aptamer technology. Some highlights include:

- One PhD and two MSc students have graduated.
- Two MSc and five PhD students are currently doing full time research. Two PhD students will graduate in the 2011 calendar year.
- Two PhD students were seconded to the Harvard School of Public Health, Harvard University, USA.
- One PhD student is currently seconded to the Scripps Research Institute, USA.
- The aptamer technology research

group has hosted and trained six visiting scientists and PhD students from universities over the past three years.

In the past year, researchers have presented their work at seven international conferences in countries including Canada, Italy, South Korea, China and France. Research was published in the following journals: Drug Discovery Today, the Journal of Biological Chemistry, Biochemistry, the Journal of Clinical Pathology, and Antimicrobial Agents and Chemotherapy. The group also holds one patent.

Products under development include:

- Aptamer-based point-of-care TB diagnostic kit
- Aptamer-based microbicide
- Aptamer-based HIV entry inhibitor drugs
- Aptamer-based breastfeeding nipple-cap to inactivate HIV in milk.

Funders

- Department of Science and Technology
- Technology Innovation Agency
- The Bill and Melinda Gates Foundation
- Canadian Grand Challenges
- Fogarty

Collaborators

- University of Pretoria
- University of the Witwatersrand
- University of Johannesburg
- University of KwaZulu-Natal
- Rhodes University
- University of Cape Town and Groote Schuur Hospital
- University of Oxford, UK
- Harvard University, USA
- The Scripps Research Institute, USA
- Los Alamos National Laboratory, USA

Dr Makobetsa Khati specialises in aptamer technology and leads the aptamer technology research group.

MATCHING TREATMENT AND DISEASE:
NOVEL TECHNOLOGY SIGNIFICANTLY INCREASES RESULTS

In brief

Life is complex. Tens of thousands of genes form the blue print for every human cell; two hundred cell types form the thousand billion cells that make up a human being[1]. High throughput biology researchers from the CSIR's Synthetic Biology emerging research area are developing the tools to study life's complexity, thereby increasing our understanding of biology to enable research in infectious chronic diseases.

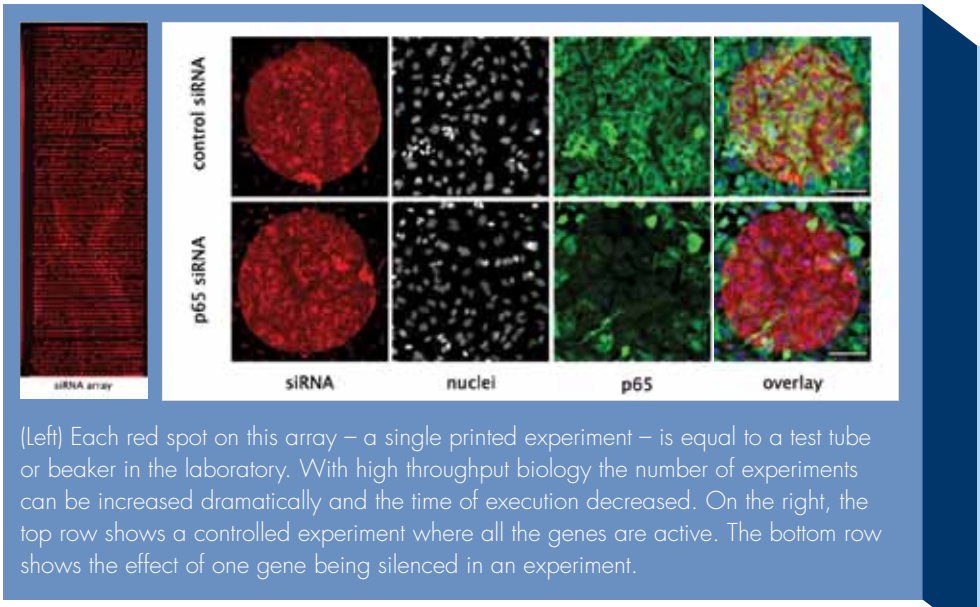
The challenge

Scientists are interested to know how cells work, how they interact with each other and how pathogens interact with them. These interactions form the basis of most diseases afflicting society. Herein lies the challenge: any one of thousands of genes can be involved and cause disease; and a pathogen can very easily find its way into cells. The CSIR's high throughput biology laboratory – one of only 40 in the world – uses cells, microscopes, automisation and miniaturised technology to confront this challenge.

CSIR research

The research begins with the use of microscopy to find and measure how cells work, and how they respond to disease. Imaging cells is one tool to investigate how they respond to change, or to infection. Image analysis allows scientists to convert what they see into numbers, for example automatically measuring how fast cancer cells grow or how HIV infection proceeds.

The high throughput biology team uses gene silencing to manipulate cells. Genes encode for proteins, and these proteins build and maintain cells – and hence human beings. Scientists use chemical probes to interrupt (silence) the flow of one gene into a newly synthesised protein. These probes are called small interfering ribonucleic acids (siRNAs). These are short stretches of RNA that specifically target and silence a single gene when they are introduced into cells. With this very powerful tool, scientists can turn genes off at will and see what happens to the cells. These siRNAs now exist in libraries and collections where a specific reagent exists to silence all the genes in human genome. The CSIR has acquired the first genome-wide human siRNA libraries in Africa.



(Left) Each red spot on this array – a single printed experiment – is equal to a test tube or beaker in the laboratory. With high throughput biology the number of experiments can be increased dramatically and the time of execution decreased. On the right, the top row shows a controlled experiment where all the genes are active. The bottom row shows the effect of one gene being silenced in an experiment.

Increased results in reduced time

Having a library that can turn off any gene in the human genetic portfolio means scientists can screen through them all and see which of them is involved in a particular disease. However, complexity comes at a price. The ability to study twenty thousand genes means many times the number of genes in experiments. This signifies that human beings can no longer do all these experiments. Biologists adopted automation technology and robotics from the pharmaceutical industry to screen all these experiments and now large industrial academic centres worldwide are performing these screens, looking at how pathogens infect cells.

Miniaturisation is used to shrink gene silencing experiments from the macro-scale to the miniature. Each experiment is printed onto a glass wafer, as a spot of gene-silencing chemistry only three hundred millionths of a metre wide. A single printed experiment is shown in the panel, and it recapitulates all the features of a macro-experiment. The next technology used focuses on scaling this up – producing thousands of these experiments printed as arrays on a glass wafer.

Scientists developed technology that takes genome wide screening and repeats it as a mass-produced resource, in a manner similar to that of a normal copy printer.

Outputs

This novel technology, built in the CSIR's high throughput biology laboratory, allows the printing of an entire array of experiments at the same time onto a glass wafer.

Furthermore, the innovative design enables a significant increase in production and decrease in time – a thousand devices can be printed per hour. This is equivalent to more than 3 million experimental sites for every hour that the arrays are being produced. Being able to mass produce

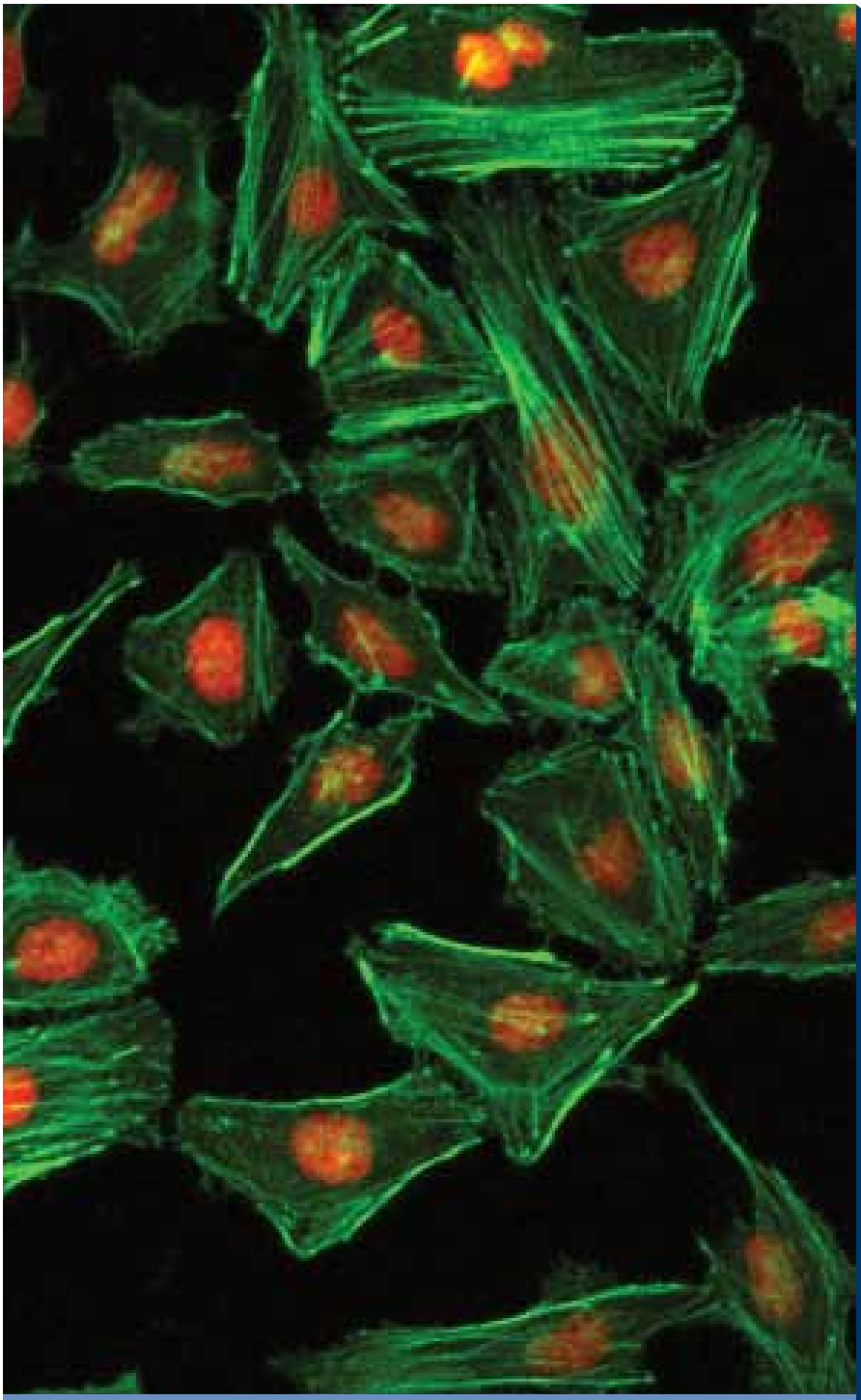
these devices now enables researchers to ask almost any research question of interest; and to use these devices to understand how infection proceeds, and how it can be treated.

The high throughput biology team has used these devices to screen for host pathogen interactions in HIV[2]; trypanosome infection[3] (such as is found in sleeping sickness and Chagas disease); and the most common genetic disease in caucasians, cystic fibrosis[4].

Apart from the technology developed, the team has also built the majority of infrastructure, including clean facilities. Several Master's and PhD students have benefited from their involvement in this novel research that offers great opportunity for improving patient treatment, by matching the treatment to the disease. Commercialising this technology to personalise high throughout biology is the team's long-term focus.

1. Bionumbers. <bionumbers.hms.harvard.edu>
2. Genovesio et al in press
3. Genovesio, A. et al. Visual Genome-Wide RNAi Screening to Identify Human Host Factors Required for Trypanosoma cruzi Infection. PLoS One 6, e19733, doi:10.1371/journal.pone.0019733 (2011).
4. Tsukasa et al in press

The printing head used to print experiments on glass wafers.



Seen here are images of the actin skeleton within cells surrounding the DNA packed nucleus.


industry
advanced
manufacturing

The importance of manufacturing in South Africa is evident from its significant contribution to exports, job creation and its contribution to the gross domestic product (GDP) of the country. The challenges lie in our ability to add value to raw material before exporting; create new manufacturing industries; and improve our competitiveness even in an adverse economic climate. The CSIR envisages contributing to the size, competitiveness and sustainability of the South African manufacturing industry through its focus on:

- Microsystems and manufacturing
- Smart systems
- Advanced materials and composites
- Additive manufacturing
- The establishment of a titanium industry
- The establishment of a bio-manufacturing industry

On the next pages, read about research and development in specific applications of micro-manufacturing; a CSIR-designed laser used by local industry because of its improved efficiency; a South African-developed system that has proven its value in detecting breaks in railway tracks; the creation of an autonomous rover, a vehicle that is capable of navigating autonomously between key points; and progress made in attempts to develop polymer nanoclay composites that will improve the properties of plastic, thus greatly extending its possible uses.

MICRO-MANUFACTURING SHOWS PROMISE FOR COMPETITIVE MANUFACTURING INDUSTRY

In brief

The advancement of micro-manufacturing technology has fuelled the development of microsystems for a wide range of electronic, biomedical and energy applications. The CSIR is working towards building a sustainable micro-manufacturing industry in South Africa.

The challenge

The future competitiveness of South Africa's manufacturing industry depends on its ability to master advanced technologies and to move from raw material-intensive manufacturing towards knowledge-intensive products and services.

Micro-manufacturing is a multidisciplinary field with the potential to act as a technology platform to enable further research, and create greater impact, in many other fields. A typical example of micro-manufacturing would be a microchip used in consumer electronics or computers.

CSIR researchers believe there is tremendous scope for this field to create employment opportunities and provide South Africa with a competitive technological advantage, provided the country invests in the right areas of micro-manufacturing. While industrialised countries are far advanced in the manufacturing of microchips for computing, there are many other applications that could still benefit greatly from the potential of micro-manufacturing.

CSIR research

The CSIR is currently focusing its micro-manufacturing research efforts in four areas:

- Microfluidics for health diagnostics
- Particle manufacture for industrial applications
- Micro cantilevers
- Devices for bacteria detection in water.

Microfluidic diagnostics for health

The CSIR started its microfluidic research group in 2007 and continues to build skills and infrastructure in this domain.

Microfluidic and microsystem-based devices are at the forefront of diagnostic development for resource-poor areas. In most developing countries, one of the pressing health care issues is the need to diagnose diseases quickly, accurately and inexpensively. Being able to do so will significantly impact on the disease burden and quality of life of those diagnosed at an early stage.

However, developing countries also face problems such as lack of reliable electric power, running water, clean laboratories and skilled people. Microfluidic and microsystems-based point-of-care (POC) devices may hold the answer to overcoming these problems.

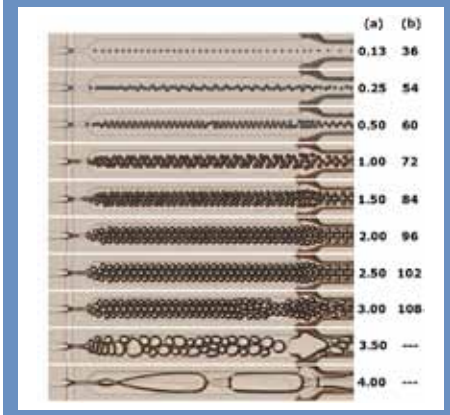
Using microfluidics, CSIR researchers are currently working to develop POC devices that can be used in resource-limited areas for diagnosing common diseases including HIV/Aids, TB and malaria.

Particle manufacture for industrial applications

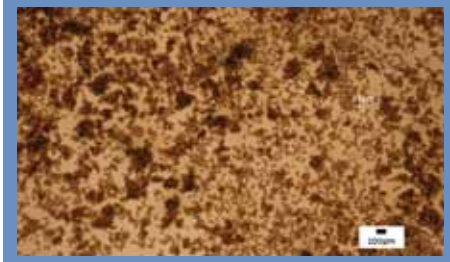
Micro-manufacturing researchers are also actively researching microfluidic droplet applications. Droplets produced in microfluidic devices typically contain picolitre to nanolitre volumes of liquid. Each of these droplets is a micro-reactor, compatible with chemical and biological reagents. In addition, these droplets can be controlled, allowing for precise introduction and mixing of these reagents, which results in decreased reaction times.

Together with the reduction in reagent usage, this allows for high throughput for biomedical research. These devices

Inspecting the quality of a microfluidic mould manufactured in the clean room.



Droplets being generated in a flow focused microfluidic device. The frequency and size (b - um) of the droplets can be precisely controlled by varying the flow rate of the various fluids (a - ul/min).



Monodisperse particles manufactured with a microfluidic device. These particles are beneficial for health-related diagnostic, drug encapsulation and industrial production applications because they are of the same size and shape.

can also be used to create monodisperse particles and gels, which are beneficial for many health-related diagnostic, drug encapsulation and industrial production applications. One of the applications being used to test the droplet platform being developed is the manufacture of highly monodisperse, self-immobilised enzymes.

Microcantilevers

Microcantilevers have captured the attention of international scientific communities and micro-manufacturing industries because of their growing importance in fundamental studies and numerous applications in various branches of science and technology development.

Conventional microcantilevers are made of silicon (Si) and similar hard materials. Polymers are much softer, offer a wide range of spring constants and allow for more deformation than conventional cantilevers. The micro-manufacturing group, together with the CSIR National Centre for Nanostructured Materials are investigating novel polymer materials and manufacturing methods to exploit these advantages.

Devices for bacteria detection in water

The consumption of pathogenic bacteria, such as *E.coli*, leads to various diarrhoeal diseases, resulting in approximately three million deaths annually worldwide. In South Africa, diarrhoea is the third highest cause of death among children under the age of five years (after HIV/Aids and low birth weight).

In view of this, the Micro-manufacturing research group is collaborating with the CSIR Polymers and Composites research group to develop a bacterial detection system which includes bacteria pre-concentration and rapid detection in water. Paper-based microfluidics, a new research direction, has the capability of providing inexpensive, POC diagnostic tools to the market. This is thanks to advantages such as low fabrication costs, low sample and reagent volume requirements, and high portability.

The proposed detection device will be made of specialised paper materials, patterned with flow channels which, through capillary movement, guide the flow of the sample to detection zones that are preloaded with analysis reagents. These reagents will then give rise to either fluorescence or colour changes, providing a visual indication of the presence or absence of the targeted bacteria. Incorporation of electronic readers or calibration charts, etc., gives these devices the potential of becoming semi- to fully-quantitative tests.

Funding and facilities

The Micro-manufacturing group has been established with funding from the CSIR and the Technology Innovation Agency (TIA). A clean room for the manufacture of microfluidic moulds has been built, and this allows for the fast turnaround of designs for testing. In addition, the clean room is also used for the manufacture of polymer-based microcantilevers. Two further laboratories are available for the testing and assembly of these devices. These laboratories are equipped with state-of-the-art microscopes and other analytical equipment.

Getting to grips

Microfluidics: Microfluidics is a multidisciplinary field that deals with the behaviour, control and manipulation of sub-microlitre fluid volumes in a constrained space. A microfluidic system consists of a series of sub-millimetre channels with micro-sized pumps, valves, reservoirs and actuators to control the fluid around a circuit on a microchip. The fluid can be anything from a blood sample to a water droplet. The ability to miniaturise and integrate complex functions, which are normally undertaken in sophisticated laboratories, holds enormous potential for lab-on-chip devices for the health domain.

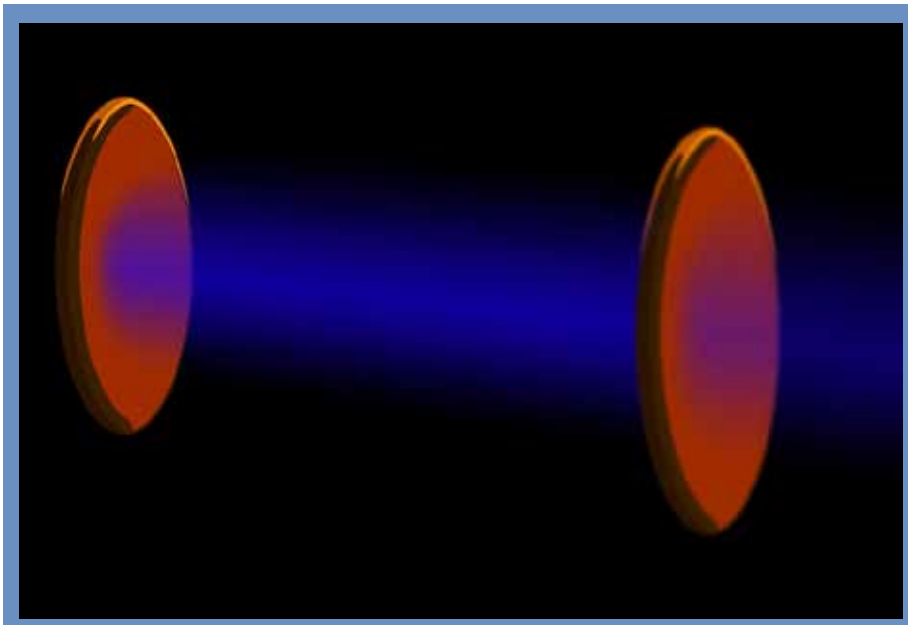
Microcantilever: A microcantilever can act as a physical, chemical or biological sensor by detecting changes in cantilever bending or its vibrational frequency. It can give qualitative as well as quantitative detection capabilities with high sensitivity, low cost, low analyte requirement, non-hazardous procedures and quick sampling, as compared to conventional analytical techniques.

A typical microfluidic mould used for the manufacturing of devices.

CSIR DEVELOPS **HIGH-BRIGHTNESS LASER** TO BENEFIT INDUSTRY

In brief

CSIR research, aimed at developing a more efficient industrial laser, has paid off, with the advantage of making local industry potentially more competitive. Using similar technology to make almost any laser operate in a 'high brightness' mode will result in more efficient lasers for long-range communication systems, and in the military for target designation. The technology may also be used to make lasers smaller and less expensive, by exploiting the extra efficiency to make the support systems work a little less.



Schematic of a laser resonator – the heart of the laser – showing light bouncing between the mirrors before exiting at the right mirror.

The challenge

With lasers one generally has to choose between having lots of energy, and having a 'nice' laser beam. A quality that incorporates both these parameters is the so-called 'brightness' of a laser: high brightness means good laser beam quality and high energy. This is difficult to achieve because good beams tend to come at the expense of energy, while high energy beams are highly distorted and difficult to use in practical applications. So is it possible to have the best of both worlds? This question was posed to the CSIR by a South African company intent on making industrial lasers to compete in the international market.

CSIR research

The CSIR has for several years invested in developing core expertise in shaping light with diffractive optical elements; optics that have feature sizes down to the micrometre scale, and sometimes to the nanometre scale. The idea is that given a laser beam of a particular intensity profile (i.e. how the energy carried by the laser is distributed in space), it is possible to reshape the profile of this laser beam by redistributing the energy.

If this is done correctly, then in principle any laser beam shape can be achieved. The group worked on achieving this same result, but inside a laser, so that the diffractive optical elements are the mirrors of the laser. The idea was that if the mirrors were correctly calculated, and then fabricated, the laser itself would select the best beam for maximum brightness. The shape of the laser beam bouncing around inside the laser was chosen to extract as much energy as possible from the laser, but in a 'good' shape. The idea worked, and the result was a 25 times improvement in the performance of the laser – just with the help of carefully designed micro-structured mirrors.

Outputs

The group reported the work in the literature for the design of novel high brightness lasers, and filed for a PCT patent on some of the concepts. The work was also featured during invited talks at key international conferences.

Outcomes

The research has been taken up by the local photonics industry with a licence agreement signed that sees the technology a permanent part of the product line of export-orientated lasers. With a 25 times improvement in performance with only a change of one mirror in the design, the company can now offer a vastly improved product at very little additional cost. Such transfer of technology is necessary for South Africa to grow its knowledge-based economy.

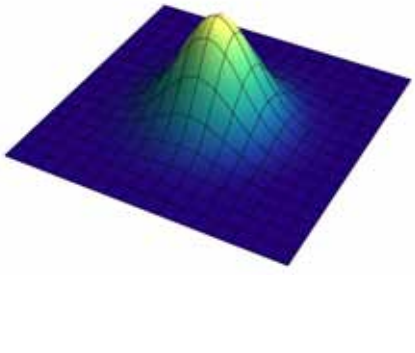


Image of a 'nice' laser beam, i.e. a laser beam of good quality and high energy: a Gaussian-shaped intensity profile.

CSIR laser outreach

Building public understanding of lasers

The Public Understanding of Laser Science and Engineering (PULSE) programme of the CSIR undertakes outreach programmes during which schools are visited by researchers from the CSIR. These visits, and instances when learners visit the CSIR, are aimed at raising laser science awareness. At school level, common laser applications are shown to the pupils, and the main emphasis is on building interest in mathematics and physical science. These outreach activities are adapted to also suit students, educators and communities.

Building research human capital through the CSIR Rental Pool Programme

The CSIR National Laser Centre manages a laser rental pool programme that provides researchers at tertiary education institutions (TEIs) the opportunity of engaging in laser-based research using a collection of state-of-the-art lasers and laser diagnostic equipment. The programme also provides much needed scientific and technical expertise to participating TEIs. The sole purpose of the laser rental pool programme is to develop laser research programmes, specifically within the context of TEIs - where the country's future researchers reside.

Getting to grips

Laser: A laser is a device that controls the way that energised atoms release photons. The word laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers are used in everyday life in, for example, supermarket scanners, laser printers, eye surgery, CD players, laser welding and cutting.

Dr Igor Litvin aligning a laser resonator for customised laser beam shapes.

ULTRASONIC TRANSDUCERS PREVENT DERAILMENTS

In brief

A South African-developed system that can effectively monitor the world's ageing railway infrastructure is drawing international attention. The system has demonstrated an ability to detect breaks in continuously-welded railway tracks and thereby avoid expensive and life-threatening derailments.

The challenge

The world's railway infrastructure is ageing - many rail systems date from the first decade of the 19th century. Consequently, cracks in railway lines that can cause derailments occur more frequently. These derailments cost South Africa's economy around R50 million per incident.

Although several methods are currently employed on railway lines throughout the world to improve the reliability and the timeliness of detecting rail breaks, these are generally labour intensive, and are not always as effective as they might be.

CSIR research

Subcontracted by the Institute of Maritime Technology (IMT), the CSIR developed ultrasonic transducers that form an integral part of an Ultrasonic Broken Rail Detector system. It provides railway operators with the benefit of continuously monitoring rails for breaks without human intervention, contributing to the prevention of costly train derailments.

The system is designed to operate from solar power. It requires little maintenance and is easy to install.

The system is based on the following concept: Ultrasonic waves are transmitted along the rail between transmit and receive 'stations' which are placed alternately along the length of the rail. If the required ultrasonic signals are not received, an alarm is activated indicating a broken rail. The entire rail can be monitored continuously and alerts the railway operator as to where a rail break has occurred.

Custom ultrasound transducer for rail break monitoring, attached to the Sishen-Saldanha heavy freight railway line.

Outputs

To date the research in guided wave ultrasound has produced four journal papers and several conference papers. A student on the project is studying towards an MEng at the University of Pretoria and has one paper in conference proceedings and a second conference presentation. Two Master's students have been supported in their efforts to apply guided wave ultrasound to other industrial applications.

Outcomes

This is a world-first solution; the first and only alternative (to track circuits) broken rail detection system developed, produced and implemented on a large scale. It has been brought to an operational test level by IMT and is installed on sections of Transnet's Coal line (460 km double track, from Ermelo to Richard's Bay) and its heavy-duty iron ore Orex line (860 km, Sishen to Saldanha).

The system's uniqueness and effectiveness have also attracted considerable attention from the international railway community. The system has been tested at the Transport Technology Centre in Colorado, USA; on a test section in Kingston, Canada; on the subways of New York City and Hong Kong; and is currently being tested in Japan.

Various changes have been made to the original design to ensure that the transducers survive in the extremely hostile environment in which they operate.

A research group has been established at the CSIR that investigates the field of guided wave ultrasound. This group has developed unique capabilities for modelling and measuring the transduction and propagation of elastic waves in rails. These capabilities are currently being employed to develop an improved transducer for longer range guided wave

transmission and detection at lower cost. The transducer is being developed to operate on two welded rail lines in South Africa. In addition, the numerical models used are being coded in software and the development procedure is being documented so that transducers for other rail profiles, used internationally, can be easily developed in future.

Impact

During 2010, the system prevented two derailments, saving Transnet (and the South African economy) an estimated R100m. It continues to play a vital role in securing the country's valuable coal and iron ore industries.

International potential

It is estimated that more than 60% of all rail worldwide is suitable for the system. This means that at least a total of 673 500 km is suitable and with a conservative estimate of 1.75 km per unit (a unit in this context is either a receiver or a transmitter) the total global market is estimated to be in the region of 385 000 units.

The team's ultimate goal is to develop a system that can detect cracks in railway lines even before breakages occur.

Funding and collaborators

The Institute of Maritime Technology (IMT) is a major collaborator on the project. While the system's transducers were developed by the CSIR, the rest of the system was developed by the IMT and it is also the implementers of the technology.

The initial development project and the production of the transducers were funded by Transnet through subcontracts via the IMT. CSIR parliamentary grant funding has been used to establish an R&D capability supporting future developments of this technology.

Getting to grips

Piezoelectric ultrasonic transducer: A device that converts an electrical signal into ultrasonic sound waves and vice versa. Piezoelectric materials have the property of changing size when a voltage is applied. Applying an alternating current across them can cause them to oscillate at very high frequencies, thus producing very high frequency (ultrasonic) sound waves.

Smart structure or material: Smart structures and materials can sense changes in their environment and respond to them without human intervention. The sensing and actuation capabilities are linked by some sort of processing, which may be implemented electronically. For instance, sensors that are placed on bridges to monitor vibrations can transmit the information wirelessly, thereby eliminating the need for cabling. However, the sensors' batteries need to be replaced periodically. Ways are now being sought to harvest energy from the bridge's vibrations to recharge the battery so that no maintenance is required.

