ScienceScope

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SCIENCE AND TECHNOLOGY FOR INDUSTRY

CSIR

our future through science

INTRODUCTION

THE SOUTH AFRICAN GOVERNMENT approved the National Industrial Policy Framework (NIPF) two years ago. The framework describes a broad approach to industrialisation as it relates to the Accelerated and Shared Growth Initiative for South Africa and its target of halving unemployment and poverty by 2014.

The NIPF lists Innovation and Technology as one of its strategic programmes. It states that "As a middle income developing country, South Africa needs to increasingly invest in its innovation and technology capabilities. South Africa has pockets of technologies and capabilities that can be leveraged in order to narrow the gap with a range of technologically sophisticated developed and developing countries."

The framework singles out science councils to protect and develop South African intellectual property and encourage its commercialisation.

The CSIR, Africa's biggest science council, is mandated to foster industrial and scientific development to improve the quality of life of South Africans.

Our role is different to that of universities and commercial research and development (R&D) bodies. In terms of industry and government, our work encompasses directed research, which aims to gain new understanding of research domains; development of new technologies, products or services; and research with a tangible impact on the economy and society.

As such, we may partner directly with industry in R&D programmes or effect benefits indirectly through our support of national strategies such as the Advanced Manufacturing Technology Strategy or the Industrial Policy Action Plan (IPAP).

IPAP identifies four lead sectors: Capital/transport equipment and metals; automotives and components; chemicals, plastics and pharmaceuticals; and forestry, pulp and paper. The CSIR contributes to all these sectors, but also to sectors such as mining, and information and communications technology (ICT).

This **ScienceScope** presents some of the work we do in aid of industry – directly or indirectly. Most examples comprise current R&D projects while the publication also features technologies already in use by industry stakeholders, as well as a brief preview of visionary science. It is important to note that industrial economic gain may not be the first or the only priority for engaging in R&D.

For example, our environmental health scientists' work helps industry to control chemical hazards, improving the quality of life of citizens in terms of health. A new approach to the design of heavy vehicles for the timber industry results in safer, road-friendly and more productive heavy vehicles. Environmental benefits are possible through the use of microreactor technology that reduces capital costs, energy input, raw material and waste production.

The multidisciplinary nature of our work means that we can add value to a number of industry sectors – from energy, health and mining, to automotive, food and non-commercial industry (through especially the deployment of ICT solutions).

The NIPF is seen as the cornerstone of an overarching policy thrust to place South Africa on a high-growth trajectory. Our intent in supporting this vision is to improve industry competitiveness and to develop human capital – science and technology to help turn the wheels of industry.

FROM THE DESK OF THE PRESIDENT AND CEO: DR SIBUSISO SIBISI

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CSIR development chemist, Subash Buddoo

MICROREACTORS

The new face of industrialisation

A LITTLE MORE THAN A DECADE AGO, IT WAS DIFFICULT FOR HUMAN MINDS TO FATHOM THE POSSIBILITY OF CHEMICAL REACTIONS TAKING PLACE ON A CHIP OR CHANNELLING THROUGH A TINY INSTRUMENT NO BIGGER THAN A R5 COIN. TODAY, COMMERCIAL PLANTS IN GERMANY AND ESTABLISHED INTERNATIONAL PHARMACEUTICAL COMPANIES IN THE USA AND EUROPE USE MICROREACTOR TECHNOLOGY FOR PRODUCTION.

IN SOUTH AFRICA, the CSIR is investigating the production of biodiesel using microreactors. The project, led by process development chemist, Subash Buddoo, was initiated in 2008. It has already produced significant improvements and offers a competitive alternative to conventional production methods.

Microreactors are increasingly gaining popularity as faster, cheaper, safer and more controlled alternatives for production due to the significant improvement in reaction performance. But, why is reaction performance that much better than conventional batch reactors? The secret lies in the minute, multiple channels with which a typical microreactor is equipped. These channels can range in diameter from 50 to 500 μm and lengths of 1to10 cm. The inherently high surface area-to-volume-ratios result in order-of-magnitude improvements in both heat- and mass-transfer, leading to faster reactions with lower energy consumption.

For example, in the biodiesel case study, a reaction that normally takes three hours was completed in under a second. This represents just over a 10 000-times increase in the reaction rate. "This microreactor, which can fit in the palm of your hand, has the capacity to produce over 10ℓ of biodiesel per hour and can fill a 240ℓ drum in a day," says Buddoo. "The process can be scaled up by merely adding more microreactors to achieve the required production capacity. Effectively, a biodiesel production plant could quite easily fit on the back of a bakkie and be moved to where it is required, thus making mobile production units a real possibility."

Buddoo has been following the trend for the past 10 years before investigating the technology's potential in the South African context. "Initially it was just lab curiosity but later I realised its value for our research. Microreactors are set to change the face of production as we know it. It is a significant paradigm shift from the more commonly-used massive plants with huge stirred tank reactors. There are quite a few commercial plants in the world that use microreactor technology. Some 30 such plants in Germany make pharmaceutical products and chemicals. In China the production of medicinal nitroglycerine, normally an unsafe reaction and explosion hazard, is quite safely done using microreactors. This technology has far-reaching implications for the South African pharmaceutical manufacturing industry, which is virtually non-existent at present."

In addition to the biodiesel project, Buddoo is also involved in a project to convert waste from the cosmetics industry into biodiesel. The project is being funded through the CSIR parliamentary grant until March 2009 and promising results have been obtained at the laboratory scale.

The plan is to progress to the pilot-plant scale and to conduct a techno-economic assessment of the project to determine its commercial viability. The CSIR has developed considerable expertise and capability in the production of biodiesel and was also responsible for developing biodiesel standards (~100ℓ at pilot-plant scale) for the South African Bureau of Standards, using various sources of vegetable oils as feedstock, e.g. sunflower, soya, canola, Jatropha, palm and peanut. Any production of biodiesel in South Africa using these feedstocks will be benchmarked against these standards.

While microreactors have the potential to revolutionise the pharmaceutical, fine chemicals and other high-end production sectors, it could result in the downscaling of human capital in production plants. Yet, for Buddoo, the benefits of microreactors far outweigh its limitations. In the making of biodiesel, microreactor technology offers a 35% saving on production costs. The only factors currently impeding the success of such a process is the availability of sufficient quantities of feedstock to meet the South African demand for biodiesel and preferably one not linked to food.

Algal lipids are currently under investigation as possible alternatives. Environmentally, microreactors leave a smaller footprint and a new local industry around production of microreactors and related equipment could be stimulated. To this end, Buddoo and fellow bioscientists as well as colleagues in the materials and manufacturing research domains are currently making good progress towards development of a micromanufacturing Centre of Excellence (CoE) in South Africa.

"Far more importantly, the implementation of microreactor technology could result in drastic reductions in the cost of drugs for the treatment of HIV/Aids, malaria and tuberculosis and make them more accessible to the people of South Africa," says Buddoo.

– Asha Speckman

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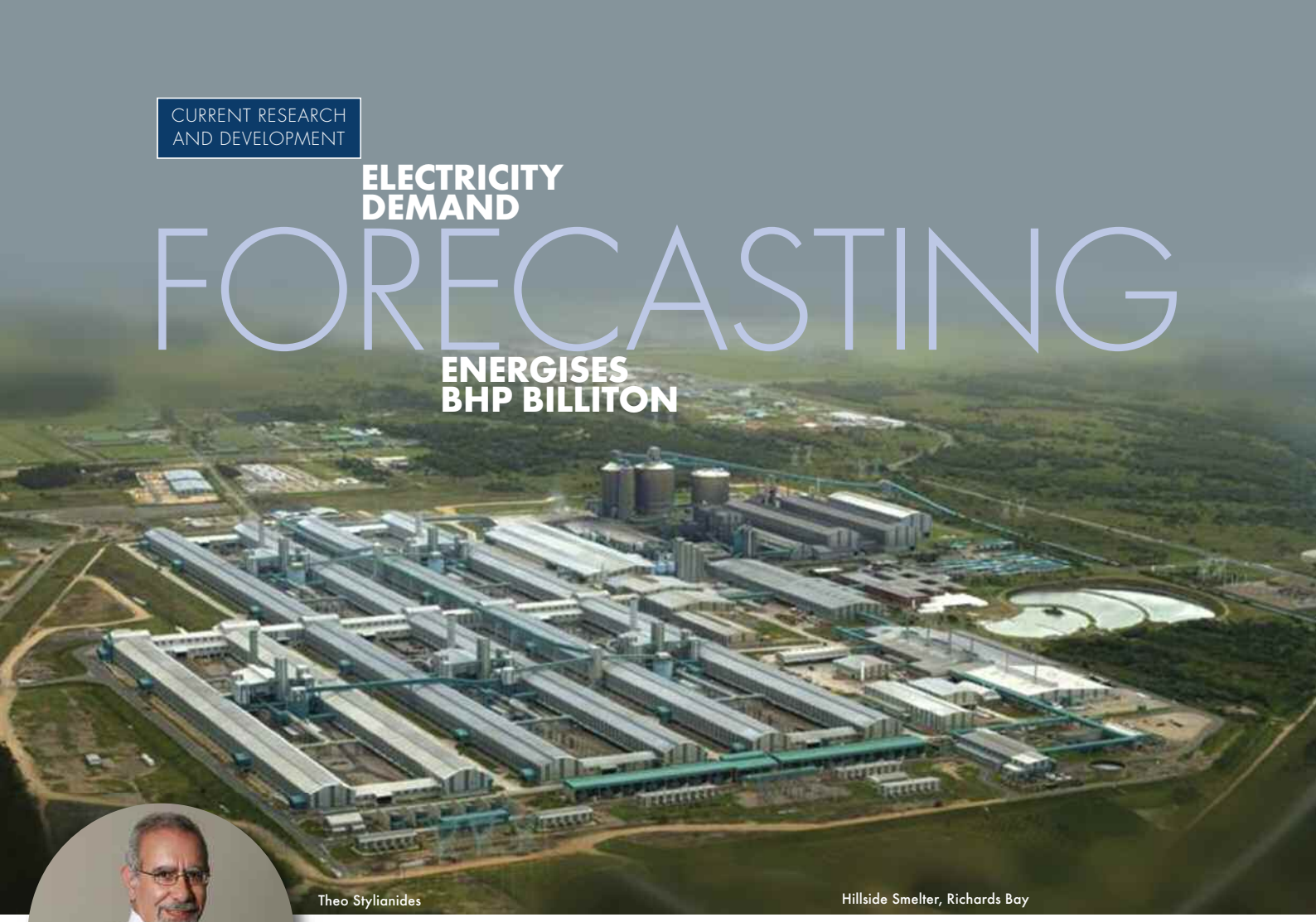
ELECTRICITY DEMAND FORECASTING ENERGISES BHP BILLITON



Theo Stylianides

Hillside Smelter, Richards Bay

OVER THE PAST five years, CSIR research has been aimed at providing strategic planners at BHP Billiton with forecasts of long-term national electricity demand. Information derived from such forecasts is an important input into the company's South African electricity pricing and cost models.

BHP Billiton is a global leader in the resources industry. It occupies significant positions in major commodity businesses, including aluminium, energy coal and metallurgical coal, copper, manganese, iron ore, uranium, nickel, silver and titanium minerals, and has substantial interests in oil, gas, liquefied natural gas and diamonds. The company relies heavily on reliable and affordable electricity for its aluminium smelters, while simultaneously selling coal to Eskom for electricity generation.

During 2003, BHP Billiton commissioned the CSIR to develop national electricity demand forecasting models to produce long-term (20-year) predictions of both electricity consumption and peak load. "These forecasts make a difference to how we plan our future power requirements in southern Africa as we get an insight into Eskom's future reserve margin position," states Kevin Morgan, General Manager: Power of BHP Billiton's Aluminium Southern Africa.

"We completed our third biennial update of forecasting models recently. We undertook extensive research on the identification of appropriate forecasting models and put considerable effort into acquiring relevant and quality data for our modelling activities," explains Theo Stylianides, manager of logistics and quantitative methods at the CSIR.

Forecasts need to take cognisance of lessons learned from the past and also take future uncertainties into account. The CSIR collected and analysed variables that describe general economic conditions that could influence consumption. "Regression is a very powerful statistical technique which, amongst other things, can be used for long-term forecasting," comments Stylianides. Multiple regression models were developed and used to relate input variables, such as population, gross domestic product, final consumption expenditure of households as well as transport and mining indicators, to the demand in each sector. The various sectors of the economy that were investigated include agriculture, commerce and manufacturing, transport, mining, and the domestic sector.

The development of annual consumption forecasts was done following a scenario approach, allowing BHP Billiton planners to select predetermined scenarios and predict various outcomes related to these. Furthermore, for each scenario, hourly, daily and weekly patterns were superimposed on the annual demand figures in order to obtain forecasts of expected peak values.

With practical projects such as these, the CSIR has over the years built a core strength in statistical and mathematical modelling. Projects where the organisation relies on its quantitative modelling skills have covered both the private and government sectors.

– Hilda van Rooyen

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SOUTHERN AFRICAN OFFICE OF WORLD'S BIGGEST ICT STANDARDISATION BODY GAINS MOMENTUM

Kagiso Mnisi - relationship manager for the southern Africa W3C office

THE SOUTHERN AFRICA OFFICE of the World Wide Web Consortium (W3C), launched in May 2007 and hosted by the CSIR's Meraka Institute, is making progress in its drive to create an international voice for the regional information and communications technology (ICT) community.

The W3C, a standardisation watchdog body, primarily pursues its mission through the creation of web standards and guidelines designed to ensure long-term growth for the web. W3C is managed by three organisations on three continents: The Massachusetts Institute of Technology in the United States, the European Research Consortium for Informatics and Mathematics, and the Keio University in Japan. It has a further 16 offices across the globe.

According to Kagiso Mnisi, relationship manager for the southern Africa W3C office, the CSIR is only the second organisation in Africa to operate as a W3C office. "The mission of a W3C office is to promote adoption of W3C recommendations among developers, application builders and standards setters, and to encourage inclusion of stakeholder organisations in the creation of future recommendations, by joining the W3C."

Since joining the W3C office in July 2008, Mnisi has focused his efforts on creating a database of stakeholders, with approximately 300 institutions and organisations already featuring on the W3C mailing list.

He identifies his key tasks as introducing stakeholders to the W3C, developing relationships with local technology or policy leaders, and guiding organisations through the steps for joining W3C. "We also provide support for existing W3C members in the region and provide feedback to the W3C on regional issues," he says.

The office's most important drive currently is to create awareness of the nature and activities of the W3C. "By publishing open (non-proprietary) standards for web languages and protocols, the W3C plays a significant role in avoiding market fragmentation and thus web fragmentation," Mnisi explains. The consortium is also involved in education and outreach, developing software and serving as an open forum for discussion about the web. Against this background, the benefits of participating in W3C activities become self-evident.

Mnisi sees the local W3C office as an opportunity for South Africa and the rest of the continent to put forward its agenda to the international community. "African ICT companies and stakeholders need to be active in global fora like the W3C to benefit from and influence innovations in technology, leading to the next generation of the world wide web. This is a requirement for making an impact on the global stage, addressing the tremendous needs that exist and fully realising the business opportunities that ICT brings to Africa."

The W3C southern Africa office aims to highlight the needs and innovations of the region within the WWW domain, by regularly engaging and interacting with local stakeholders. It acts as a link between the W3C and local stakeholders, and ensures that the region has the opportunity to influence and participate in the international ICT community.

Mnisi is fortunate to have two highly experienced researchers from the Meraka Institute, Dr Quentin Williams and Martin Pistorius, as his mentors. He also looks toward the most active and dynamic W3C offices, such as those in Australia and Spain, for best practice and inspiration.

When asked how he would define success for the southern Africa W3C office, Minisi lists an active and growing local web community, regularly participating in events held by the local office; active participation on W3C working groups; and the inclusion of southern African needs in W3C recommendations, specifications and standards. "Another measure of success will be when both the W3C and local regional organisations recognise the W3C southern African office as an authority on web-related issues," he says.

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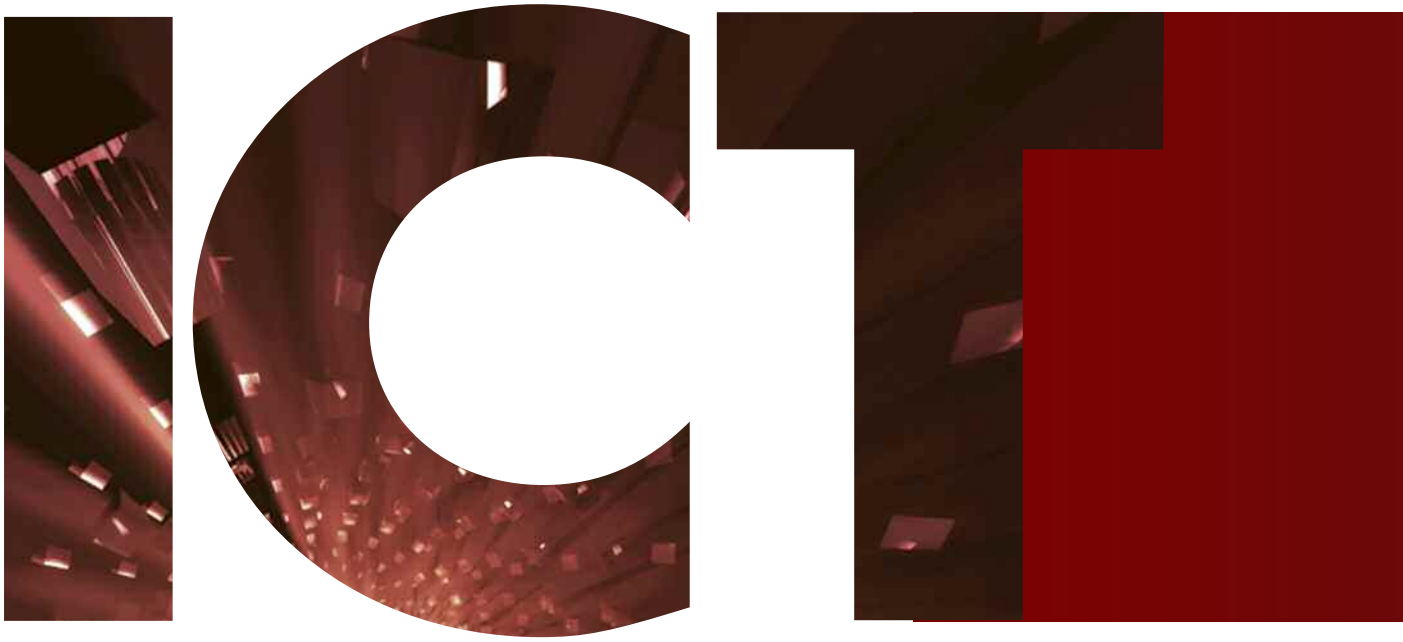

ICT INNOVATION

FOR VERY SMALL ENTERPRISES IN EMERGING MARKETS

THE STRATEGIC PARTNERSHIP COMPRISING THE CSIR'S MERAKA INSTITUTE, MULTINATIONAL SOFTWARE GIANT SAP AG AND THE DEPARTMENT OF SCIENCE AND TECHNOLOGY (DST) HAS GIVEN RISE TO EXCITING INNOVATIONS IN INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT) SINCE THE ESTABLISHMENT OF THE SAP-MERAKA UNIT FOR TECHNOLOGY DEVELOPMENT (UTD) IN 2006.

THE UNIT'S UNIQUENESS and competitive edge are due, in part, to the fact that it focuses on finding ICT solutions to ensure sustainability of very small enterprises in emerging markets. Being the first of its kind in South Africa, the UTD has come a long way in using ICT to promote social and economic development through ICT research and innovation. SAP and the DST have committed to co-invest R100 million for the first five years of the UTD's operation.

According to co-manager of the UTD, Johan Eksteen, the UTD is uniquely positioned to contribute to South Africa's strategy for science and technology development. "Our approach in this case has three key elements: To attract more foreign direct investment in ICT research and development; to focus our research agenda on very small enterprises in emerging economies and finally, to enhance advanced human capital development."

"We cannot afford to be left behind in terms of ICT innovation," says the DST's general manager for international resources, Mmboneni Muofhe. "ICT is a proven magnet for other investments and we are therefore keen on establishing strategic partnerships with the aim of promoting South Africa's participation in global, competitive research programmes."

Focusing on very small enterprises makes sense because these form the backbone of most emerging economies. They play a significant role in creating employment and are more flexible in terms of technology than bigger companies. It is important to note that although the UTD works with such small enterprises, these are not survivalist in nature. They do not exceed 50 employees, are registered for tax, have continuous business, low levels of diversification, simple and agile business processes, and are flexible and responsive to opportunities.