AUTONOMOUS ROVER
TO 'LEND A HELPING HAND' WITH REPETITIVE TASKS

In brief
The CSIR is developing an autonomous rover, the primary objective of which is to reduce the workload of operators performing repetitive tasks with vehicles. Potential examples include haulage of ore in mines, sowing and harvesting of agricultural crops, and other transport applications. Additionally, tele-operated or remote control vehicles typically require a large degree of concentration to drive, due to the limited sensory information available to the operator. An autonomous rover will be able to reduce the burden of simple tasks while allowing for control to be referred back to the operator in periods of uncertainty.


A panoramic view from the rover, while traveling on the CSIR campus.

The challenge
An autonomous rover is a vehicle capable of independently performing point-to-point navigation tasks without human intervention. This autonomous navigation capability can be applied to reduce the cognitive load for operators controlling vehicles. Activities which can be performed autonomously leave operators free to allocate time to other critical tasks. This can be useful in applications such as search and rescue.

The task of autonomously navigating between two desired points requires several crucial components. The vehicle must be able to plan an optimal path between the points of interest; it requires an accurate estimate of its current position and orientation, and appropriate control inputs must be calculated to guide the vehicle along this path. There should also be an ability to adapt to unforeseen changes in the environment.

The CSIR Mobile Intelligent Autonomous Systems (MIAS) research group – an emerging research area – has undertaken the development of a system that is capable of performing these tasks.

CSIR research
Over the past few years, the MIAS group has conducted research in the field of autonomous vehicles, focusing on aspects such as perception, data fusion, planning and control. With a focus on partial automation of user-operated systems, algorithms were developed to plan paths, estimate position and execute planned trajectories. The system is also capable of identifying scenarios which it might not handle correctly, and refers the more complex task of negotiating these unforeseen circumstances to the operator.

Movement was restricted to roads on the CSIR campus. The path planning problem can be likened to typical in-car navigation systems: simply choosing the shortest route to a destination. By contrast, the tasks of localisation and control are not as simple.

The CSIR autonomous rover uses Global Positioning System (GPS) data to determine its position and orientation, a process collectively defined as localisation. Unfortunately, GPS is subject to a variety of errors including satellite geometry, orbital errors, multipath as well as relativistic and atmospheric effects. To overcome these problems, the MIAS group developed a sensor fusion algorithm to combine inputs from several sensors on the robotic platform, including GPS, as well as a motion model, to estimate the location of the platform robustly.

The group has also produced an arbitrary path-following control algorithm that computes the desired steering and acceleration inputs to the platform's actuators to maintain smooth motion of the platform, while countering any disturbances encountered in everyday driving. Finally, effort was directed towards environmental perception, to identify possible obstructions and take the action necessary to avoid collisions.

Outputs
The culmination of these technologies has led to the CSIR autonomous rover, a vehicle that is capable of navigating autonomously between key points on the example network of the CSIR campus. Special attention was paid to the introduction of safety systems such as collision avoidance.

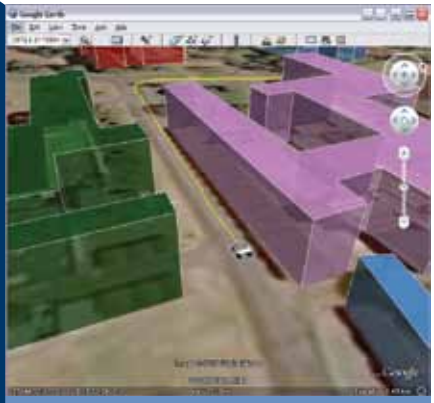
The rover was designed with the ability to switch easily between fully autonomous and tele-operated modes, so that a human operator can take control of the platform at any stage. In addition to being a possible

technology demonstrator, the work has led to a number of publication outputs and has attracted external interest.

MIAS publications arising from this work and related projects have been accepted at international conferences such as the 2010 International Conference on Robotics and Automation (ICRA) and the forthcoming 2011 IFAC World Congress.

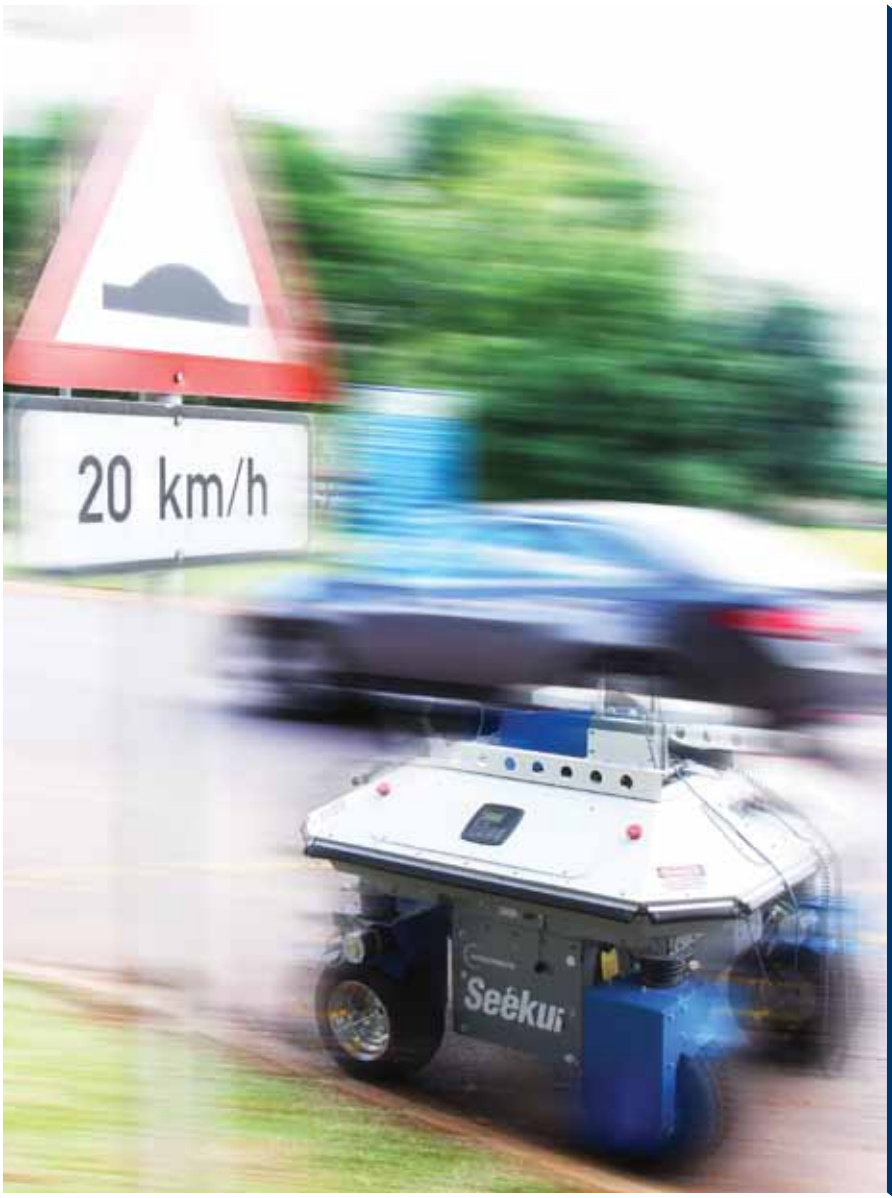
The project was conducted with the primary aim of developing the enabling technologies for an autonomous rover, which can now be used for a number of applications. The work also played an important role in capability building and skills development in the field robotics domain. Robotics is a nascent field in South Africa and one of the project's aims was to promote skills development in the area, a target which has been achieved.

Work conducted on the autonomous rover is being furthered in an autonomous mule project, the aim of which is to create a 'pack-mule' robot which can assist personnel on foot with the transport of equipment. Additional elements involved in the autonomous mule project include the ability to follow pre-defined targets and navigate the rover along routes not previously explored by the robot.



The rover's current location and path history is shown in Google Earth for remote observation.

CSIR Mobile Intelligent Autonomous Systems researchers.



ADVANCED **POLYMER NANOCOMPOSITE RESEARCH** TAKES THE BEND OUT OF PLASTICS

In brief

Plastics have become indispensible in the modern world because of its relative ease of forming components by injection moulding, extrusion and casting as well as its great mechanical properties. New applications in sports, automotive, aeronautic and packaging applications, however, continue to place an increasing demand on researchers to develop new applications and make the plastics stronger, lighter, biodegradable, fire retardant and bio-compatible etc. Internationally the pressure is on to find new ways of achieving these properties in a polymer, and researchers at the CSIR National Centre for Nano-Structured Materials (NCNSM) aim to develop polymer nanoclay composites with some of these advanced properties based on South African nanoclays.

The challenge

The worldwide demand for polymer nanocomposites (PNCs) is increasing rapidly in advanced packaging, automotive, construction, functional membranes, and other applications due to their superior barrier, thermal, mechanical, and other properties. The development of the industry related to PNCs with enhanced features, and the expanding research activities in this field, are some of the factors that will drive the PNC market which has a projected growth rate of 56%.

Even though PNCs show huge industrial potential as next generation smart and advanced composite materials, they have not yet achieved the expected commercial success. Currently, the main stumbling block is the inability to control the nano-level dispersion of the clay particles during large-scale production.

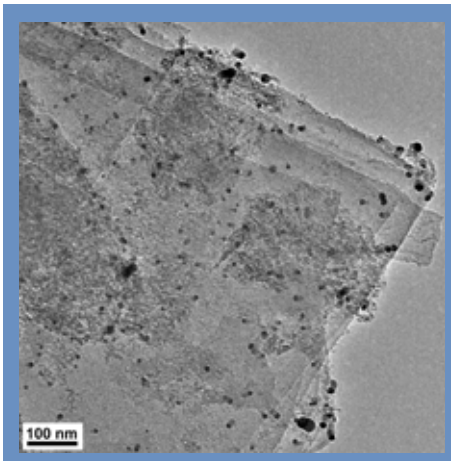
CSIR research

For the preparation of advanced plastics with a balance of properties, it is important to introduce fillers into the polymer matrices. The current use of nano-fillers pushes this strategy to the next level by exploiting the advantages that nanometer-sized particulates offer, compared with conventional fillers, such as huge interfacial area per volume of particles, large number density of particles as well as the particle-particle co-relation arising at low volume fractions. The polymers containing the nano-scale fillers are generally known as PNCs, and play a significant role in one of the most promising 21st century technologies – nanotechnology.

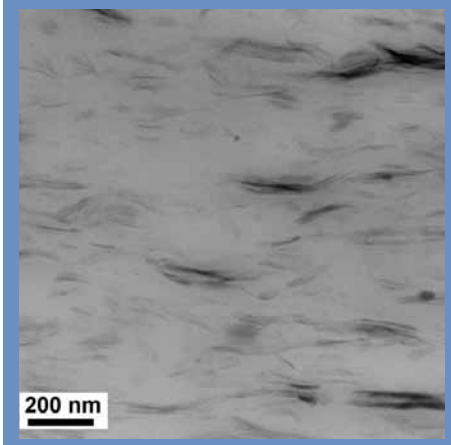
The main ongoing research activities at the NSNSM are focused on applying innovative and smart interfacial chemistry to solve the aggregation of nanoclay platelets into the polymer host during processing. Successful nano-level dispersion will lead to a vast increase in the contact area between the clay platelets and the polymer chains. It is the true nano-effect that results in the improved properties such as increased mechanical strength, stiffness and thermal stability.

One project in the centre aims to develop PNC applications in South Africa. The goal is to develop multifunctional polymer nanoclay composites, based on South African nanoclays and the ingenuity of a good team as well as the expertise of world leading nanocomposites specialist and centre leader Professor Suprakas Sinha Ray, who was ranked among the top 50 chemists in the world by Thomson Reuters during early 2011.

The team is also investigating the dispersion of nanoclay and silver nanoparticles in paints, to make them more durable and smooth as well as antibacterial, all important aspects for its application in hospitals, clinics or in the harsh South African sun. Rather than basing its research on the best imported nanoclays, the Advanced Nanocomposites project team is attempting to find and chemically modify the best natural nanoclays the southern African region has to offer.



A transmission electron microscope image of the corner of a South African clay particle (platelets are clearly visible) decorated with silver nanoparticles (dark dots).



A scanning electron microscope image of nanoclay platelets dispersed in a polymer. Each dark line is a platelet viewed from the side.

Outputs

While more papers are expected in the duration of the project, 20 papers have already seen the light in nanocomposites over the past three years.

One PhD and two MSc students, three interns and two postdoctoral students will work on the project and further expansion is expected. Once more clays have been collected and modified, the project is expected to produce patents.

In collaboration with university research groups, the centre intends using these lower cost nanoclays to develop the nanocomposites industry in South Africa which will create jobs and through products manufactured in the industry, result in benefits to ordinary people. It intends to also produce nanocomposite paints and plastics with unique properties, including anti-bacterial properties based on silver nanoparticles.

An important aspect of the project will be the licensing of the technologies to industry. The excellent characterisation equipment as well as good collaboration with universities and various local and international industries will enable the centre to make this a reality. Contract negotiations with one Indian company and a South African paint producer are the early leads in commercialisation of the nanoclay modification process and nanocomposites production process.

Funding and collaborators

That NCNSM was created in 2007 as part of the implementation of government's National Nanotechnology Strategy. The centre is hosted by the CSIR as one of its emerging research areas, and is co-funded by the Department of Science and Technology. Collaborators are numerous and include local and international universities and scientific institutes.

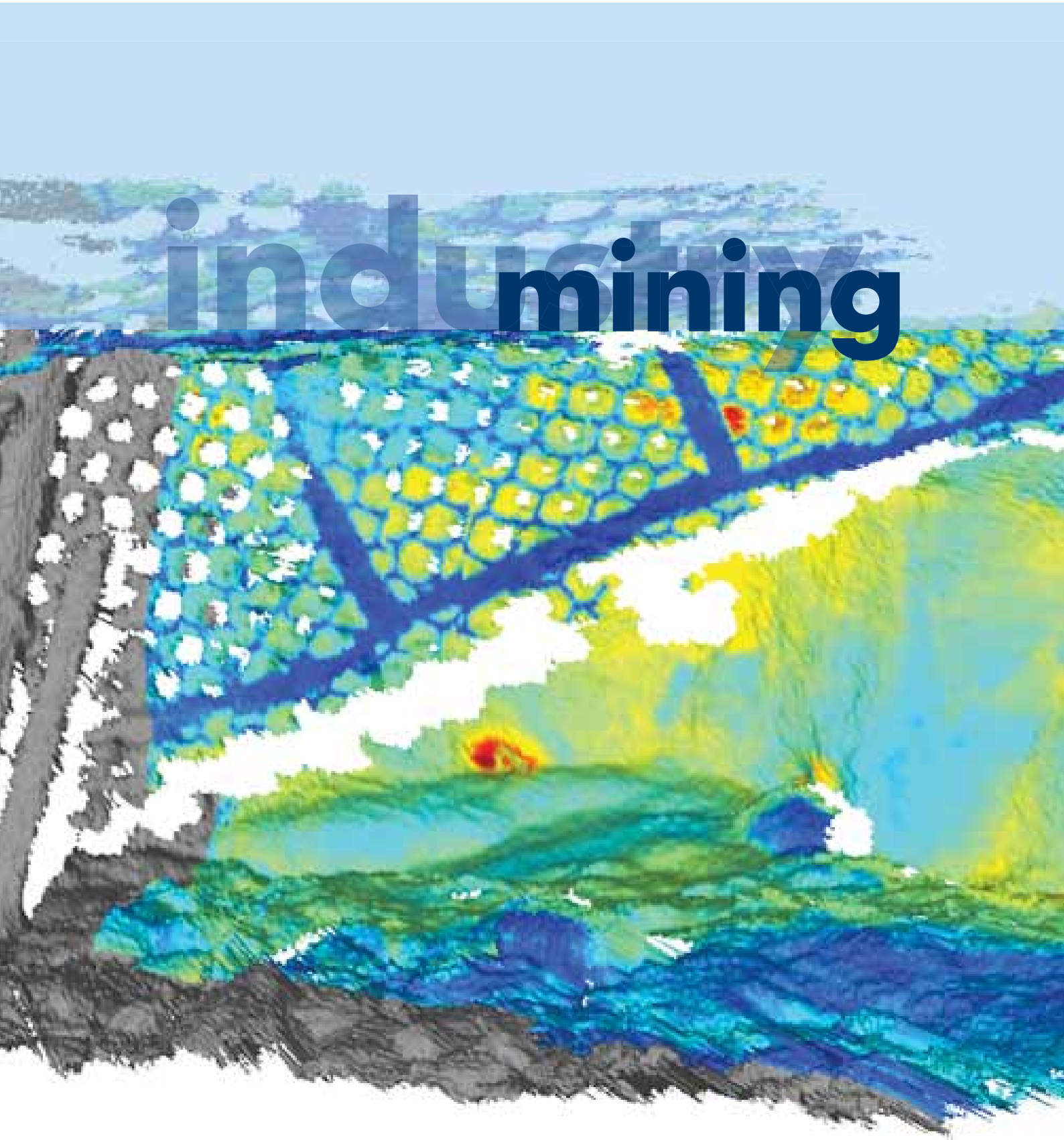
The polymer nanocomposites team are from left (seated) Charity Maepa, (standing) Dr Lucky Sikhwivhilu, Thomas Malwela, Dr Manfred Scriba, Dr Jayita Bandyopadhyay, Innocentia Mashilwane (holding the bucky ball), Dr Sreejarani Pillai, Professor Suprakas Sinha Ray (NCNSM Manager), and Ntombi Mathe (seated, right).

Getting to grips

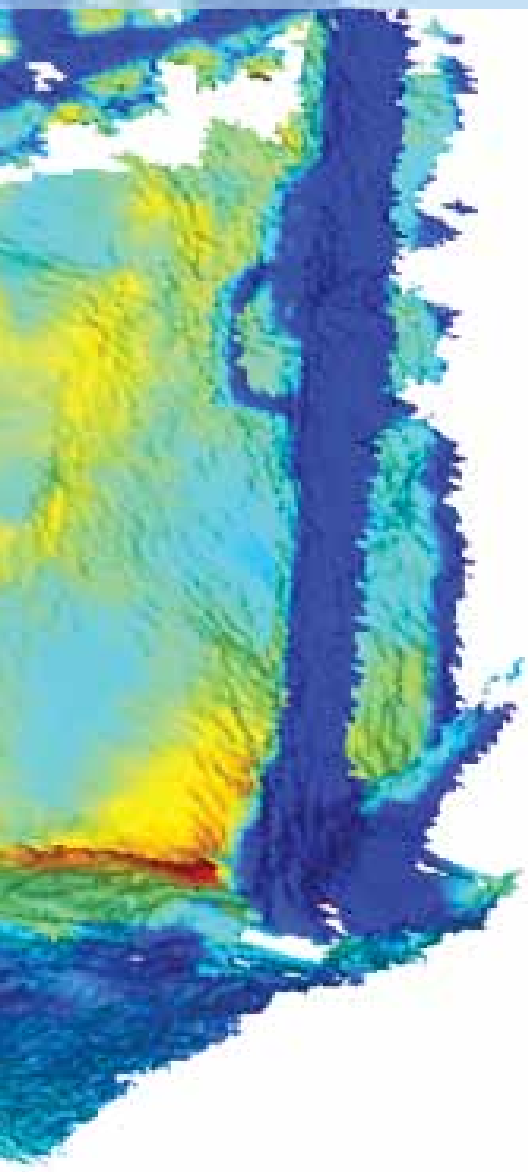
Nanoclay: A very old mineral derived from weathered volcanic ash, comprising 1 nanometer thin mineral plates stacked together like a deck of playing cards, but just about 1 million times smaller. Untreated clay powders are used to bleach beer and wine and to absorb pollutants in water. However, through chemical modification the plates can be pried and kept apart by specific organic molecules called surfactants. When properly dispersed in a polymer (plastic) matrix they show their great potential.

The newly-acquired, industry-scale extruder at the National Centre for Nano-Structured Materials is a machine which is normally used for melting a plastic polymer and then converting it to a certain shape through a process called extrusion. The extruder can be used to mix the polymer with additives or nanostructured materials to prepare a polymer nanocomposite in order to enhance the properties of the polymer such as fire retardance performance.

industry
mining



This visualisation of a mine stope acquired with a CSIR multi-sensor 3D scanner shows a portion of a 3D model of a platinum mine stope face, coloured by rock temperature. These visualisations are helpful in determining areas where a unique combination of temperature and structure indicates an area of potential rock fall risk where remedial action is required to make the area safe.



With its 495 000 workers and R162 billion merchandise exports, the South African mining sector continues to create wealth for the country's people. Its challenges lie in health and safety: Reducing accidents, noise and dust; as well as keeping productivity at an optimum. The CSIR intends to contribute to a sustainable mining industry that is smart, innovative and efficient and that keeps its people safe, thereby extracting maximum value from minerals for the people of South Africa. To do this, the CSIR will focus on:

- Health and safety
- Smart systems
- New mining methods
- Decision-support systems

In the next article, read about the CSIR's contribution to the elimination of silicosis.

SCIENCE AT WORK TO **ENSURE THE HEALTH OF SA'S MINERS**

In brief

Nationally and internationally, silicosis, a lung disease associated with mining activities, has caused major health concerns. In South Africa, the CSIR was appointed to assist the mining industry to reduce and eliminate the dust exposures of their workers by identifying and implementing dust control technologies in the underground work environment.

The challenge

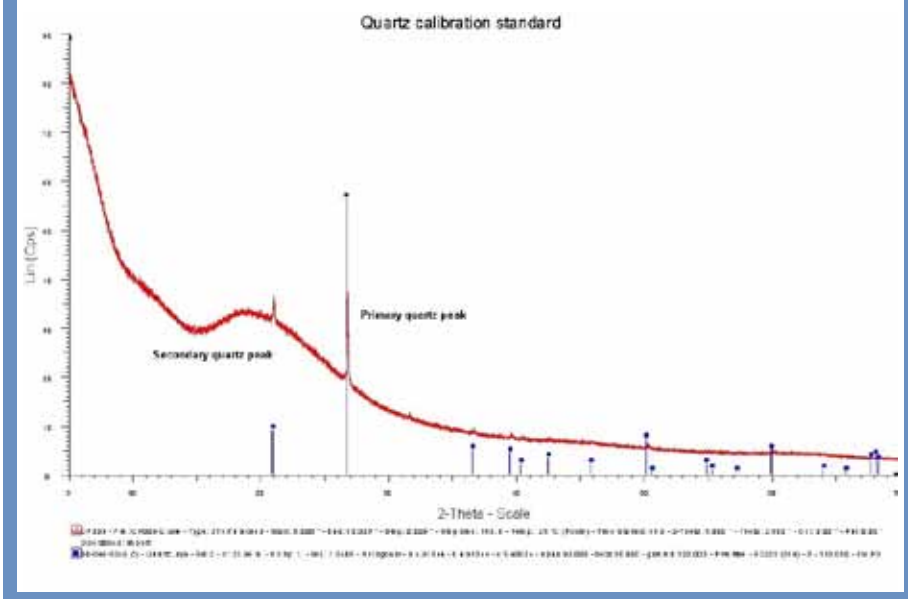
The silicosis problem in South Africa has its origin in the inadequate dust control and high disease rates found in the 'silica industries'. The severity of the disease is determined by the total dose and intensity of dust exposure.

The disease is characterised by the scarring of lung tissue, and consequently, a reduced ability of the lung to exchange oxygen with waste gasses that are produced in the body.

The danger of silicosis as a disease lies in the fact that it is progressive; even after exposure has ceased, deterioration continues. Silicosis also increases the risk of tuberculosis, another serious concern in South Africa.

The Mine Health and Safety Council (MHSC) held a Summit in 2003 where it was decided to address this disabling disease. It called for a reduction of silica dust exposure in accordance with the following milestones:

- By December 2008, 95% of all dust exposure measurement results must be below the occupational exposure limit (OEL) for respirable crystalline silica of 0.1 mg/m^3; and
- After December 2013, using present diagnostic techniques, no new cases of silicosis must occur among previously exposed individuals (i.e. equivalent to a new person entering the industry in 2008).



A typical spectrum obtained from an X-ray diffractometer in measuring quartz in dust.

CSIR research

A Safety in Mines Research Advisory Council silicosis control programme (SIM 03 06 03) study was initiated and awarded to the CSIR to assist the South African mining industry in achieving these milestones.

The focus of the SIM 03 06 03 project was to assist the mining industry to reduce and eliminate the dust exposures of its workers by identifying and implementing dust control technologies in the underground work environment. Primary outputs comprised the following:

- A risk assessment to identify the priority dust sources and the applicable control technologies in underground mines
- Assessment of the filtration efficiency for respirable dust of the current filter media used for dust control
- Compilation of internationally acceptable best practice materials, including manuals, for dust control.

The CSIR project team obtained information on current local and international practices for dust control by visiting selected mines and speaking with dust control experts. The team assessed current dust control practice in developed mining countries and compared this with data from South Africa. Following this, potential dust control methods in identified project mines (gold, coal and longwall coal) were piloted to determine the effectiveness of the controls to lower dust liberation in the mining environment. Work also included a literature review on dust control methods for South African quarries.

Outputs

The following good practice manuals were developed from the study to guide the mining industry to work towards the

elimination of silicosis through dust control practices:

- Operations manual for Data Visualisation Software (DataViz) and Activity Recognition Software (Scorekeeper)
- Manual of good practice for dust sampling protocols for coal mining
- Manual of good practice for dust sampling protocols for gold mining
- Operations manual for laboratory dust filtration efficiency testing
- Operations manual for full-scale operational dust filtration efficiency testing
- Manual of good practice for dust control in quarries.

Getting to grips

Chronic silicosis: The most common form of silicosis brought on by low, but frequent silica dust exposure where the dust contains 18-30% crystalline silica. In this form silica dust accumulates in the lungs and causes fibrotic changes.

Acute silicosis: Appears within a few weeks to two to five years after initial exposure to exceptionally high concentrations of crystalline silica. Characterised by intra-alveolar deposits in the lungs.

Accelerated silicosis: The results of inhaling very high concentrations of silica dust over a relatively short period of about five to ten years. With accelerated silicosis the time from initial exposure to the onset of the disease is a relatively short period and the progression to complicated silicosis is much faster.

Respirable dust: Dust particles of less than 10 microns (µm) in diameter and small enough to enter the gas exchange region of the human lung when inhaled.

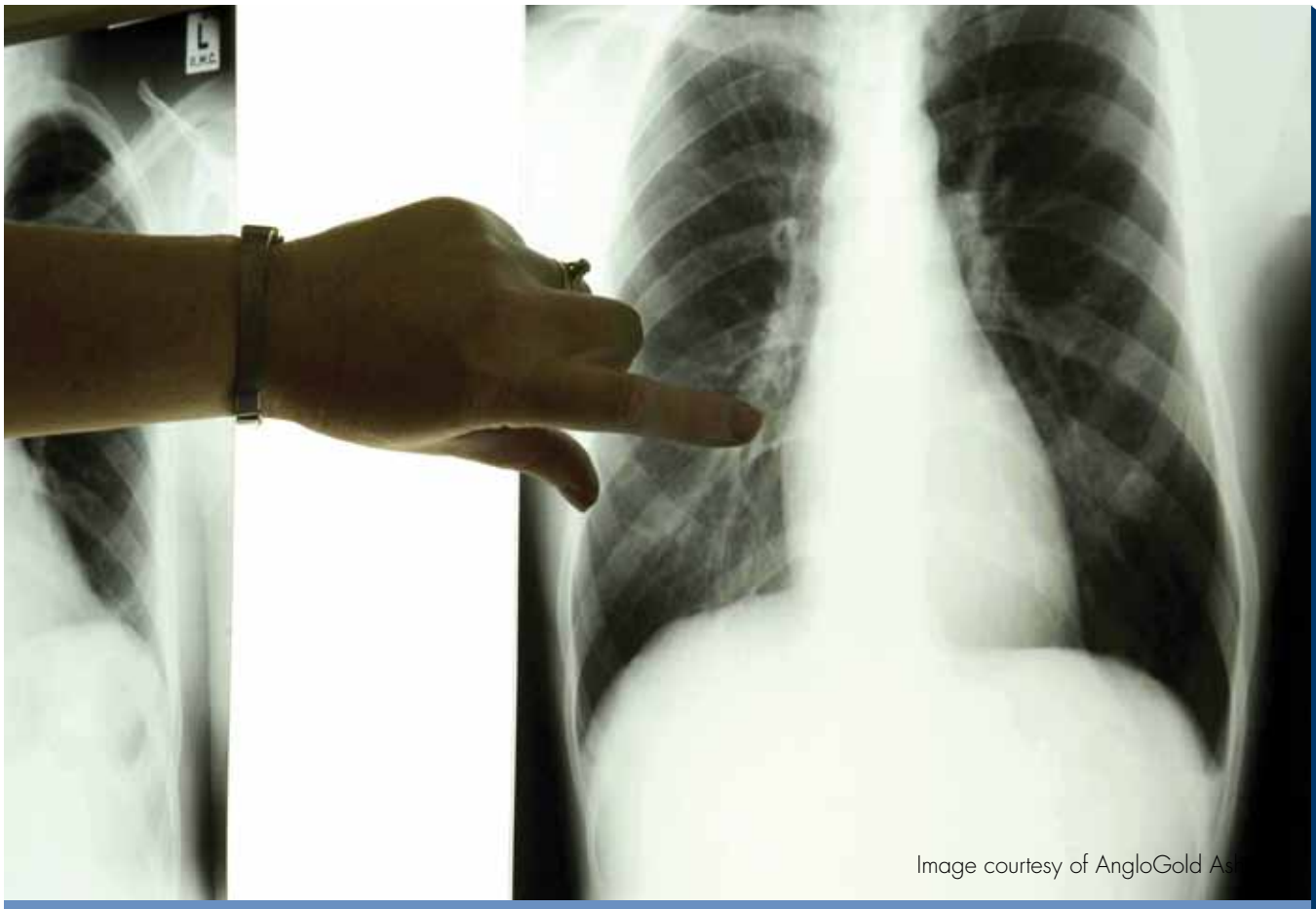


Image courtesy of AngloGold As

The scarred lung tissue of a miner shows the onset of silicosis. The excessive exposure to dust, or silicosis, remains a major cause of premature retirement and death among South African miners. (Department of Mineral Resources Annual Report 2009/10)


natural
environment

The natural environment is both an important source of economic opportunity - agriculture, forestry, fisheries, ecotourism - and an irreplaceable habitat for humans and other species. CSIR research in this domain embraces both of these aspects, and the critical tradeoffs between them. It is about the environment that we live in and use, rather than exclusively about undisturbed nature.