The Meraka Institute also works with other partners in terms of research that enhances small business development and sustainability. As Eksteen explains, "We engage with our colleagues in the built environment to look at ICT support for the building industry, focusing on small construction businesses. The aim is to enable them to do their business better. Big companies are often commis-

Progress by the SAP/Meraka UTD was showcased on 3 November 2008 when a number of students gave presentations on their research. The event was attended by Maphum Nxumalo, Chief Operating Officer: SAP SA (Pty) Ltd; Johan Eksteen, Manager: Technology Research Programme, Meraka Institute; Naledi Pandor, Minister of Education; Imraan Patel, General Manager of Science & Technology for Economic Impact, Department of Science and Technology; Kagiso Chikane, Centre Manager: Meraka Institute; Professor Dr Christoph Meinel, CEO: Hasso Plattner Institute for Software Systems Engineering, University of Potsdam, and Danie Kok: SAP Research Director and UTD co-manager

sioned to handle major projects and tend to subcontract parts of those projects. By empowering small businesses with relevant information and technology, we facilitate a seamless sub-contracting process that gives the smaller companies access to big contracts while easing the risk on the bigger companies."

"We are also considering other industries across emerging markets, particularly manufacturing, construction and agroprocessing because of their potential impact on poverty alleviation and job creation."

By partnering with institutions in Brazil, Russia, India, China and South Africa (BRICS), the UTD is able to focus on research that is relevant to very small enterprises in similar markets rather than importing technologies designed for the European market.

According to SAP's research director and UTD co-manager, Danie Kok, the UTD's current portfolio of research includes ACTOR, which looks at how very small enterprises access resources, and ALLIGATOR, which looks at the unique business processes of such enterprises. The next step will now focus on NOVELLA, which seeks to develop novel ICT solutions to address the challenges faced by very small enterprises. "We believe that sustainability of these enterprises will be significantly enhanced if they collaborate among themselves and with medium and large enterprises." This programme is currently being piloted in the rural area of Sekhukhune where spaza shops collaborate *via* software systems and with the help of an infopreneur. What makes this programme work, according to Kok, is the fact that the design is done with user participation.

Advanced human capital development is key to the UTD's agenda. "This emphasis is important not only for the DST and its partners but for the country as a whole," says Muofhe. "We might not bridge the human capacity gaps completely, but the SAP-Meraka UTD model enables us to 'import' fewer skilled ICT people. The unit's staffing model works brilliantly because it uses skilled researchers from various institutions without destroying those institutions. Instead, we enter into joint appointments with them, thereby giving our young researchers access to the knowledge and expertise of accomplished researchers."

Eksteen agrees that joint appointments give academics the opportunity to have a positive impact on industry, while also gaining a deeper exposure to the business world. "Taking scarce skills away from universities would be like killing the goose that lays the golden eggs," he quips.

Kok shares this sentiment. "We currently have nine PhD and nine Master's students on board, mainly but not exclusively, from historically disadvantaged backgrounds," he explains. "By aligning their UTD research projects with their academic work, we enable them to earn a living while studying.

"Four scholarships have been made available for students to pursue their Master's degrees in Bruchsal in Germany, and then work for the UTD when they complete their studies. We have even invited academics from renowned institutions in the BRICS to do sabbaticals with us and we are hoping to have senior academics from China and Brazil on board soon."

Eksteen says the advantage of this approach is that the students gain academic qualifications and industry experience simultaneously. "We produce people who are ready to be taken up by industry. Because they are gaining useful skills at the UTD, they are destined to have a positive effect on the ICT innovation landscape in South Africa. This bodes well for industry as well as the broader economy." – ***Manana Makhanya***

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A NORTH-SOUTH ICT PARTNERSHIP TO PURSUE SOCIAL AND ECONOMIC DEVELOPMENT GOALS

Kristiina Lähde and Ashraf Patel

SAFIPA

The South Africa-Finland Knowledge Partnership on ICT Programme (SAFIPA) has hit the ground running since it started operating in July 2008, thanks to the single-minded focus and passion of its team. The programme stands to benefit all participants in South Africa's emerging knowledge economy.

SAFIPA IS THE RESULT of a government-to-government deal between South Africa and Finland aimed at creating an environment that facilitates the development and deployment of ICT service application for the benefit of South African citizens. The Finnish government has committed three million Euros, while the South African government will contribute R9m. The CSIR's Meraka Institute is the implementing agency and will host SAFIPA for the next three years.

Explaining why the two governments selected ICT, SAFIPA chief technical advisor, Kristiina Lähde says, "Although ICT is not a key that fits every door, it is a useful tool for achieving specific social and economic development goals. The benefit does not lie specifically in access to ICT, but rather in its ability to create powerful social and economic networks by improving communication and exchange of information."

Lähde describes their goal as "e-inclusion", which would assist in bridging the information and communication gaps between rich and poor. e-inclusion is something that resonates well with the SAFIPA's national coordinator, Ashraf Patel. With his keen understanding of public policies and regulations and passion for using ICT for development, his mind is always attuned to the need to build capacity in those communities that need it most.

SAFIPA's approach to the enormous task at hand consists of three components, namely institutional capacity development, innovative information society applications and new solutions for end users, as well as network creation and dissemination.

According to Lähde, "Enhancement of ICT deployment is not simply a matter of developing new technical solutions and applications, but increasing citizens' motivation, skills and access to enable them to utilise ICT. This means transforming society and its value systems towards a knowledge society."

She believes continuous learning is the best way to achieve this. "A knowledge society calls for the creation of models that enhance continuous learning. Continuous learning models are needed in all levels of society, especially among those who are responsible for educating and training others."

Institutional capacity development is expected to take on several forms to suit local conditions. Various players will be involved, including the Meraka Institute and other public institutions, regional organisations, teacher training organisations, entrepreneur training organisations, NGOs, national networks dedicated to ICT development as well as entrepreneurs and SMMEs.

SAFIPA's work in terms of network creation will not be limited to South Africa and Finland. Lähde notes, "Networks of trust power the knowledge economy, so cooperation between businesses, learning institutions and public institutions will be encouraged. We will assist in creating and strengthening networks within South Africa, Africa and Finland as well as between Africa and Europe. As part of the monitoring and evaluation of our work in this regard, we will host an annual conference at which learning and outcomes of the project will be discussed."

Following its first call, SAFIPA received 45 proposals. For more information please visit www.safipa.com. – *Manana Makhanya*

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PUTTING INDIGENOUS KNOWLEDGE TO WORK: A NOVEL APPLICATION FOR THE DIGITAL DOORWAY

A WELL-KNOWN INNOVATION FUNDED BY THE DEPARTMENT OF SCIENCE AND TECHNOLOGY (DST) – THE DIGITAL DOORWAY – HAS FOUND A NEW APPLICATION AS A VEHICLE FOR THE CAPTURING, STORAGE AND DISSEMINATION OF INDIGENOUS KNOWLEDGE (IK) TO ADVANCE SOUTH AFRICA'S EVOLUTION TO A KNOWLEDGE ECONOMY.

THE MERAKA INSTITUTE of the CSIR is responsible for the research on the Digital Doorway and is working closely on this IK project with Dr Otsile Ntsoane, manager: IKS knowledge management, and Carol Van Wyk, Deputy Director of the National Indigenous Knowledge Systems Office (NIKSO) of DST.

The DST has identified the knowledge-based economy as the goal of its 10-year plan for South Africa, in which innovation is seen as a key enabler.

As part of this process, the Digital Doorway is seen as a mechanism by which know-how can be leveraged in response to the societal needs of communities. This is an important component of the value chain by which developing countries can stimulate entrepreneurship and non-commercial industry.

"The IKS portal in the Digital Doorway is an infrastructure by which information and knowledge can be provided. It is the spark that will ignite further research, product development, efforts to improve food security and e-learning," explains Ntsoane.

Creating these opportunities is necessary for ordinary citizens to act upon social and economic imperatives, and contribute to both industry and a growing body of knowledge. "Untapping troves of innovation becomes an exciting reality when indigenous knowledge is presented through local languages," he confirms. This social cohesion underpins the drive to entrepreneurship, local innovation and establishment of local industry.

Three sites are set to pilot these multimedia platforms: The science centre in Richards Bay, KwaZulu-Natal; the Mmabana Cultural Foundation in Mafikeng, and a site in Mpumalanga. These sites have been selected to give access to information and technology to young and old alike. Rollout is planned for 2009.

These Digital Doorways will provide (initially with varying content based on African science and technology evolution) a national recorder system, a knowledge infrastructure and a network of databases. Categories of local indigenous knowledge to be included are life sciences and biodiversity, anthropology, astronomy, industrial management, mathematics, metallurgy and mining, and subsets of information for skills development. It is envisaged that knowledge from the African continent will also be included as well as international best practices.

Ntsoane posits that, "This information technology advocates for the protection and research on IKS by local communities. By adding to the value chain, these communities can mitigate effects of the innovation chasm and, most importantly, contribute to the knowledge hub as seen from an Afro-centric perspective." He sees this development as a step towards the future in which society adds value to industry through recognition of its local knowledge, "It allows a response from our people: What they know can be shared with others through this information and communications infrastructure." – ***Biffy van Rooyen***

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Dr Otsile Ntsoane of DST with Thabo Mthombeni and Nicki Koorbanally of the Meraka Institute

SMOOTHING THE DELIVERY OF VIDEO VIA THE INTERNET FOR COMMERCIAL AND SOCIAL SERVICES

BY DR KEITH FERGUSON

THE REAL-TIME VIDEO CODING (RTVC) RESEARCH GROUP of the Meraka Institute at the CSIR is tackling some of the challenges to deliver smooth video over the internet where network congestion is at the order of the day.

Have you experienced the frustration of watching video on the internet where it takes minutes to start and plays in bursts with re-buffering messages in between?

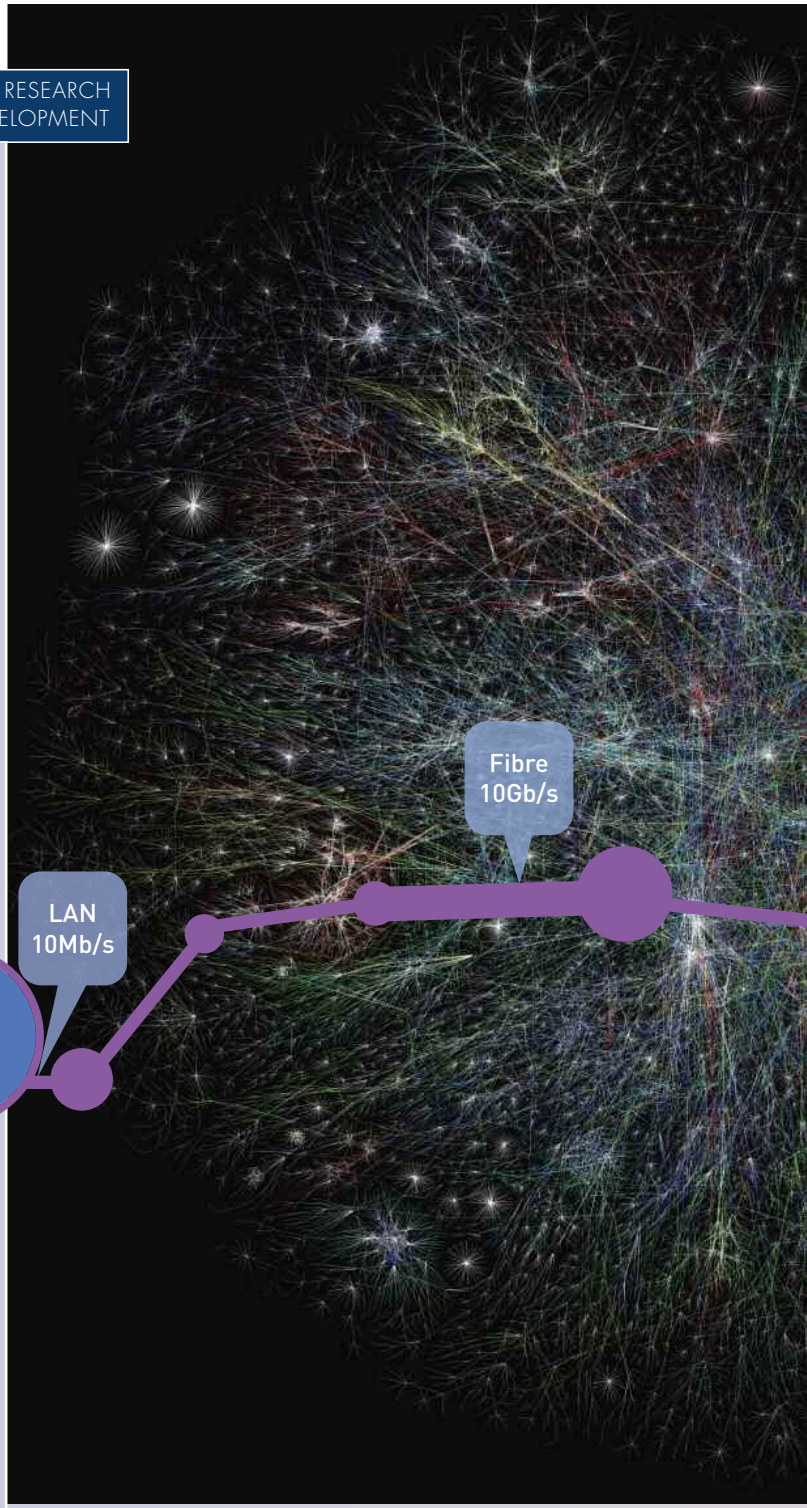
This is caused by millions of people using the internet at the same time, with everyone sharing the same internet infrastructure. The problem is exacerbated by the size of the video data, which is thousands of times larger than an average web page. Imagine thousands of people watching the same video at the same time or a million people simultaneously watching a live music concert. Just like vehicles in a traffic jam: the flow-through rate is reduced to a trickle and congestion ensues. Developing countries with limited infrastructure and internet connectivity are being largely excluded from the growing global appetite for internet video services. If this technological barrier can be overcome, immense potential exists for a wide variety of social and commercial services that can contribute to the competitiveness of developing countries.

One of the objectives of the group is to pursue actively a holistic approach to the innovation chain where the route from concepts and ideas to commercial products is treated as a single problem to solve. Therefore, the research, development and commercialisation agenda spans the modelling of network behaviour under congested conditions, video encoding and optimisation techniques, massively scalable architectures for commercial-grade video delivery and built-in new media advertising models.

WHAT DOES THE INTERNET LOOK LIKE?

To deliver any form of real-time data over the internet requires a comprehensive understanding of the static and dynamic behaviour of this medium. The meteoric growth of the internet can be ascribed to the homogeneous nature of the protocols used to exchange data between the server of information and the reception at an individual's desktop computer or edge device. However, the communications technologies underneath these protocols are far from homogeneous. Connections are made from home using ADSL (asymmetric digital subscriber line, a data communications technology), from work on company LANs (local area networks) and even from phones. These all behave differently and operate at different throughput rates between the multiple routers along the connected session as illustrated. Furthermore, their behaviour changes with time during the same online session, when congested conditions arise.

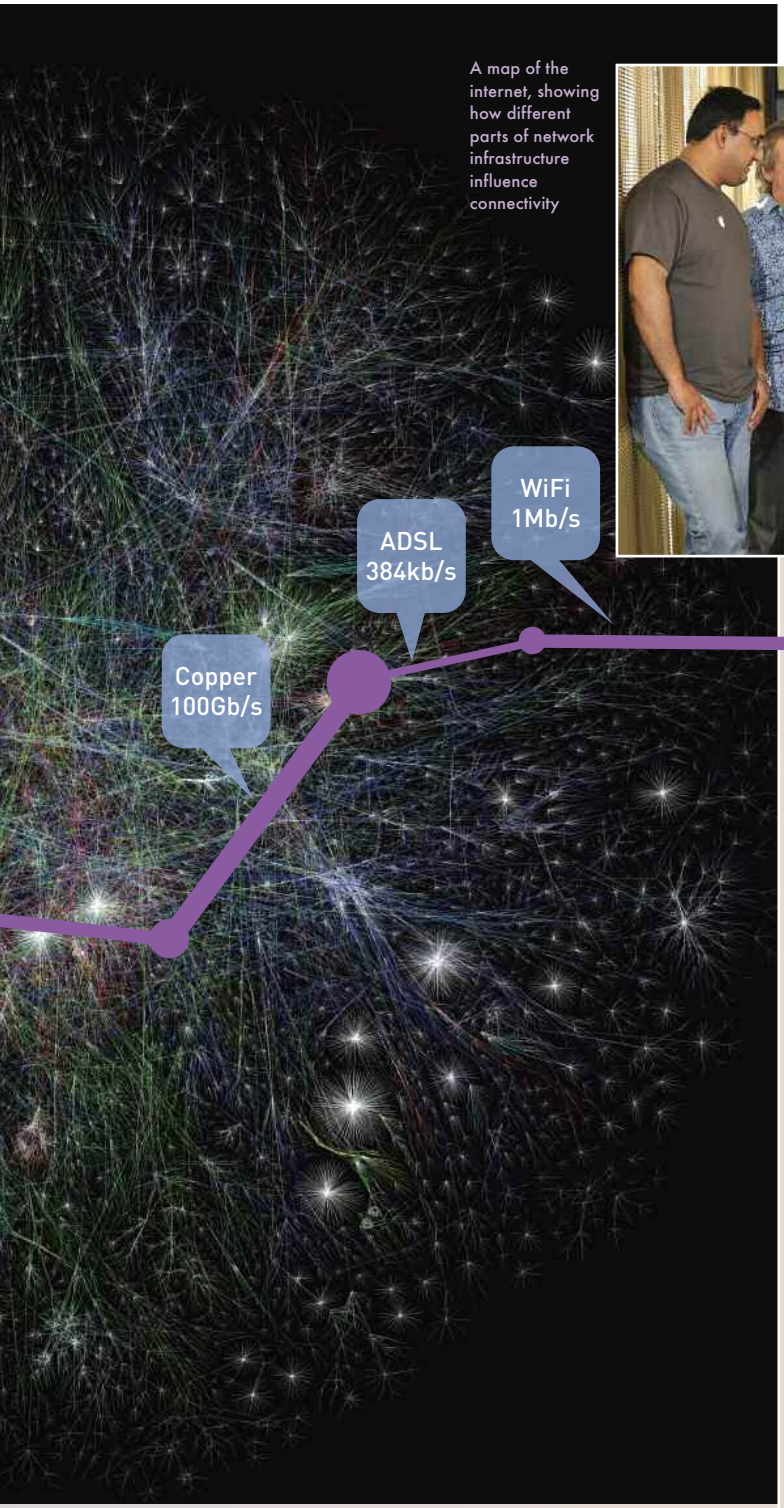
A model for the behaviour of real-time data flow for video sessions over the internet in congested conditions is under investigation.



What is the instantaneous throughput rate between any arbitrary server and client, and what is the minimal delay that can be sustained between them? These are just some of the questions that are being investigated by the group. If an approximated model can be found then the rate or delay can be predicted to some extent and, if this behaviour can be predicted, then the source video encoding can be adapted to match the given conditions.

CAN WE MAKE EXISTING STANDARD VIDEO ENCODERS INSTANTANEOUSLY ADAPTABLE?

Fortunately, existing international video compression standards have modes of operation that permit fine-grained quantisation settings that can be used to adjust the quality, balanced by the amount of data (bits) consumed, for each small region of the picture. So, for every frame in a



A map of the internet, showing how different parts of network infrastructure influence connectivity

The team tackling real-time video encoding: Anice Hassim (East Coast Access), Dr Keith Ferguson, Nicki Koorbanally, Dhiren Seetharam, Ralf Globisch (all of the Meraka Institute), Professor Mqhele Dlodlo (UCT) and Louis Joubert (Meraka Institute)

video sequence, the quality can, in principle, be increased or decreased to match the instantaneous data throughput of the network either up or down. But just because these modes are built into the standards does not mean that the balancing act of picture quality versus data consumed is acceptable to a viewer. Finding optimal solutions to this technological tightrope performance is a core area of research within the RTVC group.

What we mean by optimal is that just the right amount of extra bits are allocated to those regions of the picture, which are objectively the worst affected by the video compression process and less bits are allocated to the least affected areas. Of great importance is a near-optimal solution that operates in real-time and can be implemented in software on general purpose computers.

But what does quality mean? If the throughput rate of a channel becomes very small and the quality has to be significantly degraded, can it be done in a 'graceful' way that minimises the viewer's annoyance? It turns out that the human eye is more sensitive to some compression artefacts than others, and if the quality balancing act can be made to include this subjective property, then the potential exists for greater compression at better subjective qualities. This same argument can be further extended to include the way human viewers experience the context of the video material they are watching. For example, football viewing is concentrated around the ball whereas Sign Language viewing concentrates around the face. Optimal context-aware quality distribution for video encoding is one of the new research areas of interest in the RTVC group.

CAN WE COMMERCIALISE THESE TECHNOLOGIES?

To broadcast live video over the internet requires designing massively-scalable systems that can cope with hundreds of thousands of simultaneous viewers and deliver appropriate advertising to each unique viewer. This is a challenging problem, particularly in developing countries where very low throughput must coexist with high throughput and viewing quality demands are stringent. The RTVC group has received an investment from the Innovation Fund at the Department of Science and Technology to form a consortium with a Durban-based BEE company, East Coast Access, and the University of Cape Town. The aim is to create such a system architecture that can house the technological advancements made by the research and deliver a service providing a competitive edge to the South African online media industry. A patent application has been made for a core element of the design in seamless video channel switching developed by the group.

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ENTERPRISE ENGINEERING

– MOVING TOWARDS A KNOWLEDGE-BASED ECONOMY

Dr Paula Kotze heads the newly-established human factors and enterprise engineering group

ENGINEERING is not often thought of as a social or business activity. However, social and business needs and pressures shape what engineers do as much as engineering and technology shape the nature of society. In this context the human factors and enterprise engineering group (HUFEE) within the Meraka Institute of the CSIR focuses on the issues affecting the development of socio-technical systems, both within enterprises and for the individual. The primary context is the development of supporting information and communications technologies (ICTs).

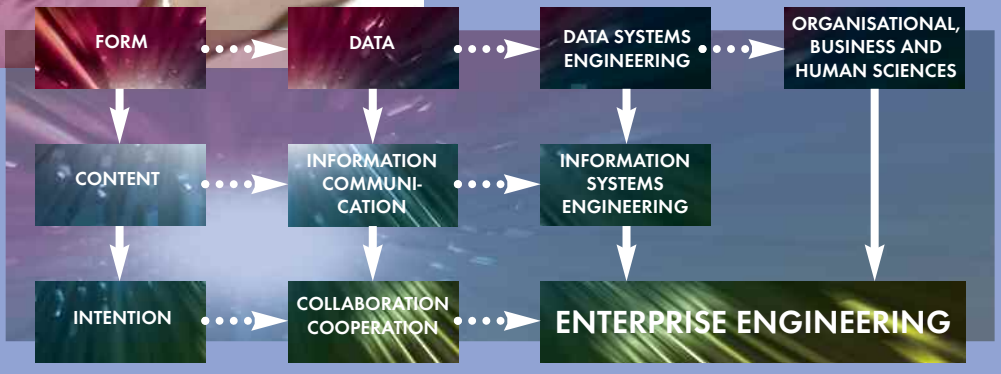
THE ENTERPRISE PERSPECTIVE

In the ICT context, an *enterprise* is seen as an 'organisation' that uses computing and communication devices to support its goals, and encompasses corporations, small businesses, non-profit institutions, government bodies, educational institutions, space stations, and other kinds of organisations such as living environments (e.g. households). It can be viewed as a complex system consisting of processes that can be engineered both individually and holistically. The majority of these processes require the involvement of or interaction with a human at some time. Enterprises are therefore in essence social systems, more specifically, socio-technical systems.

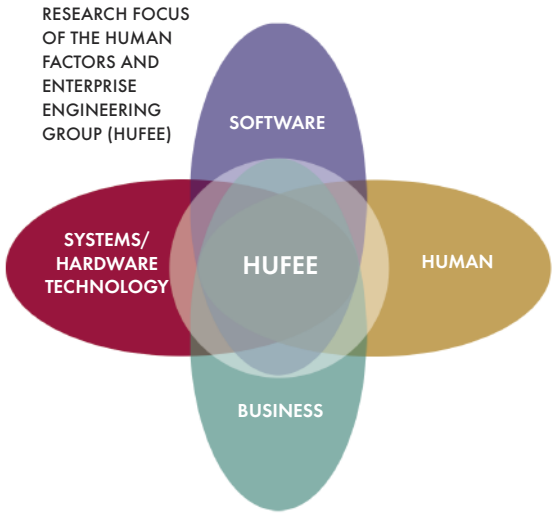
ENTERPRISE ENGINEERING

The current evolution in the information systems sciences marks the transition from the era of information systems engineering to the era of enterprise engineering. Enterprise engineering, however, emerges not only from information systems engineering but also the organisational and behavioural (human) sciences. Enterprise engineering is hence closely related to organisations and social issues, and thus it focuses on the construction of enterprises as *socio-technical systems*.

Enterprise engineering involves the use of engineering rigour in transforming the enterprise and is defined as that body of knowledge, principles and practices having to do with the analysis, design, implementation and operation of an enterprise. In a continually changing and unpredictable competitive



THE EVOLUTION OF ENTERPRISE ENGINEERING



WHAT'S IN A NAME?

HUFEE is a waypoint off the coast of Massachusetts in the USA. Waypoints are sets of coordinates that identify a point in physical space. A waypoint is a reference point (coordinates) in physical space used for purposes of navigation. For the purposes of terrestrial navigation, these coordinates usually include longitude and latitude, and sometimes altitude (particularly for air navigation). HUFEE (the group) will use human factors engineering and enterprise engineering as its longitude and latitude indicators and the ICT domain as its altitude indicator.

environment, the enterprise engineer addresses a fundamental question of how to design and improve all elements associated with the total enterprise, including the human element, through the use of engineering and analysis methods and tools, to achieve its goals and objectives more effectively. As such, enterprise engineering can be seen as integrating four sub-domains: systems and technology ('hardware'), software, business and humans. These components interface with each other to promote the goals and objectives of the enterprise.

SYSTEMS ENGINEERING

Systems engineering is the application of engineering to solutions of a complete problem in its full environment by systematic assembly and matching of parts in the context of the lifetime use of the system. It focuses on the development and organisation of complex artificial systems: From spacecraft to chip design, from robotics to creating large software products to building bridges. It uses a host of tools that include modelling and simulation, requirements analysis, and scheduling to manage complexity.

SOFTWARE ENGINEERING

Software engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software – the application of engineering to software. It is also the study of approaches to achieve this objective. The software engineering process is the total set of software engineering activities needed to transform a user's requirements into software.

BUSINESS PROCESS ENGINEERING

Business process engineering is a set of techniques an enterprise uses to design its 'business' according to specific goals. These techniques can be used for business re-engineering, business improvement and business creation. Business process re-engineering is a methodology and approach by which the business process of an organisation is analysed and its functionality improved. In the context of innovation, business engineering includes all activities that are necessary to develop and maintain an independent line of business.

HUMAN FACTORS ENGINEERING

Human factors engineering uses a systems approach to fit tasks to human capabilities and skills while optimising technology and human interactions. The term 'human factors' is comprehensive, including all biomedical and psychosocial considerations affecting the human in the enterprise. It focuses on how people interact with these tasks, machines, etc., with the consideration that humans have limitations and capabilities. Human factors engineering is thus intertwined with the entire enterprise engineering process and is a complementary systems engineering approach from the perspective of the human (user), rather than the software and hardware alone.

WHAT IS MISSING?

Each of enterprise engineering's sub-domains has its own supporting engineering discipline: But what happens in the overlap between these four domains?

Several aspects of the socio-technical system emerge when combining the contexts of systems, software, business and human factors engineering within the enterprise engineering domain. The goals and aspirations of individuals are distinct from those of institutions, companies, nations, regions, societies, and the interrelationships between them that operate on many levels and vastly different scales of time and space. Since these relationships are never static, engineers and engineering constantly face the challenge of serving both ends of this huge spectrum.

Also, the ongoing nature of this change is rapid and complex, sometimes resulting in fast-moving and false directives for technological innovation, as well as constraints on the adoption of new technology by slowly evolving social constructs for adapting and coping with the potential consequences.

The overlap is thus a still largely neglected field and points to an intense need for people who understand all the sub-domains and how to integrate them to meet the goals and objective of the entire enterprise. HUFEE's research concentrates on this overlap. It focuses on a human-technological partnership of maximum efficiency and effectiveness in which learning takes place at every level, leading to the satisfaction of all parties involved in the enterprise domain. The group's research is aimed at a knowledge-based economy, focusing on the human, business and software elements of enterprise engineering elements individually, but also the important interaction between them and the supporting role played by all in a socio-technical system. The focus is on 'soft issues' and not on the hardware technology as such, although the outcome of the group's research would inform hardware and technology design. HuFEE has a strong multi-cultural and multi-context focus to extend the use and usability of ICT systems in a variety of ways that will serve the people and needs of South Africa and beyond.

– Biffy van Rooyen

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SCUBUNTU – PUTTING OPEN SOURCE COMPUTING RESEARCH TOOLS UP FOR GRABS

BY LELANTHRAN MANICKUM & MIXO SHIBURI

FREE/LIBRE AND OPEN SOURCE SOFTWARE (FLOSS) HAS AS ITS BASIC TENETS COLLABORATING AND SHARING. IT IS IN THIS SPIRIT THAT THE SCUBUNTU PROJECT WAS INITIATED WITHIN THE MERAKA INSTITUTE TO DEVELOP A SCIENTIFIC COMPUTING PLATFORM OF QUALITY, TO BE USED ROYALTY-FREE BY RESEARCHERS AND STUDENTS GLOBALLY.

Lelanthran Manickum and Mixo Shiburi – putting Scubuntu out there for researchers to use for the benefit of industry

FLOSS

SOME HANDY DEFINITIONS

Free/libre and open source software is software that is liberally licenced to grant the right of users to study, change and improve its design through the availability of its source code. This approach has gained both momentum and acceptance as the potential benefits have been increasingly recognised by both individuals and corporate players.

SCUBUNTU IS AN OPERATING SYSTEM consisting of free and open source software for scientists. It primarily provides researchers and scientists with high-quality scientific applications and tools to surf the web, read email and create documents and spreadsheets. Scubuntu is powerful and flexible for researchers everywhere – at university, at the office and at home. It is easy to install, free of viruses and suitable for laptops, desktops and servers.

Based on the Ubuntu Linux distribution, Scubuntu is envisaged as a platform where the best ideas from the actual users can be incorporated. This ensures its evolution to the premier scientific computing platform for researchers, with the secondary advantage of being totally free.

To achieve the above-stated objective, the Scubuntu team undertook research into scientific computing. The outcome has been stabilisation of the composition of the platform to provide the greatest utility to the greatest number of users. In support of this aim, flagship categories are included to display the best in Scubuntu, namely geographic information system (GIS) and biosciences functionality. Other scientific packages (such as general office packages, statistics packages and charting/graphing utilities) are also included.

SCUBUNTU FLAGSHIPS: STADEN AND GRASS

Staden is a highly flexible set of tools used in genetics for DNA sequence assembly, analysis and related functionality. Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms and some viruses.

Staden is a reputable product; it has been cited in the literature on the subject at least 54 times, which includes two peer-reviewed papers that both feature exclusive research using Staden only. Included in this list of Staden users (and, of course, co-authors of the 54 papers) are six Nobel prize-winners, putting future users in impeccable company. However, getting Staden running can be a little troublesome for new Ubuntu users.

The Scubuntu team's decision to give priority to Staden for immediate release, was based on its importance to many users. Efforts were devoted to ensuring that Staden would be available to biosciences researchers from the inception of the project. Feedback is welcomed from these users, following successful liaison with the Staden development team.

The flagship of Scubuntu is a GIS known as GRASS (geographic resources analysis support system). GRASS is used for geospatial data management and analysis, image processing, graphics/maps production, spatial modelling and visualisation. It was originally developed by the US Army Construction Engineering Research Laboratories for and management of environmental planning. It has since evolved into a utility used in many different areas and is now a project under the Open Source Geospatial Foundation.

GRASS is available on many operating systems and platforms. It contains several hundred tools to render, manage and manipulate geospatial data information. The user interface to GRASS is Windows and command line based, allowing for easy operation for new and accomplished users. Quantum GIS (QGIS) can also serve as an alternate interface to the two GRASS user interfaces. Both GRASS and QGIS are free and available with the Scubuntu platform.

GRASS supports various two-dimensional (2D) raster data, three-dimensional (3D) raster data and topological vector data (2D and 3D). The support for these formats is done through the geospatial data abstraction library available in Scubuntu. It also contains spatial analysis, map generation and data visualisation tools.

From January to November 2008, a total of 747 840 people visited the GRASS website. Of these visitors, 240 901 were unique.

ENSURING THE WAY FORWARD

Since the greatest value of Scubuntu is the open-source nature of the project, contributions are welcomed. These make FLOSS not only viable, but also desirable in the long term. In this way, a platform will become self-sustainable through the efforts of researchers interested in the long-term viability of their work. Interest from researchers in new or particular disciplines is of great value.

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USEFUL LINKS:

http://www.meraka.org.za/scubuntu.htm
http://staden.sourceforge.net/
http://www.gdal.org/ogr/ogr_formats.html
http://www.gdal.org/formats_list.html
http://www.osgeo.org/search_profile
http://www.gdf-hannover.de/media.php?id=0&lg=en

BROADBAND FOR ALL

PROJECT ENDORSED BY ACTIVATOR

Parsec manufacturing plant – used in producing the Broadband for All devices. From left are: Ajay Makan (Meraka Institute), Madeleine van den Berg (Meraka Institute), Rynier van der Watt (Parsec Director), Andries van Schalkwyk (Business Manager: Parsec) and Kobus Roux (Meraka Institute)

THE BROADBAND FOR ALL PROJECT, LED BY THE CSIR'S MERAKA INSTITUTE, IS ONE OF THE FIRST TWO PROJECTS TO BE ENDORSED BY THE RECENTLY LAUNCHED ACTIVATOR PLATFORM. THE PROJECT AIMS TO REMOVE OR MINIMISE TECHNOLOGY BARRIERS, ENABLE BOTTOM-UP CREATION OF WIRELESS ACCESS INFRASTRUCTURE AND PROVIDE CHEAPER BROADBAND IN REMOTE AND RURAL COMMUNITIES.

ACTIVATOR is a collaborative initiative between the Innovation Hub – Africa's first internationally accredited science park and the leading knowledge-intensive business cluster in South Africa – and the Cooperation Framework on Innovation Systems between Finland & South Africa (COFISA). The platform is aimed at coordinating collaboration, stimulating industry-focused innovation and leveraging public and private sector funding, while creating opportunities for developing small, medium and micro enterprises and hi-tech jobs.

Formerly known as the Centres of Expertise Programme, the platform was formally launched on 17 October 2008.

According to Jeanette Morwane, manager of Activator, the programme is based on a Finnish model that utilises top-level knowledge and expertise as a resource for business operations, job creation and regional development, with the aim of identifying the region's strengths and creating economic growth.

"The initial announcement of the programme included a call for proposals to prospective consortia, promoting the spirit of collaboration between industry, research, academic institutions and government in projects from the aerospace, ICT and biotechnology sectors," Morwane says.

Six ICT consortia projects were selected, and are currently operating on the Activator platform. Two of these projects are fully endorsed, including the Broadband for All project. Apart from the Meraka Institute, the consortium also includes Sentech, Parsec & Redline SA and the Universal Service and Access Agency of South Africa.

According to Kobus Roux of the Meraka Institute, research has been focused in the areas of mesh networking, low-cost voice/messaging devices, low-cost access points and antennas, and network security. "The specific focus of the intervention, differentiating it from other communication networks, is on the use of community wireless networks as an approach, with wireless mesh networking technology underpinning this approach," he explains.

"Community wireless networks are networks where the infrastructure is owned and/or operated locally, local networking costs contained within the community and traffic is aggregated at the community level to save by means of bulk purchase of bandwidth," Roux points out. "Mesh networking research is interesting in that a community can grow a wireless network in an *ad hoc* manner without the need for large capital investment in radio masts."

Meraka Institute researcher Madelein van den Berg explains the concept of a wireless mesh network as a communications network made up of radio nodes in which there are at least two pathways of communication to each node. "The coverage area of the radio nodes, working as a single network, becomes a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network," she says.

"A mesh network improves reliability through the redundancy it offers. When one node can no longer operate, the rest can still communicate with each other, directly or through one or more intermediate nodes."

Van den Berg also points out that the project focuses primarily on the infrastructure business and not on establishing small rural infrastructure businesses. These infrastructures will enable great applications and other business in their environments.

"Endorsement by the Activator platform has undoubtedly strengthened the Broadband for All consortium."

"As a research organisation, the Meraka Institute welcomes the opportunity to work with industry partners in a joint effort to bring remote and rural communities into the broadband fold," Roux concludes.

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FROM POLLUTION TO SOLUTION:

HOPE FOR HEALTH

The quest of the CSIR's environmental health researchers to determine and alleviate the health risks associated with personal exposure to environmental hazards, has resulted in a number of initiatives.

"The CSIR assists industry to control chemical hazards."

ENVIRONMENTAL HEALTH RESEARCHERS have gone beyond health to look at quality of life by assessing, controlling and preventing environmental factors that potentially adversely affect both present and future generations.

Senior scientist, Rietha Oosthuizen explains, "the CSIR's pollution and waste environmental health scientists strive to make an impact to improve the health and quality of life of South Africans. Our work includes assessing health impacts associated with industrial development and climate change, vulnerability interventions as well as performing air pollution human health risk assessments."

A unique feature of this team's work is the focus on quality of life in vulnerable communities. "By assisting industries to control hazards, particularly chemical hazards, we are able to play a role in making the quality of life better for everyone in terms of health. In addition, we are able to predict future health risks when we know what the industry is going to emit. In this way, we are able to help in the prevention of future health risks," she adds.

The main focus areas of research done in this regard include assessing health impacts under a changing climate; toxicity of nanoparticles and products; vulnerability and intervention assessments as well as air pollution population exposure and risk prioritisation.

In terms of assisting industry to eliminate or minimise health risks associated with criteria pollutants and those associated with specific industries, the scientists provide input through specialist studies to environmental impact assessments (EIA), strategic environmental assessments (SEA) and human health risk assessments.

The CSIR has longstanding contracts with a number of industries where a range of air pollutants are monitored. These pollutants not only include the criteria pollutants identified in the National Environmental Management Act Number 39 of 2005 (e.g. sulphur dioxide), but also other gases, particles and industry-specific heavy metals and volatile organic compounds. The air quality monitoring is carried out to assist in evaluating air pollution concentrations associated with industry-specific activities. Continuously updated data are used to determine human health impacts of ambient air pollution in and around the area in which the industry is located. These results inform decision-making and implementation of mitigation measures to ensure that neighbouring communities are not adversely affected.

Explaining the difference between an EIA and an SEA, Oosthuizen says, "An EIA is a process followed to determine the impact of a planned development on the environment and possible mitigation measures to avoid or reduce negative impacts. Industries are required to determine their impact on the environment in order to make informed decisions on environmental matters particularly for future developments. An SEA, on the other hand, is a process to determine the capacity of the environment to cope with, or assimilate, the proposed development. This is a broader procedure that also entails the environmental implications of policies, plans and programmes. The role of the SEA is to allow for the decision-maker to proactively determine the most suitable development type for a particular area before development proposals are formulated."

Human health risk assessments performed by the environmental health group focus specifically on chemical pollutants and can be either quantitative (numeric) or qualitative, which is more descriptive. For example, the group determines the risk of specific pollutants to human health.

Other projects focus on climate change, and specifically pollution and waste- induced changes, and the possible health impacts thereof. Oosthuizen uses the incidence of malaria in certain areas as an example. "Malaria used to be present in parts of Gauteng a few decades ago and it was widely believed that the use of DDT had eliminated it. We are now looking at the possibility that high temperatures might bring it back to these areas."

Similarly, Mamopeli Matooane, an environmental health researcher, is currently investigating climate change-induced heat stress, air pollution and associated mortality for South African conditions.

Vulnerability of communities to environmental pollution is also of interest to this group of scientists. "We are not all equally vulnerable to environmental pollution," says Oosthuizen. "Some people's genetic make-up or diseases can make them more vulnerable. Our vulnerability research, being driven by researcher Juanette Johan, is interested in developing reliable tools to assess the level of vulnerability as well as interventions that can make communities less vulnerable by increasing their resilience or reducing their exposure.

"A methodology to determine exposure and prioritise risk of populations is being developed by postdoctoral student Dr Caradee Wright. This tool is aimed at supporting municipalities in their decision-making around development and associated impacts on human health."

The group's nanotechnology research focuses on the potential safety, health and environmental impacts of nanoparticles and products on human and ecological systems. Nanoparticles tend to have different effects compared to larger particles of the same material, so by assessing the effect of nanoparticles on human beings and the environment, the group is able to alert industry and government partners in the event of toxic nanoparticles, particularly when these are emitted, discharged or disposed of within the environment.

Oosthuizen believes the value of their work lies in the fact that it is an investment for the future. "By determining now what is potentially hazardous, we allow industry the opportunity to responsibly plan its developments and operations. We provide the scientific knowledge to ensure that what it does now, does not have a detrimental effect in the future."

– Manana Makhanya

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GROWING THE ESSENTIAL OILS AND MEDICINAL PLANT INDUSTRY THROUGH COMMUNITY-BASED ENTERPRISES

EMERGING SOUTH AFRICAN FARMERS ARE RESPONDING TO GROWING CONSUMER DEMANDS FOR PERSONAL AND HEALTHCARE PRODUCTS BASED ON NATURAL INGREDIENTS BY CULTIVATING AND PROCESSING INDIGENOUS PLANTS FOR THE LOCAL AND INTERNATIONAL MARKET.

Some community members in the Western Cape are involved in projects in which they sell processed products to companies that produce herbal medicines and fragrances

THESE ARE THE NEW AGE FARMERS who in many cases obtained their land through the land redistribution programme but initially lacked the technical skills to transform the farms into productive units.

These communities typically approach the CSIR to obtain access to the knowledge and market linkages required to establish businesses based on cultivation and processing of essential oil and medicinal plants.

Aided by its rich biodiversity, the South African medicinal plant and essential oils industry can be classified as an emerging industry in comparison to those of other developing countries.

It was envisaged by the Department of Science and Technology (DST), in partnership with the CSIR, that the creation of new community-based enterprises will require a systematic process of technology transfer and business incubation. The aim is to demonstrate, through the creation of enterprises that cultivate, process and sell value-added herbal products, how this sector can be rapidly developed to make it a competitor in the world's biotechnology market.