Our research aims to develop innovative R&D platforms to provide strategically-focused environmental solutions in support of a resilient economy. This involves:

- Strategic investment in state-of-the-art platforms for assessing and monitoring the state of the natural resource base
- Apply systems analysis and integrated modelling for complex decision making and resource planning support
- Develop and deploy R&D capabilities in environmental technology and engineering.

Read about the CSIR's work to assist in decision making on aspects around freshwater in South Africa and the development of an atlas to outline priority areas for the country's freshwater ecosystems. Also read about the CSIR's investigation into the threat of acid mine drainage at the Cradle of Humankind World Heritage Site; and about measurement and modelling at the heart of work done to establish a seasonally unbiased estimate of CO_2 ocean-atmosphere fluxes for the Southern Ocean.

NEW FRESHWATER ECOSYSTEM ATLAS SHOWS WHICH RIVERS AND WETLANDS TO KEEP IN A NATURAL CONDITION

In brief

South Africa's freshwater ecosystems are under increasing pressure and cannot all be kept in a good condition. In this project, the CSIR and a number of partners carefully mapped those which should be protected. Experts believe that if the rivers and wetlands that have been identified as priority areas are kept in a good condition, it will help support the sustainability of the entire network of freshwater ecosystems in South Africa.

The challenge

Water is South Africa's lifeblood. It influences the well-being of the country's people and water shortages or a decline in water quality will hamper economic development. Water is intrinsically linked with the ecosystems through which it passes, and deteriorating ecosystems will adversely affect the quantity and quality of water. In recent years, numerous studies have found that more than half of the ecosystems associated with rivers are classified as threatened.

While there is widespread agreement on the importance of sustainable water resource development and freshwater biodiversity conservation as a national priority, the question remains: How many and which rivers and wetlands do we have to maintain in a natural condition to sustain economic and social development and still conserve our freshwater biodiversity? The National Freshwater Ecosystem Priority Areas project (NFEPA) addressed this question.

CSIR research

One of the most important considerations in tackling this challenge was that of cooperation: No single entity is responsible for decisions on freshwater-related matters; progress in managing and conserving freshwater ecosystems is dependent on cooperation.

Many different players were therefore involved, including government departments and their regional and provincial counterparts as well as conservation groups and universities. In addition to the project team and reference group, the project also relied on the participation of well over 150 stakeholders, representing approximately 1000 person years of collective experience in either aquatic science or biodiversity planning.

What makes an area a priority?

The criteria for identifying freshwater priority areas were based on earlier work in which government departments had agreed on a vision for managing and conserving freshwater ecosystems. These criteria were reviewed during regional expert review workshops. The underlying principle is that by conserving habitat, species are conserved, so a representative part of all river, wetland and estuary ecosystems has to be conserved.

Other criteria included:

- Areas where populations of threatened or near-threatened freshwater fish occurred
- Areas that are considered high water yield or high groundwater recharge areas
- Free-flowing rivers, which are rivers that have not been dammed and of which there are very few left globally
- Connectedness, as ecosystems that are connected are most likely to support biodiversity.

Once the criteria had been established, the process of collecting data sets began. The team used the best existing and available data sources. This typically included data from the river health programme, the reserve determination data of the then Department of Water Affairs and Forestry, as well as the ecostatus data for the present ecological status of rivers. These data

Conservation scientist and GIS specialist, Dr Jeanne Nel of the CSIR, pictured in the Upper Berg river with Dean Impson of Cape Nature, one of many contributors in this project.

sets were converted to a spatial format, and taken to freshwater experts in six different regions of the country for review. Refinements were made to these input data and priorities were determined using a conservation planning algorithm that seeks to find the most spatially efficient solution to achieving all the criteria.

These priority areas were then taken to a national review workshop in which the same experts from the different regions, and managers, gathered to review the priority outputs. Refinements, with appropriate reasons, were made to the priority areas to produce Freshwater Ecosystem Priority Areas maps ('FEPA maps') for the 19 different Water Management Areas of South Africa.

Key findings

- Only 35% of the length of SA's mainstem rivers is in a good condition, compared to 57% of the tributaries.
- 57% of river ecosystems and 65% of wetland ecosystems are threatened.
- Only 22% of South Africa's river length has been identified as freshwater ecosystem priority areas and this puts conservation and development aims within reach.

- South Africa has only 62 free-flowing rivers, which constitutes only 4% of our river length.
- The priority areas identified in the atlas protect over 50 fish species that are on the brink of extinction.

Outputs

In the process of creating a strategic intervention that will help South Africa conserve its freshwater ecosystems, numerous products were delivered. The most prominent of these was an atlas which visually summarises the location of areas which should remain in a healthy and well-functioning state.

The atlas contains 19 priority area maps, one for each water management area in South Africa.

Participants at one of six national workshops gave input and reviewed priority areas for freshwater ecosystems.

In addition, the technology package includes a DVD with data and GIS viewer, an implementation manual, and a look-up table listing ecosystem types, species and special features recorded in priority areas. A technical report describing the scientific approach applied to identify priority areas was also produced.

The work has also led to numerous research papers that have been published in reputable international journals. These include Biological Conservation, Freshwater Biology as well as Ecology and Society.

Outcomes

The Department of Water Affairs indicated that it has already used the maps in water resource classification endeavours as well as for ecological reserve determination. The Endangered Wildlife Trust has used the maps as input in defining its priority areas for its relatively new involvement in freshwater conservation through the Healthy Rivers Programme, while Cape Nature says it is using the maps to determine the priorities around invasive plant clearing, and deciding on where alien fish may be stocked.

Funding and collaborators

In addition to CSIR funding through its parliamentary grant, direct financial support was received from the Water Research Commission (WRC), the South African National Biodiversity Institute (SANBI); the Department of Water Affairs (DWA), the Department of Environmental Affairs (DEA) and the World Wide Fund for Nature (WWF). Invaluable in-kind contributions were received from the South African Institute for Aquatic Biodiversity (SAIAB), the South African National Parks (SANParks), and the University of the Witwatersrand (Wits).

ESTABLISHING A **WATER RESOURCES MONITORING PROGRAMME** FOR THE CRADLE OF HUMANKIND

In brief

The Cradle of Humankind World Heritage Site (COH WHS), in one of the world's most important protected karst landscapes, is threatened by acid mine drainage (AMD).

Perceptions of this threat have generated widespread concern since the Cradle houses some of the world's most revered fossil sites, including the famous Sterkfontein Caves. In 2008, the Management Authority of the COH WHS commissioned a study to develop a water resources monitoring programme for the area.

The challenge

The Cradle of Humankind is one of seven World Heritage Sites in South Africa. It has yielded some of the oldest hominin fossils ever found, some dating back as far as 3.5 million years. The fossil record spans more than a third of the total record of human evolution in Africa, and there is informed expectation that further sites and fossils will be unearthed at this location.

In late August 2002, the Western Wits Basin outside Krugersdorp started to decant acid mine water. This was some six years after the last mine to shut down underground mine workings in this basin stopped dewatering its operations. This followed 120 years of mining in the Witwatersrand goldfields.

CSIR research

Led by the CSIR, a multidisciplinary research team investigated the surface water and groundwater resources and their relationship in a study area of nearly 65 000 hectares. The assessment also included an evaluation of the vulnerability of all fourteen fossil sites to water-related threats such as AMD and municipal waste water. Researchers had to understand the interaction between surface water and groundwater; the groundwater levels that define hydrogeologically separated compartments; and monitor the quality of surface and groundwater sources.

Better understanding critical for evaluation

Based on the assessment, researchers built a conceptual model to understand the different pathways where AMD enters, impacts on and leaves the system.

For the first time, we now understand the cave morphology associated with each fossil site. This means that a cave system is classified in relation to its setting in the landscape. For example, a 'near-surface' setting describes a shallow cave system that is mainly exposed on surface, whereas an 'underground' setting describes a cave system that also extends underground, sometimes intersecting the groundwater level. In this project, researchers redefined earlier information regarding groundwater compartments and sub-compartments in the study area. This was established on the basis of new groundwater level data and a clearer understanding of spring localities, since these indicate groundwater flow directions. This means that the geographic extent of contaminated water movement in the groundwater environment will be restricted to the southern part of the Cradle of Humankind, leaving the more remote and natural part unaffected.

It is especially the redefinition of groundwater compartments, and the location of the fossil sites within these compartments, that determined the hydro-vulnerability of each fossil site.

Some findings

The study concluded that nine of the 14 fossil sites are not in any danger of being impacted by contaminated water either from AMD or municipal waste water. This is mainly because the fossil sites are located in groundwater compartments that are unlikely to ever receive contaminated water.

CSIR geohydrologist Phil Hobbs measuring the pH of acidic mine water decanting from abandoned mines in the Western Basin.

The Cradle of Humankind World Heritage Site lies in a karst landscape that was formed over 2300 million years ago. The Cradle, and specifically the Sterkfontein Caves, has yielded some of the oldest hominin fossils ever found, some dating back as far as 3.5 million years.

Apart from Bolt's Cave and the Sterkfontein Caves, all the other fossil sites lie well above the ambient groundwater level.

Fortunately, the water quality in the Sterkfontein Caves has been monitored for the past six years, and its quality has not been adversely impacted yet, despite the cave water level having risen by some three meters.

Among others, the study recommends regular monitoring of both the cave water level and cave water chemistry by tour guides, as well as a more complete water chemistry analysis twice a year. In addition, routine monitoring of the cave-dwelling fauna in the Sterkfontein Caves

is strongly recommended, to serve as an early warning system of impact. The rationale for this is that in the generally food-poor environment of caves, an increase in nutrients typically associated with eutrophication, will also result in a population increase.

Outputs

The study has provided the opportunity to produce a number of technical and popular articles that will disseminate new information on the karst hydrogeology of the COH WHS and the vulnerability of its fossil sites to water-related threats. The data that inform the interaction between AMD and the dolomitic strata into which it flows are still being studied, and these results will also be published in the near future.

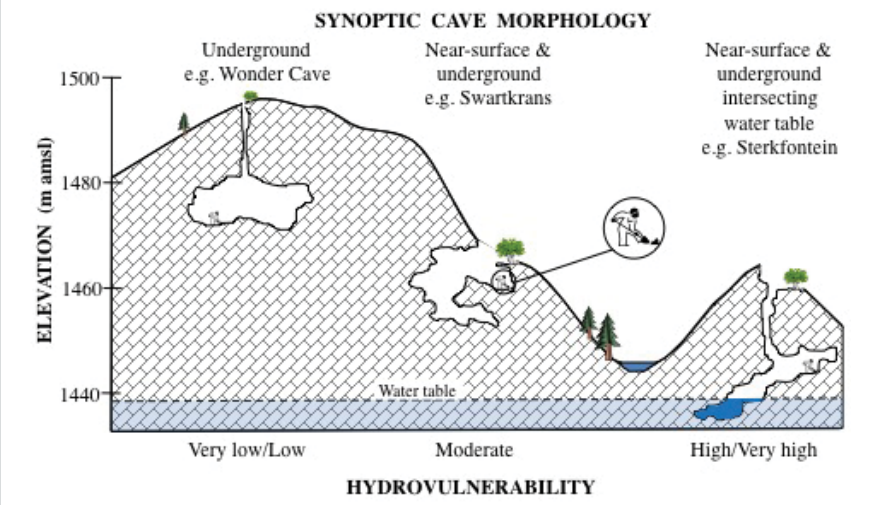
Six junior staff members had the opportunity to get more familiar with field measurement methods including synoptic discharge measurements using a current meter, field water chemistry variable determinations, water sampling procedures and groundwater level measurements.

The beneficiaries included interns and studentship holders, and junior personnel from the Department of Water Affairs.

In addition to research outputs, the principal investigator assisted UNESCO and the Gauteng Management Authority to provide science-based information during dramatic media coverage of the AMD impact and perceived effects on the Cradle. In February 2011 he also addressed the Tourism Summit Programme on the AMD issue as it might impact on tourism as part of Parliament's "Parliament to the People" initiative.

Collaborators

The Department of Water Affairs was an important stakeholder and established 14 new monitoring boreholes in the study area. The Mogale City (Krugersdorp) Local Municipality provided valuable data for the project, as did numerous landowners.



Getting to grips

Karst landscape: A karst landscape is characterised by streams, sinkholes, caves and springs formed over millions of years, among others by naturally acidic infiltrating rainwater that slowly dissolves the calcium-carbonate mineral matrix that forms the limestone or dolomitic strata.

In late August 2002, the Western Wits Basin outside Krugersdorp started to decant acidic mine water, causing wide-spread concern for the potential impact on the fossil sites in the Cradle of Humankind. In 2008, the Management Authority of the Cradle commissioned the CSIR to develop a water resources monitoring programme for the area.

UNDERSTANDING THE ROLE OF **CARBON FLUX** BETWEEN THE ATMOSPHERE, LAND AND SEA

In brief

The Southern Ocean is arguably the most important carbon-climate system on Earth. According to recent estimates, 40% of all CO_2 emitted are stored in the Southern Ocean. Despite this, the Southern Ocean carbon cycle remains little understood and has the potential to weaken the role of the global oceans as a CO_2 sink. How the Southern Ocean carbon cycle will adjust to climate change is a global challenge that could impose further constraints on minimum emissions reduction rates. The CSIR and its partners are working together for a better understanding of the Southern Ocean.

The challenge

South Africa is likely to be particularly vulnerable to global change, given its aridity, highly diverse ecosystems and the high dependence on ecosystem services for water, agriculture, fisheries, forestry, tourism and other land uses. As global change research reveals increasing evidence of climate-linked changes, it is clear that these changes are likely to impact many sectors of South African society.

One of the challenges being addressed in the Department of Science and Technology's (DST) Ten-year Innovation Plan, is science and technology for global change, with a focus on climate change. The challenge has three objectives:

- Enhance scientific understanding of global change
- Develop innovations and technologies to respond to global change
- Understand the social context within which solutions will have to be implemented.

CSIR research

In one of its research programmes, the CSIR leads a multi-institutional initiative to understand the link between climate and the carbon cycle in the Southern Ocean. Understanding the changing carbon fluxes between the atmosphere, land and sea is one of the challenges that scientists must confront if the consequences of political decisions regarding carbon emissions are to be effectively assessed.

The CSIR and its partners in the Southern Ocean Carbon-Climate Observatory (SOCCO) programme participate in the annual cruises to South Africa's bases in Antarctica, Gough and the Prince Edward Islands, enabling researchers to put in place a long-term observational programme. The SOCCO programme focuses research on developing an integrated physical and biogeochemical understanding of the coupled carbon-climate system in the Southern Ocean through measurement and modelling.

Researchers can contribute high-quality data to the global integrated carbon-climate observing network, while at the same time developing skills and future leadership in climate and Earth systems science by including postgraduate students to work with experienced scientists on these cruises.

With the support of DST and South Africa's National Antarctic Programme (SANAP), the SOCCO programme has established several national research and development facilities at the CSIR and its research partners. These include a high precision CO_2 and partial CO_2 measuring facility (CSIR), an ocean bio-optics facility (CSIR), an ocean profiling facility (CSIR and the Department of Environmental Affairs); a high precision nutrient and oxygen measuring facility, as well as an ocean productivity facility (University of Cape Town); and an iron clean analytical experimental facility (University of Stellenbosch).

Dr Thato Mtshali (front) took part in the sampling and measuring of iron during an international research cruise in the South Pacific. Iron is one of the essential micronutrients to phytoplankton and a key role player in our understanding of the role of the oceans in global CO_2 trends. He will employ these newly-acquired skills at the brand new iron chemistry facility at the University of Stellenbosch.

In 2011, observational capabilities at the ocean profiling facility are expanding to include long-range ocean gliders – another first for South Africa.

Outputs

This group of nine researchers has published over thirty research articles in high-impact and prestigious international science journals such as Trends in Ecology and Evolution; Environmental Research Letters; Climate Dynamics; Progress in

Oceanography; Biogeosciences; Global Biogeochemical Cycles; and Geophysical Research Letters.

CSIR researchers in this field are active participants and contributors to international forums that address questions of science of ocean CO_2 and its impact on reducing the rates of CO_2 build-up in the atmosphere. Research group leader and chief oceanographer, Dr Pedro Monteiro, made high-level inputs to OceanObs'09 – an international conference representing the global ocean science community and convened to map research priorities for the next decade. He also sits on the scientific steering group of the International Ocean Carbon Coordination Programme (IOCCP). A significant finding during 2010 was the group's contribution to the understanding of the regional differences in the seasonal variability of Southern Ocean productivity, a key factor in CO_2 fluxes. This shows that differences in the spatial characteristics of productivity are not as closely linked to large scale fronts as previously thought. Rather the Southern Ocean's productivity can be linked to the dynamical character of both seasonal and sub-seasonal variability of the surface mixed layer.

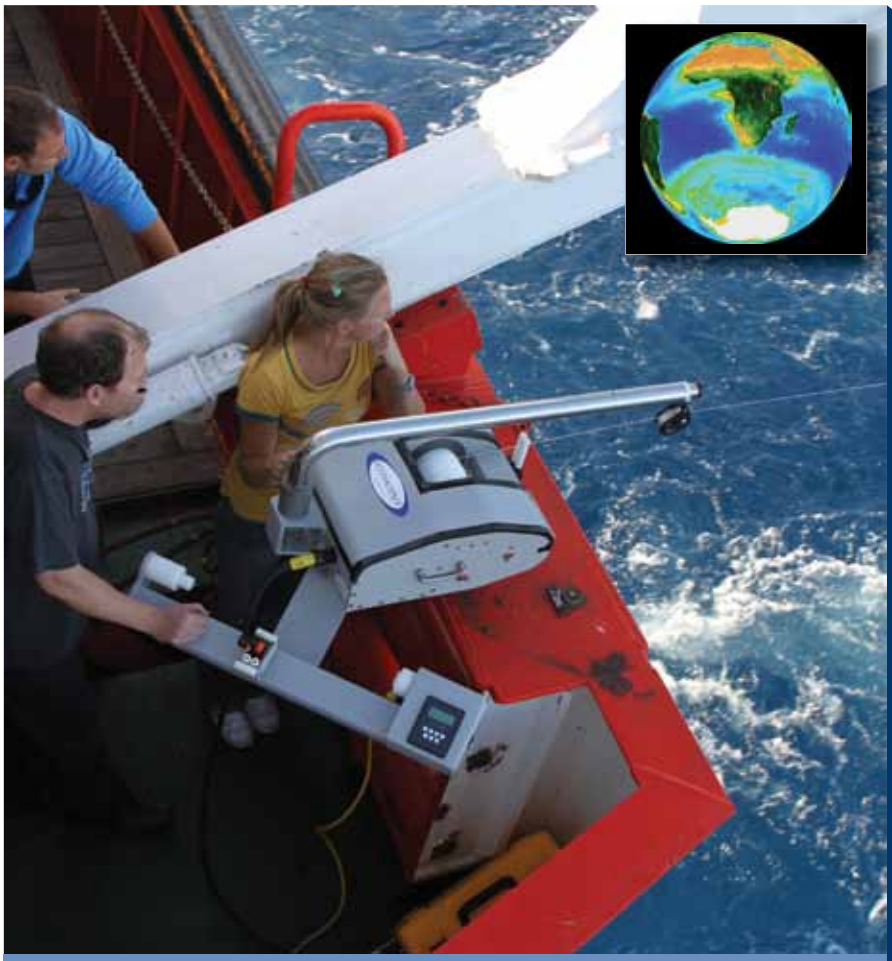
With these improved observational and research facilities, South African researchers can now lead the planning of international experiments as well as collaborate with international partners through such programmes as GEOTRACES – a global experiment to help the science community understand past, present and future cycles of trace metals, and how changes in the environment are impacting on these cycles.

The group has been preparing for South Africa's participation in a planned multi-country international experiment, starting in 2014 and combining both ship and long-range ocean gliders, to improve global understanding of the link between the carbon cycle and climate in the Southern Ocean. As part of this initiative, the CSIR convened and hosted an international expert workshop in August 2010.

Funding and collaborators

Through the CSIR, the DST funded the modernisation of the physics and biogeochemical observational capability of the SA Agulhas, South Africa's polar research vessel since 1977. This project has now been extended to fund a new polar research ship as well as a number of new national facilities that provide advanced scientific and engineering training and research capabilities.

Local and international research partners are the universities of Cape Town, Western Cape and Stellenbosch; the Department of Environmental Affairs; the South African Weather Service and the South African National Antarctic Programme. Key international partners are the Bjerknes Centre for Climate Research at the University of Bergen, Norway, and Princeton University in the United States.



Researchers on board the SA Agulhas – South Africa's polar research vessel – monitor the equipment used to measure underway conductivity, temperature and depth during the annual trip to Antarctica.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ict

The CSIR's work in information and communications technology (ICT) research and development takes its cue from the concept of the information society. Our vision is to contribute to South Africa's development towards an advanced information society in which everyone can benefit from their enhanced ability to create, manipulate, organise, transmit, store and act on information.

Advances in ICT, brought about by research and experimental development, are worthy of pursuit both in terms of enabling impact in areas such as health, energy and the environment, and as an area of impact in itself.

The CSIR's research and development focuses specifically on:

- Integrative systems, platforms and technologies
- Networks and media
- Cyberinfrastructure
- Earth observation science and information technology
- Human language technologies and knowledge technologies

In this section, find out how CSIR researchers hope to contribute to making the Internet of Things work for South Africans; how research is making a contribution to providing affordable broadband connectivity to under-serviced rural communities; the status of a sustainable national cyberinfrastructure system for research, development and innovation across the entire national system of innovation; and what advances are being made in harnessing the massive amount of Earth observation data. Also read about a project in which ICT has been used to benefit several sporting codes.

INTERNET OF THINGS

In brief

Relatively new in South Africa, the Internet of Things is a worldwide trend that enables integrated solutions incorporating the physical world, cyberspace and humans. It makes possible, for example, a world in which energy demands are optimised, the load managed and controlled through the intelligent control of appliances, utilities and devices, or where the devices at home could make sense of weather predictions and pre-emptively change settings on 'things' to make houses more comfortable.

The CSIR is researching various applications and technologies to make the Internet of Things work for South Africans.

The Internet of Things team, led by Dr Louis Coetzee (second from right): Andrew Smith, Sizakele Mathaba, Laurie Butgereit, Promise Mvelase, Guillaume Olivrin and Dr Nomusa Dlodlo.

The challenge

Access to information for enhanced decision making has become a priority in today's world. Accurate information in real time is needed by individuals, industry and governments for effective and responsible use of resources, and improved planning and execution of activities.

More and more devices and physical objects are being connected to the Internet. Each is creating volumes of data; when processed, the data can be used by decision makers.

Appropriate actions impacting on the environment can be executed once the information received from the many heterogeneous elements has been processed.

CSIR research

The Internet of Things posits a world where all devices and physical entities are connected to the Internet, creating a network of unprecedented scale, each device or physical entity with its own Internet Protocol number, each with its own published set of 'services', based on the physical attributes and virtual 'personality', allowing people and other devices to interact with the physical world through cyberspace.

These objects are identifiable in terms of status, geo-location and ability – an expanded Internet to which services and intelligence are added. As these objects will be connected in both a sensory and intelligent manner, masses of data are intelligently processed.

The CSIR is researching various applications, such as the technology required to optimise and balance energy consumption in a 'smart city'. This involves a fusion of research trends – distributed intelligence, statistical analysis and interoperability mechanisms for heterogeneous devices and cloud computing.

Unsolved issues in the context of the Internet of Things phenomenon are the rights of individuals, governance and trust. In addition, many technological platforms and solutions make up the Internet of Things. Ensuring interoperability through appropriate standardisation is a high priority. The envisioned scale and complexity introduced by the large number of participating elements is an enormous challenge. It raises questions such as how the robustness of solutions can be ensured. Internet of Things solutions and applications will face a data deluge; researchers will have to consider how the data from billions of things will be processed, stored and maintained for future generations.

Outputs

The Internet of Things concept has been demonstrated in domains such as logistics, transport and asset tracking, smart environments, health, energy, defence and agriculture.

Research at the CSIR has shown the success of smaller, vertical solutions, such as finding and identifying misplaced objects or using quick response (QR) codes for tree identification. This was done in the context of a code-sprints training programme for five students.

The research has been documented in papers and conference presentations, such as the presentation, *Linking the Internet of Things to Social Media: A Look at the Vaal Dam*, at the zawww2011 conference. Two other recent papers include contributions to the IST-Africa 2011 conference proceedings.

Outcomes

A project with the Department of Water Affairs (DWA) has demonstrated the viability of communicating important information on water levels of three South African dams (Vaal, Bloemhof and Van der Kloof) by using the Internet of Things concepts. Information is retrieved from the DWA website and posted automatically to social media, i.e. Twitter and Facebook, for interested parties to access. The dam then becomes a 'thing' with cyber representation.

Monitoring of electricity consumption at the CSIR has been another outcome of the use of this technological concept. Consumption in small work areas is collected automatically and disseminated via social media. Patterns of energy usage can in turn inform decisions regarding usage of appliances to support energy efficiency.

The value of the Internet of Things lies in its potential to support decision making through computing that is part of business, personal and societal environments. Knowledge benefiting society is created through solutions that integrate things and people.

Decision making at a higher level stands to gain from this research. An example is the combination of environmental data on polluted water and high rainfall with data on deforestation, to make it possible to extract information on polluted flooding. An appropriate response can thus be generated.

Getting to grips

Internet of Things: Connectedness of everyday objects ('things') to the Internet. Everything will be connected to everything else – any place, any time, anything, anyone, any service; creating unprecedented masses of data to store and process.

A QR or quick response code is a specific matrix bar-code (or two-dimensional code), readable by dedicated QR bar-code readers and camera phones. The information encoded can be text, URL (Internet address) or other data.

ICT R&D AND INNOVATION FOR **BROADBAND ACCESS**

In brief

The Broadband for All (BB4All) initiative is one example of how new technology and local research, development and innovation are used to support and contribute to national broadband infrastructure. At its completion, the project aims to have connected about 450 facilities (e.g. schools, clinics and other government facilities) and developed at least 45 village operator businesses.

The challenge

Broadband is a critical enabler of economic growth. However, its penetration is poor in most African countries. Broadband infrastructure in rural areas will help with access to essential services such as health care and education, and bring other services, such as government services, closer to people.

CSIR research

The CSIR offers unique information and communications technology (ICT) capability and approaches to improve access to broadband in an innovative and relevant way. Research work includes wireless mesh networks for community-based rural broadband as a key enabler of the BB4All initiative.

Wireless mesh networks

Wireless mesh technologies use unconventional methods to communicate information. Instead of the traditional point-to-multi-point communication, it is based on peer-to-peer communication between network nodes.

The CSIR's wireless mesh technologies make use of high performance nodes (HPNs) to establish peer-to-peer communication within the network. Imagine a community with HPNs installed at certain points (users). If a person in one house wishes to relay a message to another at a different house where direct communication is not possible, the message will go through the other nodes until it reaches its destination. These nodes do not necessarily use one route; if one node goes down, the others are able to relay the message using another route. Since this technology enables self-healing of the network, the HPNs are able to find these other routes automatically.

Broadband for All using wireless mesh networks

BB4All aims to provide affordable broadband connectivity to under-serviced, rural communities. It uses low-cost infrastructure that is owned and supported by the local community, to create socio-economic and commercial opportunities.

At the heart of the BB4All initiative is the Wireless Mesh Network (WMN) project. It is funded by the European Union through the Sector Budget Support programme of the Department of Science and Technology. The collaborative project started in 2009, with roll out of a broadband network in the Nkangala district in Mpumalanga. The project will also roll out to the Sekhukhune district in Limpopo and the John Taolo Gaetsewe district in the Northern Cape.

Outcomes

Developing human capital in communities

The key success factor in this initiative is the village operators (VOs), who work within communities to provide and manage the BB4All network. There are 18 VOs working in 15 communities in the Nkangala district. VOs are young local entrepreneurs with a keen interest in ICTs and who want to be self-employed. They are sourced from the targeted communities and will service their own communities.

Installation of wireless mesh equipment at a school.

To date, wireless mesh equipment has been installed in more than 200 facilities to connect them to the Internet. These facilities include 175 schools, school circuit manager offices and a community radio station.

The initiative uses established wireless mesh research and transforms it into an innovative approach to real-life situations. Through this intervention, the improvement of the quality of life of rural or underserviced areas of South Africa has become a possibility. This project also provides the opportunity for multidisciplinary research where social and business aspects are integrated with technological research to provide a sustainable business model.

The VOs are encouraged through training and mentoring to build and maintain their own businesses. They receive business and basic technical training, which is augmented by training on WMN technology and experiential learning. All these aspects support and encourage self-learning, a key skill for the VOs and communities to be self-sustainable.

The BB4All model learns from other past and current CSIR ICT innovations and models such as Infopreneurs® and the Digital Doorway™.

Developing local ICT businesses

Local manufacturers are used to manufacture some of the wireless mesh equipment, for example, Parsec manufactures the HPNs. This stimulates the use of local products and local labour. Ingwapele Technologies employs 10 permanent staff members, who through this project, are trained to install the nodes and other equipment unique to the WMN.

Wireless mesh networks connecting schools.

Nkangala Village Operators – new entrepreneurs who received an ICT boost. One of the village operators, Sibusiso Mazibuko says, "We wake up every morning to go to the office. You should see Michael Mabena and Innocent Nene going to their office; you would be convinced they are working on Wall Street! Such is the pride we have in this project."

SANReN: CLOSING THE DIGITAL DIVIDE FOR SOUTH AFRICA'S RESEARCH & DEVELOPMENT

In brief

South Africa is making substantial progress in realising its vision of broadband connectivity through the investment by the Department of Science and Technology (DST) in a sustainable national cyberinfrastructure system for research, development and innovation across the entire National System of Innovation. The South African National Research Network (SANReN) is a component of South Africa's national cyberinfrastructure system and is working towards achieving these goals together with the Centre for High Performance Computing, the South African Very Large Scale Database Initiative, and the South African National Grid initiative, providing a software platform for joint research at universities and research organisations.

The challenge

One of the major requirements for all South African public universities to participate fully in local and international research collaboration, is access to broadband connectivity. Unlimited computing power combined with unlimited bandwidth and unlimited storage holds the promise of unprecedented research and development possibilities, now and in the future.

CSIR research

Following the signing of a contract between the DST and the CSIR in 2006, the CSIR was tasked with designing and implementing the rollout of the SANReN network. This task commenced in 2007, and the first part of the national research infrastructure went live in 2008. South Africa's Telkom was contracted to install the first phase of the national backbone which was completed in December 2009.

Designing an NREN

The initial hardware design was done together with industry partners, and the Tertiary Education Network (TENET). Design decisions are taken in-house and aligned with best practices followed by international NREN communities.

The network topology design (for the backbone extensions) was done jointly with TENET and the requirements and priorities of institutions were taken into account. The network was planned based on inputs from all higher education institutions (facilitated by the Association of South African University Directors of Information Technology), science councils, and national facilities managed by South Africa's National Research Foundation.

A sea change in connectivity

SANReN provides South African researchers with world-class networking, enabling them to collaborate nationally and with their international peers. A 10 gigabit-per-second fibre-optic ring network provides the national broadband connectivity network for public research institutions and universities. It is linked to international networks, such as GéANT, a multi-gigabit pan-European data communications network.

As the contracted operator for SANReN, TENET has acquired international bandwidth from Seacom which is distributed via the SANReN national backbone network. Seacom is a 1.28 terabytes-per-second, 17 000 km-long submarine fibre-optic cable system linking southern and East Africa to global networks via India and on to Europe. The SANReN backbone will connect universities and public research organisations at speeds of between 1 and 10 gigabit-per-second over the next few years. About 150 sites, including all rurally-based universities, together with KAT7, the precurser to the Square Kilometre Array (SKA), and South African Large Telescope (SALT), will be connected by the end of the 2011/2012 financial year.

Dr Colin Wright (left) and the SANReN team: Simeon Miteff, Zukisani Makalima, John Hay, Uli Horn, Thabo Koeshe, Geoff Daniell and Christiaan Kuun

What's in it for South Africa?

With access to high-quality cyber-infrastructure, it is now possible for South African researchers and scientists to find solutions to national and regional problems in a range of areas, from health and energy to industrial innovation. Large science projects, such as SALT, MeerKAT, the Applied Centre for Climate and Earth Systems Science (ACCESS), the International Centre for Genetic Engineering and Biotechnology, and the National Bioinformatics Network, all stand to gain from SANReN.

South Africa is now positioned internationally as a player in global science efforts, as the unprecedented benefits from SANReN's high-speed connectivity become apparent. The availability of SANReN has demonstrated South Africa's readiness to host the connectivity requirements of the SKA. The Hartebeesthoek Radio Astronomy Observatory has been enabled to participate in international radio astronomy experiments through very long baseline interferometry (e-VLBI) data provision to the Joint Institute for e-VLBI in Europe. Data from South Africa's SumbandilaSat are downloaded at the South African National Space Agency space operations and sent to SunSpace in a short period of time to

allow engineers to make adjustments to the satellite.

Universities and research institutions stand to benefit greatly from SANReN. It brings opportunities for and access to quality teaching and learning, while lowering costs for universities. Its connectivity for campuses of universities, which straddle the urban and rural divide, wil create equal digital connectivity opportunities for all researchers in South Africa. It provides researchers with remote access to instruments such as the High-Resolution Transmission Electron Microscope at the Nelson Mandela Metropolitan University.

Highlights in 2010/11 include completion of the Ethekwini metropolitan network and of the dense wavelength division multiplexing and north rings as part of the Tshwane metropolitan network. Additional funding was received for SKA and SALT connectivity (R64 million) and backbone extensions (R55 million), and the eduroam service has been piloted and enabled on the network.

Funding and collaborators

The DST has funded the rollout of SANReN as part of its national cyberinfrastructure initiative. Initial funding of R365 million over three years was received in 2006; further funding of R303 million (over the course of three years) was received in 2010. In 2010 the DST made an additional R55 million available to accelerate the rollout of SANReN connectivity to rural and remotely located sites. The DST also provided a further R64 million for the connection to the SKA core site and the SALT telescope in Sutherland. TENET operates the SANReN network.

Professor Thandwa Mthembu, Vice-Chancellor and Principal, Central University of Technology, Free State (CUT), states: "The knowledge and information society is a society of networks. Broadband connectivity is one of the most reliable facilitators of these networks. For this reason, CUT and the higher education sector are excited that the SANReN has already borne fruit through the main points-of-presence it has created in the cities. Universities are now reaping the benefits of easy, cheaper, faster and efficient broadband connectivity. With undersea cables being developed, we will soon be a few seconds from any piece of research information available anywhere in the world."

This view is shared by Professor Mvuyo Tom, Vice Chancellor: University of Fort Hare: "Alice has the highest need for access to the Centre for High Performance Computing. Connecting the Alice campus to SANReN will make many things possible. The implementation of the e-campus strategy will allow for video content and large data communication between the Alice and East London campuses and other universities, allowing the university to improve research productivity and the delivery of quality education to students."

Getting to grips

NREN: A National Research and Education Network (NREN) is a specialised Internet service provider dedicated to supporting the needs of the research and education communities within a country.

Optic fibre/fibre optics: An optical fibre is a flexible, transparent fibre made of very pure glass (silica) (not much thicker than a human hair) that acts as a waveguide, or 'light pipe', to transmit light between the two ends of the fibre. The field of applied science and engineering concerned with the design and application of optical fibre is known as fibre optics. Optical fibre is the fastest transmission medium for telecommunications circuits. Most of the SANReN network is built using optical fibre technology.

Gigabits-per-second: A gigabit-per-second (or Gbps) is a unit of data transfer rate equal to 1 000 000 kilobits per second.

A map showing the SANReN national backbone in blue. Yellow lines indicate extensions under completion. The orange lines indicate future backbone extensions.

USING ICT TO UNLOCK EARTH OBSERVATION DATA SETS FOR MANAGING ENVIRONMENTAL CRISES

In brief

Using information and communication technologies (ICT) to manage data from Earth observation and land-based monitoring has the potential to help us in many ways, from weather prediction to disaster management. The question is how to harness this massive amount of data to empower society to protect itself against environmental and human-induced disasters. The CSIR has a number of projects in this field and also plays a role in various international networks.

Background

Over the past 10 years, South Africa has played a leading role in international efforts such as the intergovernmental Group on Earth Observations (GEO) and one of its initiatives, the Global Earth Observation System of Systems (GEOSS). GEO was formed after the 2002 Johannesburg conference, with remote sensing and geographic information systems (GIS) highlighted as important tools in helping a broad base of stakeholders to manage natural resources and ecosystems.

CSIR research

As part of the process of transforming experimental space technology tools into critical infrastructure for development, the CSIR has made significant investment in the associated ICTs, such as information processing, algorithm development, innovative analytical techniques and management philosophies for large data sets. Lately, researchers have embarked upon producing the next wave of experimental space technology demonstrators by borrowing from communications signal processing, middleware concepts used in transparent networked application development and web service provisioning, and applying it to remote and in situ Earth observation sensing.

Unlocking the potential of these new tools, microbiologists, data analysts, modellers and computer scientists are involved in several multi-partner and international projects to build systems that link various forms of data sets with one another in a user-friendly and widely-accessible manner. This is in line with GEOSS' objective to empower the international community to protect itself against natural and human-induced disasters; understand the environmental sources of health hazards; manage energy resources; respond to climate change and its impacts; safeguard water resources; improve weather forecasts; manage ecosystems; and promote sustainable agriculture and conserve biodiversity.

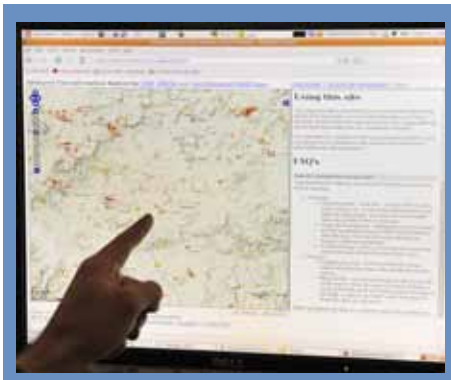
In one of these projects, researchers aim to develop a system whereby different forms of data sets – from the microbial to remote sensing – are coded in such a way as to enable environmental researchers to combine them with Earth observation data in larger-scale models by the click of a key. Called EO2Heaven, it addresses the GEOSS objective of using Earth observation data and environmental monitoring for the mitigation of health risks.

International reach

The collaborative nature of Earth observation research entails partnerships with and involvement in many national and international networks. The CSIR plays a role in the following groups and programmes, among others:

European Biodiversity Observation Network

CSIR botanists and remote sensing specialists are testing the transferability of the methods developed by EBONE in the European context for the large-scale application in non-European Mediterranean regions like the Sandveld in the Western Cape. EBONE is the European contribution to the GEO Biodiversity Observation Network (GEO BON), a network dedicated to the development of standardised global biodiversity monitoring systems.



Fire products developed by the CSIR are being made available in SADC via the AMESD project.

Open Geospatial Consortium (OGC)

A scientific workflow system is a specialised form of a workflow management system designed specifically to compose and execute a series of computational or data manipulation steps, or a workflow, in a scientific application. Operationalised for Earth observation science, it can bridge the gap between Earth observation and statistical toolsets. The CSIR's research in this domain focuses on ICT for Earth observation and operates within the workspace of the OGC and its Sensor Web Enablement framework. OGC is an international voluntary standards organisation, encouraging

development and implementation of open standards for geospatial content and services.

SANSA Space Operations

The CSIR Satellite Application Centre now forms part of the South African National Space Agency (SANSA). SANSA Space Operations processes large amounts of data. It centralised Earth observation services into a spatial portal that acquires, processes and distributes remotely-sensed data from Earth observation satellites. The data are processed as remote-sensing products and imagery and provide valuable input for a broad range of decision makers.

Chlorophyll Globally Integrated Network (ChloroGIN)

This network aims to broadly disseminate accessible marine Earth observation products, and empower users through training. CSIR researchers are closely involved with implementing these aims for Africa through EU-funded projects such as the Europe-Africa Marine Network (EAMNet) and GEONETCast for and by Developing Countries (DevCoCast).

African Monitoring of the Environment for Sustainable Development (AMESD)

This is a continent-wide, pan-African project for the development of geo-information systems to improve decision-making processes in the fields of environmental resource and environmental risk management in Africa.

Global Water Quality Information System

The Global Water Quality Information System seeks to develop a fully operational, spatially-comprehensive water quality information system in inland and coastal waters. Contributing national research initiatives are the CSIR-funded Safe Water Earth Observation System (SWEOS) project, developing this capability for local pilot ecosystems; and aligned DST-funded initiatives to build operational capability.

Continues >

The CSIR processes the images from the MODIS satellite.

Outputs

There are currently three PhD students and two Master's students studying in the marine and freshwater Earth observation field, with one postdoctoral student focusing on bio-optics and the Southern Ocean.

The Earth observation science and information technology field has two PhD students and one Master's student working on remote sensing research. Two Master's students are working in the ICT for Earth observation domain.

The GEONETCast group also offered a very successful African Operational Oceanography training workshop, attended by 29 delegates from fourteen institutes across nine African countries. They received training in GEONETCast Receiving Station Operations; marine Earth observation; ocean modelling and data analysis.

Outcomes

AFIS is a satellite-based fire monitoring system which monitors the whole country and generates alerts via SMS when there are large fires that pose a threat. These SMS alerts are sent to Eskom and fire protection associations in South Africa. This is done using data from two sensors, MSG and MODIS, which are processed at the CSIR.

The CSIR's expertise in developing fire products has seen it take on an important role in the South African Development Community (SADC) economic region as part of the African Monitoring of the Environment for Sustainable Development (AMESD) project. An innovative combination of ICTs is being used to ensure that fire services and products developed at the CSIR are replicated in the SADC.

The AMESD project is unique as information is disseminated via a communications satellite, which makes it independent from the Internet. The GEONetCast dissemination portal requires the CSIR to provide daily products via a file transfer protocol server to Germany. These products are then relayed up to the communications satellite and downloaded to receiving stations.

An active fire detected using data from the MODIS sensor on NASA's Aqua and Terra satellites.

A total of 20 receiving stations, one for each ministry of the environment in the SADC region, are being rolled out. The AFIS terminal will be used as part of the receiving stations. Through remote access, software will be continuously downloaded to ensure that receiving stations remain in prime working condition. Fixed mesh antennas of 2.1 m are the second vital component of these receiving stations to be installed.

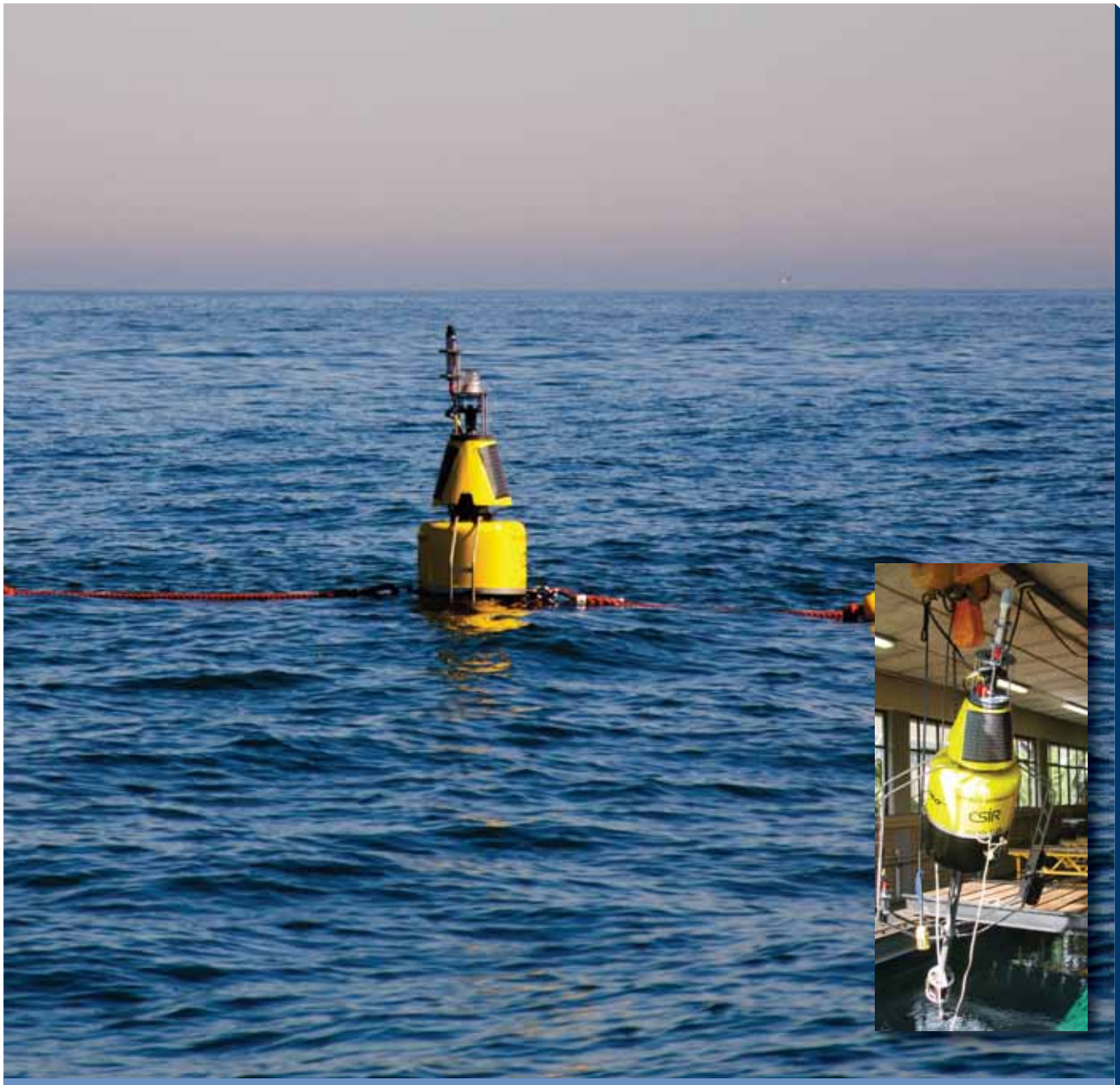
Also under the banner of GEONETCast, CSIR researchers were involved with establishing nine GEONETCast receiving stations in African countries with established marine research institutions. The countries are Egypt, Senegal, Côte d'Ivoire, Benin, Ghana, Namibia, Uganda, Mozambique and Tanzania. Five of these stations are currently operational and sending data to African users, who would otherwise not have had access to this information because of limited bandwidth.

In the SWEOS project, CSIR researchers developed a low-cost robotic observation system for marine and freshwater – this serves as 'proof of concept' that the CSIR has the capability to design and build low-cost robotic observation systems for aquatic ecosystems.

For South Africa to have this kind of technology at hand and at low cost will have a huge impact on our ability to monitor water quality issues such as red tide on the west coast or problems with cyanobacteria and eutrophication in inland waters.

Currently, marine research vessels are very expensive to operate, and are unable to provide daily observations, while commercially available autonomous measurements systems can be prohibitively expensive or unsuitable for local conditions. Earth observation data, coupled with measurements from critically located buoys, can offer very low-cost data in near real time across many different ecosystems.

The project's ultimate aim is to build Earth observation-based information systems to provide products for ecosystem monitoring and characterisation, ultimately facilitating a predictive capability. The new buoys will be used both to provide real-time data on algal blooms, and to develop and verify new satellite techniques, which will then allow satellite data records from 10 years or longer to be used to characterise change in South African coastal and inland ecosystems.



As part of the CSIR's Safe Water Earth Observation Systems project, researchers developed a low-cost, low-weight pencil-buoy that is easy and fast to deploy. It will also soon feature new low-cost radiometric sensors, also developed by the CSIR. These new buoys will be used to provide real-time data on algal blooms. They will also verify new satellite techniques, which will then allow satellite data records from 10 years or longer to be used to characterise change in South African coastal and inland ecosystems.

CSIR TECHNOLOGY IN SUPPORT OF **SPORT IN SOUTH AFRICA**

In brief

Sport science and technology can assist with talent identification, fast-track development, enhance performance, prevent injuries and improve decision making. The CSIR was contracted to establish a framework that would assist in modernising the sport science and technology support provided to elite sport in South Africa. Through software systems, video-based biomechanical analysis and notational analysis, telemetry and tracking technologies, high-performance athletes and coaches have been able to utilise world-class products and services aimed at improving their performance.

The challenge

In the highly competitive world of professional sports, winning cannot be left to chance. Excellence is the result of superior performance, underpinned by a complex and intricate mix of effective talent management, good coaching, exceptional academies, and cutting-edge sports science and technology.

The South African National Lottery Distribution Trust Fund (NLDTF) – through its Sports and Recreation Distribution Agency – saw the opportunity to identify, supply and coordinate sports performance enhancement strategies in an integrated, high-performance framework that will deliver top-class athletes to Team SA. For this reason, the NLDTF contracted the CSIR to respond appropriately to a previous needs assessment and devise a sports science delivery mechanism that would provide access to modern performance analysis technologies to elite and high-performance sport in South Africa. The project is conducted as a multi-year initiative of which the first year was completed in early 2011, funded by a grant of R4.2 million from the National Lotteries Board.

The ability to quickly and accurately analyse performance in real time (i.e. while the game is played or the athlete is participating) is increasingly important in elite-level sport. Performance information supports the coach's decision making to influence individual or team strategies or tactics.

CSIR response

Sports science and technology support relies on a robust technology management process that includes market assessments, technology selection and acquisition, strategies for optimal technology deployment and a plan for ongoing monitoring, evaluation and continuous learning.

In this domain, the CSIR has achieved international recognition as a pioneer in the development and application of world-class sports performance analysis technologies.

A number of sport science and technology support options, sources of technologies, service delivery mechanisms, etc. exist. These were investigated in the first phase of the project to identify the optimal technology options to modernise the technology support programme at the elite level. CSIR expertise was complemented by inputs from stakeholders such as the SA Sports Confederation and Olympic Committee (SASCOC), national federations, universities, sports academies and testing centres.

The optimal technologies were identified as:

- Information and knowledge management
- Notational analysis
- Video-based biomechanical analysis
- Telemetry
- Tracking.

Outputs

To implement the technology choices, a comprehensive technology acquisition plan was formulated and the necessary technology packages acquired through the approved grant amounts.

It was agreed with SASCOC that the technology support would be focused on seven priority sports codes. These were athletics, boxing, canoeing, cycling, paralympics, rowing and swimming. Subsequently, the technology packages and equipment have been in use since April 2011 at several sporting events, across these sports disciplines. The analyses were interpreted and reported back to training authorities and athletes. Their assessments and feedback of the technology support have been overwhelmingly positive.

With Coaching Education being an important component of the investment strategy, the acquired technology was also used in streaming a coaching conference live on the Internet, as well as the SASCOC Coaching Conference 2010.

For many athletes, it was the first time that they had been exposed to sophisticated performance analysis tools. The funding instilled the sense that they were being given the appropriate scientific support in the quest to improve their performance. Even in instances where only minimal tangible evidence of performance improvement was detected, the psychological boost of cutting-edge technology support was often evident. The NLDTF grant was used to establish a framework on which further enhancements to service delivery can be built. In particular, the federations and individual athletes and coaches now have access to an on-line video repository of baseline data that can be used as an input into

their long-term athlete development programmes.

Heading towards the Olympic Games in London in 2012, the necessity of data gathering and ongoing athlete feedback is becoming increasingly important in striving for success. Based on the analysis provided, coaches and athletes have been able to focus their efforts more specifically on minimising highlighted weaknesses and improving strengths to achieve the best possible performance.

Getting to grips: Components of sports science and technology

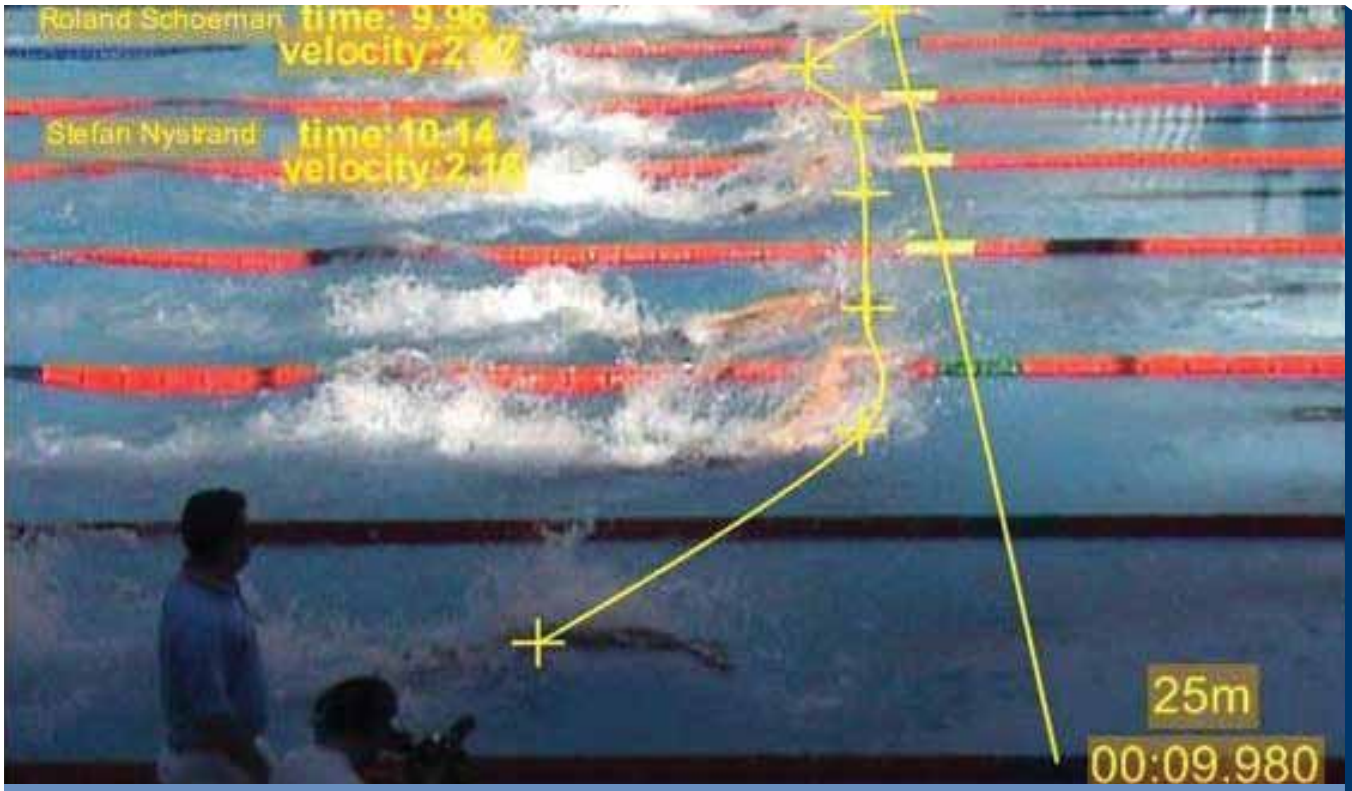
Information and knowledge management: Includes the provision of databases and data mining technologies to manage and monitor information about athletes. Such databases can contain personal information, video footage, contact details, previous performance data or medical information.

Notational analysis: Provides objectivity and quantification in the identification of critical incidents (tactical and strategic) in game performance that influence the outcome of a game or individual performance. Information can be delivered in real time by the sports technologist to the coach, to immediately influence game strategy. The information can also be processed and summarised in video format for consultations with coaches and/or players prior to their next practice session.

Video-based biomechanical analysis: A range of powerful software tools for the analysis of high-speed video material, thus allowing for detailed analysis of selected events (e.g. the take off of a high jumper).

Telemetry: Advanced technology that enable remote monitoring of athletic performance in real time via telemetry. Current technology permits the monitoring of heart rate over Bluetooth for athletes performing in a defined space (tennis, cricket, soccer, netball, etc.) or attributes such as velocity, altitude and position via GPS over GSM or radio transmission.

Tracking: Provides the ability to monitor position, direction and velocity of an athlete using a variety of technologies. Some systems now permit real-time monitoring of this information, providing unprecedented information for decision support.



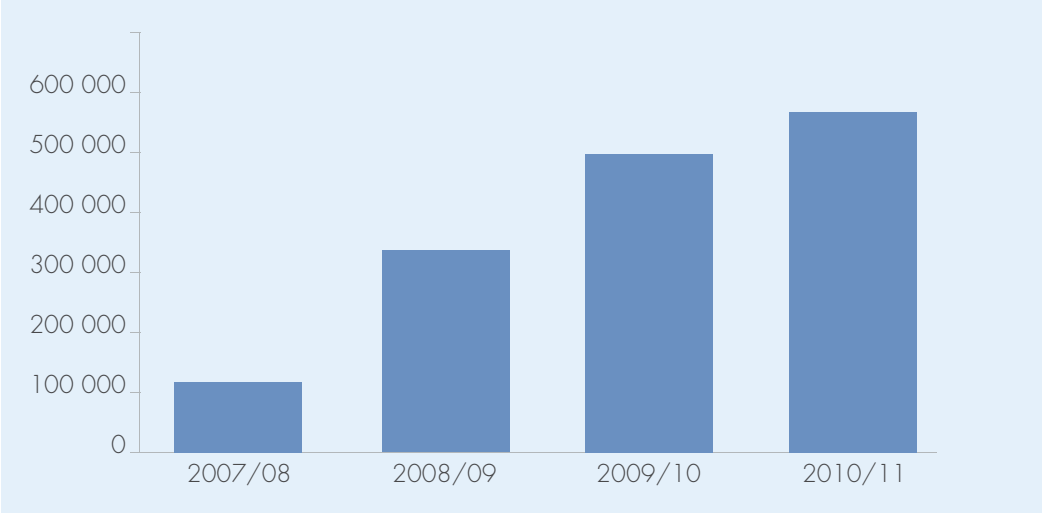
SA in European waters: CSIR analysts accompanied the national swimming team on tour in Europe and at the Commonwealth Games in 2010. Video footage of the team's performance in the water was analysed and interpreted to identify areas of strength and weakness of individuals and relative to closest competitors.

3 KNOWLEDGE DISSEMINATION

The CSIR's institutional repository of research publications, known as CSIR Researchspace, launched in August 2007. It remains the only open access, online repository by a South African research council. CSIR Researchspace currently (July 2011) holds the highest ranking amongst institutional repositories from Africa and is positioned 196th in the world ranking.