But to achieve this accelerated growth, communities had to be empowered to enable them to contribute to the creation and growth of this industry.

The CSIR's Marthinus Horak says it has been a rewarding 10 years since the CSIR started to identify and address technical hurdles that inhibited the local growth of the medicinal plant and essential oil sector.

The CSIR initially worked closely with commercial farmers and with the local horticultural and manufacturing industry to create technology solutions that are currently being implemented in more than a dozen DST-funded community-based projects.

In addition, the CSIR undertakes a range of projects aimed at developing the sector, such as investigation of markets, sourcing of improved processing technology and investigating appropriate business models for community-based enterprises in the sector.

Horak says there is a wealth of knowledge within the CSIR to allow it to transfer the technology and skills to communities.

In addition, this does not only empower South Africans but helps the country's medicinal and essential oils industries to grow.

"We do this by working with community farmers in a practical sense. We help communities by identifying a viable business concept for the farm, based on the cultivation and processing of plants species carefully selected on a basis of agro-potential of the farm and an identified buyer of the processed products. In addition to the provision of technical and business skills, growers are also assisted to conform to the legislation that governs the use of land and irrigation water as well as conservation of indigenous plant species."

Horak also explains the importance of growing indigenous plants on these farms.

"This gives us an edge because it means we are not competing with other countries on the same products. We have something different to offer, something that no one else has," he says.

The enterprise creation and incubation process takes about three to five years. Thereafter, the CSIR exits the projects. After this period the community would have had practical experience of producing products that conform to the quality standards of buyers and have experience of managing its own business.

"The community eventually sells processed products to companies that produce herbal medicines and fragrances."

Horak says the CSIR only gets involved in these communities if the members show an interest in the medicinal or essential oils plants.

"If they want to grow conventional food crops then we do not get involved. The aim is to develop the essential oils and medicinal plant industries by transferring knowledge created at the CSIR and other research institutes, universities and in the private sector."

The CSIR is currently involved in establishing a cultivation site for African ginger in KwaZulu-Natal, where this popular medicinal plant is considered by many to be regionally extinct due to overharvesting from the wild. It is also transferring knowledge to communities in the Eastern Cape with the growth of *Pelargonium sidoides*, an indigenous species that forms the basis of a popular treatment for bronchitis in many parts of the world.

Rose geranium is one of the most popular essential oil plants grown across the country. Buchu essential oil is produced in the Western Cape, as well as *Lippia javanica* and lemon grass in Limpopo.

Other projects also funded by the DST and implemented by the CSIR, include rose geranium in Elandskraal in Limpopo and Kwa-Ngwanase in KwaZulu-Natal.

The CSIR currently manages pilot projects in the Kalahari and in the Free State to determine the feasibility of cultivating and processing commercially valuable aromatic and medicinal plant species in areas subjected to extreme climatic conditions.

– Kamogelo Seekoei

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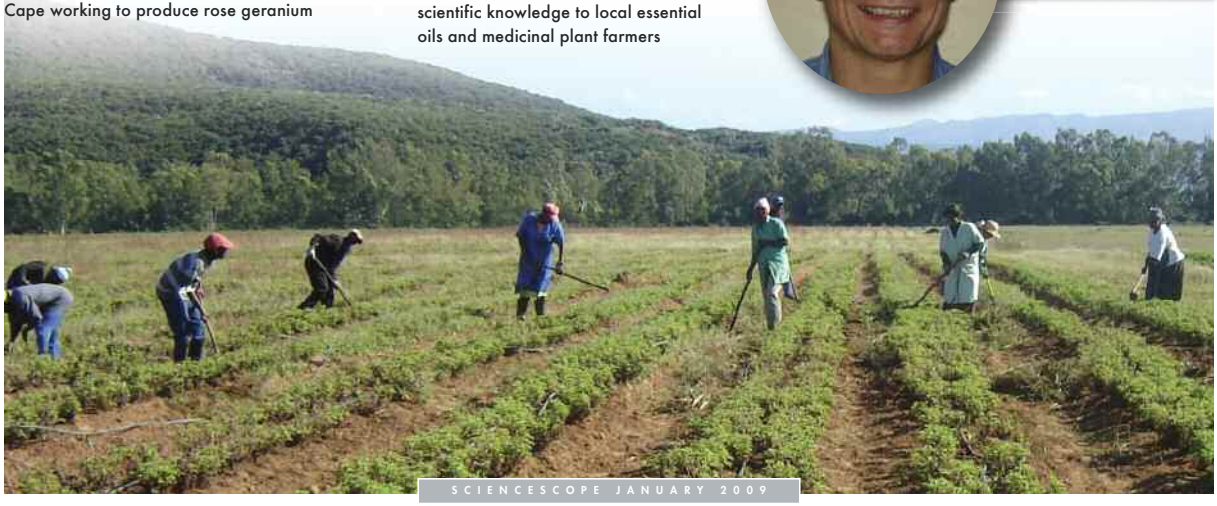
Dr Marthinus Horak is part of a CSIR team that champions projects aimed at developing the sector by transferring scientific knowledge to local essential oils and medicinal plant farmers

Farm workers, in KwaNobuhle in the Eastern Cape working to produce rose geranium



A NOVEL, ECONOMICALLY-COMPETITIVE METHOD FOR ARV PRODUCTION

Dr Moira Bode

CSIR BIOSCIENTISTS embarked on a project in 2004 to examine mechanisms of reducing the cost of manufacturing generic antiretrovirals, first through CSIR funding and later through Life*Lab* – an agency established by government to fund biotechnology innovations.

Antiretrovirals are increasingly administered according to a combination strategy – highly active antiretroviral therapy (HAART) – which is a cocktail of several drugs from different classes. This strategy minimises the risk of resistance by the HIV/Aids virus to any one of the drugs being developed.

The CSIR project focused on reducing the cost of preparing nucleoside reverse transcriptase inhibitors (NRTIs), by using a biocatalytic step for preparation of one of the important intermediates in the preparation of drugs such as stavudine and AZT. NRTIs are used in first-line and second-line treatment regimens. Drug resistance or serious side-effects can be overcome by switching regimens.

To date, globally, the approved therapies for HIV/Aids treatment include NRTIs and non-NRTIs, both acting against the viral enzyme reverse transcriptase; protease inhibitors, acting against the viral enzyme protease and entry inhibitors that hinder either entry or fusion of the virus to its target in the mammalian cell. The first inhibitor of the viral enzyme integrase was approved by the American Food and Drug Administration in October 2007.

According to Dr Moira Bode, her team's research outcomes have the potential to stimulate the local production of active pharmaceutical ingredients, which according to her knowledge is presently not undertaken in South Africa.

This effort would enable especially African governments to supply more people with the life-saving drugs.

Bode's team worked on technology for the production of 5-methyluridine and thymidine. "5-Methyluridine can be an intermediate in the production of stavudine, but thymidine, which we prepare from 5-methyluridine, is the most valuable intermediate in the production of antiretrovirals such as stavudine and AZT."

The work conducted at the CSIR included total development of the biocatalysis reaction to produce 5-methyluridine as well as the chemistry to convert 5-methyluridine to thymidine. This involved, among other things, initial screening work to identify useful enzymes, the fermentations to produce enzymes and the process development for scale-up of the biocatalytic reaction, as well as the chemistry. The entire process

A NEW ECONOMICALLY-COMPETITIVE METHODOLOGY FOR THE PREPARATION OF AN INTERMEDIATE IN THE PRODUCTION OF AZT AND STAVUDINE HAS EMERGED FROM CSIR LABORATORIES. THESE RESEARCH OUTCOMES HAVE THE POTENTIAL TO STIMULATE LOCAL PRODUCTION OF ACTIVE PHARMACEUTICAL INGREDIENTS.

was scaled at the CSIR to produce thymidine at kilogram scale.

Before achieving success, the team encountered several challenges particularly with regard to obtaining optimal yields. "Initially, low yields were obtained in the biocatalysis reaction for enzyme production, as well as in the chemistry. Much development work was undertaken to turn this into a viable process. The belief team members had in the process and its potential was largely responsible for their determination to make it work. Hard work allowed this to happen in the end," says Bode. Pricing of ARV production varies but according to Bode the CSIR aimed to lower the costs to under $120-170 per kilo – the current cost for 5-methyluridine according to her records.

The team also investigated the production of AZT and stavudine. However, the final package developed was a process to reduce the costs of producing thymidine *via* 5-methyluridine.

This technology has been licenced to Arvir Technologies – a start-up biotechnology venture to build a low-cost generic antiretroviral business based on proprietary technology from the CSIR.

Dr David Walwyn, CEO of Arvir, said the company would explore various options for commercialisation of the technology including the granting of licences to existing ARV active pharmaceutical ingredient producers and the establishment of such a facility in South Africa. The latter will make AZT and other ARV products. "Due to the high risk nature of such a facility, negotiations are presently underway with government on how to support Arvir's projects and specifically how to ensure that the South African ARV treatment programme has access to a well-secured supply of high quality ARVs," says Walwyn.

"In South Africa, with the number of people requiring ARV drugs estimated at approaching 1 million (where the CD4 count of the individual is less than 200), the local manufacturing of these drugs is an imperative."

The CSIR has filed a patent application on the relevant technology. – ***Asha Speckman***

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VOLKSWAGEN SA BECOMES LATEST BENEFICIARY OF CSIR 3D LASER CUTTING APPLICATIONS

BY HANSIE PRETORIUS

LASER EXPERTS 'CUT OUT' FOR THEIR WORK

THE CSIR HAS BEEN SERVING INDUSTRY with the development of prototype parts and limited production of components for local and internationally-produced motor vehicles for some time. Three-dimensional laser cutting applications specifically, are extensively used by the automotive industry. The CSIR's latest project involved trim pressed body panels for Volkswagen (VW) South Africa.

A pressed body part is a piece of sheet metal that is formed by using a metal press and pressing tool to shape the sheet in the form of the body part. This body part has excess material that needs to be trimmed to achieve the correct outline or shape so that the part fits into position onto the motor vehicle. Using a five-axis laser system, the CSIR is able to process 3D components.

VWSA is a wholly-owned subsidiary of Volkswagen Aktiengessellschaft (VWAG) in Germany. It is the largest German investment in South Africa and is a major contributor to foreign direct investment, technology transfer and skills development.

The automotive manufacturer supplied the CSIR with the pressed body panels and a 3D CAD model (a computer-generated 3D drawing of the component, which included the trim line – this indicates the outer shape of the panel). A specialist group was responsible for the programming of the profile, as well as the design and manufacturing of a holding fixture to be used for positioning the body panels on the laser bed. The CSIR produced five laser-trimmed prototypes for verification and after a few adjustments, 650 parts were laser-cut for VWSA. These parts are destined for VW in Germany.

The five-axis laser processing abilities of the CSIR enable clients to develop the trimmed part without investing money in expensive trim tools and tool modifications. Clients are able to develop the trim using the laser and only manufacture the trim tools once the trim line development is complete. The delivery time of the prototype parts are also significantly shorter compared to developing trim lines using trim tools.

Three-dimensional five-axis laser cutting involves the laser cutting metallic pre-formed components using a CO_2 laser system. What makes this technology unique, is that the laser beam can be manipulated by the five-axis beam delivery to perform laser cutting of preformed components. This 3D motion can also be combined with rotary axis to achieve 3D pipe cutting. A 3D model of the component is required to generate a 3D cutting program for the laser processing. A holding fixture is also produced by the program and the fixture components are manufactured using a laser to cut the pieces of the holding fixture. Once the holding fixture and parts are positioned on the laser bed, the cutting process begins.

The CSIR's laser material processing group specialises in laser ablation, laser welding, laser cladding, laser cutting of non-metallic materials, laser pipe cutting, 2D laser cutting and 3D five-axis laser cutting.

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LASER METAL DEPOSITION OFFERS UNIQUE TECHNOLOGY TO SOUTH AFRICAN INDUSTRY

BY CORNEY VAN ROOYEN & HERMAN BURGER

THE CSIR'S LASER MATERIALS processing experts have been focusing on the research and development of laser-based manufacturing techniques for South African industry for the past five years. While processes such as laser cutting are already well established, highly efficient production methods and new technologies are under development. One such technology is laser metal deposition (LMD), which the CSIR has identified as offering great potential for South Africa.

LMD – essentially a weld overlay technique – is primarily used for the refurbishment of worn surfaces on industrial components. The advantage of LMD over similar processes, based on arc welding and thermal spraying processes, is the unparalleled degree of control over the heat input, which is both highly localised and much lower compared to conventional arc welding techniques. Special features include very low levels of component distortion, good quality metallurgically-bonded layers free from defects such as cracks and porosity, small heat-affected zones and comparatively low dilution of the deposited layers by substrate material.

The CSIR has already developed several industrial applications based on LMD; these include the refurbishment of spindles, shafts, hydrogen seals and end plates for Siemens Power Generation, hydraulic coupling fittings for Huletts Aluminium and gas pistons for Denel. Current projects include the development of a refurbishment process for glass bottle moulds and rolls used in steel production. Although LMD was originally developed as a surface engineering process, the inherent power and versatility of the technique has enabled the diversification of various specialised manufacturing; most notably that of rapid prototyping and more recently, rapid production.

The CSIR is currently involved in a European Framework project aimed at developing rapid manufacturing and refurbishment processes for the aero-engine industry. Another application of LMD, which is showing great potential, is to utilise it as an extremely flexible high-integrity joining process. Conventional laser welding requires tight tolerances both on part fit-up and the positioning of the laser beam with respect to the joint. LMD significantly relaxes these tolerances and eliminates the risk of weld metal porosity associated with keyhole laser welding. The CSIR has been able to exploit these advantages to great effect in the context of a process development project that was undertaken in collaboration with Denel, the largest manufacturer of defence equipment in South Africa. As a result, metallurgical engineers at the CSIR are for the first time using LMD welding in the manufacturing of rocket motor casings.

During the trial process, thin-walled Grade 250 maraging steel cylindrical tubes were welded by a laser to determine its suitability as a joining process for rocket motor casings. Metallurgical investigations were also performed to compare the microstructures produced by the various welding techniques. Metallurgy studies the physical and chemical behaviour of metallic elements and their inter-metallic compounds. Laser welding offers excellent process control, often in combination with high welding speeds. As such, it is ideally suited to applications that demand high quality joints. The very low heat input also limits distortion and thermal damage, while laser welding can also be applied close to heat-sensitive components. Further, in the case of rocket motor casings, it allows for easy accessibility, welding configuration and positioning requirements.

"The most challenging part of the project was the attachment of small (10 mm x 10 mm) lugs to the casing. LMD was applied to join the lugs. LMD joining has subsequently also been applied to the circumferential welding of the end pieces to the casing. Excellent results have been obtained during full-scale pressure testing of a complete motor casing. Twenty-one casings will be welded during the next three months as part of the project," the CSIR's Corney van Rooyen says.

Francois Steyn, senior project manager at Denel Munitions (Tactical Missile Subsystems), says, " The venture has been in a trial phase since 2005 but has now been formalised after the CSIR proved the effectiveness of its laser welding expertise."

He adds, "We are extremely pleased with the outstanding service and quality of work conducted under an extremely tight schedule. What was one of our biggest technical challenges in manufacturing the rocket motor casings, turned out to be just another welding opportunity conducted by the CSIR. This technology will now be used in the production of all future A-Darter and other similar tactical missiles manufactured for the South African Defence Force, the Brazilian Air Force and other export countries.

It is hoped that this venture will give Denel the competitive edge over other defence equipment manufacturers, which will have major benefits for the South African economy.

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TIMBER INDUSTRY

BENEFITS FROM NEW DESIGN APPROACH TO HEAVY VEHICLES

THROUGH INTERNATIONAL RESEARCH COLLABORATION, THE CSIR ENCOUNTERED A NEW APPROACH TO THE DESIGN OF HEAVY VEHICLES, WHICH RESULTS IN SAFER, ROAD-FRIENDLY AND MORE PRODUCTIVE HEAVY VEHICLES.

CSIR RESEARCH on this approach – performance-based standards (PBS) – has led to a PBS national strategy and more recently, two PBS demonstration vehicles in the forestry industry. The forestry and timber industry is an important one in South Africa, with our climate allowing for a shorter turnover period than some other countries.

"One of the demonstration vehicles, which is a Sappi project, was developed and manufactured in South Africa, while the Mondi trailer chassis was imported and assembled locally," explains the CSIR's Paul Nordengen. The two vehicles will be run and monitored for a period of at least three years.

"The design of these vehicles is based on a performance rather than a prescriptive approach, thereby focusing on the dynamic behaviour of the vehicle under various critical operating conditions. Through computer simulation, vehicle parameters such as axle spacing, wheel track, suspension and the placement and length of the fifth wheel or drawbar are optimised to improve safety performance," says Nordengen.

The PBS vehicles are usually limited to operations on predefined routes. The condition of the road impacts the overall cost of transportation in the timber industry – it affects payload (the amount of timber a vehicle can transport), vehicle maintenance, fuel efficiency and driving technique. The demonstration vehicles have been engineered to function optimally for the timber industry, with the ability to carry increased payload. These PBS vehicles are up to 5 m longer than standard timber trucks and can thus carry a bigger load.

The success of the PBS project is linked to the Road Transport Management System (RTMS), which is also being pioneered in the timber industry. RTMS is aimed at reducing overloading, enhancing driver wellness and improving safety. Its introduction into the forestry industry helped to pave the way for the PBS project. To run a PBS vehicle, the transport operator has to be RTMS accredited.

"Premature road deterioration, as a direct result of heavy vehicle overloading, is costing South Africa more than R800 million annually in accelerated road wear as well as in excess of R10 billion a year in increased heavy vehicle operating costs," notes Nordengen. In the Department of Transport's National Overload Control Strategy, the CSIR recommended self-regulation in heavy vehicle transport, not only to reduce heavy vehicle overloading, but also to improve vehicle maintenance and drivers' primary health, training and driving hours.

The Sappi demonstration vehicle that is used for transporting timber

Paul Nordengen

Overloading in forestry (timber transported to pulp mills) has reduced by approximately 40% since the inception of the RTMS initiative in that industry.

One of the key concepts of self-regulation is to involve the total logistics chain in the accreditation system, thereby taking responsibility for heavy vehicle transport on the public road network. This initiative has resulted in three SABS standards being developed and self-regulation initiatives – in various stages of implementation – in industries relating to forestry, sugar, coal, agriculture, aggregate and sand, ready-mix concrete, bitumen and abnormal loads.

With the PBS vehicle, a significant reduction in delivered costs can be realised in the supply chain process throughout the forestry industry. Mondi reports that the PBS unit delivered more than 18 400 ton from December 2007 to July 2008, as compared to the standard unit's close to 15 500 ton.

Fuel efficiency has also been improved dramatically, with tests indicating a reduction of 0,6 ℓ per ton delivered in one of Mondi's projects that involves the transport of 400 000 ton of timber annually. The conversion of the fleet to PBS would work out to a saving of 215 000 ℓ annually and a reduction in the fleet size by 17%.

According to Sappi, the PBS vehicle has meant a saving of R13,9 million per year for Sappi Forests alone. As it is able to carry increased loads, it will result in 20% less timber vehicles on the road, which denotes a reduction in damage to the road network, as well as reduced emissions and lower fuel usage per ton of timber moved. The PBS project leader at Sappi received the coveted Gold Award at the 2007 Sappi African Achievement Awards ceremony.

The CSIR is involved in testing and developing a framework for monitoring the vehicles' impact on the roads and the environment. Initial monitoring results of the two vehicles indicate savings of approximately 18% in total transport operations, which could translate into millions of rands' savings per year for the forestry industry.

"We envisage a larger-scale demonstration project in forestry, hoping to have 10-20 vehicles running in order to make a thorough investigation for assessing PBS locally. We also aim to run demonstration projects in other industries," says Nordengen.
– Hilda van Rooyen

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WINNING PARTNERSHIPS STRENGTHEN FORESTRY AND FOREST PRODUCTS INDUSTRY

BY FLIC BLAKEWAY

THE FORESTRY AND FOREST PRODUCTS SECTOR, ONE OF SOUTH AFRICA'S LARGEST EMPLOYERS IN THE INDUSTRIAL SECTOR, CONTRIBUTES APPROXIMATELY R18,5 BILLION ANNUALLY TO THE SOUTH AFRICAN ECONOMY.

THE SECTOR PLAYS A MAJOR PART in the lives of South Africans in both the first and second economy, from the rural areas to the well-developed, highly capital-intensive and internationally-recognised timber processing and pulp and paper sector. Plantations cover some 1,26 million ha of South Africa, and the forestry, timber, pulp and paper (FTPP) sector employs close to 170 000 people. Forestry is one of the sectors identified as a key growth area in terms of the Accelerated and Shared Growth Initiative for South Africa (AsgiSA), which aims to reduce poverty and unemployment and help the country achieve an economic growth rate of 6% per annum.

The South African industry is globally competitive, but due to challenges like declining expertise, limited plantation land, decreasing investment in research, and losses due to wildfires, pests and diseases, the ability to successfully compete internationally is becoming more challenging. The CSIR's forestry area focuses a significant proportion of its research on contributing to the global competitiveness of the South African forestry and forest products industry. This it does through long-term research contracts with industry stakeholders.