The number of items downloaded from Researchspace increased from 113 327 per annum in 2007/08 to 567 654 in 2010/11. Figure 1 depicts the annual growth pattern for the past four financial years. On average 47 305 copies of articles were downloaded from the repository per month during the reporting year. CSIR Researchspace is accessible at **http://researchspace.csir.co.za/dspace**

Figure 1: Annual growth in the number of downloads from Researchspace



Publication equivalents allocated to journal articles published by CSIR staff have steadily increased since 2006 and the past year showed an increase of 12% from 266 in 2009/10 to 297 in 2010/11. Total publication equivalents increased from 502 in 2009/10 to 576 in 2010/11. See figure below.

Year	External publications for which publication equivalents were assigned				Other external publications			Total publication equivalents
	Articles in accredited journals	Conference papers (Peer reviewed)	Books	Book chapters	Journal articles (Other)	Conference papers & presentations (Other)	Books	
2006/07	129	115	2	27	43	250	0	220.0
2007/08	180	202	12	50	31	136	0	343.0
2008/09	208	393	9	38	69	228	5	451.5
2009/10	266	334	14	48	46	149	1	502.0
2010/11	297	418	5	62	41	226	4	576.0

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A

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Patent no: 2007138642

Flagellin (USA):
Patent no: 11/792242

Hoodia (EPO):
Patent no: 05017768.2

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Patent no: 05017768.1 - 114

Hoodia (Mexico): Patent no: 280248

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Patent no: 1629248

Wheel & Track (UK):
Patent no: 1629248

Wheel & Track (Germany):
Patent no: 602004031009.3-08

Wheel & Track (EPO):
Patent no: 04734870

CSIR Rheocasting System (CSIR RCS) Device (Japan): Patent no: 4452778

Spherezymes (US):
Patent no: 7,700,335

CSIR Rheocasting System (CSIR RCS) Device (US): Patent no: 12/820,823

Bio-Reactor System (CA):
Patent no: 2,422,230

Integral Chemical/Biological Process (Canada): Patent no: 2418472

Invention disclosures

Kinases and Synthetases

Home-based care

Wavenet

Membrane filter

Bisphenol A

Biotinylation Kit

Control of Slurry Flow II

Electrochemical extraction of energy from acid mine drainage

Rail transducer

Cross pavement carriers

Upgrading of Titanium Nitride

Titanium-platinum alloy process

Specific Aptamers against the mannose receptor protein

Bioplastic from polyfurfuryl alcohol

Process for inch worm motor

Low cost LOC

Quantitative and multiplexed lateral flow device

PBR application (CSIR GxN2107)

HaP Process

Method to construct an all solid state laser gyro

High Speed Additive Manufacturing

Fossil Tagging

Technology packages

BioDX Microbial formulation

Bio-prospecting 5

Resyn

Emulsion Hand Sprayer

Road Maintenance Kit

Anaerobic Digester

Electronic Sounding Device

Muscle 1

Roll over protection system (ROPS)

Air Support System

Flutter Flight Test

Gripen

LYNX

Sensor and Electronic Warfare Engagement Simulation (SEWES)

TFMS

Airblow Seat Cover

CSIR Rheocasting System (CSIR RCS) Device

Cross Pavement Carrier

InTouch Africa

National Indigenous Knowledge Management System (NIKMAS) Catalogue System

Wireless Access Point Management System

Woefzela

Auto Secretary

Crime Prevention Toolkit

Ecosystem Service

GxN2107

MuniWaste Guidelines

National Freshwater Ecosystem Priority Areas (NFEPA)

Laser resonator with phase correcting elements

4 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 and transparency.

The CSIR is committed to principles and practices that will 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, including investment and risk management and reviews. It also approves financial objectives, plans, goals and strategies. 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.

The CSIR Board and the CSIR Executive Management Committee believe that the organisation has in all material respects applied and complied with the principles incorporated in the Code of Corporate Practices and Conduct, as set out in the King 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 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 South African Statements of Generally Accepted Accounting Practice. 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 South African Statements of Generally Accepted Accounting Practice. The Auditor-General's Terms of Reference do not allow for any non-audit work to be performed.

Risk management

The CSIR Board is accountable for the process of risk management which is reviewed regularly for effectiveness. Appropriate risk and control policies are established and communicated throughout the organisation. The CSIR Board retains control through the final review of key risk matters affecting the organisation and is satisfied that the risk management process is effective.

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.

A structured process of risk management has been put in place to ensure that the growth and development of human capital, strengthening of the science, engineering and technology (SET) base, operational excellence and financial sustainability will be achieved and maintained.

CSIR systems have been put in place to review aspects of economy, efficiency and effectiveness. Management is involved in a continuous process of improving procedures to ensure effective mechanisms for identifying, managing and monitoring risks in the following major broad risk management areas: research, business, fraud, environmental management, occupational health and safety, operating and financial management.

Documented and tested processes are in place, which will allow the CSIR to continue its critical business process in the event of a disastrous incident impacting on its activities, and to ensure complete, timely and relevant reporting by management.

Based on the work of internal audit and the organisational results achieved, the Board is satisfied that the system of risk management has been effective during the year under review.

Research risk management

The Group recognises that research has to be conducted in compliance with the existing legal framework, aligned to CSIR strategies and in accordance with the standards and practices that would ensure outputs that support the CSIR's mandate. In order to mitigate research-related risks, the CSIR has an established Good Research Guide, research ethics and institutional governance structures such as the Research and Development (R&D) core management function; the Strategic Research Panel (SRP); and the Research Advisory Panels (RAPs).

The CSIR has established a Research Ethics Committee which is accountable to the Strategic Review Committee of the Board. The committee reviews all projects which require evaluation from a research ethics perspective.

Business risk management

The organisation has effective mechanisms in place for identifying and monitoring risks that impact on the CSIR Group. The procedures for implementing the Group's business risk management process include a focus on areas such as human capital assessment and development, technological development and business continuity.

Fraud risk management

The objective is to manage the fraud risk and to raise the level of fraud awareness among the CSIR's internal and external stakeholders. The CSIR's fraud prevention plan intends to reduce the risk of fraud and protect the interests of the organisation. The proactive approach consists of the responsibility for prevention, detection,

reporting, communication and reaction to fraud.

Environmental management, occupational and health and safety

The CSIR is committed to the promotion of environmental, health and safety principles and practices to create a safe and healthy environment for all and to meet the requirements of all relevant environment and health and safety legislation as a minimum standard. This commitment is depicted in two ways: in the manner it serves business as a supplier of environmental management-related products, and in the way it demonstrates sound environmental practices at all CSIR sites.

Operating risk management

The CSIR endeavours to minimise operating risk by ensuring that the appropriate infrastructure, controls, systems and people are in place throughout the Group. Key practices employed in managing operating risk include 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, operating unit and centre executive directors and group managers, oversees operational matters.

Financial risk management

Financial risks are managed within predetermined procedures and constraints as identified and detailed in the various policies and the setting of annual goals and objectives. Controls are designed to give assurance that assets are safeguarded and that liabilities and working capital are managed effectively. Organisational policies, procedures, structures and an approval framework provide for segregation of duties and contain self-monitoring mechanisms. Compliance is measured through regular reporting against the business goals, internal audit checks and external audit verification. The requisite skills and qualifications are in place for the management of the finance function.

Going concern

The CSIR Board has reviewed the Group's financial budgets for the period 1 April 2011 to 31 March 2012 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 control

The CSIR Board has ultimate responsibility for the system of internal controls. The key controls required to mitigate risk and ensure the integrity and reliability of financial statements have been identified in conjunction with the internal and external auditors. Close cooperation between the internal and external auditors ensures adequate and efficient audit reviews of the proper functioning of these key controls.

The annual audit plan is based on the key risks to the organisation and the results of the risk management process. The work programme that gives effect to the plan is reviewed by the Audit and Risk Committee and approved or modified as required.

Internal financial controls have been assessed as effective to mitigate related risks.

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 and acquisition and disposal of assets. 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.

Each subsidiary company's board of directors has adopted an approval framework, which mirrors that of the

CSIR. All subsidiary companies are under the control of the CSIR Board and CSIR Executive Management Committee.

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

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 self-directed staff sessions; formal induction programmes; road shows; technical and strategic focus groups; and task teams.

Code of ethics and organisational values

The CSIR Board and CSIR Executive Management Committee have approved and adopted a code of ethics, which reflects its commitment to a policy of fair dealing and integrity in conducting its operations. The code aligns closely to the CSIR's 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, in all reasonable circumstances, is beyond reproach. Monitoring ethical behaviour is devolved to operating unit level and transgressions are addressed by means of procedures detailed in the CSIR's 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 President and 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 Board 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 29 June 2010, 16 September 2010, 16 November 2010 and 17 February 2011 .The Annual Financial Statements for the 2010/11 financial year were approved on 30 June 2011.

The CSIR Board has the following sub-committees: the Human Resources and Remuneration Committee; the Audit and Risk Committee; and the Strategic Review Committee (see pages 102 to 104). These committees are selected according to the skills sets required for the committees to fulfil their functions.

For the 2010/11 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. For the year under review, the Board has assessed its performance and that of its committees. There are no issues of concern in this regard.

Schedule of attendance of the CSIR Board and CSIR Board Committee meetings (1 April 2010 - 31 March 2011)

Board member	Board meetings (4)	Audit and Risk Committee (2)	Human Resources and Remuneration Committee (3)	Strategic Review Committee (2)
Petersen	4			2
Behrens	4	1*		1
Benadè	3	1**		1•
Hall	2			
Knott-Craig	4		3	2•
Sibanda	4	2	3	1•
Silinga	3	2		
Thoka	3		3	
Wingfield	4			2
Sibisi	4	2▫		2

* Replaced by Benadè

** Appointed to the CSIR Board with effect 1 September 2010; Replaces Behrens on the Audit and Risk Committee

▫ Attends in capacaty as President and CEO

• Attendance as per invitation

CSIR Board Members (1 April 2010 - 31 March 2011)

The Board and all its committees were appointed on 1 January 2009. The following changes occurred during the year under review:

- Phillip Benadè appointed to the Board and as Chairperson of the Audit and Risk Committee with effect from 1 September 2010.
- Prof Denis Hall resigned from the Board with effect from 21 March 2011.

Professor Francis Petersen (Chair), Dean: Faculty of Engineering and the Built Environment, University of Cape Town

Mr Pepi Silinga, Chief Executive Officer, COEGA Development Corporation

Mr Norbert Behrens, Group General Manager: Strategy and Planning, Sasol Limited

Professor Mike Wingfield, Director: Forestry and Agricultural Biotechnology Institute, University of Pretoria

Mr McLean Sibanda, Head of Innovation Fund IP Management Office

Ms Khomotso Thoka, Managing Executive, The Talent Hub

Mr Alan Knott-Craig, Director of Companies

Mr Phillip Benadè, retired

Dr Sibusiso Sibisi, CSIR President and CEO

Executive Management Committee

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

- **President and CEO:** Dr Sibusiso Sibisi
- **Group Executive, Operations:** Dr Hoffie Maree
- **Group Executive, R&D Outcomes and Strategic Human Capital Development:** Khungeka Njobe
- **Group Executive, Research and Development:** Dr Thulani Dlamini
- **Chief Financial Officer:** Chris Sturdy
- **Executive Director, Services:** Raynold Zondo

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

CSIR Executive Management Committee

Back row from left: Raynold Zondo, Executive Director: Services; Dr Sibusiso Sibisi, CSIR President and CEO; and Dr Hoffie Maree, Group Executive: Operations
Front row from left: Chris Sturdy, Chief Financial Officer; Khungeka Njobe, Group Executive, R&D Outcomes and Strategic Human Capital Development; and Dr Thulani Dlamini, Group Executive: R&D

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 Service Committees, the Strategic Research and Contract Research & Development Forums, 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 98 to 100 of the Corporate Governance Report. The membership and Terms of Reference of each Board committee are further described on pages 102 to 103.

Remuneration of Board members and the Executive Management is set out in Note 19 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 and the evolution thereof.

We shall continue to comply with all major recommendations of the Code of Corporate Practices and Conduct as set out in the King Report on Corporate Governance.

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. The Group complies, in all material aspects, with the Act.

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 54(2) of the PFMA, has been finalised and incorporated into the Shareholder's Compact. No material losses through criminal conduct and irregular, fruitless and wasteful expenditure were identified as having been incurred during the year.

CSIR Board Committees 2010/11

Audit and Risk Committee

Chairperson	Mr P Benadè (appointed with effect from 1 September 2010)
Members	Mr P Silinga Mr M Sibanda Mr N Behrens (February 2010 – August 2010)
Meetings	29 June 2010 10 February 2011
Purpose	To deal with all matters prescribed by the regulations issued in terms of the PFMA and the King Report on Corporate Governance; 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 without restrictions.

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

Chairperson	Mr A Knott-Craig
Members	Ms K Thoka Mr M Sibanda
Meetings	22 April 2010 29 June 2010 15 September 2010
Purpose	To provide a vehicle for the CSIR Board to influence and control human resources and remuneration in the organisation; To determine human resources policy and strategy and review remuneration against industry benchmarks; and To approve remuneration changes and bonus payments; in addition, it reviews the remuneration and expenses 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.

Strategic Review Committee

Chairperson	Prof F Petersen
Members	Prof M Wingfield Mr N Behrens Dr S Sibisi

Meetings	7 October 2010 24 March 2011
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 Strategic Review 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 (1 April 2010 – 31 March 2011)

Board meetings

	29/06/10	16/09/10	16/11/10	17/02/11
Petersen	Present	Present	Present	Present
Behrens	Present	Present	Present	Present
Benadè		Present	Present	Present
Hall	Apology	Present	Apology	Present
Knott-Craig	Present	Present	Present	Present
Sibanda	Present	Present	Present	Present
Silinga	Present	Present	Apology	Present
Thoka	Present	Apology	Present	Present
Wingfield	Present	Present	Present	Present
Sibisi	Present	Present	Present	Present

Audit and Risk Committee meetings

	29/06/10	10/02/11
Benadè		Present
Silinga	Present	Present
Sibanda	Present	Present
Behrens	Present	

Human Resources and Remuneration Committee meetings

	22/04/10	29/06/10	15/09/10
Knott-Craig	Present	Present	Present
Sibanda	Present	Present	Present
Thoka	Present	Present	Present

Strategic Review Committee meetings

	07/10/10	24/03/11
Petersen	Present	Present
Behrens	Present	Apology
Wingfield	Present	Present
Sibisi	Present	Present
Knott-Craig	Present	Present
Benadè	Present	
Sibanda		Present

Strategic Review Committee meeting held on 7 October 2010 – all Board members were invited to attend.
Strategic Review Committee meeting held on 24 March 2011 – Sibanda and Knott-Craig attended by invitation.

Report of the Audit and Risk Committee

Year ended on 31 March 2011

Report of the Audit and Risk Committee as required by Treasury Regulations 27.1.7 and 27.1.10 and S(51)(1)(a)(ii) of the Public Finance Management Act (No 1 of 1999), as amended by Act 29 of 1999.

The committee is pleased to present its report for the financial year ended 31 March 2011.

Committee members and attendance

The committee consists of the members as stated on page 102 of this report. In accordance with its approved Terms of Reference, the committee met twice during the year under review (i.e. 29 June 2010 and 10 February 2011). Schedule of attendance is shown on page 103 of this report.

The committee's responsibility

The committee has adopted formal Terms of Reference in its charter in line with the requirements of S(51) (1) (a) of the PFMA and Treasury Regulations 27.1.7 and 27.1.10 and has discharged all of its responsibilities for the year, in compliance with the charter.

The effectiveness of internal control

Through the review of the internal audit activity, the committee is satisfied that an adequate system of internal control is in place to mitigate risks to an acceptable level. These controls have been effective during the period under review. The system is designed to manage, rather than eliminate, the risk of failure and to maximise opportunities to achieve business objectives. This can provide only reasonable but not absolute assurance.

Internal audit

The committee has evaluated the internal control environment and based on the information provided has assessed the internal controls as effective to mitigate related risks.

Risk management

The committee is satisfied that the CSIR has an ongoing risk management 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.

Evaluation of financial statements

The committee has evaluated the Annual Financial Statements of the CSIR Group for the year ended 31 March 2011, and based on the information provided to the Audit and Risk 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 therefore recommends the adoption of the Annual Financial Statements and the associated reports by the CSIR Board.

Phillip Benadè
Chairperson of the Audit and Risk Committee
Date: 30 June 2011

05

Report of the Auditor-General

Report of the Auditor-General to Parliament on the Council for Scientific and Industrial Research for the year ended 31 March 2011

Report on the consolidated and separate financial statements

Introduction

1. I have audited the accompanying consolidated and separate financial statements of the Council for Scientific and Industrial Research, which comprise the consolidated and separate statement of financial position as at 31 March 2011, the consolidated and separate statement of comprehensive income, statement of changes in equity and statement of cash flows for the year then ended, and a summary of significant accounting policies and other explanatory information, as set out on pages 123 to 168.

Accounting authority's responsibility for the consolidated financial statements

2. The accounting authority is responsible for the preparation and fair presentation of these consolidated and separate financial statements in accordance with South African Statements of Generally Accepted Accounting Practice (SA Statements of GAAP) and the requirements of the Public Finance Management Act No. 1 of 1999 (PFMA), and for such internal control as management determines 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

3. As required by section 188 of the Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996) and, section 4 of the Public Audit Act of South Africa, 2004 (Act No. 25 of 2004) (PAA), my responsibility is to express an opinion on these consolidated and separate financial statements based on my audit.

4. I conducted my audit in accordance with International Standards on Auditing and General Notice 1111 of 2010 issued in Government Gazette 33872 of 15 December 2010. 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.

5. 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.

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

Opinion

7. 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 2011, and their financial performance and cash flows for the year then ended in accordance with the South African Statements of Generally Accepted Accounting Practice (SA Statements of GAAP) and the requirements of the Public Finance Management Act No.1 of 1999.

Report on other legal and regulatory requirements

8. In accordance with the PAA and in terms of General notice 1111 of 2010, issued in Government Gazette 33872 of 15 December 2010, I include below my findings on the annual performance report as set out on pages 112 to 117 and material non-compliance with laws and regulations applicable to the public entity.

Predetermined objectives

9. No material findings to report on the report on predetermined objectives as set out on pages 112 to 117.

Compliance with laws and regulations

10. No material findings to report on non-compliance with laws and regulations.

Internal control

11. I considered internal control relevant to my audit of the consolidated and separate financial statements and the report on predetermined objectives and compliance with the PAA and in terms of General notice 1111 of 2010, issued in Government Gazette 33872 of 15 December 2010, but not for the purposes of expressing an opinion on the effectiveness of internal control. There are no matters to report in this regard.

Other reports

Agreed upon procedures engagements

12. The following agreed-upon procedures were performed:

- Water Research Commission projects: Agreed upon procedures on the income and expenditure reports for the periods ending 31 March 2010 and 31 March 2011.
- National Research Foundation projects: Agreed upon procedures on the income and expenditure reports for the period ending 31 March 2010.

Auditor-General

Pretoria
29 July 2011

AUDITOR-GENERAL
SOUTH AFRICA
Auditing to build public confidence

Executive Report

Introduction

On behalf of the CSIR Board, we take pleasure in submitting to Parliament, through the Minister of Science and Technology, this report and the audited Annual Financial Statements of the CSIR Group for the financial year ended 31 March 2011.

In the opinion of the CSIR Board, the financial statements fairly reflect the financial position of the CSIR Group as at 31 March 2011 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), as amended by Act 71 of 1990. The organisation is listed as a Public Business Enterprise in terms of the PFMA Act (No 1 of 1999), as amended by Act 29 of 1999.

The CSIR mandate

The CSIR's mandate is as stipulated in the Scientific Research Council Act, section 3.

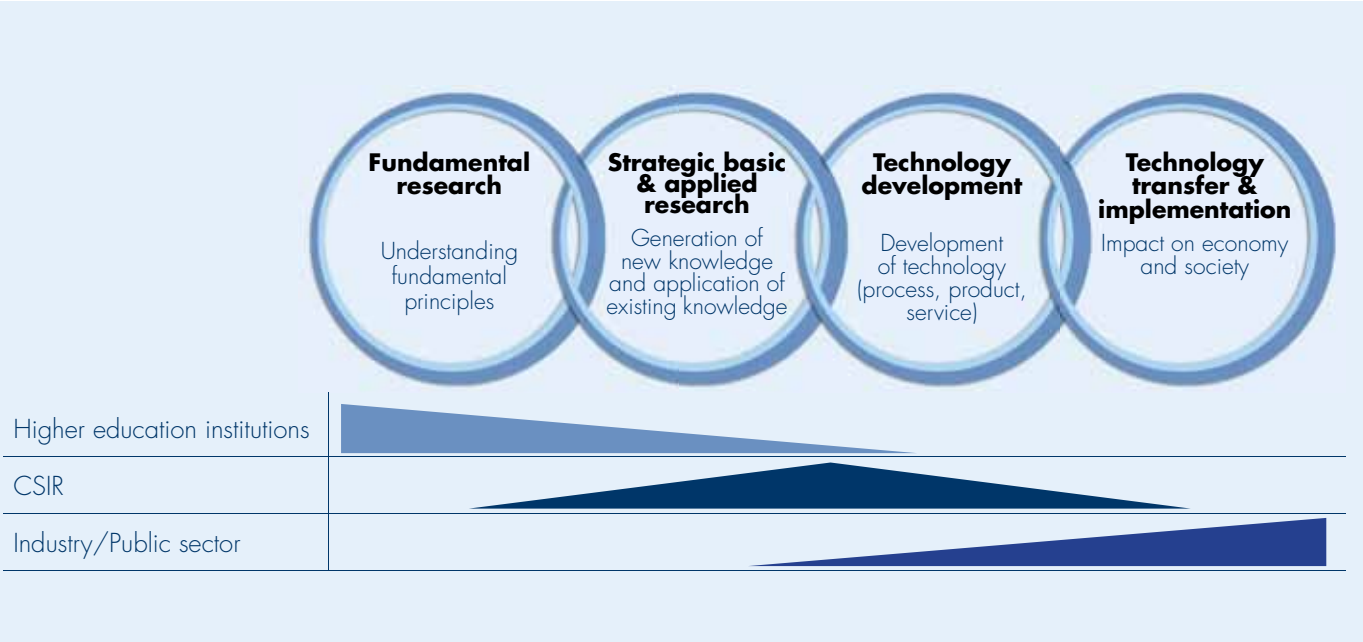
Extract from Scientific Research Council Act (No 46 of 1988), as amended by Act 71 of 1990:

"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."

Income sources

The CSIR derives income from baseline and ring-fenced grants from the Department of Science and Technology (DST); Contract R&D income from local and international public and private sectors; and income from intellectual property exploits and technology transfer efforts. Grant funding is invested in research programmes and research infrastructure as well as R&D skills development. Processes, policies and guidelines underpin the effective utilisation of grant funding.

Figure 1: The CSIR's role within the National System of Innovation



Role in the National System of Innovation (NSI)

The CSIR conducts research across the R&D value chain, a role that distinguishes it from higher education institutions (HEIs) and private sector R&D players (see Figure 1). The CSIR conducts a degree of basic research, but focuses mainly on directed research, development and technology or knowledge transfer for commercial or social benefit.

The CSIR strategy is guided by the strategic goals established in 2005. Key principles are the need to elevate the scientific capabilities of the organisation, enhance human capital development and focus on innovation. This requires an appropriate balance between strategic basic and applied research; technology development; and technology transfer and implementation, as depicted in Figure 1. At the same time, the excellent business and other organisational capabilities are to be maintained and enhanced.

The international strategic review of the CSIR in 2009 continues to guide organisational endeavours. The review confirmed the existing CSIR strategic goals, highlighting the need to:

- Achieve more focus in our research;
- Ensure increased impact of our work and improve the communication about impact;
- Continue with the development of significant numbers of highly-skilled people;
- Consider more partnering with the private sector and increase Contract R&D income from this sector and international funding sources; and
- Safeguard financial sustainability and our good corporate governance record.

Responding to national imperatives

The CSIR's research agenda is influenced by national priorities, as identified by government, the private sector and society. Government priorities are defined by the various national departments and CSIR units keep in close touch with departments to support the development and implementation of policy. The Medium Term Strategic Framework (MTSF) for 2009 to 2014 identified strategic priorities for South Africa (see Table 1).

Table 1: CSIR relevance to South African strategic priorities

Priority	MTSF National priorities	Level of CSIR relevance to the priority
1	Speeding up growth and transforming the economy to create decent work and sustainable livelihoods	High
2	Massive programme to build economic and social infrastructure	High
3	Comprehensive rural development strategy linked to land and agrarian reform and food security	Medium
4	Strengthen the skills and human resource base	High
5	Improve the health profile of all South Africans	Medium
6	Intensify the fight against crime and corruption	Low
7	Build cohesive, caring and sustainable communities	Low
8	Pursuing African advancement and enhanced international cooperation	Medium
9	Sustainable resource management and use	High
10	Building a developmental state including improvement of public services and strengthening democratic institutions	Low-Medium

In January 2010, cabinet identified 12 outcomes that will reflect progress in achieving national priorities, and which form the basis for ministerial performance agreements and direct departmental and interdepartmental activities. The CSIR contributes extensively to the attainment of 11 of the outcomes in line with its role in the NSI, and in collaboration with implementing partners such as line departments, state-owned enterprises and the private sector.

The CSIR's role in job creation

The January 2011 Cabinet Lekgotla identified the creation of jobs as the key driver to underpin achieving many social and economic objectives.
In line with its mandate, the CSIR engages with government and the private sector to assist in maintaining employment through a competitive South African economy and to stimulate economic development through technology leading to the creation of new employment opportunities. The role of the CSIR is to undertake R&D and transfer technology that stimulates future industrial activity and job creation, in the short-, medium- and long-term. This role supports the New Growth Path approved by cabinet in 2010. Further, the CSIR's investment in human capital development contributes towards the creation of skilled workforce, with better prospects for employment and creation of entrepreneurs.

The CSIR's role in infrastructure and service delivery

Cabinet has identified the upgrading of social and economic infrastructure as a major area of focus. The CSIR has a wide range of activities that support infrastructure development and maintenance. Research activities usually support longer-term objectives and include advanced materials for building construction, cement and bitumen replacements and advanced road building materials. The CSIR is developing advanced methods for the optimisation of infrastructure planning, design, construction and operation (including infrastructure investment decision support). R&D is undertaken for short-term application in infrastructure development, which often addresses job creation.

The CSIR has made progress in defining its role in supporting service delivery and developed a framework to enhance the impact of the organisation on service delivery in the shorter term, focusing on:

- Support for integrated planning and resource allocation;
- Support for sustainable implementation, and monitoring and evaluation in the fields of roads, housing, water supply and sanitation and waste water treatment; and
- Support for extension of service reach and access.

CSIR partnerships

The CSIR engages with a number of government departments in support of technology development, policy development and advice as well as providing thought leadership on technology related matters. These engagements are positioning the CSIR as a preferred and key partner for the delivery of government's mandate.

State-Owned Enterprises (SOEs) support the implementation of government strategies, and the CSIR in turn supports SOEs with R&D and technologies. In 2010, the CSIR signed a Memorandum of Agreement with Eskom to collaborate in areas of mutual interest and national importance. The CSIR is engaging with Transnet and the Development Bank of Southern Africa (DBSA) with a view to establishing similar strategic relationships. The CSIR undertakes R&D and technology development for Denel on an ongoing basis.
The CSIR has a long history of relevance to and partnership with the South African private sector. The relationship with the private sector will be enhanced through development of sector-based value propositions aimed at increasing partnering and collaboration, focusing on aerospace, automotive, chemicals, mining, textiles, defence, forestry, health and built environment sectors.

The CSIR's strategic partnership with HEIs is a key component of its human capital development and R&D strategies. Currently, the CSIR has Memoranda of Agreement on research collaboration with 11 HEIs in South Africa. Particular attention is paid to developing partnerships with previously-disadvantaged HEIs. New agreements are being developed with the Universities of the Free State, KwaZulu-Natal and Venda.

The partnerships with HEIs involve almost all of the CSIR units and centres. Twenty projects were implemented with these institutions in 2010/11, supported by seed funding from the CSIR Cooperation Fund. The outputs arising from these partnerships are monitored and show significant numbers of joint publications and joint projects with students, who are exposed to CSIR work. CSIR staff members are enrolled as students at these universities and there are various modalities for sharing human resources, for example, appointments to committees, and lecturing and co-supervision of students. Discussions are being held with several universities with respect

to accessing each other's research facilities, and possibly establishing joint facilities.

Numerous international research partnerships provide additional capacity to support national priorities and ensure world-class R&D standards.

The CSIR has developed an Africa strategy that aims to contribute to Africa's development, and which will be implemented in the coming year. Implementation will build on current CSIR activities in Africa such as infrastructure development; Information and Communications Technology (ICT) development; environmental issues; human capital development; and support to peace-keeping missions. The strategy will be implemented in collaboration with regional institutions such as the World Association of Industrial and Technological Research Organisations (WAITRO) and the Regional Research Alliance (RRA).

The CSIR will seek to increase its networks in Africa through mechanisms similar to the NEPAD Southern African Network for Biosciences (SANBio) hosted at the CSIR and the NEPAD Water Centres of Excellence, in which the CSIR is a partner. The CSIR signed a Memorandum of Understanding with the Uganda Industrial Research Institute (UIRI) recently, with an emphasis on assisting UIRI in business incubation in the agro-processing sector, and human capital development.

Overview of 2010/11 performance

Despite a challenging economic environment, the CSIR performed very well in attaining the objectives set in its annual Strategic and Operational Plan. Once again, the organisation has demonstrated a balance between high standards of science and high standards of corporate governance.