Light microscopy of wood samples to assess fibre anatomical characteristics

The CSIR has two key research centres, a tree improvement research group, based in Pretoria, Nelspruit, and Pietermaritzburg and the Forest and Forestry Products (FFP) Research Centre, a research initiative of the CSIR and the University of KwaZulu-Natal (UKZN), based in Durban.

For CSIR researchers in this area, the challenge is to contribute to the growth of the FTPP sector and in particular expand and diversify the downstream opportunities that exist. To meet the challenge, projects are conducted in tree improvement, forest assessment (remote sensing, physiology), wood science (physical and chemical properties of wood, resource optimisation) and fibre processing.

INDUSTRY LINKS AND COLLABORATIONS

The four CSIR forestry research groups have strong relationships with several commercial forestry companies, both domestic and international. This includes alliances with industry giants Sappi, Mondi, Nampak, Hans Merensky, NCT, Singisi and York Timbers. The pulpwood industry currently receives considerable focus although services are provided to the sawlog industry.

Within South Africa, the research offered by the tree improvement team and the FFP Centre is unique, and they offer services that have been built up in partnership with the South African industry.

The FFP Centre undertakes collaborative research projects with the Pulp and Paper Technology Department of the Durban University of Technology, the Pulp and Paper Manufacturers Association of South Africa and numerous academic departments at UKZN. In addition, research collaboration exists with the University of Pretoria, the Institute for Commercial Forestry Research, the Forestry and Agricultural Biotechnology Institute/Tree Pathology Cooperative Programme, the departments of Science and Technology (DST), of Trade and Industry and of Water Affairs and Forestry, TAPPI, Forestry South Africa, the Australian Centre for International Agricultural Research, the Swedish Pulp and Paper Research Institute and Dresden University.

Above from left: Seed sorting and cleaning

Pollen storage of elite pollen

Sorting cuttings of pine for trial establishment

Discs and wood chips of Eucalyptus for anatomical and pulping studies

New strategic alliances are being forged with Stellenbosch University, Technical Research Centre of Finland, Helsinki University of Technology, the University of Napier, the Ugandan Forestry Research Organisation, the Tanzanian Forestry Research Organisation and the Kenya Forestry Research Organisation.

The tree improvement research group focuses on ensuring superior genetic quality of the planting material supplied to plantation forestry operations. Research group leader Dr Steve Verryn ensures that the key competences of quantitative genetics, breeding strategy development, forest genetics, gene conservation, reproductive biology of plantation species, software development and propagation technologies are aligned to best meet stakeholders' needs. The benefits of this genetic research and development (R&D) are shared in the South Africa industry, through partnering with industry in breeding programmes, releasing the group's very best genetic seed and clones to the forestry industry for testing and commercial use, experience-sharing and the development of technical skills through research partnerships, and the provision of courses.

Various research projects have come into being as a result of the collaboration between tree improvement researchers and industry.

PROJECT PULP

Project Pulp, a collaboration between the CSIR, the DST's Innovation Fund and National Co-operative Timbers (NCT) Forestry, is focused on increasing the value of the plantation resource currently used for pulp production. Project Pulp includes new species' crosses between high pulp yield-high density species and fast growing advanced generation improved material suited to South African conditions to produce a new resource with both improved fibre quality and good adaptation to sites in South Africa. Controlled pollinations are made between advanced generation *Eucalyptus grandis* and other selected Eucalyptus species.

THE PINE PLATFORM

Another long-term industry partnership designed for pine breeding, the Pine Breeding Platform, has been established with York Timbers (previously Global Forest Products). In this project, the genetic resources and teams of the two organisations have combined to provide a significant, long-term sustainable platform for research in producing superior genetic resources.

The overall objectives are to:

- Secure continued improved genetic pine material for the industry
- Ensure that the CSIR's years of considerable investment in improved pine populations are not lost during company and market changes - i.e. assurance of long-term stability to the breeding of key South African pine species
- Ensure that the scarce supporting skills and knowledge for the breeding of a competitive pine resource are developed in response to industry needs.

The FFP Centre offers an understanding of the fibre characteristics that are influenced by the activities in the plantation supply chain, and contribute to understanding the characteristics of the raw material so as to add value in processing operations. Research is directed at understanding the fibre characteristics of timber, the properties of raw material, how this knowledge can add value in processing operations, and how processing can be improved. This research builds on an existing world-class capability, and is rendered in support of the global competitiveness of forest products' companies. The key value addition lies in supporting companies to better understand the quality of the fibre resources that they own, or buy, and to support them in extracting maximum value from that resource.

Key competences are in wood chemical and physical properties, wood anatomy, pulp and paper manufacture, remote sensing, GIS and tree physiology. Access to state-of-the-art equipment at the centre ensures relevant quality research is conducted. "It's creating a centre of excellence in fundamental and applied research for the South African pulp and paper industry," says Dr Tammy Bush, Director of the FFP Centre and research group leader in the CSIR's forestry area. The centre received ISO9001 and ISO14001 accreditation during 2004, which it has retained since then.

Research projects flowing from collaboration between industry and the FFP Centre include:

THE FIBRE PROCESSING COOPERATIVE RESEARCH PROGRAMME AND RAPID SCREENING TOOLS

These involve Mondi, Sappi and FFP and provide valuable information for industry partners in the area of fibre characterisation




From left:
Hot water extractives for chemical analysis of eucalypt

Pollination and protection of emasculated buds

Felicity Blakeway

and optimum beneficiation. The impressive track record and results from these co-operatives have resulted in focused one-on-one projects being initiated for individual clients such as Sappi and Mondi. The FFP Centre has developed rapid screening tools to assist industry partners understand their plantation resource. These tools have facilitated the process of evaluating and modelling commercial timber resources more rapidly than was previously possible. The screening tools contribute to the development of an effective fibre management and optimisation system by allowing rapid analysis and quantification of the factors influencing wood properties. The screening techniques developed are image analyses for the evaluation of wood anatomical characteristics, near infrared spectroscopy to predict wood chemical composition and gamma ray densitometry to assess wood density.

RESEARCH TO DEVELOP SOUTH AFRICAN COMPETENCE IN WOOD CHEMISTRY

This is a partnership with Sappi Saiccor to enhance the competitiveness of the South African dissolving pulp industry. The relationship with Sappi Saiccor involves funding postgraduate studies focused on evaluating the basic chemical and physical characteristics of SA Eucalyptus species and their impact on the characteristics of dissolving pulp for the viscose, ether and acetate markets.

REMOTE SENSING IN FORESTRY

A partnership with Mondi Forests investigates the potential of remote sensing to address a wide range of business, social and environmental issues in the forestry industry. A three-year cooperative agreement between the CSIR and Mondi has borne fruit and is set to yield more positive results. To date, the agreement has led to the successful completion of three PhDs and an MSc project. A further PhD will be completed in 2009 and one in 2010. In addition, the Forest Assessment Technology Demonstrator is due to be commissioned in 2009.

The cooperative allows Mondi to keep abreast of the rapid changes in remote sensing technologies, while finding technologies and methodologies that enhance forestry management decisions, and are more efficient and cost-effective than current methodologies. Building capacity around these technologies in South Africa is a key focus of the project.

SIMSAW 6 AND THE SAWMILL PRODUCTION PLANNING SYSTEM

This involves software packages that simulate the sawing process in a sawmill and predict board recovery and total recovery by value and volume, and computer models that find the optimal production solutions that maximise profit while maintaining the resource, demand and production constraints. These also provide the financial impact of different production, demand and supply scenarios. The products have been used by Global Forest Products (now York Timbers) Steinhoff/Braecraft, Northern Timbers, Mountain to Ocean (MTO) Forests, Sappi, eMpuluzi Timbers, Nicholson and Mullin, Mondi Forests, Safcol and Tweefontein Sawmills.

A key objective of the FFP Centre and the CSIR's tree improvement research is to develop and align both contract and postgraduate research activities with the forestry and forest products sectors' needs. In fulfilling these needs, the CSIR plays a major role in the development of much-needed capacity and research competence in the field of forestry and forest products in South Africa. Most student projects undertaken are aligned with cooperative efforts between the CSIR and industrial partners such as Mondi, Sappi, Nampak and Sappi-Saiccor on a national scale, as well as with international research institutes.

Forests currently provide 95% of the global wood resource, yet it is predicted that as population growth intensifies, the demand for plantation-grown timber and the understanding of it as a raw material will increase locally and globally. There is environmental pressure to conserve natural forests in regions with large natural forestry activities by cultivating a managed timber resource with improved planting stock. The sustainability of the country's forestry (natural and plantation) industry is of paramount importance.

The CSIR's forestry area acknowledges the importance of this industry, and offers unique R&D solutions and services to the South African forestry and forest products industry at critical points along the value and supply chain.

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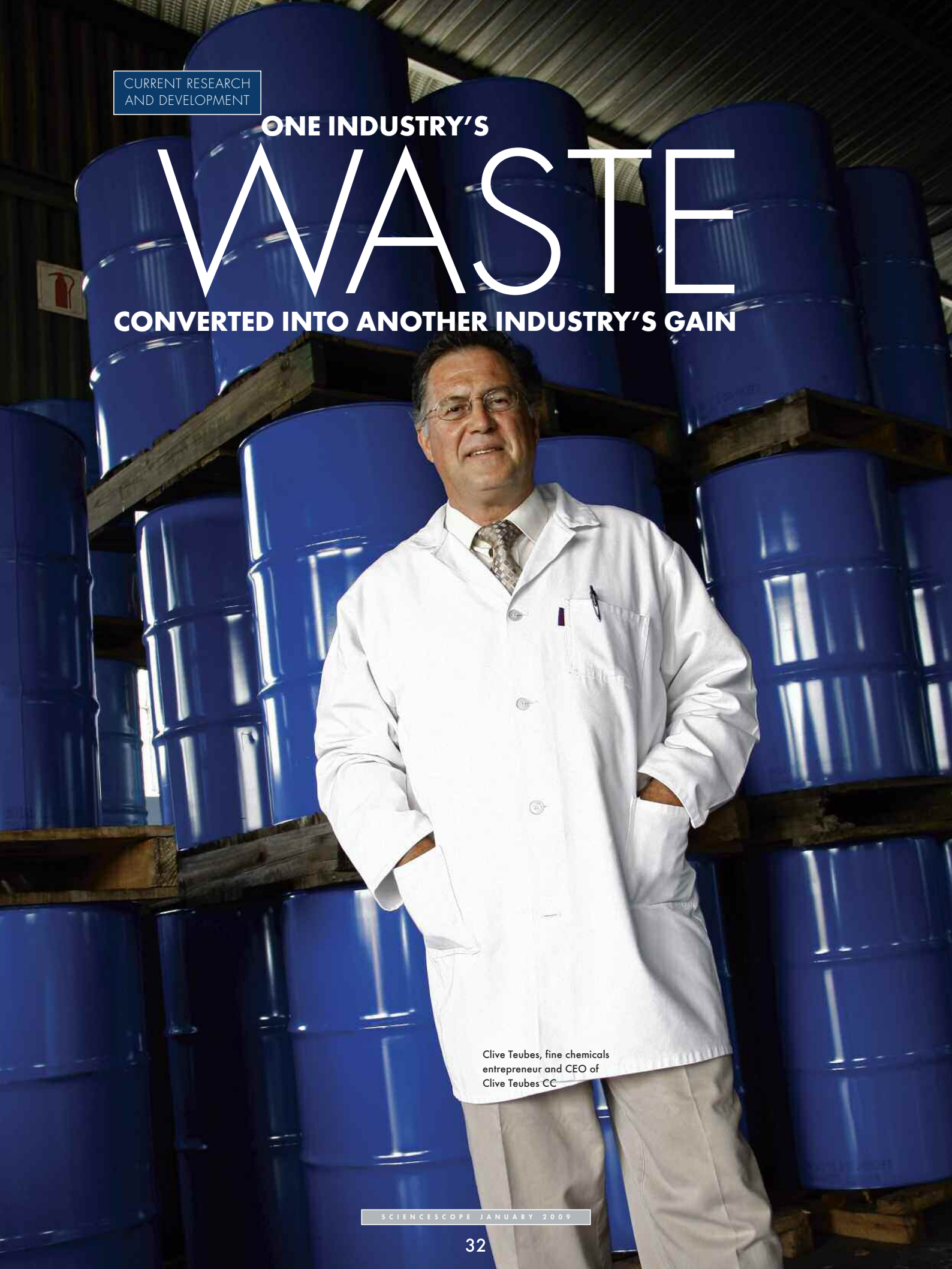
ONE INDUSTRY'S WASTE

CONVERTED INTO ANOTHER INDUSTRY'S GAIN



Clive Teubes, fine chemicals entrepreneur and CEO of Clive Teubes CC

"THE TECHNOLOGY POOL THAT EXISTS AT THE CSIR IS A VERY VALUABLE RESOURCE FOR A PRIVATE COMPANY."

TO SOUTH AFRICA'S PULP and paper industry, crude sulphated turpentine (CST) is an odorous, environmentally-unfriendly by-product produced in excess of 400 ton per annum. But, it was converted into a valuable product when Clive Teubes CC, a leader in the South African flavour and fragrance industry, approached the CSIR in 2005 to help develop a new process using microreactor technology to convert CST waste into a key ingredient in fragrance-making.

The management of costs is paramount to any business. So, while the route to producing raw materials for the flavour and fragrance industry from CST is well-established, Teubes tapped into his decade-long relationship with the CSIR to investigate cost-effective production of citral (lemon fragrance), citronellol, and citronellal (the variation used to scent soaps and give a rosy, floral tone to detergents), from CST.

The CSIR was brought on board at a time when Clive Teubes experienced a growth surge in his now 25-year old company. "As our company grew, the need for deeper and more technically-oriented research and development (R&D) became necessary. It was sensible for us to look at outsourcing this requirement," he says. "At the time, the CSIR was offering this capability. Therefore we moved forward to develop a consultancy relationship with the CSIR on the basis of it taking over a number of our R&D projects on a consultancy basis," he adds. "This allowed us to cut back on our own R&D technology needs and to use the significant skills within the CSIR."

"The idea was to develop an aromatic chemical industry using CST as a raw material base to produce related chemicals," explains Teubes, a trained chemist. The basic material derived from CST raw material leads to a wide number of alcohol esters and acetates, all of which play an important role as synthetic products within the flavour and fragrance industry. "These products are basically building blocks to develop specific flavours and fragrances," he adds.

Other products of interest being evaluated are verbenone, terpineol, terpin-4-ol and cineole, all of which are used in the flavour and fragrance industry.

The CSIR-developed method hopes to save production costs by utilising highly efficient microreactors that reduce capital costs, energy input, raw material requirements, and waste production. Conventional chemical reactors were used to scale up the project to bench and pilot plant scale but CSIR scientists later began investigating the use of microreactor technology. "The initial project was completed in 2007. We provided the client with 1kg market samples of the main products and key intermediates, as well as demonstrating the process up to pilot scale," explains Subash Buddoo, research group leader of themical technology.

"The next phase involved soliciting feedback on the samples and conducting a full techno-economic study to determine the feasibility of the project. As far as the technical aspects are concerned, scale-up studies have to be conducted on at least two of the steps and we will continue to investigate the use of microreactor technology as a viable alternative," says Buddoo.

"Microreactor technology has already been successfully applied for some of the reactions and will be extended to the rest of the process. Reactions conducted in micro-reactors are faster, safer, cheaper and more selective. Also, capital costs can be reduced by as much as 30-50%, thus making the process an inexpensive alternative to conventional reactors and more affordable to smaller enterprises," he says.

For Teubes, the partnership with the CSIR has yielded positive results beyond the scope of the CST project.

"The technology pool that exists at the CSIR is a very valuable resource for a private company such as ourselves. Over the past 10 years of collaboration with the CSIR, a number of commercially-operating processes have been implemented, which were developed in the laboratories and pilot-plants of the CSIR. A number of these products have been used for local and export applications within our market. Therefore, the CSIR has provided a valuable support in terms of achieving our product range development programme," Teubes concludes.

– *Asha Speckman*

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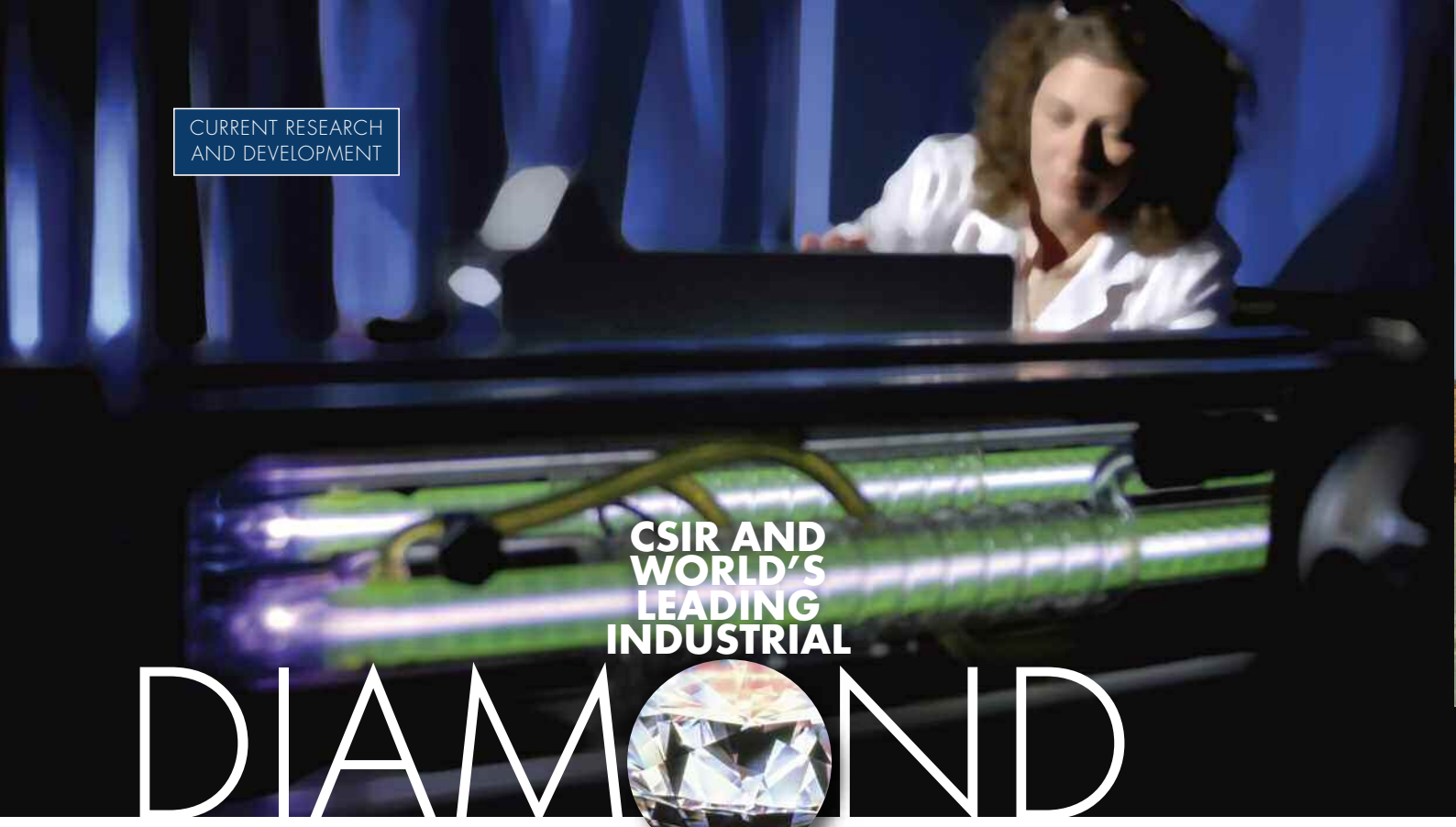
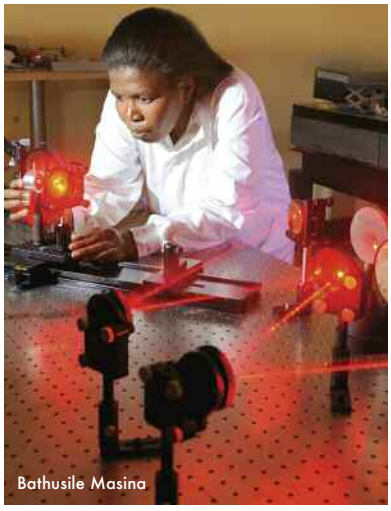


CSIR AND WORLD'S LEADING INDUSTRIAL DIAMOND SUPPLIER IN R1,3 MILLION RESEARCH DEAL

SCIENTISTS AT THE CSIR will be using optical techniques to study industrial diamonds exposed to extreme conditions. This follows the clinching of a R1,3 million research contract between the science council and Element Six; the world's leading supplier of high-quality superabrasives and industrial diamond materials, including synthetic and natural diamonds and superabrasive cubic boron nitride.

Diamonds are the hardest known natural material and as such are embedded in drill tips or saw blades, or ground into a powder for grinding and polishing different materials such as ferrous and non-ferrous metals, natural stone and concrete, wood-based materials, plastics, glass and ceramics. Diamonds are also excellent abrasives because they can be scratched only by other diamonds. Industrial diamonds, in particular, are valued for their hardness and heat conductivity.