The CSIR has delivered positive financial results, with total turnover continuing to grow and the net margin exceeding target. There was a pleasing increase of 28% in South African private sector income compared with 2009/10. The CSIR maintained a customer satisfaction index better than 80%.

Attraction and retention of suitably qualified and capable staff members is becoming an overarching challenge. The target total size of the SET base was not quite achieved, and this had a knock-on effect on transformation of the SET base. However, the CSIR approach to human capital development and human resources management ensured that other relevant targets were met or very nearly met. The Human Capital Development (HCD) pipeline has grown significantly in terms of the number of studentships supported.

Strategic research alliances also increased. The value of capital investment in scientific equipment and facilities was deliberately curtailed in response to the economic climate. Despite this, the CSIR made an impressive investment of almost R119 million. Research outputs in terms of publication equivalents increased considerably yet again.

The target of a level 2 Broad-based Black Economic Empowerment (B-BBEE) contributor was not achieved. However, although the measures are not directly comparable, the CSIR B-BBEE score would benchmark favourably within the top 20 South African private listed companies. Employment Equity will receive focussed attention in 2011/12.

The CSIR energy utilisation was reduced by over 20% from the previous year. A renewed focus on employee safety has improved the injury index substantially.

The CSIR has maintained its record with an unqualified audit report. No material findings on CSIR Key Performance Indicators were identified by the auditors.

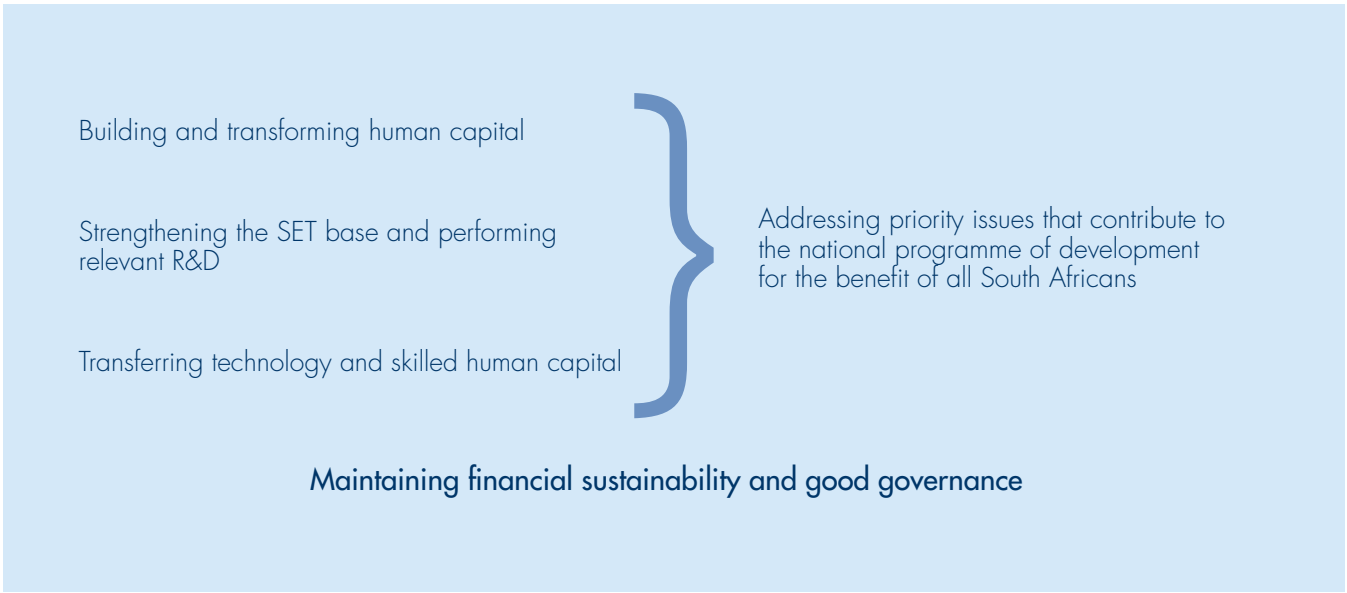
Setting of Key Performance Indicators (KPIs) and performance reporting

The CSIR enters into a Shareholder's Compact Agreement annually with the DST. The compact comprises a rolling three-year strategic plan and an operational plan with very specific KPIs. Strategic planning in the CSIR is supported by ongoing benchmarking against similar research organisations, and trend analysis of KPIs. Quarterly reports and the annual Science, Engineering and Technology Institution (SETI) scorecard report to the department address performance in terms of KPIs. The CSIR has a proud record of attaining KPI targets over the past few years.

Organisational priorities

The CSIR's strategy is translated into organisational priorities as the

Figure 2: Organisational priorities



framework for the annual operational plan. Organisational priorities have remained consistent over the past few years and have allowed for cumulative performance and entrenchment of strategy. The organisational priorities are reflected in Figure 2. Portfolio offices exist to coordinate and support strategic priorities such as those of the R&D, Human Capital Group; the Intellectual Property Management and Technology Transfer Support Unit; the Contract R&D office; and the Strategic Initiatives Implementation Unit. Organisational support units form a CSIR Shared Services grouping and render transactional or specialist strategic support and administrative services to the rest of the organisation.

Priority area: Building and transforming human capital

Human capital development is essential to achieving the CSIR strategic goals. The CSIR strategic goals require transformation of the profile of CSIR staff in line with the needs of a research organisation. Progress has been made through the establishment of career ladders for researchers and technical staff, and in improving the qualification profile of staff. HCD remains essential to organisational success, and is being achieved in line with the CSIR Human Resources (HR) strategy that was approved in 2008 (see Table 2). To date, significant progress has been made in the following areas:

- A revised remuneration strategy, including the bonus and incentive scheme;
- Establishing a centralised recruitment office staffed by specialists;
- Continued exploration of new recruitment territories such as international sources, cross-over industries and learnerships;
- A re-engineered new employee induction process; and
- Continued assurance of excellence in HR administration, systems and service.

Evidence of the progress made in human capital was provided by the Best Employer status awarded to the CSIR by the CRF Institute in 2010.

Table 2 shows performance against the targets set for human capital development and human resource management Key Performance Indicators. Figure 3 illustrates the five year trend in growing the staff complement with doctoral degrees.

Table 2: Building and transforming human capital

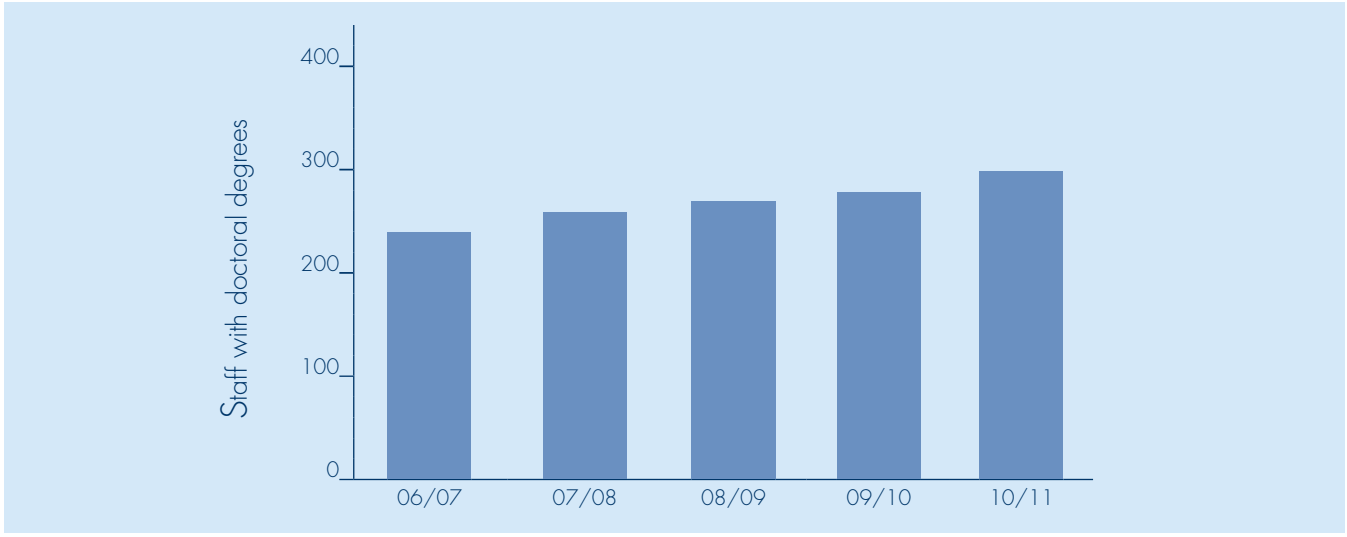
Strategic Focus Area	Key Performance Indicator	2010/11 Target	2010/11 Actual
Human capital development	Number of permanent CSIR staff studying towards Master's and PhD degrees	220	226
	Number of studentships supported	210	246
	Number of interns supported	125	124*
	Number of bursars appointed	165	160*
Human resource management	Total size of SET base (Number, %)	1 575 (65.5%)	1 560** (64.5%)
	% of SET base who are black	54.4	52.6***
	% of SET base who are female	33.3	33.2*
	Number of staff with PhD-level qualifications	303	299*

* The numbers of interns, bursars and staff with PhD qualifications, and the percentage of the SET base that are female are for all practical purposes on target.

** The total size of the SET base is slightly less than target, reflecting the challenge of sourcing sufficient suitable skills for the CSIR.

*** The transformation of the SET base continues to improve, but was slower than expected owing to the shortfall in the total SET base and challenges in the retention and attraction of highly-qualified black SET staff.

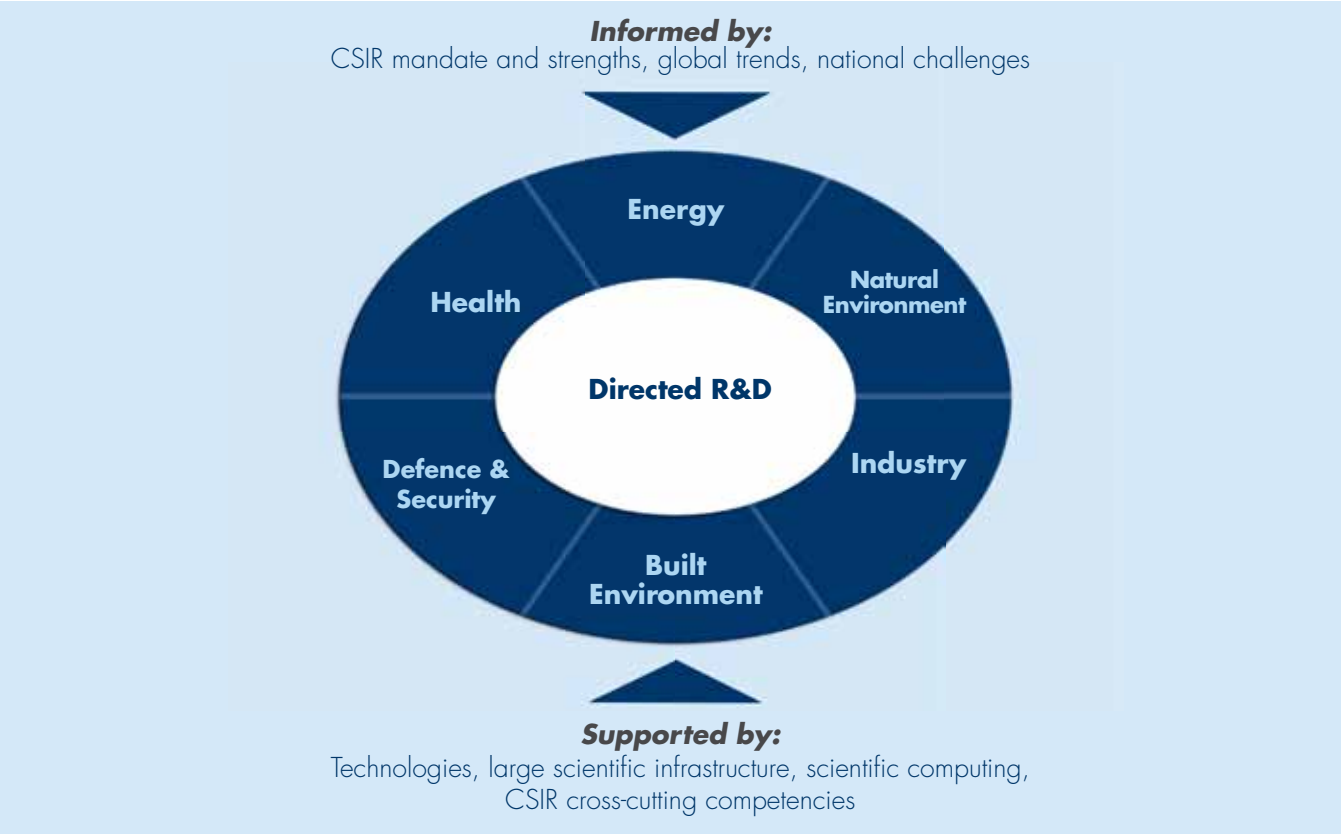
Figure 3: Five-year trend of CSIR staff with doctoral degrees



Priority area: Strengthening the SET base and performing relevant R&D

The CSIR continues to fulfil an increasingly important role in support of sustainable socio-economic development in South Africa in satisfaction of its mandate, by making science and technology of the highest quality available to markets and society. The overall strategic intent of this organisational priority is to continue to strengthen the capability to perform relevant research and innovation, and to achieve socio-economic impact in support of national priorities. Greater impact can be achieved through better focus of the organisation's R&D portfolio. To ensure that the R&D portfolio is focused on key areas that align with South Africa's priorities, the CSIR has identified the Research Impact Areas (RIAs) depicted in Figure 4. The RIAs form the basis for the CSIR's R&D strategy.

Figure 4: CSIR Research Impact Areas in support of our mandate



The strategic intent of each RIA is presented in Table 3.

Table 3: CSIR Research Impact Areas (RIAs)

Research Impact Area		Strategic intent
Health		To apply multi-disciplinary innovation to the design of effective and efficient health care systems, and to develop affordable preventative, diagnostic and treatment solutions to address the priority diseases in South Africa
Energy		To develop, implement and demonstrate renewable and alternative energy technology options; and provide decision support to achieve an energy-secure, low-carbon national economy with reduced water impact
Defence & Security		To contribute scientific and technological solutions towards the achievement of a peaceful, safe and secure South Africa and the region through better safe-guarding of infrastructure, borders, territorial waters and making South Africa an informed buyer and user of technology in defence and national security
Built Environment		To contribute technological innovations that support planning, design, construction, maintenance and management of the built environment and its interaction with human activities
Natural Environment		To develop decision-support tools, capabilities to monitor the state of the natural resource base and to apply environmental engineering to provide technological innovations to address key resource base issues that support a resilient South African economy
Industry	Advanced Manufacturing	To develop and transfer new technologies and technology-based solutions that will improve the size, competitiveness and sustainability of the South African manufacturing industry
	Mining	To develop technological innovations that support a healthy, safe, smart, innovative, efficient and sustainable mining industry

The CSIR achieved outstanding performance with regard to its objective of strengthening the SET base, when measured against targets set for its Key Performance Indicators (see Table 4). Significant progress was made with both the quality and quantity of research outputs. The success in this area was supported by numerous active and successful research partnerships.

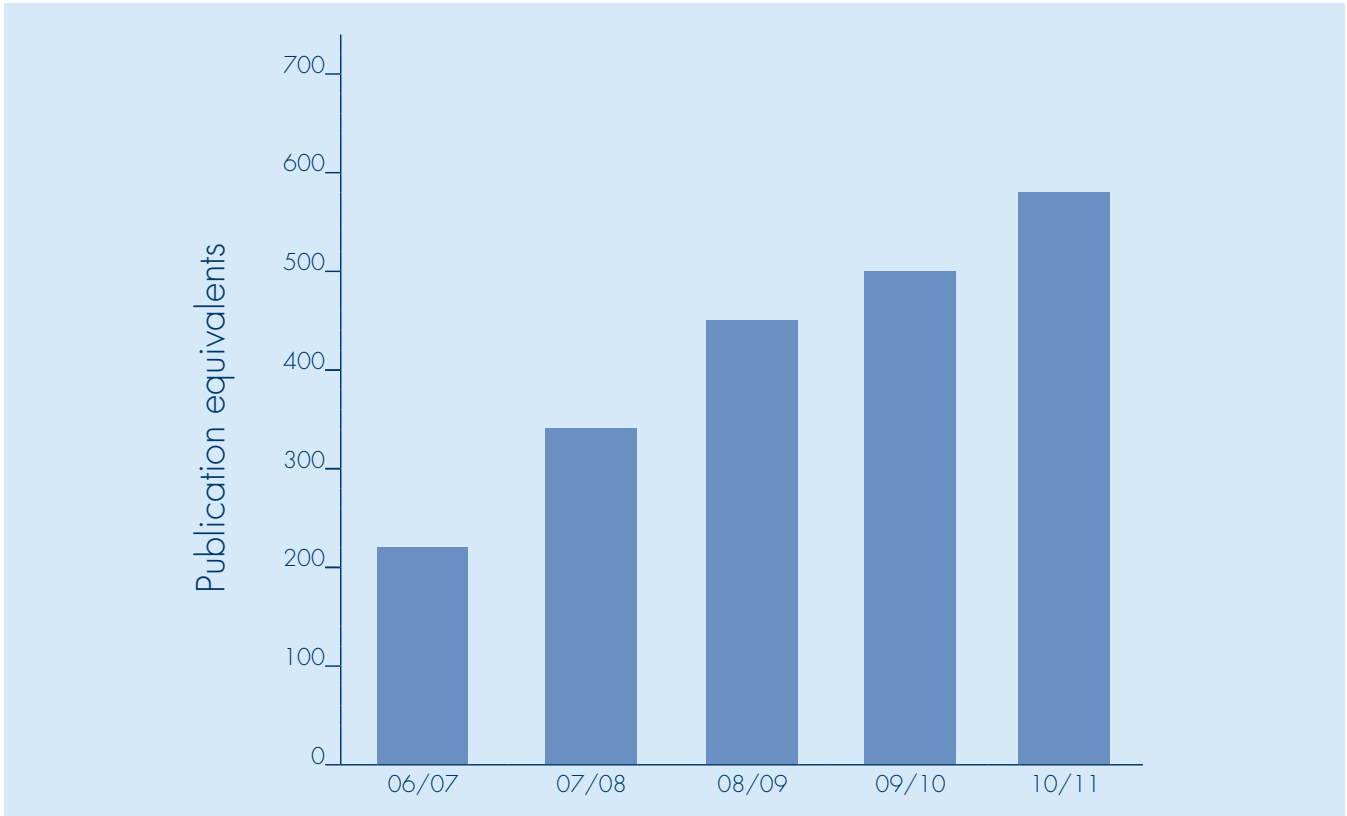
Table 4: Strengthening the SET base and performing relevant R&D

Strategic Focus Area	Key Performance Indicator	2010/11 Target	2010/11 Actual
R&D outputs	Publication equivalents	466	576
	New technology demonstrator equivalents	31	37
Strategic research alliances	Value and number of collaborative R&D activities with a value exceeding R1.5m	R226.0m 53	R242.7m 70
	Value and number of collaborative research projects with TEIs	R133.7m 110	R186.3m 150

Research productivity

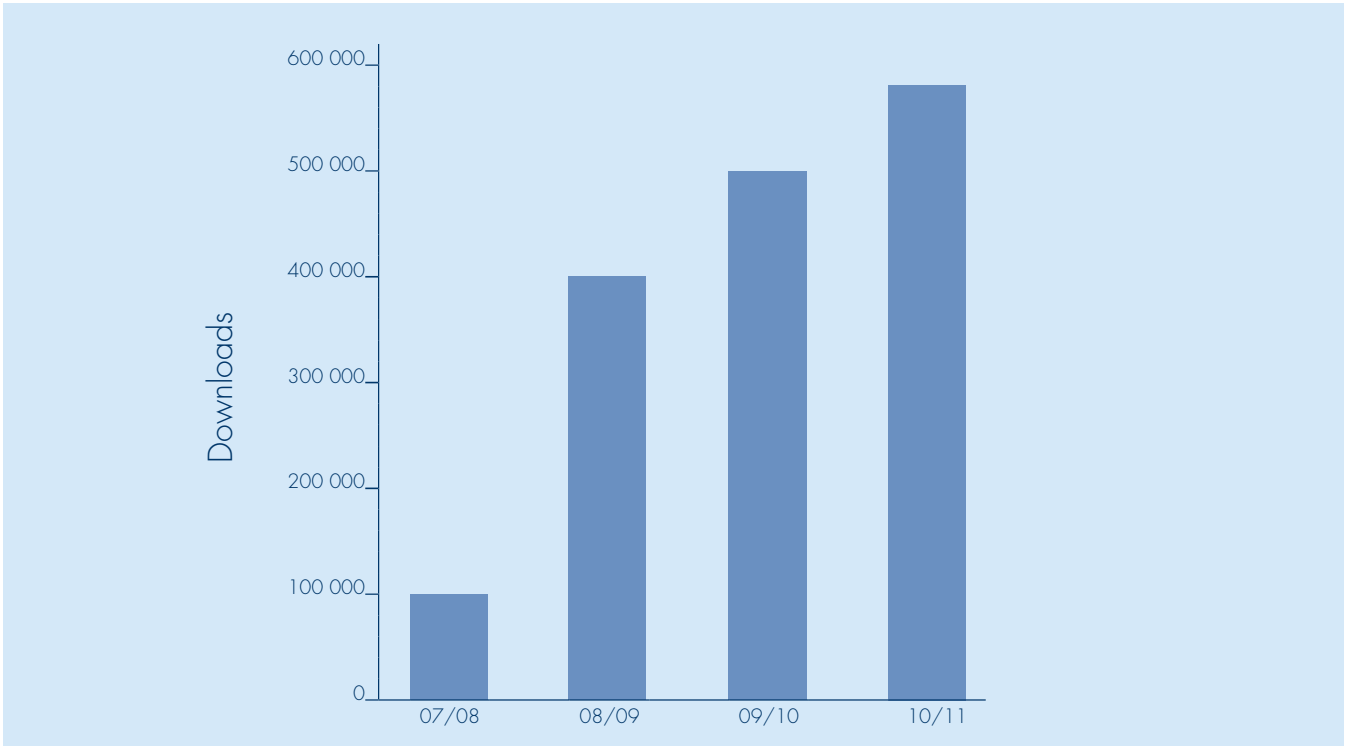
The total number of publication equivalents increased by nearly 15% in 2010/11 compared to the previous year. Figure 5 shows the consistent growth of publication equivalents output over the past five years. The CSIR continues to place emphasis on the quality and quantity of research outputs, especially in scientific journals that undergo a rigorous peer-review process and have good citation indices. The number of articles published in accredited journals has shown a steady increase over the years and in the last year increased by nearly 12%; from 266 in 2009/10 to 297 in 2010/11. Similarly, articles published in ISI journals with an impact factor greater than 2 increased to 42.5% of all published articles.

Figure 5: Five-year trend of publication equivalent output



The CSIR continues to make information available to decision makers and society in various ways. The CSIR Researchspace has become a popular source of information, and over 47 000 items were downloaded monthly in 2010/11. Figure 6 shows the trend of annual downloads since Researchspace was launched in 2007.

Figure 6: Annual trends of downloads



Priority area: Transferring technology and skilled human capital

The CSIR R&D capacity provides value to society through the Contract R&D it undertakes and through the commercialisation of formally protected intellectual property.

The CSIR has provided significant value in terms of support to national priorities.

Examples include:

- The development of the South African Risk & Vulnerability Atlas, which translates global change science to information to support planning and decision-making at national, provincial and municipal levels;
- Publication of the Municipal Waste Management Guidelines, providing good practice in waste service delivery;
- Publication of a technical guide on causes, identification and repair of potholes and a non-technical guide on causes and prevention of potholes in support of an improved road network infrastructure;
- Emergency response doctrine development and implementation to support improved effectiveness and efficiency of Joint National Emergency Response teams in support of the 2010 FIFA World Cup;
- Enterprise creation for development; supporting more than 460 project beneficiaries in 2010/11; and
- Implementation of a new TB facility design to reduce the risk of cross-infection and counter the growing TB epidemic.

The CSIR Intellectual Property (IP) strategy focuses on:

- *Intellectual property management:* To ensure the effective identification, disclosure, protection and management of discoveries and inventions and other IP, to be able to make deliberate choices as to how to benefit society and the economy with this intellectual property; and
- *Technology transfer:* To develop practical applications from the results of scientific research and transfer these applications for the benefit of the economy and society.

Significant progress was made in 2010/11 in identifying 13 priority commercialisation priorities for the CSIR and developing rigorous, peer-reviewed plans to execute them over the next three years.

Table 5 shows the excellent performance in exceeding all R&D outcomes and Contract R&D targets. The continued growth in Contract R&D illustrates customer confidence in the CSIR ability to deliver value.

Table 5: Transferring technology and skilled human capital

Strategic Focus Area	Key Performance Indicator	2010/11 Target	2010/11 Actual
R&D outcomes	New international patents granted	11	14
	Number of new technology packages available for transfer	16	29
	Royalty and licence revenue	R8.3m	R8.62m
Contract R&D	Contract R&D income	R1 093.0m	R1 175.1m
	Value of Contract R&D formally recognised as supporting national strategies	R603.0m	R671.9m
	Customer satisfaction	80%	80.19%

Priority area: Financial sustainability, good corporate governance and citizenship

The CSIR continues to maintain an excellent record in corporate governance, and special mention was made in Parliament of the exemplary CSIR performance. External benchmarking showed the CSIR procurement capabilities to be one of the best in South Africa.

Table 6: Financial sustainability, good corporate governance and citizenship

Strategic Focus Area	Key Performance Indicator	2010/11 Target	2010/11 Actual
Financial sustainability	Value of investment in property, plant and equipment	R140.9m	R118.8m*
	Total income	R1.64 billion	R1.72 billion
	Net profit	R33.0m	R35.5m
Corporate governance and citizenship	B-BBEE rating	Level 2 contributor	Level 3 contributor **
	Energy efficiency	Achieve 1.2% reduction in energy consumption on previous year	Achieved 21.4% reduction in energy consumption on previous year
	Environmental stewardship: ISO 14001	Compliance to ISO 14001	Compliance maintained
	Disabling injury frequency rate (DIFR)	<0.3 disabling injuries	0.12

* During the financial year management curtailed investment in property, plant and equipment due to the economic conditions facing the organisation at the time.

** The new B-BBEE audit will take place later in 2011. However, the CSIR expects the score to be approximately 2 points less than that required for Level 2 status owing to a lower than expected employment equity score.

Financial performance overview

A Income

The total operating income of the CSIR increased by 2.6% to an amount of R1 723.6 million (2009/10: R1 680 million). The CSIR Group's total operating income amounted to R1 735.8 million (2009/10: R1 697.5 million).

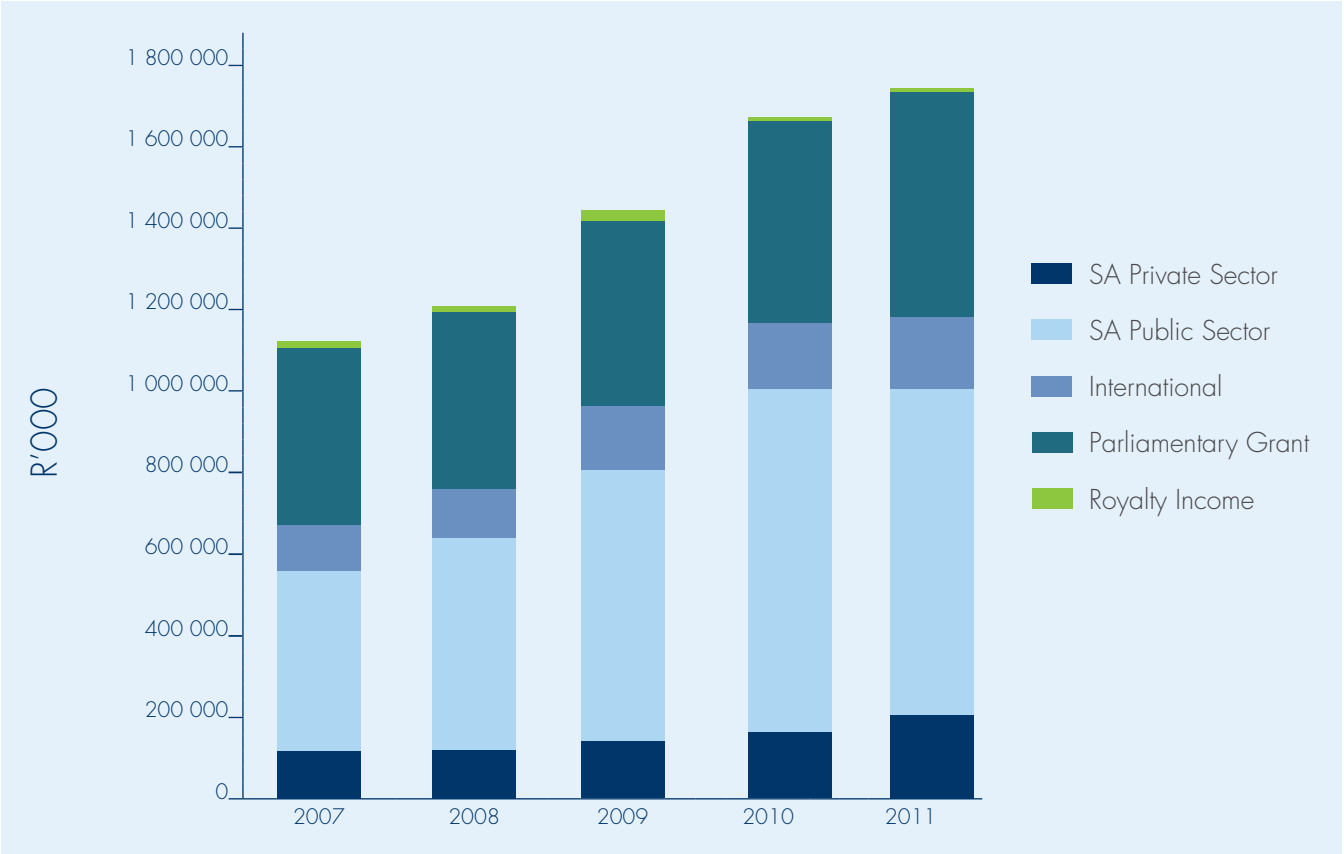
The Parliamentary Grant recognised as income in 2010/11 amounted to R535.3 million, an increase of 5.1% from the prior year amount of R509.1 million.

The CSIR's total Contract R&D income increased marginally by 1.3% to R1 175.1 million (2009/10: R1 159.8 million). This includes R64.9 million (2009/10: R99.5 million) ring-fenced funding from the DST. The CSIR Group's total Contract R&D income increased to an amount of R1 187.2 million (2009/10: R1 176.8 million).

A strategy to increase income from the South African private sector resulted in growth of this income stream of 28% from 2009/10. Income from the South African private sector amounted to R193.3 million (2009/10: R151.3 million). 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, amounting to R820.7 million (2009/10: R848.8 million). International contract income increased marginally due to the slow economic recovery in international markets. Contract income from the international sector amounted to R161 million (2009/10: R159.6 million).

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 four financial years R572 million has been invested in property, plant and equipment.

Figure 7:CSIR income streams for financial years ending 2007-2011



B Five-year review of income and expense indicators

	2011 R'000	2010 R'000	2009 R'000	2008 R'000	2007 R'000
Total income	**1 776 827**	**1 748 848**	**1 554 910**	**1 271 062**	**1 150 467**
Parliamentary Grant recognised as income	535 357	509 122	480 320	429 013	428 055
Contract income, royalty income, other income and net finance income	**1 241 470**	**1 239 726**	**1 074 590**	**842 049**	**722 412**
Local private sector	193 362	151 339	147 752	137 683	134 647
Local public sector	820 705	848 846	661 682	508 779	435 391
International sector (including Africa)	161 027	159 610	142 002	119 584	106 027
Royalties and other income	13 197	11 168	40 516	22 908	17 321
Net finance income	53 179	68 763	82 638	53 095	29 026
Total expenditure	**1 741 317**	**1 695 419**	**1 495 442**	**1 219 665**	**1 125 588**
Employees' remuneration	940 776	873 445	763 867	619 529	579 035
Operating expenses	759 048	779 832	694 435	572 454	496 752
Depreciation	41 493	42 142	37 140	27 682	49 801

C Net profit and cash flow

The net profit of the CSIR amounts to R35.5 million (2009/10: R52.4 million). The net profit for the CSIR Group was R33.8 million (2009/10: R57.6 million).

The reduction in net profit for the CSIR is attributable to an increase in employee remuneration in excess of operating income growth and reduced net finance income.

Cash flow generated from operating activities for the CSIR for the year under review is R298.6 million (2009/10: R25.9 million). The cash and cash equivalent holdings, including long-term fixed deposits of the CSIR increased to R975.7 million (2009/10: R766.2 million). The current ratio remains the same as the previous financial year at 1.1.

D Five-year ratio analysis

	2011	2010	2009	2008	2007
	R'000	R'000	R'000	R'000	R'000
Operating expenses					
Remuneration as a percentage of total income (excluding finance income)	54.6%	52.0%	51.9%	50.9%	51.6%
Remuneration as a percentage of total operating expenditure	54.0%	51.5%	51.1%	50.8%	51.2%
Asset management					
Investment in property, plant and equipment (Rm)	118.8	179.0	188.3	85.9	79.2
Investment in property, plant and equipment as a percentage of revenue	6.9%	10.7%	13.0%	7.1%	7.1%
Net asset turn	3.3	3.4	3.4	3.2	3.2
Current ratio	1.1	1.1	1.0	1.2	0.9
Cash flow					
Net cash from operating activities	298 668	25 967	285 546	167 307	341 357
Cash and cash equivalents at end of year (including long-term fixed deposits)	975 755	766 278	834 830	673 309	557 529

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 SA GAAP, AC133: Financial instruments - recognition and measurement have been excluded for the comparison of financial indicators.

7 ANNUAL FINANCIAL STATEMENTS

Statements of comprehensive income

for the year ended 31 March 2011

	Notes	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
Revenue	2	1 731 174	1 696 558	1 719 067	1 679 435
Other income		4 592	1 001	4 581	650
Total operating income		1 735 766	1 697 559	1 723 648	1 680 085
Expenditure					
Employees' remuneration		946 485	880 745	940 776	874 458
Depreciation and amortisation	6&7	42 067	42 787	41 493	42 142
Operating expenses	3	768 176	787 400	759 048	779 832
Total operating expenditure		1 756 728	1 710 932	1 741 317	1 696 432
Finance income	4	58 861	78 468	57 243	75 921
Finance expense	4	(4 063)	(7 152)	(4 063)	(7 152)
Share of profit/(loss) of joint ventures and associates	8	119	(214)		
Profit for the year before income tax		33 955	57 729	35 511	52 422
Income tax expense	5	(60)	(122)		
Profit for the year		33 895	57 607	35 511	52 422
Other comprehensive income					
Foreign currency translation differences for foreign operations		(17)	50		
Other comprehensive income for the year		(17)	50	-	-
Total comprehensive income for the year		33 878	57 657	35 511	52 422
Profit attributable to:					
Stakeholders of the parent		33 895	57 607	35 511	52 422
Total comprehensive income attributable to:					
Stakeholders of the parent		33 878	57 657	35 511	52 422

Statements of financial position
as at 31 March 2011

	Notes	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
ASSETS					
Non-current assets		**394 317**	351 994	**419 677**	378 211
Property, plant and equipment	6	**392 480**	350 203	**392 105**	349 183
Intangible assets	7	**18**	46	**-**	-
Interest in joint ventures and associates	8	**1 419**	1 487	**1 376**	1 499
Interest in subsidiaries	9			**26 196**	27 529
Other investments	10	**-**	-	**-**	-
Deferred tax asset	13	**400**	258		
Current assets		**1 312 351**	1 104 552	**1 280 194**	1 070 078
Trade and other receivables	11	**118 509**	128 752	**123 631**	130 086
Inventory and contracts in progress	12	**89 549**	80 928	**85 918**	78 824
Cash and cash equivalents	24	**1 009 403**	799 982	**975 755**	766 278
Non-current asset held for sale	6.1	**94 890**	94 890	**94 890**	94 890
TOTAL ASSETS		**1 706 668**	1 456 546	**1 699 871**	1 448 289
EQUITY AND LIABILITIES					
Reserves		**541 030**	507 152	**534 221**	498 710
Retained earnings		**540 267**	506 372	**534 221**	498 710
Non-distributable reserve: Foreign currency translation reserve		**763**	780		
Non-current liabilities		**10 142**	9 875	**10 142**	9 875
Post-retirement medical benefits	18.4	**10 142**	9 875	**10 142**	9 875
Current liabilities		**1 155 496**	939 519	**1 155 508**	939 704
Advances received	14	**628 626**	493 943	**628 626**	493 943
Trade and other payables	15	**526 542**	445 195	**526 882**	445 761
Provisions	16	**328**	381	**-**	-
TOTAL EQUITY AND LIABILITIES		**1 706 668**	1 456 546	**1 699 871**	1 448 289

Statements of changes in equity

for the year ended 31 March 2011

	Retained earnings	Self-insurance reserve	Non-distributable reserve*	Total
	R'000	R'000	R'000	R'000
GROUP				
Balance at 31 March 2009	438 015	10 750	730	**449 495**
Total comprehensive income	57 607	-	50	**57 657**
Profit for the year	57 607	-	-	**57 607**
Other comprehensive income for the year:				
Foreign currency translation differences for foreign operations	-	-	50	**50**
Transfer of self-insurance reserve to retained earnings	10 750	(10 750)	-	-
Balance at 31 March 2010	**506 372**	-	**780**	**507 152**
Total comprehensive income	33 895	-	(17)	**33 878**
Profit for the year	33 895	-	-	**33 895**
Other comprehensive income for the year:				
Foreign currency translation differences for foreign operations	-	-	(17)	**(17)**
Balance at 31 March 2011	**540 267**	-	**763**	**541 030**
CSIR				
Balance at 31 March 2009	435 538	10 750	-	**446 288**
Total comprehensive income	52 422	-	-	**52 422**
Profit for the year	52 422	-	-	**52 422**
Transfer of self-insurance reserve to retained earnings	10 750	(10 750)	-	-
Balance at 31 March 2010	**498 710**	-	-	**498 710**
Total comprehensive income	35 511	-	-	**35 511**
Profit for the year	35 511	-	-	**35 511**
Balance at 31 March 2011	**534 221**	-	-	**534 221**

*The non-distributable reserve consists of a foreign currency translation reserve. The foreign currency translation reserve comprises all foreign currency differences arising from the translation of the financial statements of foreign operations as well as from the translation of liabilities that hedge the Group's net investment in a foreign subsidiary, if applicable.

Statements of cash flows
for the year ended 31 March 2011

	Notes	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
Cash flows from operating activities					
Cash receipts from external customers		1 210 338	1 208 457	1 189 047	1 190 502
Parliamentary Grant received		550 305	510 951	550 305	510 951
Cash paid to suppliers and employees		(1 514 505)	(1 778 483)	(1 493 863)	(1 744 249)
Cash generated/(utilised) from operating activities	23	246 138	(59 075)	245 489	(42 796)
Finance income	4	58 861	78 468	57 243	75 921
Finance expense	4	(4 064)	(7 158)	(4 064)	(7 158)
Income taxes paid		(202)	(122)		
Net cash from operating activities		300 733	12 113	298 668	25 967
Cash flows from investing activities					
Acquisition of property, plant and equipment	6	(90 450)	(95 624)	(90 311)	(95 056)
Proceeds on disposal of property, plant and equipment		654	1 299	397	1 222
Decrease/(increase) in subsidiary loans				1 365	(685)
Decrease in investments		-	100 000	-	100 000
Acquisition of intangible assets	7	(858)	(406)	-	-
Net cash (utilised)/generated in investing activities		(90 654)	5 269	(88 549)	5 481
Cash flows from financing activities					
Decrease in long-term liabilities		(642)	-	(642)	-
Net cash utilised in financing activities		(642)	-	(642)	-
Net increase in cash and cash equivalents		209 437	17 382	209 477	31 448
Cash and cash equivalents at beginning of the year		799 982	782 528	766 278	734 830
Effect of foreign exchange rate changes		(16)	72	-	-
Cash and cash equivalents at end of the year	24	1 009 403	799 982	975 755	766 278

Notes to the Annual Financial Statements
for the year ended 31 March 2011

1 PRINCIPAL ACCOUNTING POLICIES

The CSIR is a parastatal (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 consolidated Annual Financial Statements are prepared on the historical cost basis except for financial instruments held for trading and financial instruments classified as available-for-sale, which are stated at fair value. The consolidated Annual Financial Statements have been prepared in accordance with statements of South African Generally Accepted Accounting Practice (SA GAAP) and the Public Finance Management Act, Act 1 of 1999 as amended by Act 29 of 1999. The following principal accounting policies have been consistently applied by group entities in all material respects.

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.

Basis of consolidation

Interest in subsidiaries

The consolidated Annual Financial Statements incorporate the Annual Financial Statements of the CSIR and the Annual Financial Statements of the entities under its control from the date that control commences until the date that control ceases. Control exists when the CSIR has the power to govern the financial and operating policies of an investee entity so as to obtain benefits from its activities. In assessing control, potential voting rights that are presently exercisable are taken into account.

On acquisition, the assets and liabilities of the relevant subsidiaries are measured at their fair values at the date of acquisition. Non-controlling interests are stated at the non-controlling interests' proportion of the fair values of the assets and liabilities recognised. The operating results of subsidiaries acquired or disposed of during the reporting period are included in the consolidated statement of comprehensive income from the effective date of acquisition up to the effective date of disposal. All significant intercompany balances between group entities are eliminated on consolidation.

Where a group enterprise transacts with a subsidiary company, unrealised gains and losses are eliminated in preparing the consolidated financial statements.

Any excess of net assets of a subsidiary over the cost of an acquisition is treated in terms of the Group's accounting policy on goodwill.

Investments in subsidiaries are measured at cost less accumulated impairment losses in the CSIR's Annual Financial Statements.

Interest in associates

An associate is an entity over which the Group is in a position to exercise significant influence, but not control, through participation in the financial and operating policy decisions of

the investee. The Group's share of the total recognised gains and losses of associates is incorporated in the consolidated financial statements, from the date that significant influence commences until the date that significant influence ceases, using the equity method of accounting. The carrying amount of such interests is reduced to recognise any impairment, other than a temporary impairment, in the value of individual investments.

Where a group enterprise transacts with an associate company, unrealised gains and losses are eliminated to the extent of the group's interest in the relevant associate company, except where unrealised losses provide evidence of an impairment of the asset transferred. When the Group's share of losses exceeds its interest in an investee, the carrying amount of that interest (including any long-term investments) is reduced to nil and the recognition of further losses is discontinued except to the extent that the Group has an obligation or has made payments on behalf of the investee.

Any excess of net assets of an associate over the cost of an acquisition is treated in terms of the Group's accounting policy on goodwill.

Investments in associates are measured at cost less accumulated impairment losses in the CSIR's Annual Financial Statements.

Interest in joint ventures

A joint venture is a contractual arrangement whereby the CSIR and other parties undertake economic activity, which is subject to joint control.

The Group's share of the total recognised gains and losses of jointly-controlled entities is incorporated in the consolidated financial statements, from the date that joint control commences until the date that joint control ceases, using the equity method of accounting. The carrying amount of such interests is reduced to recognise any impairment, other than a temporary impairment, in the value of individual investments.

Where a group enterprise transacts with a joint venture, unrealised gains and losses are eliminated to the extent of the group's interest in the relevant joint venture, except where unrealised losses provide evidence of an impairment of the asset transferred. When the Group's share of losses exceeds its interest in an investee, the carrying amount of that interest (including any long-term investments) is reduced to nil and the recognition of further losses is discontinued except to the extent that the Group has an obligation or has made payments on behalf of the investee.

Any excess of net assets of a joint venture over the cost of an acquisition is treated in terms of the Group's accounting policy on goodwill. Investments in joint ventures are measured at cost less accumulated impairment losses in the CSIR's Annual Financial Statements.

Foreign currencies

Foreign operations

All foreign subsidiaries of the CSIR are foreign operations.

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

- Assets and liabilities, including goodwill and fair value adjustments on consolidation, at rates of exchange ruling at the reporting entities' financial year-end;
- Revenue, expenditure and cash flow items at the average rates of exchange during the relevant financial year (the average rates approximate fair value).

Differences arising on translation are reflected 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.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

PRINCIPAL ACCOUNTING POLICIES (continued)
Foreign operations (continued)

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 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 stated in South African rand using the rates of exchange ruling at the reporting date. The resulting exchange differences are recognised in the statement of comprehensive income. Non-monetary assets and liabilities stated at fair value are translated at foreign exchange rates ruling at the date the fair value was determined.

Property, plant and equipment
Owned assets
Land is stated at cost less accumulated impairment losses. Buildings, plant, 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.

The estimated lives of the main categories of property, plant and equipment are as follows:
- 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.

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

PRINCIPAL ACCOUNTING POLICIES (continued)

Research and development (continued)

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.

Goodwill

Goodwill arising on the acquisition of subsidiaries, associates or joint ventures represents the excess of the cost of an acquisition over the fair value of the Group's interest in the net assets of the acquired subsidiary, associate or joint venture at the date of the acquisition (refer to basis of consolidation). All business combinations are accounted for by applying the purchase method.

Goodwill arising from the acquisition of a joint venture or an associated company is included within the carrying amount of the joint venture or associated company. Goodwill arising from a subsidiary is presented separately in the statement of financial position and tested annually for impairment and is stated at cost less accumulated impairment losses. Goodwill is allocated to cash-generating units. On disposal of a subsidiary, joint venture or associated company, the attributable amount of goodwill is included in the determination of the profit or loss on disposal.

When an excess arising on an acquisition is negative (negative goodwill), it is recognised directly in profit or loss.

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. 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
- Development expenditure and intellectual property: 1 to 3 years

Impairment

Financial assets

A financial asset 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. An impairment loss in respect of an available-for-sale financial asset is calculated by reference to its current fair value.

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. Any cumulative loss in respect of an available-for-sale financial asset recognised previously in other comprehensive income is transferred to profit or loss.

An impairment loss is reversed if the reversal can be related objectively

Notes to the Annual Financial Statements
for the year ended 31 March 2011

PRINCIPAL ACCOUNTING POLICIES (continued)
Financial assets (continued)

to an event occurring after the impairment loss was recognised. For financial assets measured at amortised cost and available-for-sale financial assets that are debt securities, the reversal is recognised in profit or loss. For available-for-sale financial assets that are equity securities, the reversal is recognised directly in other comprehensive income.

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 to sell. 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.

Non-current assets held for sale

Non-current assets (or disposal groups comprising assets and liabilities) that are expected to be recovered primarily through sale rather than through continuing use, are classified as held for sale. Immediately before classification as held for sale, the assets (or components of a disposal group) are remeasured in accordance with the Group's accounting policies. Thereafter, the assets (or disposal group) are generally measured at the lower of their carrying amount and fair value less cost to sell. Impairment losses on initial classification as held for sale and subsequent gains or losses on remeasurement are recognised in profit or loss. Gains are not recognised in excess of any cumulative impairment loss.

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 the statement of comprehensive income 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 the statement of comprehensive income on a systematic basis over the employees' working lives within the Group.

Actuarial gains and losses are recognised in full in the statement of 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 aid contribution reduced by the fair value of the plan assets. 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.

Inventory and contracts in progress

Raw materials and finished goods are stated at the lower of cost and net realisable value. Cost of inventory is determined by the weighted average method. 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.

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 charge for taxation 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, in which case it is recognised in other comprehensive income.

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 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.

The amount of deferred tax provided is based on the expected manner of realisation or settlement of the carrying amount of assets and liabilities using tax rates enacted or substantively enacted at the reporting date. Deferred tax is charged to the statement of comprehensive income

Notes to the Annual Financial Statements
for the year ended 31 March 2011

PRINCIPAL ACCOUNTING POLICIES (continued)
Income tax (continued)

except to the extent that it relates to a transaction that is recognised directly in equity. The effect on deferred tax of any changes in tax rates is recognised in the statement of comprehensive income except to the extent that it relates to items previously charged or credited directly to equity.

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 determined by discounting the expected future cash flows at a pre-tax rate that reflects current market assessments of the time value of money and the risks specific to the liability.

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.

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.

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.

The annual Parliamentary Grant is adjusted for the grant received for projects started before year-end, but not completed as detailed above (refer to Government grants).

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

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 the

statement of comprehensive income as it accrues, using the effective interest rate method.

Dividend income is recognised in the statement of comprehensive income 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.

Expenses

Operating lease payments

Payments made under operating leases are recognised in the statement of comprehensive income on a straight-line basis over the term of the lease. Lease incentives received are recognised in the statement of comprehensive income as an integral part of the total lease expense, over the term of the lease.

Finance lease payments

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.

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 below.

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.

Receivables originated by the Group and not held for trading are measured at amortised cost using the effective interest method less any impairment losses if these have a fixed maturity.

Investments and loans

Investments, other than in subsidiaries, associates or joint ventures, are recognised at fair value. Dividends are accounted for on the last day of registration in respect of listed investments and when declared in respect of unlisted investments. On disposal of an investment, the difference between the net disposal proceeds and the carrying amount is charged or credited to the statement of comprehensive income.
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 on hand is stated at amortised cost, which is its fair value. Cash and cash equivalents comprise bank balances, cash on deposit and cash on hand.

Forward exchange contracts

Forward exchange contracts are fair valued and gains and losses are recognised in the statement of comprehensive income. Hedge accounting is not applied.

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 the statement of comprehensive income.

Financial liabilities (or a portion thereof) are de-recognised when the obligation specified in the contract

Notes to the Annual Financial Statements
for the year ended 31 March 2011

PRINCIPAL ACCOUNTING POLICIES (continued)
De-recognition (continued)

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 the statement of comprehensive income.

Fair value methods and assumptions

The fair value of financial instruments traded in an organised financial market is measured at the applicable quoted prices necessary to realise the asset or settle the liability.

The fair value of financial instruments not traded in an organised financial market is determined using a variety of valuation methods and assumptions that are based on market conditions and risk existing at the reporting date, including independent appraisals and discounted cash flow methods.

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.

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 2011, the following standards and interpretations were in issue but not yet effective:

Standard/Interpretation	Description	Effective date
IFRS 1 (AC 138) amendment	Limited exemption from comparative IFRS 7 disclosures for first-time adopters. This amendment will not affect the Group's results.	Annual periods commencing on or after 1 July 2010
IFRIC 19 (AC 452)	Extinguishing financial liabilities with equity instruments. IFRIC 19 is not expected to have an impact on the Group's results.	Annual periods commencing on or after 1 July 2010
11 individual amendments to 6 standards	Improvements to International Financial Reporting Standards 2010. The impact of these amendments on the Group's results cannot be determined at this stage.	Annual periods commencing on or after 1 July 2010 or for annual periods commencing on or after 1 July 2011
Revised IAS 24 (AC 126)	Related party disclosures. The amendments will have an impact on the Group's disclosure for significant related party transactions.	Annual periods commencing on or after 1 January 2011
IFRIC 14 (AC 447) amendment	Prepayments of a minimum funding requirement. The impact of this amendment on the Group's results cannot be determined at this stage.	Annual periods commencing on or after 1 January 2011
IFRS 1 amendment	Severe hyperinflation and removal of fixed dates for first-time adopters. This amendment will not affect the Group's results.	Annual periods commencing on or after 1 July 2011
IFRS 7 (AC 144) amendment	Disclosures - Transfers of financial assets. The impact of this amendment on the Group's results cannot be determined at this stage.	Annual periods commencing on or after 1 July 2011
IAS 12 amendment	Deferred tax: Recovery of underlying assets. The amendment is not expected to affect the Group's results.	Annual periods commencing on or after 1 January 2012
IFRS 9 (AC 146)	Financial instruments. The impact of this amendment on the Group's results cannot be determined at this stage.	Annual periods commencing on or after 1 January 2013

Notes to the Annual Financial Statements
for the year ended 31 March 2011

2 REVENUE

	GROUP				CSIR			
	2011 R'000	%	2010 R'000	%	2011 R'000	%	2010 R'000	%
Parliamentary Grant	**535 357**	**31**	509 122	29	**535 357**	**31**	509 122	29
Parliamentary Grant received	**550 305**	**32**	510 951	30	**550 305**	**32**	510 951	30
Less:								
Grant received for projects started before year-end but not completed	**(57 365)**	**(3)**	(42 417)	(3)	**(57 365)**	**(3)**	(42 417)	(3)
Add:								
Grant received in prior year for projects completed in this year	**42 417**	**2**	40 588	2	**42 417**	**2**	40 588	2
Contract R&D income	**1 187 201**	**69**	1 176 895	70	**1 175 094**	**69**	1 159 795	71
Local private sector	**185 781**	**11**	148 802	9	**193 362**	**11**	151 339	9
Local public sector	**820 705**	**48**	848 846	50	**820 705**	**49**	848 846	52
International sector (including Africa)	**180 715**	**10**	179 247	11	**161 027**	**9**	159 610	10
Royalties	**8 616**	**-**	10 541	1	**8 616**	**-**	10 518	-
	1 731 174	**100**	1 696 558	100	**1 719 067**	**100**	1 679 435	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 R7,969 million (2010: R13,324 million) and is included in finance income (note 4).

Included in public sector Contract R&D income is R64,97 million (2010: R99,58 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 amouting to R24,45 million (2010: R25,84 million).

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

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
3 OPERATING PROFIT				
The net operating profit is arrived at after taking the following items into account:				
Audit fees	3 501	4 225	3 423	4 157
Fees for services	4 829	6 108	4 530	5 491
Patent costs	4 611	5 660	4 312	5 043
Legal costs	218	448	218	448
Operating leases	16 036	16 169	14 988	15 057
Buildings	8 839	8 944	7 791	7 832
Equipment	4 357	4 639	4 357	4 639
Vehicles	2 840	2 586	2 840	2 586
Net realised foreign exchange (gain)/loss	(5 060)	2 684	(5 194)	3 510
Net unrealised foreign exchange loss	1 619	7 254	1 676	8 411
Board members' and Executive Management's emoluments (note 19)	19 513	17 995	17 525	15 898
Impairments/(reversals of impairments)	187	(6 944)	(813)	(7 252)
Impairment on subsidiaries, joint ventures and associates	187	464	18	461
Reversal of impairment on trade receivables	(831)	(7 713)	(831)	(7 713)
Impairment on intangible assets	831	305	-	-
Provision for warranty	(53)	(1 046)	-	-
Bad debt written off	544	3 558	544	3 558
Write-down of inventory to net realisable value	230	-	230	-
Loss/(profit) on disposal and write-off of property, plant and equipment	5 506	(647)	5 499	(658)
Profit on disposal of interests in joint ventures and associates	-	(559)	-	-
Lost and/or stolen equipment and vehicles*	800	937	800	937
Losses incurred	2 419	1 464	2 419	1 464
Losses recovered	(1 619)	(527)	(1 619)	(527)

* 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 loss/(profit) on disposal and write-off of property, plant and equipment amounts.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
4 FINANCE INCOME/EXPENSE				
Finance income	58 861	78 468	57 243	75 921
Interest on bank balances and investments	50 892	65 144	49 274	62 597
Adjustment on initial recognition of Contract R&D income*	7 969	13 324	7 969	13 324
Finance expense	(4 063)	(7 152)	(4 063)	(7 152)
Fair value adjustment on trade and other receivables	1	6	1	6
Adjustment on initial recognition of operating expenses*	(4 064)	(7 158)	(4 064)	(7 158)
	54 798	71 316	53 180	68 769

*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 taxation due by subsidiaries	60	122
Current taxation	202	122
Deferred taxation - temporary differences	(142)	-
	60	122
South African normal rate of taxation	28%	28%
Profit attributable to tax exempt entities	(29%)	(25%)
Assessed loss (refer to note 13)	1%	(3%)
Current and deferred taxation - effective rate	0%	0%

6 PROPERTY, PLANT AND EQUIPMENT

	2011			2010		
	Cost	Accumulated depreciation	Carrying value	Cost	Accumulated depreciation	Carrying value
	R'000	R'000	R'000	R'000	R'000	R'000
GROUP						
Land	5 549	-	5 549	5 549	-	5 549
Buildings	277 842	70 850	206 992	249 665	77 463	172 202
Equipment	630 098	453 314	176 784	608 025	438 645	169 380
Vehicles	7 426	4 271	3 155	7 154	4 082	3 072
	920 915	528 435	392 480	870 393	520 190	350 203
CSIR						
Land	5 549	-	5 549	5 549	-	5 549
Buildings	277 842	70 850	206 992	249 665	77 463	172 202
Equipment	627 767	451 358	176 409	605 351	436 991	168 360
Vehicles	7 426	4 271	3 155	7 154	4 082	3 072
	918 584	526 479	392 105	867 719	518 536	349 183

Notes to the Annual Financial Statements
for the year ended 31 March 2011

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 2009	5 549	137 197	152 042	3 187	**297 975**
Additions	-	35 207	60 132	285	**95 624**
Disposals and write-offs	-	-	(652)	-	**(652)**
Depreciation	-	(202)	(42 120)	(400)	**(42 722)**
Exchange differences on translation of foreign operations	-	-	(22)	-	**(22)**
Carrying value 31 March 2010	5 549	172 202	169 380	3 072	**350 203**
Additions	-	40 138	49 773	539	**90 450**
Disposals and write-offs	-	(5 146)	(982)	(32)	**(6 160)**
Depreciation	-	(202)	(41 386)	(424)	**(42 012)**
Exchange differences on translation of foreign operations	-	-	(1)	-	**(1)**
Carrying value 31 March 2011	**5 549**	**206 992**	**176 784**	**3 155**	**392 480**
CSIR					
Carrying value 31 March 2009	5 549	137 197	150 900	3 187	**296 833**
Additions	-	35 207	59 564	285	**95 056**
Disposals and write-offs	-	-	(564)	-	**(564)**
Depreciation	-	(202)	(41 540)	(400)	**(42 142)**
Carrying value 31 March 2010	5 549	172 202	168 360	3 072	**349 183**
Additions	-	40 138	49 634	539	**90 311**
Disposals and write-offs	-	(5 146)	(718)	(32)	**(5 896)**
Depreciation	-	(202)	(40 867)	(424)	**(41 493)**
Carrying value 31 March 2011	**5 549**	**206 992**	**176 409**	**3 155**	**392 105**

6 PROPERTY, PLANT AND EQUIPMENT (continued)

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 R1,6 million (2010: R3,4 million) decrease in the depreciation amount for the current financial year.

Included on the previous page are assets with a cost of R306,1 million (2010: R301,5 million) that are fully depreciated as the remaining useful life is incidental.

During the current financial year, assets to the value of R28,5 million (2010: R83,9 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 R244,2 million (2010: R216,9 million).

6.1 Non-current asset held for sale

A building of R94,89 million is in the process of being transferred to the Department of Public Works.

The sale of the building is subject to the finalisation of all conveyancing documentation and registration of the transfer by the relevant authorities.