Dr Andrew Forbes, mathematical optics researcher at the CSIR says, "The research will entail the design and implementation of an optical system to determine the temperature of a laser-heated industrial diamond." The contract, negotiated by his colleague, Dr Paul Motalane and counterpart Dr Richard Bodkin of Element Six, was awarded based on the success of an MSc project undertaken by researcher Bathusile Masina two years ago. "Masina successfully displayed



Bathusile Masina

that a diamond could be laser heated and that the temperature could be measured accurately, using optical techniques," says Forbes.

The key point of the research is that the diamond is heated and measured using light, thus at no stage is there physical contact with the diamond. It is hoped that the study will reveal how industrial diamonds can be used to secure higher efficacy and a longer lifespan in thermally-demanding applications.

The combination of material science skills from Element Six and optical skills from the CSIR makes this project feasible.

Bodkin says, "The importance of thermally-resilient tools in application is critical to the economic viability of those applications. The ability to de-convolute the thermal behaviour of such tools is essential for the sustainable development of meaningful competence in this industry. Finding a partner that was prepared to develop the techniques required for such a study was critical. That is exactly what we found in the CSIR through the efforts of Forbes and his team. Coupling our skill set with this resource will generate highly sound competence that will serve as a catalyst for the development of a range of products geared towards thermally demanding applications."

Element Six operates internationally with processing and manufacturing facilities in South Africa, Ireland, Sweden, the Netherlands and the United Kingdom. It operates a diamond research laboratory in South Africa as well as numerous sales and distribution offices worldwide. The project will take three years to complete.

– *Chiara Lincoln*

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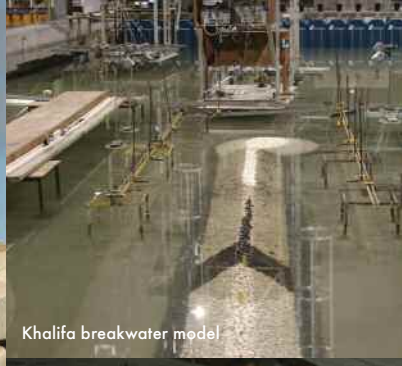
Accropode armour units



Khalifa breakwater model

Dave Phelp

CSIR RESEARCH TO ENHANCE DESIGN OF UNITED ARAB EMIRATES PORT

PORTS PLAY A VITAL ROLE in global trade facilitation, while also supporting the competitiveness of national and regional economies. The CSIR's coastal engineering and port infrastructure group in Stellenbosch provides predictive engineering solutions and decision support for the safe and cost-effective development and operation of ports and coastal sites. It has a unique physical model hall, the only one of its size and complexity in Africa.

"Our hydraulics laboratory in Stellenbosch was the site for extensive physical model studies for the development of a multi-billion dollar port in the United Arab Emirates," says the CSIR's Dave Phelp. "We were contracted by Halcrow, an international port design consultant to the Khalifa Port and Marine Consortium, to carry out the physical model studies. The value of this contract was about R10 million, making it the largest model investigation ever to be carried out by the CSIR," he says. The contract was obtained in competition with international laboratories, which is an indication that the hydraulics facility is considered world-class. The laboratory was upgraded recently with new HR Wallingford wave generators, new wave probes and wave floats with supporting software and an improvement of the inhouse-developed keogram video monitoring system for moored ship dynamics.

The Khalifa Port, located between the cities of Abu Dhabi and Dubai, forms part of one of the largest multi-purpose maritime facilities in the world, covering an area of 22 km². The port will be developed in five stages, starting with the creation of a 260 ha marine platform. The island platform will be made from reclaimed seabed material that will be dredged to create the harbour basin and approach channel. On completion of the first phase, the port is anticipated to have an annual throughput of two million TEU (20-foot equivalent container units), and over six million ton of general cargo.

"We built a 3D physical model to test the layout of the first phase of the harbour basin, at a scale of 1:100. This comprised the determination of the stability of port structures and the response of six moored vessels at six different quays," comments Phelp. The latter required an efficient mooring system analysis and the optimisation of the mooring layout of such vessels. "To meet the client's stringent specifications of accuracy, we developed the keogram system to provide better accuracy than similar systems available internationally," he notes. In addition to the numerical model simulations undertaken by Halcrow, the CSIR conducted 3D physical model tests to calibrate these wave models. The Keofloat system was developed to meet the client's needs for accurate measurement of very small model waves in the harbour basin.

The mooring conditions of three container vessels and three bulk carriers moored in the harbour were determined, using the 1:100 scale physical model of the port. Irregular waves, long-crested as well as short-crested, were generated outside the port for propagation into the port. The motions of the moored ships were monitored with the CSIR's keogram monitoring system, which also yielded the associated mooring forces through the associated mooring line elongations and fender deflections. The rate of loading and unloading of container vessels, in particular, is very dependent on vessel motions at the quay. The CSIR also undertook a dynamic mooring analysis to determine the required fender type and size, and strength of the bollards at the quays of the new port.

Halcrow had also requested the CSIR to conduct physical model studies to evaluate the layout and design of the wave protection structures in the first phase of the development. This was required to determine the overtopping and stability performance of the revetments, breakwaters and roundheads. The researchers used 3D physical model studies to evaluate the stability of the environmental breakwater head section and the wave attenuation breakwater head. For more detailed investigation, these models were built at a scale of 1:40. This part of the study evaluated the hydraulic stability of the armouring, wave reflection, wave transmission through the breakwaters and overtopping.

Through these model studies, the CSIR has determined the downtime for the loading and unloading of vessels in the port, established the stability and overtopping of the wave protection structures and has in general contributed to the optimisation of the design of this new port. The CSIR completed modelling and research for this first phase successfully and hopes that future work for the Khalifa project will follow. "Halcrow commended the CSIR on meeting the tight international deadlines and on its stringent accuracy criteria. In fact, with this project we beat the international accuracy standards for physical modelling," concludes Phelp.

– Hilda van Rooyen

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PROGRESSING TO WORLD-CLASS SUPPLY CHAINS

TO BECOME TRULY COMPETITIVE

BY HANS W ITTMANN

IN TODAY'S MARKETPLACE IT IS NOT PRODUCTS THAT COMPETE ANYMORE, BUT SUPPLY CHAINS. THE IMPLICATION IS THAT HIGH QUALITY PRODUCTS ARE NO LONGER THE ULTIMATE DETERMINANT OF WHETHER A PRODUCT WILL SELL BUT RATHER THE ABILITY OF THE PRODUCT'S SUPPLY CHAIN TO ENSURE THAT IT IS DISPLAYED ON THE SHOP FLOOR OR SHELF. THOSE WITH SUPERIOR SUPPLY CHAINS WILL BE MORE COMPETITIVE AND WILL GROW SUCCESSFULLY. BEYOND LOGISTICS COSTS AND TIME TO DELIVER GOODS, THE PREDICTABILITY AND RELIABILITY OF SUPPLY CHAINS ARE INCREASINGLY IMPORTANT IN A WORLD OF JUST-IN-TIME PRODUCTION.

THE COUNCIL FOR SUPPLY CHAIN Management Professionals (CSCMP) defines the term 'supply chain management' as follows: "Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers. In essence, supply chain management integrates supply and demand management within and across companies."

In his book, The World is Flat, Thomas L Friedman identified 'supply chaining' as one of the 10 fundamental flatteners in the new global economy. A new premium is being placed on moving goods within the global marketplace on what is being referred to as the 'physical internet' and this is seen increasingly as a key determinant of a country's competitiveness.

A recent report by the World Bank shows that South Africa is performing very well in terms of logistics competitiveness – 24th out of 150 countries. However, our internal logistics costs are rated 124th in the world. The cost of moving goods or freight within the country is making us less competitive. The CSIR reported in the 4th State of Logistics survey that South Africa's logistics costs as a percentage of GDP are close to 16%. This is very high and does not compare favourably with a country such as the USA where logistics costs are just over 10% of GDP. Our logistics costs are also much higher than countries we traditionally compete with, which seriously affects our ability to compete in the global marketplace.

In 2006, more than 87% of the total freight moved in South Africa was by road and only 13% by rail. Over the past 10 years the growth in freight has been predominately in road transportation. The main contributor to the high logistics costs is transportation costs and while freight moved by road is possibly faster than on rail, it is much more expensive. Transport costs contribute 56,9% to total logistics costs, while the global average is about 40%.

To prove this point, the American Association of Railroads calculated that trains "can move a ton of freight 431 miles on one gallon of diesel – about three times as far as a truck can". High fuel prices aggravate the situation. In addition, congestion on our roads causes delivery of freight to take longer and this adds to the costs.

How do we improve our ability to compete globally? South Africa's adverse geographic location will always be problematic and most of the economic activity in the country happens inland, notably in Gauteng. Nevertheless, the internal logistics costs can be decreased. Various types of freight are ideally suited for rail, including containers and motor vehicles. Furthermore, a large component of freight that is currently transported on road on the two main corridors namely, Cape Town – Johannesburg and Durban – Johannesburg, should ideally be on rail. Industry should also continuously look for opportunities to collaborate and in this way reduce costs and effort.

Within larger metros the idea of urban consolidation centres should be investigated. These will reduce costs in what has become known as the 'last mile' of delivery in cities.

Government should consider the possibility of encouraging industries to locate closer to harbours with their export facilities.

Skills development is a huge issue in the logistics environment and this needs serious attention. Many people in companies, including management, have no understanding of the importance of supply chain management. They require training and the appropriate exposure to supply chain management. Within the supply chain everyone involved should understand the importance of their respective roles and responsibilities. An example of this, although it may seem trivial, is in our ports, where a vital productivity measurement – crane operations per hour – was on average 15 operations per hour three years ago, and has now improved to an average of 25 operations per hour. While we are still lagging behind the rest of the world, we are catching up. This is significant, as this function is at the beginning or end of many supply chains and these supply chains are only as good as their weakest link. Collaboration within and across industries is becoming increasingly necessary and essential.

The South African government is promoting growth in our manufacturing industry with the clear understanding that this will lead to growth in exports. To be competitive in the global marketplace, the products produced will have to be world-class. However, the supply chains used to get these products to the global marketplace will have to be world-class too. This is the only way in which our country can hope to become really competitive in a very competitive world.

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Peter Bosscha with the SmartFactory demonstrator

The 'SmartHistory' software module, showing collected manufacturing data

SMARTFACTORY™

– THE AFFORDABLE, FLEXIBLE AND INTELLIGENT AUTOMATION SYSTEM FOR SMMES

FUTURE COMPETITIVENESS OF THE SOUTH AFRICAN MANUFACTURING INDUSTRY DEPENDS ON THE ABILITY TO MASTER ADVANCED TECHNOLOGY DOMAINS AND TO MOVE FROM RAW MATERIAL-INTENSIVE MANUFACTURING TOWARDS KNOWLEDGE-INTENSIVE GOODS AND SERVICES.

MECHATRONICS and micro-manufacturing researchers focus on the development of digital manufacturing techniques, involving smart materials, processes and intelligent systems, and the development of affordable, flexible and intelligent automation systems for manufacturing.

One such system is the SmartFactory – a project of the Department of Science and Technology's Advanced Manufacturing Technology Strategy (AMTS). The SmartFactory system is an automation solution, centred on an open source database. It will operate with both industry standard sensors and actuators or with custom-developed low-cost sensors.

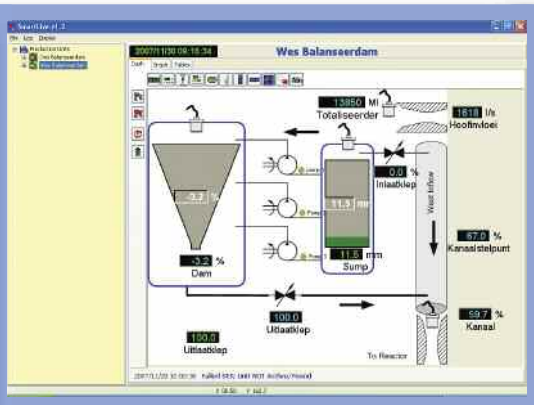
In SMMEs within the South African manufacturing environment, there is a need for seamlessly integrated suites of low-cost, plug-and-play sensors and monitoring systems in order to monitor process execution and to provide real-time feedback to process controllers and actuators.

Larger manufacturing companies use sophisticated systems to address these and other contributing causes of poor product quality and inefficiencies. A range of integrated systems are employed with varying degrees of success in complex plants and large corporations. The high costs associated with such systems, however, put them beyond the reach of small manufacturers.

Smaller companies (with fewer than 100 employees) within the manufacturing industry often find it difficult to compete with their larger counterparts. Although less complex and expensive automation and reporting alternatives do exist, these tend to cater for the medium-sized manufacturing companies and are not readily affordable for a small manufacturing business. This situation is perpetuated by a perceived lack of market opportunity for solutions to this problem. Thus, absence of economies of scale and the resultant high costs associated with erecting and sustaining a manufacturing facility, make survival and growth difficult for smaller manufacturing companies.

"We address the neglected field of appropriate information and communications technologies (ICT) for small companies in the manufacturing industry, through the development of an architecture that integrates various open and low-cost technologies. The SmartFactory architecture consists of simple and easily installed factory network and data monitoring and collection software, making it easy for factories to install their own system without requiring high levels of expertise," says senior technologist, Peter Bosscha.

The 'SmartHistory' software module, showing analysed data



The 'SmartLive' software module, showing real time process values

Where existing advanced systems can cost millions of South African rand and basic systems have limited control functions, the SmartFactory system is modular and scalable; it can grow with the company and allows open access for other parties to work on or improve it. It is very affordable and easy to install, requiring no special or high levels of training.

The dream approach was to create a factory floor ICT solution for SMMEs that would assist these companies, without the solution costing an arm-and-a-leg. In a small manufacturing company that cannot afford advanced management systems, there can be various causes for poor product quality and inefficiency, and the SmartFactory system has been designed to address challenges such as delays in problem identification and intervention, poor job scheduling, and poor inventory management of both raw materials and manufactured products.

The system has been rolled-out on a trial basis to different industry partners, with great success. Companies that have used the system include Fine Blanking (Pty) Ltd (Devland J-Burg), Universal Clips (Pty) Ltd (Roodepoort, J-Burg), Rooiwal Waste treatment (Pretoria), and Global Materials Technology (Babelegi, North West). Each of these companies is completely different in their production set-up and they have had outstanding results from the system.

Edward White, Operations Manager at GMT, says, "The system has allowed us a real time view on our production, something that is useful to both operators and management. We are impressed with how easy it is to generate reports.

"We've seen the great potential of the system and want to expand it in the near future to all the aspects of our production and maintenance."

From an implementation perspective, the SmartFactory architecture contains two main components. Each of these components enables different functions that address the three influential causes of poor product quality and inefficiency:

- A control area network consisting of CSIR developed Sensor, PLC and Operator interface modules that perform factory floor monitoring and factory floor reporting
- A central server operating a MySQL database and accompanying software providing a historian and reporting module, real-time alarming functions
- A SCADA-like system showing live status and factory floor history.

The CSIR is also focusing on human capital development. In this project, students from tertiary institutions will be trained to install, monitor and maintain a typical SmartFactory installation. This will enable the students to obtain practical experience, it will provide the factory with a hands-on operator for six months, and the potential problems or new requirements of the system will be identified.

The benefit of the system is that it is a low cost, locally engineered and supported ICT solution for SMMEs to improve production efficiency. Future research will be done to refine the software, improve on the radio frequency networks and integration with factories systems. – ***Kelly-Anne Matthews***

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SMARTi (II) is used as the interface between existing and/or new sensors

HMI (II), functions as an operator interface for logging of special events and/or AutoID interface

COMMi for linking with existing automation

SMARTrf, used when cable-runs are too expensive or impractical

Danie Wilkins from the CSIR with a rheocast-formed test specimen from the prototype rheocasting machine

RHEOCASTING TECHNOLOGY FOR LIGHT-WEIGHT AUTOMOTIVE AND AEROSPACE COMPONENTS

The engine bracket specifically manufactured through rheocasting for application in the automotive industry

WITHIN THE AERONAUTICAL and automotive industries, the demand for lighter, stronger and smarter materials and structures has increased over the past decade. Both consumers and legislation require vehicles to be safer, more fuel efficient and emit less carbon emissions. In the aerospace industry the reduction of aircraft weight is even more important, as it holds the key to reducing fuel consumption and increasing payload.

"There is a social push for lighter and more economic vehicles and aeroplanes as well as the need for them to be environmentally sustainable," says the CSIR's Dr Willie du Preez. "For South Africa to respond to these international trends and be competitive in manufacturing, the Department of Trade and Industry identified the automotive and aerospace industries as priority sectors for research and development initiatives.

"While South Africa's prospects of becoming a major manufacturing player in either of these industries are fairly limited, there are a few niche areas within which we are internationally competitive. One particular area where we are considered to be well-positioned is the development of light-weight structures and materials such as aluminium, titanium and metal-fibre composite hybrid structures." In 2006 the Department of Science and Technology (DST) contracted the CSIR to lead the Light Metals Development Network with its focus on aluminium and titanium.

One of the flagship projects conducted by the CSIR and its partners in the field of light metals is the semi-solid metal (SSM) casting of aluminium for high integrity lightweight components, such as those that can be used in the automotive and aerospace industries. A CSIR team developed a derivative of the SSM technology that resulted in the patenting of a new rheocasting technology and its associated equipment.

The CSIR rheocasting technology has now been patented in South Africa, the USA, China and Mexico and the patent has been validated in eight European countries. The automotive industry has already expressed serious interest in applying the CSIR rheocasting technology locally while discussions have been initiated with the French aerospace company Snecma, on possible applications.

EXPLAINING RHEOCASTING TECHNOLOGY

A semi-solid metal is in a thixotropic state, which is suitable for both casting and forging operations. Thixothropy is a special property of a gel that temporarily becomes liquid when sheared, reverting back to a gel when static. For a metal to become thixotropic it must be heated to a temperature where it becomes a semi-solid metal slurry. This metal slurry can then be formed in a die by a high pressure die casting (HPDC) machine to form the specific component needed.

Du Preez says that there are two versions of SSM technology that can produce the desired metal slurries, namely thixocasting (a two-step process) and rheocasting (a one-step process). The big advantage of rheocasting is that the slurry can be made on demand and 'in-house'. The chemical composition of the cast metal can also be modified and tailored to meet the quality and property specifications of the components. Another advantage is the fact that there is less wastage, as scrap and other used metal can be directly re-melted in the rheocasting machine, which helps reduce productions costs.

"It is specifically this last fact that has seen the popularity of rheocasting grow among research centres and industry players," explains Du Preez. "There are also several other technological advantages, such as the fact that rheocasting produces parts that are close to the desired final shape with excellent surface finish and high structural integrity."

Some of the CSIR's more recent research on SSM casting focused on heat treatment processes for semi-solid cast aluminium alloy A356, the laser welding of alloys and segregation effects occurring in the alloy during SSM processing. Current research is also being conducted on utilising high strength aluminium casting alloys, such as A201, to cast components for aerospace application.

"We now have an HPDC cell on-site that assists with industrial pilots so that the CSIR rheocasting technology can be fully industrialised. Meanwhile, we collaborate widely with private sector stakeholders and forums such as the AMTS Casting Technology Consortium, Boeing Phantom Works in the USA and the South African company Aerosud. We maintain healthy relations with the automotive, aerospace and metals industries to ensure the successful transfer and commercialisation of our technology, products and processes," says Du Preez.

He concludes: "The CSIR's rheocasting technology project is aligned to address the specific need for high performance, lightweight materials that will ultimately assist the automotive and aerospace industries in achieving greater fuel efficiency. It will also ultimately lead to environmental protection and new cost-effective processing routes. We expect the impact to be reflected over a period of time as improved industry competitiveness." – *Petro Lowies*

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"The CSIR's rheocasting technology project is aligned to address the specific need for high performance, lightweight materials that will ultimately assist the automotive and aerospace industries in achieving greater fuel efficiency."