7 INTANGIBLE ASSETS

	2011			2010		
	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	10 555	10 537	18	9 697	9 651	46

	GROUP
	R'000
Carrying value 31 March 2009	10
Additions	406
Impairment	(305)
Amortisation	(65)
Carrying value 31 March 2010	46
Additions	858
Impairment	(831)
Amortisation	(55)
Carrying value 31 March 2011	18

Notes to the Annual Financial Statements
for the year ended 31 March 2011

8 INTEREST IN JOINT VENTURES AND ASSOCIATES

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
Cost of investments less impairment losses	1	1	1	1
Loans to joint ventures and associates	33 937	33 937	33 937	33 937
Share of post-acquisition losses	(18 463)	(18 582)	-	-
	15 475	15 356	33 938	33 938
Impairment of joint ventures and associates	(14 056)	(13 869)	(32 562)	(32 439)
	1 419	1 487	1 376	1 499

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

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 2011 are as follows:

Name of joint venture/ associate	Place of incorporation	Portion of ownership interest	Portion of voting power held	Principal activity	Carrying value 2011 R'000	Carrying value 2010 R'000	Financial year-end
Joint ventures							
Sera (Pty) Ltd	South Africa	50%	50%	Commercialisation and licensing of patents	14 056	13 869	31 March
Ellipsoid Technology (Pty) Ltd	South Africa	50%	50%	Development of encapsulation technology	1 419	1 487	31 March
Associates							
Eyeborn (Pty) Ltd	South Africa	26%	26%	Holding, licensing and exploitation of intellectual property technology	-	-	31 March
					15 475	15 356	

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	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
Current assets	28 229	30 020	16	113
Non-current assets	22 593	1 076	-	-
Current liabilities	42 564	366	16	113
Non-current liabilities	48 232	67 874	-	-
Income	1 775	1 834	142	245
Expenses	3 752	2 367	142	245

9 INTEREST IN SUBSIDIARIES

	CSIR	
	2011 R'000	2010 R'000
Shares at cost less impairment losses	5 108	5 003
Indebtedness	21 088	22 526
- by subsidiaries	37 727	39 165
- impairment of loans	(16 639)	(16 639)
	26 196	27 529

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.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000

10 OTHER INVESTMENTS

	% held	Number of shares held 2011	Number of shares held 2010	Class of shares	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
Unlisted shares					-	-	-	-
Breathetex (Pty) Ltd	20,1	12 000	12 000	Ordinary	11 025	11 025	11 025	11 025
		11 680	11 680	Preference				
Accumulated impairment losses					(11 025)	(11 025)	(11 025)	(11 025)
					-	-	-	-

11 TRADE AND OTHER RECEIVABLES

	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
Trade receivables	92 752	112 847	99 089	115 015
Prepaid expenditure	24 157	14 945	24 156	14 945
Other receivables	1 600	960	386	126
	118 509	128 752	123 631	130 086

Trade receivables are shown net of impairment losses. Refer to note 22 for more detail on trade receivables.

12 INVENTORY AND CONTRACTS IN PROGRESS

	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
Contracts in progress less provision for losses	85 713	76 868	84 796	76 821
Raw materials and consumables	2 906	4 060	1 122	2 003
Work in progress	735	-	-	-
Finished goods	195	-	-	-
	89 549	80 928	85 918	78 824

Estimates on contract in progress recognition are based on cost to completion, budgets and percentage of completion. The write-down of inventory to net realisable value amounted to R230 154 (2010: R nil).

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000

13 DEFERRED TAX ASSET

Balance at the beginning of the year	258	258		
Movement for the year:				
Accelerated capital allowances	32	78		
Provisions	24	21		
Impairment on trade receivables	-	(99)		
Income received in advance	86	-		
	400	258		

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:
- deductible temporary differences, and
- the carry forward of unused tax losses.

Opening balance	4 380	9 604		
Assessed tax loss generated/(utilised) for the year	1 764	(5 224)		
Assessed tax loss carried forward	6 144	4 380		

14 ADVANCES RECEIVED

Advances on contracts received from clients and stakeholders	628 626	493 943	628 626	493 943

Included in advances received is an amount of R116,8 million excluding VAT (2010: R116,8 million excluding VAT) that relates to the transfer of the building to the Department of Public Works (refer note 6.1).

15 TRADE AND OTHER PAYABLES

Accounts payable and accruals	402 014	305 847	402 879	306 413
Salary related accruals	124 528	139 348	124 003	139 348
	526 542	445 195	526 882	445 761

Notes to the Annual Financial Statements
for the year ended 31 March 2011

16 PROVISIONS

GROUP	2011 Opening balance	Additional provisions	Utilised & reversed	Closing balance
	R'000	R'000	R'000	R'000
Warranty provision	381	328	(381)	328
The warranty provision relates to goods sold under a 12 month warranty. The provision amount is determined based on a percentage of the replacement value of all sales made within the current financial year. This percentage is management's estimate of the likely returns of goods under warranty for repairs.				
	381	328	(381)	328

17 OPERATING LEASE COMMITMENTS

	GROUP 2011 R'000	GROUP 2010 R'000	CSIR 2011 R'000	CSIR 2010 R'000
Financial commitments under non-cancellable operating leases will result in the following payments falling due:				
Within one year:	5 938	6 701	5 817	6 211
Land and buildings	4 311	4 670	4 190	4 180
Vehicles	1 627	2 031	1 627	2 031
Within two to five years:	2 442	6 868	2 442	6 868
Land and buildings	1 485	5 039	1 485	5 039
Vehicles	957	1 829	957	1 829

Agreements relating to operating lease payments for vehicles vary from 12 to 60 months and payments are fixed for the term of the agreements.

The CSIR leases buildings under operating leases. The lease periods vary from 24 to 60 months. Lease payments are increased with a fixed annual escalation percentage to reflect market rentals. None of the leases include contingent rentals.

18 RETIREMENT BENEFITS OF EMPLOYEES

18.1 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 R63,5 million (2010: R56,1 million) and employee contributions of R37,2 million (2010: R32,9 million) were paid over during the year. Employer contributions are charged against income when incurred.

18.2 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 holds no liability for the CSIR other than paying the monthly employee contributions. The funds are defined benefit plans.

On 1 March 2001 the members of the Chamber of Mines Pension Fund moved to Sentinel.

In respect of the two employees (2010: two employees) who had formally converted their secondment to a CSIR appointment, employer contributions of R92 222 (2010: R107 781) and employee contributions of R50 966 (2010: R59 437) were paid over during the year. Employer contributions are charged against income when incurred.

18.3 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 (2010: two employees) who is a member of the AIPF as at 31 March 2011. The fund is controlled by the state, which has assumed responsibility for the unfunded portions of these funds.

Employer contributions of R9 847 (2010: R12 577) and employee contributions of R6 154 (2010: R7 860) were paid over during the year to the AIPF.

18.4 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 independant 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 24 continuation members (2010: 26 continuation members) was recalculated by the actuaries as at 31 March 2011 and will be funded through cash and cash equivalents. These cash and cash equivalents have not been set aside specifically for this benefit.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000

18 RETIREMENT BENEFITS OF EMPLOYEES

18.4 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	10 142	9 875	10 142	9 875
Net liability on statement of financial position	10 142	9 875	10 142	9 875

Amounts recognised in the statement of comprehensive income in respect of the scheme are as follows:

Interest cost	860	709	860	709
Actuarial loss recognised during the year	49	304	49	304
	909	1 013	909	1 013

Movement in the net liability recognised in the statement of financial position is as follows:

Net liability at the beginning of the year	9 875	8 862	9 875	8 862
Movement for the year	267	1 013	267	1 013
Net expense recognised in the statement of comprehensive income	909	1 013	909	1 013
Settlements	(642)	-	(642)	-
Net liability at the end of the year	10 142	9 875	10 142	9 875

Principal actuarial assumptions at the reporting date:

Discount rate at 31 March	9.00%	8.00%	9.00%	8.00%
Medical inflation costs	4.80%	3.85%	4.80%	3.85%

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	755	749	755	749

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	(664)	(657)	(664)	(657)

Historical information	2011	2010	2009	2008	2007
Present value of the defined benefit obligation	10 142	9 875	8 862	8 595	12 751
Deficit in the plan	10 142	9 875	8 862	8 595	12 751

19 REMUNERATION OF BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT

	Entity	Managerial Services			Total
		Fees for services as director	Basic salary	Bonuses and performance-related payments	Retirement fund and medical aid contributions	
		R'000	R'000	R'000	R'000	R'000
Board members and Executive Directors						
Dr S Sibisi	CSIR	-	2 720	1 678	452	**4 850**
Foreign subsidiaries						
Mr AA Davidson	Quotec Limited (UK)	-	917	-	16	**933**
Dr A Hickman	Quotec Limited (UK)	-	1 040	-	15	**1 055**
Remunerated in British pound						
Non-executive Board members						
Mr N Behrens	CSIR	47	-	-	-	**47**
Mr P Benadè (from Sept 2010)	CSIR	42	-	-	-	**42**
Professor DR Hall (until March 2011)	CSIR	16	-	-	-	**16**
Mr A Knott-Craig	CSIR	79	-	-	-	**79**
Professor F Petersen	CSIR	64	-	-	-	**64**
Mr M Sibanda	CSIR	79	-	-	-	**79**
Mr M Silinga	CSIR	42	-	-	-	**42**
Ms KL Thoka	CSIR	47	-	-	-	**47**
Professor M Wingfield	CSIR	47	-	-	-	**47**
Executive Management						
Dr T Dlamini	CSIR	-	1 587	648	137	**2 372**
Dr JH Maree	CSIR	-	1 646	778	242	**2 666**
Ms K Njobe (until March 2011)	CSIR	-	1 621	662	200	**2 483**
Mr CR Sturdy	CSIR	-	1 555	716	264	**2 535**
Mr RM Zondo	CSIR	-	1 422	591	143	**2 156**
2011		**463**	**12 508**	**5 073**	**1 469**	**19 513**

Notes to the Annual Financial Statements
for the year ended 31 March 2011

19 REMUNERATION OF BOARD MEMBERS, DIRECTORS AND EXECUTIVE MANAGEMENT (continued)

	Entity	Fees for services as director	Managerial Services: Basic salary	Managerial Services: Bonuses and performance-related payments	Managerial Services: Retirement fund and medical aid contributions	Total
		R'000	R'000	R'000	R'000	R'000
Board members and Executive Directors						
Dr S Sibisi	CSIR	-	2 504	1 861	419	4 784
Foreign subsidiaries						
Mr AA Davidson	Quotec Limited (UK)	-	938	-	12	950
Dr A Hickman	Quotec Limited (UK)	-	1 134	-	13	1 147
Remunerated in British pound						
Non-executive Board members						
Mr N Behrens	CSIR	30	-	-	-	30
Professor DR Hall	CSIR	37	-	-	-	37
Mr A Knott-Craig	CSIR	67	-	-	-	67
Professor F Petersen	CSIR	60	-	-	-	60
Mr M Sibanda	CSIR	69	-	-	-	69
Mr M Silinga	CSIR	35	-	-	-	35
Ms KL Thoka	CSIR	52	-	-	-	52
Professor M Wingfield	CSIR	15	-	-	-	15
Executive Management						
Dr T Dlamini	CSIR	-	1 259	421	101	1 781
Dr JH Maree	CSIR	-	1 414	813	209	2 436
Ms K Njobe	CSIR	-	1 424	730	173	2 327
Mr CR Sturdy	CSIR	-	1 355	744	210	2 309
Mr RM Zondo	CSIR	-	1 221	551	124	1 896
2010		365	11 249	5 120	1 261	17 995

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000

20 CONTINGENT LIABILITIES AND FACILITIES

Facilities of subsidiaries guaranteed by the CSIR	20 000	20 000	20 000	20 000

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.

21 CAPITAL COMMITMENTS

Property, plant and equipment	9 337	7 770	9 337	7 770

This capital expenditure is to be financed from internal sources.

22 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.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

22 FINANCIAL INSTRUMENTS (continued)

22.1 Market risk

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 currencies of Group entities, primarily the rand, and on investments in foreign operations.
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 2011					
	Total R'000	ZAR R'000	EURO R'000	USD R'000	GBP R'000	Other R'000
Trade receivables	**92 752**	77 860	2 950	10 491	1 088	363
Bank accounts	**179 663**	92 143	17 336	68 378	1 745	61
Trade payables	**(526 542)**	(518 275)	(2 349)	(4 903)	(996)	(19)
Gross statement of financial position exposure	**(254 127)**	(348 272)	17 937	73 966	1 837	405
Forward exchange contracts	**(1 109)**	-	-	-	-	(1 109)
Net exposure	**(255 236)**	**(348 272)**	**17 937**	**73 966**	**1 837**	**(704)**

	31 March 2010					
	Total R'000	ZAR R'000	EURO R'000	USD R'000	GBP R'000	Other R'000
Trade receivables	112 847	96 869	4 397	9 293	1 268	1 020
Bank accounts	87 764	24 646	8 586	53 658	697	177
Trade payables	(445 195)	(443 283)	-	-	(1 912)	-
Gross statement of financial position exposure	(244 584)	(321 768)	12 983	62 951	53	1 197
Forward exchange contracts	(2 564)	-	(2 564)	-	-	-
Net exposure	(247 148)	(321 768)	10 419	62 951	53	1 197

	GROUP	
	2011	2010

22 FINANCIAL INSTRUMENTS (continued)

22.1 Market risk (continued)

The following significant exchange rates applied during the year:

	R	R
Average rate of forward exchange contracts		
Euro	-	9.9392
CHF	7.4239	-
Year-end spot rate		
Euro	9.6418	9.9426
USD	6.8387	7.3926
GBP	10.9642	11.1420

Sensitivity analysis

A 10% strengthening of the rand against the following currencies at 31 March would have decreased 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 2010.

	R'000	R'000
Euro	(1 794)	(1 042)
USD	(7 397)	(6 295)
GBP	(184)	(5)
Other	70	(120)

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	567 795	518 115

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 (interest rate swaps) 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.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

22 FINANCIAL INSTRUMENTS (continued)

22.1 Market risk (continued)

	GROUP 2011 R'000	GROUP 2010 R'000
Variable rate instruments: Carrying amount		
Financial assets: Call deposits	261 289	193 724
Financial assets: Bank balances	179 663	87 764
	440 952	281 488

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 2010.

Variable rate instruments	4 410	2 815

A decrease of 100 basis points would have had the equal but opposite effect to the amounts shown above.

22.2 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. Accordingly, the Group does not have a significant concentration of credit risk.

The carrying amounts of financial assets included in the statement of financial position represent the Group's exposure to credit risk in relation to these assets.

The Group does not have any significant exposure to any individual customer or counterparty.

Bank balances and deposits
The Group's bank balances and cash are placed with high credit, quality financial institutions.

Guarantees
Refer to note 20 for details on bank guarantees issued with respect to facilities.

22 FINANCIAL INSTRUMENTS (continued)

22.2 Credit risk (continued)

	GROUP	
	2011 R'000	2010 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:		
Held-to-maturity investments:		
- Current fixed deposits	567 795	518 115
Other cash and cash equivalents:		
- Call deposits	261 289	193 724
- Bank balances	179 663	87 764
- Cash on hand and cash deposits	656	379
Loans and receivables:		
- Trade and other receivables	118 509	128 752
- Contracts in progress less provision for losses	85 713	76 868
	1 213 625	1 005 602
The maximum exposure to credit risk for trade receivables at the reporting date by type of customer was:		
Local public	76 253	71 173
Local private	727	22 611
International	15 772	19 063
	92 752	112 847

The Group's most significant customers are government institutions.

Notes to the Annual Financial Statements
for the year ended 31 March 2011

22 FINANCIAL INSTRUMENTS (continued)
22.2 Credit risk (continued)

	2011		2010	
	Gross R'000	Impairment R'000	Gross R'000	Impairment R'000
The aging of the Group's trade receivables at the reporting date was:				
Not past due	54 021	387	82 305	1 909
Past due 0 - 30 days	19 748	342	19 059	1 935
Past due 31 - 120 days	18 965	807	15 060	3 205
Past due more than 120 days	10 285	8 731	7 521	4 049
	103 019	10 267	123 945	11 098

The movement in the allowance for impairment in respect of trade receivables during the year was as follows:

	GROUP	
	2011 R'000	2010 R'000
Balance at 1 April	11 098	18 811
Impairment loss reversed	(831)	(7 713)
Balance at 31 March	10 267	11 098

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 movement in the impairment allowance account is due mainly to the following: recoveries of R7,6 million (2010: R11,7 million), utilisation of R2,6 million (2010: R6,3million) and new impairment allowances of R9,4 million (2010: R10,3 million).

22 FINANCIAL INSTRUMENTS (continued)

22.3 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 CSIR has a short-term general banking facility of R500 000 (2010: R500 000) available.

The following are the contractual maturities of financial liabilities, including interest payments and excluding the impact of netting agreements for the Group:

	2011			2010		
	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	(526 542)	(526 542)	-	(445 195)	(445 195)	-
Derivative financial liabilities						
Forward exchange contracts	(28)	(1 136)	-	(115)	(2 679)	-
	(526 570)	(527 678)	-	(445 310)	(447 874)	-

	GROUP	
	2011	2010
	R	R
Rate of forward exchange contracts:		
Euro	-	10.3849
CHF	7.6104	-

Notes to the Annual Financial Statements
for the year ended 31 March 2011

22 FINANCIAL INSTRUMENTS (continued)

22.4 Fair values

At 31 March 2011 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.

22.5 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 2011				
Derivative financial liabilities		(28)		(28)
31 March 2010				
Derivative financial liabilities		(115)		(115)

23 RECONCILIATION OF OPERATING PROFIT TO CASH GENERATED FROM OPERATING ACTIVITIES

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
Operating profit for the year before taxation	33 955	57 729	35 511	52 422
Adjusted for:				
Profit on disposal of interests in subsidiaries, joint ventures and associates	-	(559)	-	-
Depreciation and amortisation	42 067	42 787	41 493	42 142
Net unrealised foreign exchange loss	1 619	7 254	1 676	8 411
Net finance income	(54 798)	(71 316)	(53 180)	(68 769)
Post-retirement medical benefits	909	1 013	909	1 013
Straight-lining adjustment of operating leases	(148)	45	(148)	45
Leave accrual and warranty provision	3 912	7 080	3 939	8 126
Impairments/(reversals of impairments)	187	(6 944)	(813)	(7 252)
Loss/(profit) on disposal and write-off of property, plant and equipment	5 506	(647)	5 499	(658)
Share of (profit)/loss of joint ventures and associates	(119)	214	-	-
Bad debt written off	544	3 558	544	3 558
Write-down of inventory to net realisable value	230	-	230	-
Operating profit before changes in working capital	33 864	40 214	35 660	39 038
Decrease in trade and other receivables	10 020	13 444	6 247	38 154
Increase in inventory and contracts in progress	(9 427)	(4 676)	(7 900)	(5 692)
Increase/(decrease) in advances received	134 683	(77 791)	134 683	(77 791)
Increase/(decrease) in trade and other payables and provisions	76 998	(30 266)	76 799	(36 505)
Net working capital changes	212 274	(99 289)	209 829	(81 834)
Cash generated/(utilised) from operating activities	246 138	(59 075)	245 489	(42 796)

Notes to the Annual Financial Statements
for the year ended 31 March 2011

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
24 CASH AND CASH EQUIVALENTS				
Fixed deposits	567 795	518 115	543 000	491 000
Call deposits	261 289	193 724	255 000	189 000
Bank balances	179 663	87 764	177 107	85 903
Cash on hand and cash deposits	656	379	648	375
	1 009 403	799 982	975 755	766 278

25 RELATED PARTY TRANSACTIONS

The CSIR is one of 29 schedule 3B National Government Business Enterprises 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.

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.

25.1 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	10	-	10	-
Services received	93	335	93	335
Amount due to	(2)	-	(2)	-
Major public entities				
Services rendered	233 232	216 163	233 232	216 163
Services received	25 570	6 759	25 570	6 759
Amount due from	10 112	16 778	10 112	16 778

25 RELATED PARTY TRANSACTIONS (continued)

25.1 Transactions with related parties (continued)

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
National public entities				
Services rendered	70 720	61 292	70 720	61 292
Services received	8 334	2 297	8 334	2 297
Amount due from	15 268	7 163	15 268	7 163
National government business enterprises				
Services rendered	2 722	2 302	2 722	2 302
Services received	4 789	3 101	4 789	3 101
Amount due from/(to)	805	(2 478)	805	(2 478)
Provincial public entities				
Services rendered	377	1 421	377	1 421
Amount due from	-	309	-	309
Provincial government business enterprises				
Services rendered	3 278	2 460	3 278	2 460
Services received	175	10	175	10
Amount due from	421	331	421	331
Government departments				
Services rendered	968 636	924 890	968 636	924 890
Services received	43 251	5 801	43 251	5 801
Amount due from	42 622	84 192	42 622	84 192

Notes to the Annual Financial Statements
for the year ended 31 March 2011

	GROUP		CSIR	
	2011 R'000	2010 R'000	2011 R'000	2010 R'000
25 RELATED PARTY TRANSACTIONS (continued)				
25.1 Transactions with related parties (continued)				
Subsidiaries				
Services rendered			9 580	4 485
Services received			4 703	3 858
Amount due from/(to)			4 017	(212)
Associates				
Services rendered	280	527	280	527
Amount due from	-	80	-	80

25.2 Transactions with key management

Total remuneration of key management is included in employees' remuneration (refer to note 19 for Executive Management'sremuneration).

26 SUBSEQUENT EVENTS

26.1 Satellite Application Centre (SAC)

In terms of the South African National Space Agency Act, Act No 36 of 2008, the South African National Space Agency (SANSA) was established as a separate public entity, the Executive Authority of which is the Minister of Science and Technology.

Pursuant to the said Act, all rights, obligations, assets and liabilities acquired or incurred by the Satellite Applications Centre (SAC) are, by agreement, transferred to SANSA as from 1 April 2011 and similarly all employees of the former SAC are transferred to SANSA.

	2011 R'000
Profit attributable to SAC is as follows:	
Revenue	85 573
Employees' remuneration	(23 701)
Operating expenses	(58 424)
Profit for the year	3 448
Assets and liabilities attributable to SAC are as follows:	
Assets	
Non-current assets	17 965
Property, plant and equipment	17 965
Current assets	20 344
Trade and other receivables	4 036
Inventory and contracts in progress	192
Bank balances and cash on hand	16 116
Total assets	38 309
Equity and liabilities	
Reserves	25 693
Retained earnings	25 693
Current liabilities	12 616
Advances received	4 930
Trade and other payables	7 686
Total equity and liabilities	38 309

Addendum A: Interest in subsidiaries
31 March 2011

Consolidated subsidiaries	Country of incorporation	Issued capital	Interests of the CSIR: Effective holding		Financial year-end	Shares at cost less accumulated impairment losses	
			2011	2010		2011	2010
		R'000	%	%		R'000	R'000
Direct investments							
Technology Finance Corporation (Pty) Ltd (Technifin)	South Africa	5 200	100	100	31 March	4 650	4 650
Technovent (Pty) Ltd	South Africa	5 000	100	100	31 March	-	-
Quotec Limited	United Kingdom	20	100	100	31 March	458	353
						5 108	5 003
Indirect investments							
Included in Technovent (Pty) Ltd carrying value:							
Uvirco Technologies (Pty) Ltd*	South Africa	-	100	100	31 March	-	-
Ulwazi Biotech (Pty) Ltd**	South Africa	-	100	100	31 March	-	-

* Issued capital R100 and shares at cost R100

** Issued capital R1 and shares at cost R1

The Group has interests in three dormant companies. Details of these interests are available at the CSIR's registered office.

Interests of the CSIR						
Net indebtness less accumulated impairment losses				Net investment		General nature of business
to subsidiaries		by subsidiaries				
2011	2010	2011	2010	2011	2010	
R'000	R'000	R'000	R'000	R'000	R'000	
-	-	12 000	13 262	16 650	17 912	The acquisition and transfer of technology to industry by licensing new inventions, providing finance to develop technology and venture capital for the exploitation thereof.
-	-	4 361	4 464	4 361	4 464	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.
-	-	4 727	4 800	5 185	5 153	The principal activity of the company is that of consulting on technology auditing, technology evaluation and technology transfer on behalf of clients in the public and private sectors.
-	-	21 088	22 526	26 196	27 529	
						The company manufactures and distributes high technology cameras for use in detecting faults on overhead electricity distribution lines.
						The principal activities of the company are to develop, commercialise and market naturally derived products for the biotechnology and pharmaceutical markets.

Disclosure of expenditure relating to the **2010 FIFA Soccer World Cup**

Details of the distribution of soccer tickets acquired for the 2011 financial year-end are as follows:

	Quantity	R'000
Clients/stakeholders	10	115
Accounting authority: Executive	3	34
Accounting authority: Non-executive	2	23
Senior management	16	97
Other employees	9	45
	40	314

Details of other world cup apparel acquired for the 2011 financial year-end are as follows:

	Quantity	R'000
Shirts	535	273
Makarapas	42	15
Soccer balls	15	1
Vuvuzelas	40	1
Flags	12	1
	644	291

None of the above expenditure was funded from CSIR Parliamentary Grant income.

09 ABBREVIATIONS

ACCESS	Applied Centre for Climate and Earth Systems Science
AMD	Acid mine drainage
AMESD	African Monitoring of the Environment for Sustainable Development
BB4All	Broadband for All
B-BBEE	Broad-Based Black Economic Empowerment
BMS	Bridge management system
BP5	Bio-prospecting 5
CEO	Chief Executive Officer
CFD	Computational fluid dynamics
ChloroGIN	Chlorophyll Globally Integrated Network
CO2	Carbon dioxide
COH WHS	Cradle of Humankind World Heritage Site
CSIR	Council for Scientific and Industrial Research
CSP	Concentrating solar power
CUT	Central University of Technology
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DNA	Deoxyribonucleic acid
DRFM	Digital Radio Frequency Memory
DST	Department of Science and Technology
DWA	Department of Water Affairs
EAMNet	Europe-Africa Marine-Network
EU	European Union
EW	Electronic Warfare
Gbps	Gigabit per second
GDP	Gross Domestic Product
GEO	Group on Earth Observation
GEO BON	Group on Earth Observation Biodiversity Observation Network
GEOSS	Global Earth Observation System of Systems
GIAMA	Government Immovable Asset Management Act
GIS	Geographic Information System
GPS	Global Positioning System
HCD	Human Capital Development
HEI	Higher education institution
HiMA	High-modulus asphalt
HIV	Human Immunodeficiency Virus
HPN	High performance nodes
HR	Human Resources
HWIL	Hardware in the Loop
IAM	Immovable asset management
ICRA	International Conference on Robotics and Automation
ICT	Information and Communications Technology
IFAC	International Federation of Automatic Control
IMT	Institute of Maritime Technology
IOCCP	International Ocean Carbon Coordination Programme
IP	Intellectual Property
KPI	Key Performance Indicator
KRA	Key Results Area
KZN	KwaZulu-Natal
MIAS	Mobile Intelligent Autonomous Systems
MDR	Multi-drug resistant
MDR-TB	Multi-drug resistant Tuberculosis
MEng	Master of Engineering
MHSC	Mine Health and Safety Council
MSc	Master of Science
MTSF	Medium Term Strategic Framework
NCNSM	National Centre for Nano-Structured Materials
NEPAD	New Partnership for Africa's Development
NFEPA	National Freshwater Ecosystem Priority Areas
NIKMAS	National Indigenous Knowledge Management System
NLDTF	National Lottery Distribution Trust Fund
NREN	National Research and Education Network

NSI	National System of Innovation
OEL	Occupational exposure limit
OGC	Open Geospatial Consortium
PCI	Peripheral component interconnect
PCT	Patent Cooperation Treaty
PED	Pin entry device
PFMA	Public Finance Management Act
PhD	Doctor of Philosophy
PIN	Personal Identification Number
PNC	Polymer Nano-Composite
POC	Point-of-care
PULSE	Public Understanding of Laser Science and Engineering
QR	Quick Response
R&D	Research and Development
RAP	Research Advisory Panel
RCS	Radar Cross Section
RDI	Research, development and innovation
R, D & I	Research, development and implementation
RIA	Research Impact Area
RNA	Ribonucleic Acid
ROPS	Roll over protection system
RRA	Regional Research Alliance
SA	South Africa
SABITA	Southern African Bitumen Association
SADC	Southern African Development Community
SAIAB	South African Institute for Aquatic Biodiversity
SALT	South African Large Telescope
SANAP	South Africa's National Antarctic Programme
SANBI	South African National Biodiversity Institute
SANBio	Southern African Network for Biosciences
SANParks	South African National Parks
SANRAL	South African National Road Agency Ltd
SANReN	South African National Research Network
SANSA	South African National Space Agency
SASCOC	South African Sports Confederation and Olympic Committee
SAWS	South African Weather Service
SET	Science, Engineering and Technology
SETI	Science, Engineering and Technology Institution
SEWES	Sensors and Electronic Warfare Engagement Simulation
Si	Silicon
SIMRAC	Safety in Mines Research Advisory Council
siRNA	Small interfering Ribonucleic Acid
SKA	Square Kilometre Array
SMS	Short Message Service
SOCCO	Southern Ocean Carbon-Climate Observatory
SOE	State-Owned Enterprise
SRP	Strategic Research Panel
SWEOS	Safe Water Earth Observation System
TB	Tuberculosis
TEI	Tertiary Education Institution
TENET	Tertiary Education Network
TIA	Technology Innovation Agency
TNPA	Transnet National Ports Authority
UBRD	Ultrasonic Broken Rail Detector
UIRI	Uganda Industrial Research Institute
UNESCO	United Nations Educational, Scientific And Cultural Organization
UP	University of Pretoria
USA	United States of America
VO	Village operator
WAITRO	World Association of Industrial and Technological Research Organisations
Wits	Witwatersrand
WMN	Wireless Mesh Network
WWF-SA	World Wildlife Fund South Africa
XDR	Extensively drug-resistant

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