AUTOMOTIVE COMPONENTS SUITABLE FOR SSM CASTING

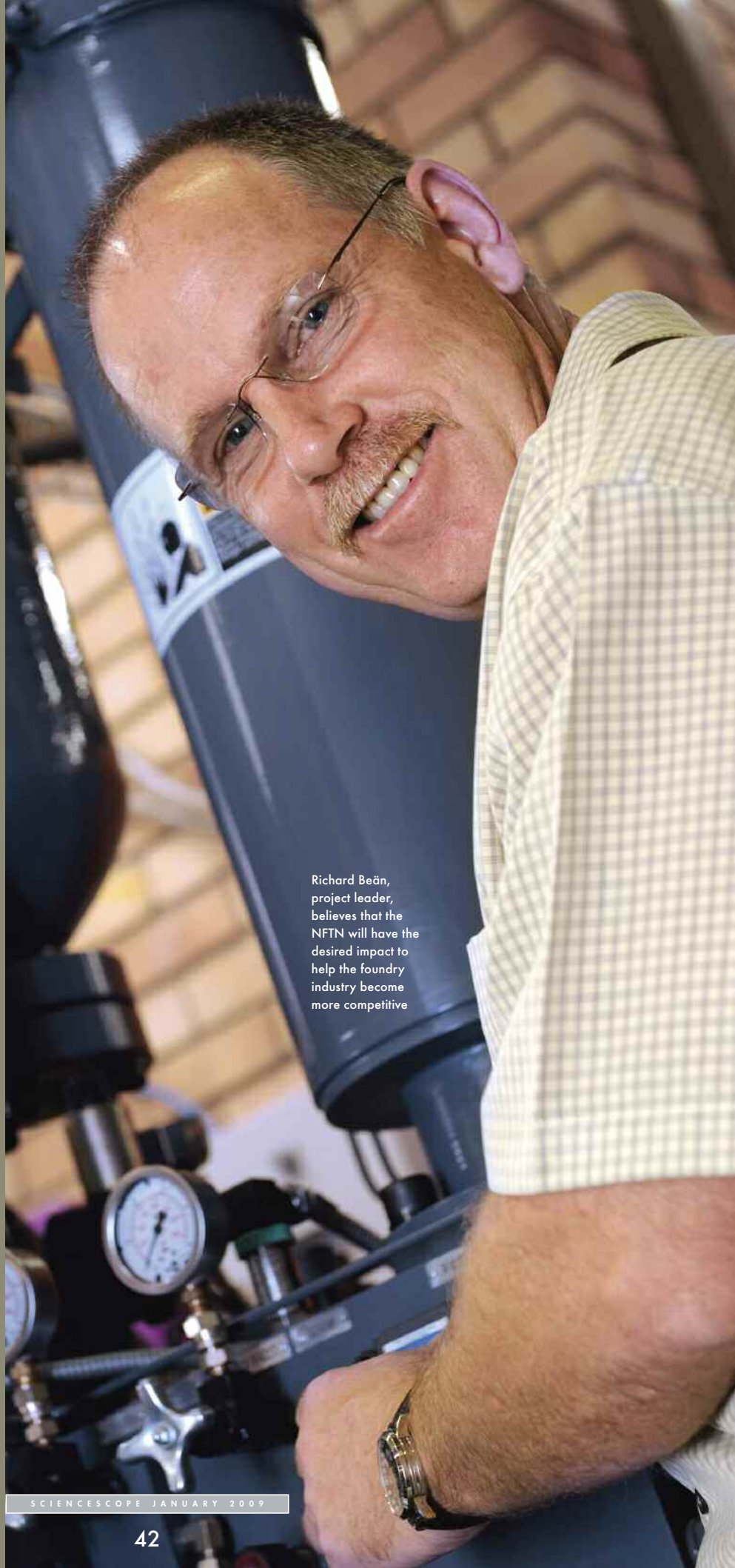
CAR UNIT	COMPONENT
Brake system	Brake calipers, master cylinder
Fuel supply system	Fuel rails, petrol collectors, diesel engine pump
Engine and suspension	Engine block, suspension arms, belt cover, pulleys, pistons
Steering system	Power-steering valve box, clutch cylinder, wheels

NEW TECHNOLOGY NETWORK TO BOOST SA'S FOUNDRY INDUSTRY

With the establishment of the National Foundry Technology Network (NFTN), the South African foundry industry is set to become more competitive. This network will not only support the industry through technology transfer initiatives and skills training, but also by spreading state-of-the-art technologies and methods. The idea is to position the local foundry industry to capitalise on the many local and international opportunities.

WHILE THE NFTN was first conceptualised and then funded by the Department of Trade and Industry (the dti), the CSIR was contracted to undertake its establishment and operation, in close collaboration with industry and other stakeholders. Richard Beän of the CSIR was appointed as the NFTN project leader.

A recently-completed round of provincial road shows and industry discussions regarding the NFTN's mandate generated full cooperation and support from all industry associations. According to Beän, these awareness activities also served as an opportunity to reiterate the fact that the NFTN is not an industry association but rather a facilitator and supporter of the current associations. It has a representative steering committee that will provide the necessary industry guidance and feedback, so that current associations will be able to fulfil their own mandates.



Richard Beän, project leader, believes that the NFTN will have the desired impact to help the foundry industry become more competitive

"WE HAVE TO FIND WAYS in which to make the foundry and casting industries in South Africa more competitive globally," says Beän. "Ten years ago approximately 400 companies operated in these industries; now only 200 are left. While several reasons exist why these industries have halved in size, it boils down mostly to them not being competitive enough internationally or even locally."

This is despite the fact that South Africa ranks 19th in the world production figures in terms of tonnage cast (about 500 000 ton per year), or the fact that the successful Motor Industry Development Plan (MIDP) has given the industry a considerable boost regarding the casting of automotive components.

The foundry and casting industries do, however, play a very important role within the manufacturing value chain, especially with other priority sectors such as the automotive and petrochemical industries. They do not only employ more than 15 000 people, but also add to the South African economy by producing an annual turnover of some R10,5 billion. "Supporting them in ways that will help them increase their capacity and competitiveness should, therefore, be viewed as an issue of national importance," says Beän.

According to the PricewaterhouseCoopers AUTOFACTS survey, the South African automotive industry will be manufacturing half a million light vehicles per year by 2009, with the majority of these units destined for export. South Africa's existing technology resource base is, however, at least 30 years behind international standards, while the average age profile of the country's foundrymen is over 55 years.

The NFTN's purpose is not to implement any physical capabilities, but rather to offer technical support and training through a network of existing service providers such as the industry associations, Mintek, the CSIR, industry consultants and universities.

Beän says the establishment of new service providers is not impossible. Within the NFTN framework, new service providers will be created or sourced only if they do not already exist within the NFTN or the industry itself. An example could be a need for a specific type of training that might not currently be offered. The NFTN would then either develop such a course or acquire it from an international source and then find a service provider to teach it.

According to Beän, the technical support offered by the NFTN will focus on waste elimination, the solving of everyday foundry problems and productivity enhancement. The network is in the process of establishing a panel of experts who can be sent to foundries to assist with these issues. A very successful intervention was recently completed involving an international die casting specialist and the Automotive Industry Development Centre (AIDC). The intervention involved 11 high-pressure diecasters and had a huge impact on their operations. This kind of intervention will now be rolled out to other foundry sectors.

"We will also facilitate foundry research into innovative new processes that could enhance the industry's technological innovation. This will be done through collaborations with Mintek, the CSIR and universities," he says.

Specific focus will also be placed on training and knowledge transfer. Beän explains: "We aim to provide both practical and theoretical training to increase foundry skills and ensure that a constant flow of skilled trainees enter the industry. Here we will collaborate closely with universities, the South African Institute of Foundrymen (SAIF) and the seta for manufacturing, engineering and related services (MERSETA)."

Foundry safety – an important imperative for the industry

The key objectives of the NFTN:

- Establish a national foundry technology network
- Implement the appropriate governance to ensure effective service delivery
- Provide relevant practical and theoretical training to increase the skills of the foundry staff and to ensure a constant flow of skilled trainees entering the industry
- Promote and develop the SMMEs in the foundry industry to ensure their economic sustainability and technology empowerment of previously disadvantaged individuals
- Ensure the availability of technical foundry support that would solve day-to-day foundry problems and enhance productivity
- Manage and coordinate information dissemination
- Conduct relevant, useful R&D that can be transferred to industry.

Another focus area with regard to training will fall on the development of management and leadership skills. Beän says this is particularly necessary in a highly technical industry such as foundries, as more attention is usually given to the product and not enough to business or managerial principles.

"An important theme of the NFTN is to support foundries within small, medium and micro enterprises (SMMEs), especially where these are black-owned and operated. The NFTN will attempt to facilitate the outsourcing of some of the non-core components of larger businesses to smaller ones, expose them to technology and assist with business development. Groups of SMMEs will also be offered opportunities to collaborate on new processes or products," says Beän.

"We want to have a direct impact on the industry," says Beän. "Should we succeed in doing everything we have set out to do, foundries will be more competitive, employ more people, generate other manufacturing opportunities and eventually benefit South Africa's economy and its people."

– Petro Lowies

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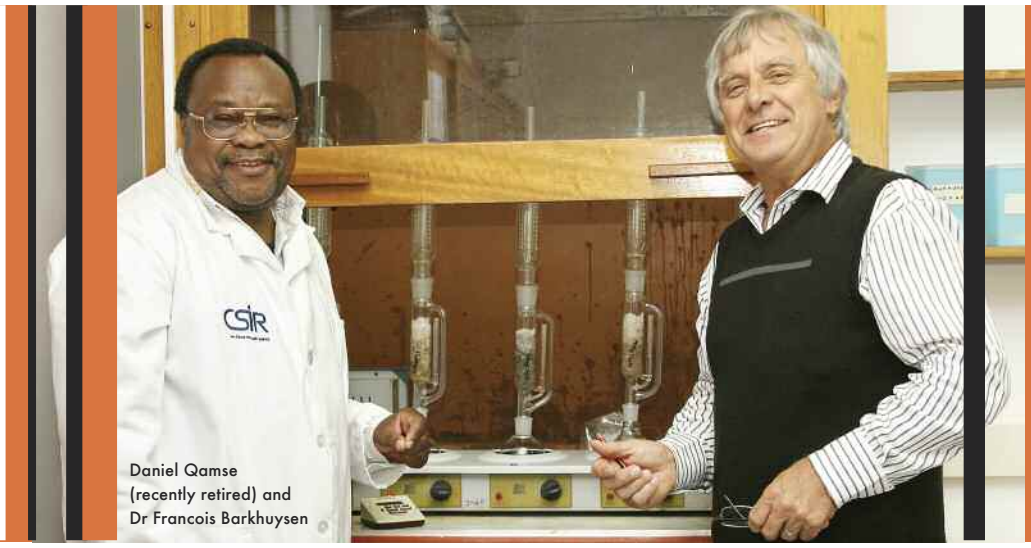
CONFIDENCE IN TEXTILES

CSIR PLAYS KEY ROLE IN HELPING LOCAL TEXTILE INDUSTRY UPHOLD STANDARDS

CONFIDENCE IN TEXTILES IS SYNONYMOUS WORLDWIDE WITH RESPONSIBLE TEXTILE MANUFACTURING: FROM RAW MATERIALS TO THE FINISHED PRODUCT. THIS IS APPLICABLE NOT ONLY TO PRODUCTION COMPANIES AND RETAILERS ALONG THE TEXTILE VALUE CHAIN, BUT ALSO TO THE CONSUMER.



Daniel Qamse (recently retired) and Dr Francois Barkhuysen

The upgraded laboratories are used to assist industry with problem solving and quality control on fibres, yarns and fabrics

CONFIDENCE IN TEXTILES manifests itself in various ways, but quality and particularly human and environmental ecology, are in high demand by the consumer. Consumers want to know that the garments they buy do not contain dyes that are potentially harmful to themselves or to the environment.

The CSIR, through its fibres and textiles area based in Port Elizabeth, is playing a crucial role in supporting the textile industry to uphold and improve its quality and ecology standards. The latter has a direct impact on the competitive position of companies that currently are, or plan to, operate in the export market where lack of certification inhibits them to compete.

In the case of quality control and improvement, the CSIR provides high level quality control testing for the textile, clothing and automotive industries in its well equipped fibre, yarn, fabric and composite laboratories. CSIR principal researcher, Dr Francois Barkhuysen, says that during the 2007/08 financial year, 158 technical test reports were submitted to the various industry sectors.

The CSIR is contracted by a major South African retailer to audit and certify its supplier quality control laboratories for compliance on an annual basis. The CSIR visits 40 such local laboratories annually to do the audit and certification. This involves auditing of the testing done by supplier laboratories, including independent comparative testing (CSIR vs. supplier laboratory) and verification prior to certification.

More recently the CSIR has been tasked to conduct the compliance in four laboratories in Mauritius and one in Shanghai, China. Part of the compliance is providing training for technicians not familiar with the test methods and procedures specified by the retailer. As part of the local accreditation of laboratories, the CSIR compiles an environmental questionnaire on the processing of textiles, analyses the feedback and reports the outcomes to the retailer for action, if necessary. This allows local environmental standards and protocols exercised by industry (code of conduct) to be established or improved, if required.

To supply these services, the CSIR, in turn, is audited annually by Specialised Technology Resources (UK) Ltd, a Marks & Spencer accredited body. "The laboratory is also participating in international round robin trials, where tests are done and results compared with that of nineteen major testing laboratories, such as Shirley Technologies (UK), Testex (Switzerland), Hohenstein (Germany), Centrocot (Italy) and ÖTI (Austria). This allows the CSIR to benchmark its testing protocols against that of world renowned test houses," says Barkhuysen.

In the environmental arena, the CSIR coordinates the Oeko-Tex® International Standard 100 in South Africa and southern Africa through Shirley Technologies (United Kingdom). There are currently over 8 000 textile and clothing manufacturers throughout the textile processing chain in around 86 countries that have their products certified according to the Oeko-Tex® Standard 100. Over 8 000 valid certificates are issued per year, of which 130 have been issued in Africa and nine in South Africa so far.

One such certificate holder in South Africa reported that the value of the certificate is based on the fact that it could not, for example, supply products to Adidas without an Oeko-Tex 100 certificate. The export market perceives this standard as an entry barrier to cheap, undisclosed garment types from emerging markets where little or no credence is given to the type, source and safety of dyes and chemicals used on garments.

Furthermore, key merits of industry subscribing to the Oeko-Tex 100 labels are:

- Screening of dyestuffs and chemicals used on the garments, especially for children's end-use
- Elimination of any carcinogenic compounds produced from break-down products of certain dye molecules on garments
- Conformance with European Union legislation in respect of prescribed azo type dyes, and Marks & Spencer and Woolworths code of practices
- Eliminates the use of chemicals and dyes that are potentially harmful to the environment.

The International Oeko-Tex® Association, a grouping of 14 well-known textile research and test institutes in Europe and Japan, met in Cape Town in October 2008 for their annual General Managers meeting. During their visit they hosted a client evening to increase the awareness of the label in South Africa. The label guarantees that textiles do not contain hazardous substances in amounts that could impair human health within normal conditions of use.

The comprehensive set of criteria covers legally banned and controlled chemicals and substances that can be harmful to health and parameters that have a preventative role. – *Kelly-Ann Matthews*

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ADVANCED MATERIALS TO HELP US TRAVEL SAFER, FASTER AND CHEAPER

FEW OF US FLY IN AEROPLANES EVERY DAY. WHEN WE DO, WE WANT TO EXPERIENCE AT LEAST SOME DEGREE OF COMFORT AND WE EXPECT THE AEROPLANE TO BE A SAFE AND COST-EFFICIENT MODE OF TRANSPORT, GIVEN THAT IT WILL COVER A GREAT DISTANCE IN THE SHORTEST POSSIBLE TIME SPAN.

Travelling in automobiles on a daily basis is far more common, but the same rules as for air travel apply: We want safe, advanced models that will provide a certain level of luxury while not costing the earth – literally.

And, while these demands for better safety and performance seem to be at odds with the demand for better cost-efficiency, the only answer may lie in the way we manufacture every component that goes into automobiles and aeroplanes.

This is where the CSIR steps in with research in the areas of advanced light metals, advanced composites, natural/green materials and smart materials. In fact, in these research areas South Africa can be internationally competitive with regard to contributing to the aerospace and automotive industries – both of them priority sectors as identified by the Department of Trade and Industry.

During the course of 2006, the Advanced Manufacturing Technology Strategy roped in the assistance of the CSIR to specifically focus on research that would benefit the aerospace and automotive industries. Since then, great progress has been made in the fields of advanced materials and several projects have already made a significant contribution to applications in these industries.

ADVANCED LIGHT METALS

The processing of light metals such as aluminium, magnesium and titanium holds specific promise in manufacturing lighter, stronger structures and components for the automotive and aerospace industries. The CSIR is focusing in particular on developing advanced metals manufacturing technologies for complex, thin-walled, lightweight components through the investment casting process.

The CSIR's investment casting research and development (R&D) facility has been upgraded to focus on the development of titanium casting processes where early results have been encouraging. The facility now has a robotic shell dipping facility that is comprehensively instrumented to assist with the technology development as well as the economic evaluation of the shell making process. The facility also hosts the only industrial vacuum investment casting furnace in South Africa. Vacuum casting is required as titanium binds with oxygen at high temperature.

Although the current development is aimed at the aerospace industry, the technology chain for titanium casting being developed and packaged will be suitable for industrial, medical, automotive and even jewellery applications.

A complementary CSIR facility has also been involved in the development of a derivative of the semi-solid metal technology that resulted in a new rheocasting technology for the casting of aluminium. This technology and its associated equipment have been patented both locally and internationally. While further research in support of its industrialisation is ongoing, the local automotive industry has expressed great interest in applying the CSIR's rheocasting technology to its benefit. With this sector in mind, an engine bracket supplied by an automotive manufacturer is being used to demonstrate the feasibility of the technology.

A third research area in the light metals programme at the CSIR is powder-based processing of titanium alloys. Here the finely dispersed powder of the metal is first compacted in a mould and then sintered at high temperature to produce a dense net-shaped component. Through a novel technology for South Africa, the powder can also be mixed with a polymeric binder and injected into a mould very similar to the way in which plastic is injection moulded. Subsequently, the formed components are heat treated to remove the binder and sinter the powder into a solid part. Smaller, complex parts can be formed *via* this processing route with material wastage almost eliminated.

The CSIR has long-standing relationships with two of the world's leading commercial aircraft manufacturers, namely Boeing and Airbus

A titanium cast shell being manufactured at the CSIR's investment casting facility receives a coating before the titanium can be cast

ADVANCED COMPOSITES

Developing novel composite material technologies for the aerospace and automotive industries is something the CSIR has done successfully for many years. The more recent research efforts focus on smart structures and novel emerging materials (especially nanocomposites).

Research in nanotechnology provides an understanding of and control over the basic building blocks and properties of all natural and man-made objects. One of the main research areas at the National Centre for Nano-Structured Materials at the CSIR is the fabrication of novel nanostructured materials. Here, focus is placed on manipulating materials at a nano-level in order to increase their performance against, for instance, wear and tear damage, to improve strength-to-weight ratios and surface finishes.

All of these research projects have very practical applications in both the aerospace and automotive industries.

One very recent example has a direct application impact on the automotive industry. CSIR researchers have found that Nafion fuel cell membranes, which are used in the automotive industry and can normally withstand temperatures of up to 80 °C, are able to withstand heat of up to 100 °C if multi-walled carbon nanotubes are used.

NATURAL/GREEN MATERIALS

In both the aerospace and the automotive industries the materials used have to adhere to very strict safety requirements. They should be fire and smoke resistant and have low toxicity levels. While many naturally-sourced fibres do fulfil these stringent requirements, they are also desirable because of their luxurious attributes. These fibres are, however, very expensive.

Natural fibre-reinforced composites not only retain the safety qualities of natural materials but also hold advantages with regard to weight-saving and thermal recycling. It can furthermore be applied to both structural and interior components.

In recent years, the CSIR has developed a strong capability in fibre-based composites, with a special focus on the use of natural fibres. Two technology platforms were developed and merged in this time, namely fibre processing through the nonwoven route, and the science and technology of composite materials.

According to Abisha Tembo, a research manager in composites, one component of the research programme deals with the fabrication of flax and kenaf nonwoven reinforced polypropylene composites for semi-load bearing applications in the automotive sector.

"Another aspect of the research programme addresses the challenges facing the aerospace industry in the next decade to fully realise the performance benefits of composite materials while dramatically lowering production and operating costs with a minimal impact on the environment," says Tembo. "The focus is on the development of composites based on natural fibres and/or bio-composites for use in secondary structures in cabin and cargo areas."

SMART MATERIALS

One current research area regarding the application of smart materials in aeronautical applications involves unmanned aerial vehicles (UAVs). Philip Loveday, a researcher in sensor science and technology at the CSIR, says they are investigating the use of piezoelectric actuators for servo systems in UAVs.

"Piezoelectric materials, notably crystals and certain ceramics, have the ability to generate an electric potential in response to mechanical stress and to generate a mechanical stress in response to an electrical potential. This electromechanical coupling makes these materials suitable for various sensor and actuator applications," he explains.

"Weight and energy consumption are important considerations when selecting or designing servo systems (motion control systems) for UAVs. We are developing piezoelectric actuators for actuating or moving the ailerons, as these actuators are efficient and require very little power to maintain a set position. The challenge here is to mechanically amplify the small displacements available from the piezoelectric materials to a useful magnitude, while retaining the advantages of low weight and high bandwidth. This development is based on a CSIR-patented amplification mechanism."

A second application involves adapting the wing profile to be more efficient during different flight conditions. This task requires even larger displacements although these can be performed slowly. For this purpose the CSIR is developing a piezoelectric motor, which essentially rectifies or accumulates the small displacements of a piezoelectric actuator to produce large displacements. This research is still in an early stage but is already showing great potential. – ***Petro Lowies***

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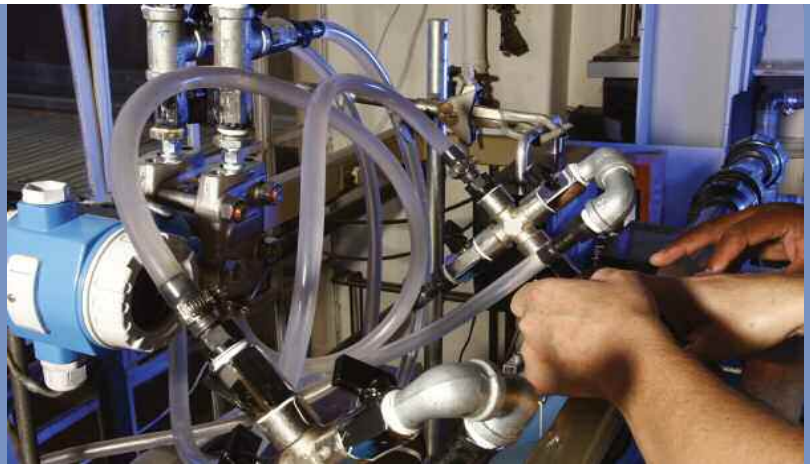
Hartmut Ilgner (front) explains to Stanford Dumbu how the new technology works

CONTROLLING THE FLOW OF SLURRY: REDUCING ENERGY AND WATER WASTAGE IN MINES

THE CONTRIBUTION OF SOUTH AFRICAN MINES TO THE ECONOMY IS UNDENIABLE. BUT SO IS THE HEFTY ENERGY CONSUMPTION OF THE MINING SECTOR IN RELATION TO THE OVERALL ENERGY CONSUMPTION OF THE COUNTRY. CSIR RESEARCHERS ARE HELPING THE MINING INDUSTRY SAVE ENERGY AND WATER THROUGH A NEWLY-DEVELOPED TECHNOLOGY FOR MANAGING THEIR SLURRY SYSTEMS.



The sensor that will help the mining industry monitor and analyse performance data

WHEN AN ENERGY CRISIS hit South Africa early in 2008, the mining industry was arguably affected most, with some mines having to close for some time to recover from the electricity deficiency. This happened despite the wheels having been set in motion by an accord signed between the mining industry and the Department of Minerals and Energy (DME) a few months earlier.

In this accord it was agreed that all involved would voluntarily achieve a 15% energy saving for the mining sector by 2015. This energy efficiency accord was signed with 32 mining and industrial companies, with the CSIR being one of the signatories. At that time, the DME had estimated that the mining sector accounted for 6% of the overall energy consumption in the country.

Soon after signing the accord, researchers at the CSIR initiated a project that would ease energy consumption in the mines.

Harmut Ilgner, a senior researcher at the CSIR's regional office in Johannesburg, says a technology was developed to determine and quantify in real time the beginning stages of particle settling in slurry systems. To put it simply, this enables pipeline operators to optimise water and energy consumption during the disposal of some 150 million ton of mine tailing per year in South Africa alone. Tailings are waste products and are transferred from the mine to the tailings dam where the water evaporates and the solids create the familiar mine dump.

"If the slurry – a liquid mixture of water and insoluble solid materials such as tailings – is pumped too slowly, the tailings particles may block the pipelines. This reduces production as the mine has to waste time fixing the problem. Understandably, operators prefer to pump far in excess of this so-called 'critical deposition velocity', but then a lot of energy and water is wasted.

This CSIR project targets slurry systems precisely because they consume a lot of energy and water.

Ilgner explains that a technology demonstrator, which is fully instrumented with state-of-the-art slurry instrumentation from Endress+Hauser, as well as customised sensing equipment, is used to fine-tune the control strategies. It does this by conducting specific assessments of gold, platinum, diamond fly ash and other slurry types. In parallel, industrial pilot trials are being conducted as part of a three-year project supported by the Innovation Fund, which is managed by the National Research Foundation.

"Because we can fit the sensor onto the existing pipelines anywhere, we can monitor and analyse performance data *via* the internet and help the client make decisions on how best to control a particular operation, depending on whether water or energy is the more valued resource in that particular region," says Ilgner.

For example, in Botswana, water is a much more scarce resource than power. Therefore, in this case the final technology product will be able to optimise the tailings disposal by maximising the savings of water, in preference to energy. Mines in Gauteng, however, need to conserve power in every process in order to delay the switching on of their on-site emergency electricity generators to produce additional power, which comes at a substantially higher cost than power supplied from the national grid.

Ilgner is optimistic that the technology will eventually be sold worldwide.

"This technology can help the mining industry save up to 4 MW of energy per year," he comments. He says the final technology product is currently being developed as part of the technology transfer process. It is set to be operational in mainstream mines in about two years.

The research and commercialisation team for this project comprise three complementary companies; the CSIR for the innovation technology and technology intellectual property as well as Stoner (Pty) Ltd, a BEE company, for conducting industrial field trials and product development. There is also Paterson and Cooke Consulting Engineers (Pty) Ltd, a company based in Cape Town that operates worldwide and specialises in slurry applications.

"We are really excited about being part of this project team. Already, we have identified some additional applications in the diamond industries," says Stanford Dumbu of Business Development Director at Stoner (Pty) Ltd.

This technology will help the mining industry reach its goal of reducing energy and water use, but this will need to be skilfully implemented. It will form part of the concerted efforts being made to fulfil the commitment to the agreed reduction in electricity use in South Africa. – ***Kamogelo Seekoei***

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MAPPING

THE STRUCTURE OF THE WATERBERG FOR FUTURE COAL

Dr Stoffel Fourie interprets airborne magnetic and radiometric data

COAL MINES IN SOUTH AFRICA, especially in the Highveld area, are becoming depleted of resources and the need to mine other areas to sustain the coal industry has become increasingly important.

CSIR scientists have interpreted airborne magnetic and radiometric data, and acquired additional airborne data, to produce the first detailed structural map of the Waterberg Coalfield. This is the first step in the process to allow mines to explore and mine more effectively. This research is set to prolong the life of the South African mining industry.

"This structural map is the first step to unravel the unknown structure for the Waterberg area and will help industry to plan and design its mines appropriately.

This will eventually help mining companies with production and with health and safety issues," explains CSIR geophysicist Dr Stoffel Fourie.

The Waterberg Coalfield in Limpopo are said to be where the country's future coal reserve is. However, the area is not geologically well understood and mining it without knowledge and planning will be a disaster. The Waterberg Coalfield is said to have the capacity to host eight power stations and there should be enough reserves to mine for the next 150 years.

Using airborne geophysics, the remote measurement of the Earth's magnetic and radiometric physical properties from the air were performed. This allowed researchers from the CSIR to map variations in these properties and their distribution.

The magnetic data are of great importance. The data reveal all the magnetic dykes and faults in the basin that are not to be mined. These structures make mining more difficult and it is important to know where they are.

"The technique that we used for the Waterberg area has the ability to give the total count of all the natural occurring radioactive areas. The radioactive signature of these areas is geology dependant and this helps industry to better understand the geology about the fields it is going to mine and to do that effectively," he says.

The CSIR conducted this research and development work for Coaltech – a research association with shareholders from various coal mining companies, including Anglo Coal, BHP Billiton, Xstrata Coal, Exxaro Mining and Sasol Mining as well as other coal consuming businesses such as Eskom and some tertiary institutions.

Fourie says they will continue to study the area and give recommendations to industry.

"Studying geology is tricky because it evolves all the time, so we have to always be on the look-out for new techniques and developments." – *Kamogelo Seekoei*

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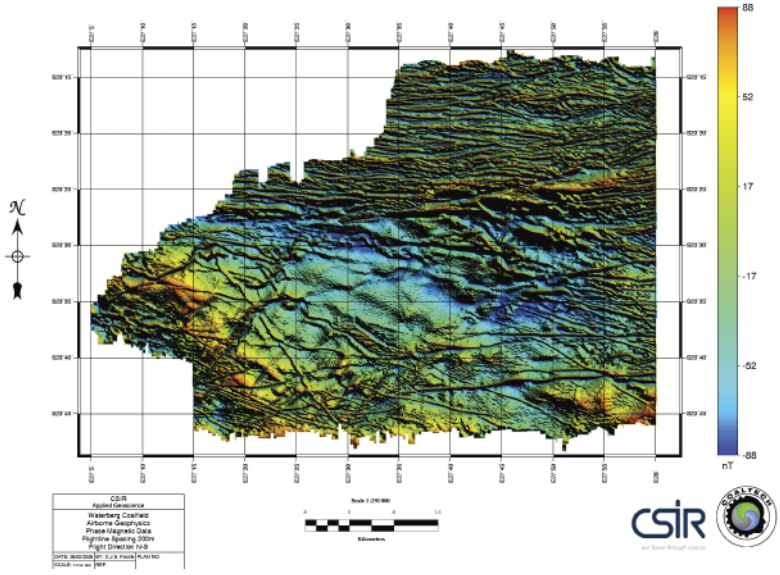
Waterberg phase magnetic data

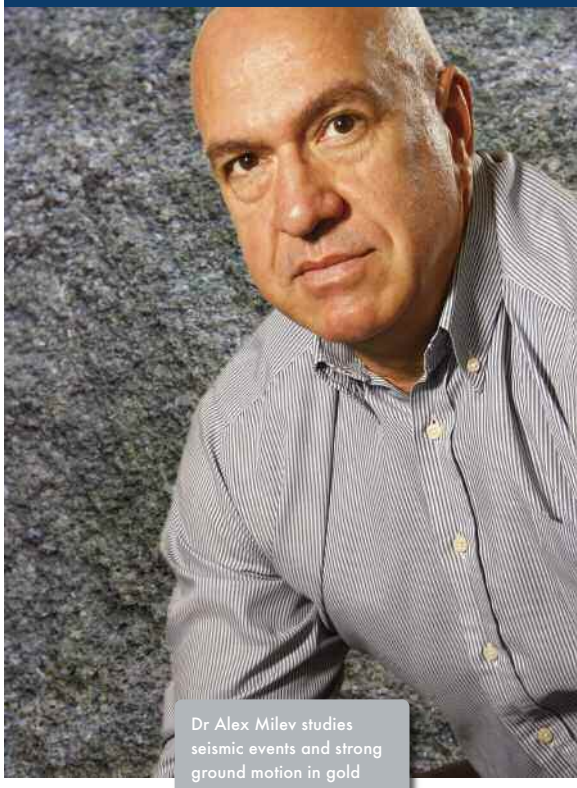


Waterberg Coalfields phase magnetic data depicting the magnetic fields in the Waterberg coal mines. This was obtained using airborne geophysics

MINING

ANALYSING SEISMIC EVENTS FOR IMPROVED MINE SAFETY

UNDERGROUND ROCK-RELATED ACCIDENTS HAVE ARGUABLY BECOME THE BIGGEST ISSUE IN THE MINING INDUSTRY. THIS, AS INDUSTRY CHANGES ITS SOCIAL ACCEPTABILITY AND STRUGGLES TO MEET THE SAFETY TARGETS SET FOR IT.



Dr Alex Milev studies seismic events and strong ground motion in gold and platinum mines

ONE OF THE MAIN CAUSES of underground accidents is rockbursts caused by strong seismic events taking place around the mining excavations.

Mining-related seismic events are earthquakes that occur as a result of mining activity. They generate seismic waves that travel through the rocks around mining excavations. Seismic events occur on a daily basis, but it is when the ground motion in the workings is too strong that they cause damage and sometimes injury and fatalities.

It is for this reason that the mining industry needs to understand the nature of seismic events to make better and informed decisions when planning mining operations.

Using state-of-the-art equipment, the CSIR has conducted research and continues to study seismic events and strong ground motion in many gold and platinum mines.

The CSIR has developed an instrument called Strong Ground Motion Detector (SGDM), which enabled the researchers to create a large database of strong ground motion recorded underground. That database is used to analyse the strong ground motion taking place at the surface of the excavations.

"Unfortunately, we can neither predict strong seismic events nor can we calculate when they will occur. What we can do is to monitor and study mining-related seismicity and then recommend possible preventative measures that mines can take to beef up the support strategies and mine layout design in order to minimise the rock-related accidents," says CSIR seismologist Dr Alex Milev.

The CSIR's mining seismologists have been working on this research for more than 10 years and the outcome of this study has benefited many gold and platinum mines in South Africa. – ***Kamogelo Seekoei***

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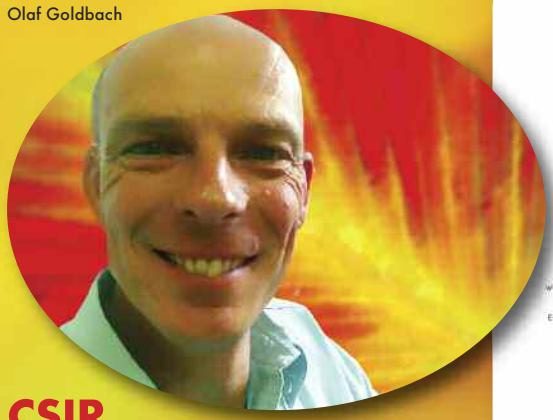
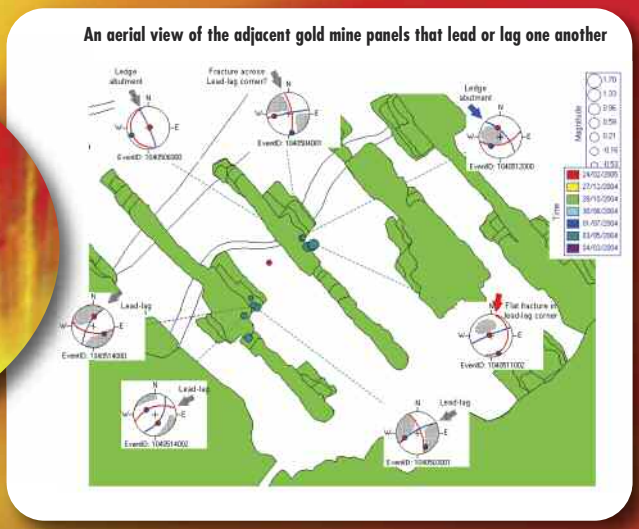
CSIR mining researcher, Olaf Goldbach



An aerial view of the adjacent gold mine panels that lead or lag one another



CSIR DETERMINES OPTIMAL LEAD–LAG DISTANCES IN GOLD MINES

THE CSIR HAS SCIENTIFICALLY VERIFIED THE OPTIMAL DISTANCES THAT ONE STOPE MAY LEAD ITS NEIGHBOURING PANEL IN SOUTH AFRICAN TABULAR GOLD MINING.

UPON REQUEST of the Mine Health and Safety Council, the CSIR initiated a project to study the effects of lead-lags on fracturing, stability, support and seismicity. After two years of research the project was completed in 2006.

The lead-lag between adjacent panels in gold mines may cause seismic events if the recommended distance between these panels is not adhered to. It is believed that the lead-lag distance between adjacent panels can affect the distribution and characteristics of fracturing within the mining faces and this may affect stability of the mine roofs and hence the safety of the mine workers.

Generally, the practice in mines has been to minimise the lead-lag distance between adjacent panels. But there has never been scientific proof of what the optimal distance between these panels ought to be.

In the past this distance was based on experience rather than on scientifically-quantified measurements. "This project was to either confirm or modify the current lead-lag design guidelines," says CSIR researcher Olaf Goldbach.

In general, mines had adopted layouts where optimum lead-lags between panels were 5 m - 10 m. Goldbach and his research group produced scientific proof of optimal lead-lag guidelines for various gold reef types.

To determine these results the researchers adopted a four-step research study. The first step included a literature review where problems associated with lead-lags were described. This stage also included evaluating the existing industry practice around lead-lags by reviewing codes of practice.

In the second phase the researchers undertook detailed fracture mapping around lead-lags at 14 gold mine sites, with different reefs, mining methods and depths.

"The fracture mapping work produced convincing evidence that optimal lead-lags are in the range of 4 m - 16,5 m, depending on the reef type. This was the most important part of the work because for the first time, there was proof that the industry's adopted lead-lag distances were in the correct range," he says.

The next step looked at seimicity associated with lead-lags as this would help determine whether the lead-lag distance had any influence on rockbursts.

The last step was numerical modelling, which was used to confirm the findings that the fracture mapping work produced.

Goldbach says: "We recommended to industry that the guidelines presented in this research work be adopted as this will increase the safety in mines and save people's lives."

The most important benefit to industry is that optimal lead-lag distances have been proven scientifically.

A gold mine may encounter geotechnical conditions that are different from those studied by the CSIR. In this case, the mine can verify its own optimal lead-lag distances by following the methodology presented in the research report. – *Kamogelo Seekoei*

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Vivian Radebe (engineer) and Harma Greben (senior researcher)

AN ENVIRONMENT-FRIENDLY TECHNOLOGY FOR BIOLOGICAL SULPHATE REMOVAL FROM AMD

Vast amounts of acid mine drainage (AMD) are being generated in South Africa, thereby affecting the water quality of the country's rivers and dams. Decant from both active and closed mines can have a negative impact on ground and surface water. Research is ongoing to find a cost-effective, environmentally-friendly treatment process to reduce the salinity and to neutralise the acidity of AMD.

CSIR SENIOR RESEARCHER Harma Greben and her colleagues have conducted various studies since 2004, focusing on high sulphate removal efficiencies applying the biological sulphate removal technology. Through this, they use the degradation products of grass-cellulose as the carbon and energy sources for the sulphate reducing bacteria.

"In simple terms, we are trying to find a biological process to clean up the mine water by using micro-organisms. These bacteria reduce the sulphate and produce sulphide, which in turn can precipitate metals, often present in the mine drainage, to metal sulphides."

AMD is not a uniquely South African challenge. As Greben explains, "Globally, research is focused on the treatment of AMD, which is continuously generated - even at closed mining sites."

The characteristics of AMD are high concentrations of sulphate, a low pH and heavy metals content, principally iron. Greben says the advantages of biological treatment of AMD include sulphate reduction, pH increase through alkalinity production and metal-sulphide precipitation, since sulphide is the reduction product of biologically-reduced sulphate.

The metal sulphide precipitates have low solubility, which makes the biological sulphate removal technology a feasible option for simultaneous metal and sulphate removal from waste waters. "Micro-organisms need food in the form of carbon and energy to do their work," explains Greben. "In our process, we degrade grass cellulose to make the degradation products, such as volatile fatty acids, available to the sulphate-reducing micro-organisms. The process is executed in a confined reactor system."

Previous studies done by this unit demonstrated that biological sulphate reduction using degradation products of grass cuttings as the carbon and energy sources, resulted in sustained sulphate reduction from sulphate rich synthetic feed water and pre-treated mine water. A reactor temperature of 37-39 °C was initially maintained to accommodate the microbes originating from rumen fluid, which are needed for the cellulose degradation process. However, full-scale treatment of mine water at elevated temperatures is not practical, since heating vast volumes of mine effluent to 37-39 °C would increase operating costs substantially.
The team then looked at the possibility of achieving similar results at room temperature (± 25 °C).

The most recent study presented by Greben and her colleagues showed that high sulphate removal efficiencies could be achieved applying the biological treatment technology at 25°C, using a one-stage hybrid reactor system, treating both sulphate-rich synthetic feed water and pre-treated acid mine drainage. The results showed that the fermentation microbes, originating from rumen fluid, derived from cattle, could be adapted to 25 °C, generating the carbon and energy sources for the sulphate reducing bacteria.

"The novelty of our latest findings is that it makes the technology significantly more cost-effective and competitive with other technologies developed in the country," Greben enthuses. "I also find it rather encouraging that micro-organisms do the work and we are able to avoid using chemicals. It is an elegant process, using something that nature provides."

Using the degradation products of grass cellulose and rumen fluid microbes is a promising option for treating high sulphate concentrations in mine and other sulphate-rich industrial waste waters. The advantage is that grass can be grown at mining sites, using the treated water for irrigation, since this water contains nutrients as degradation products of grass, while the residual carbon is beneficial as soil improver.

Mining houses are faced with the ongoing challenge of balancing financial and environmental considerations. These latest findings offer them a cost-effective and environmentally-friendly alternative. This CSIR research was co-funded by BioPAD and the Water Research Commission. – *Manana Makhanya*

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CURRENT RESEARCH AND DEVELOPMENT

CSIR INVESTIGATES HOW A FATIGUED WORKFORCE CAN BE A TICKING TIME-BOMB

THE GROWTH OF THE GLOBAL ECONOMY AND ADVANCES IN TECHNOLOGY SEEM TO HAVE EXPANDED THE NUMBER OF JOBS THAT OPERATE OUTSIDE THE BOUNDARIES OF THE NORMAL WORK DAY, INCLUDING MANY JOBS IN THE MINING SECTOR. '24/7' OPERATIONS IN MANY INSTANCES CREATE THE NEED FOR STAFF TO WORK WHEN THEIR BODIES TELL THEM THEY SHOULD BE SLEEPING.

CSIR principal researcher, Schu Schutte conducts research in the mines to measure the extent of fatigue and its implications

SEVERAL HIGH-PROFILE accidents in the South African mining industry were attributed to fatigue. Operator fatigue is a critical safety issue that affects all modes of mining, giving rise to much needed research. The CSIR conducted studies in the mining industry to understand fatigue, its causes and to develop guidelines on how to manage it.

CSIR principal researcher Schu Schutte describes fatigue in the mining context as a state of impaired mental or physical performance and lowered alertness. Fatigue can be the result of hard physical work, high mental workload, shift work, inadequate sleep, compromised health conditions, psycho-social factors, or a combination of these.

Schutte says while conducting the research, they looked at the holistic picture to understand all the factors that contribute to fatigue. This enabled the project team to identify suitable means to manage fatigue.

"The management of fatigue is not simply a matter of correct shift scheduling – a more comprehensive approach is needed."

In order to be successful, a fatigue management programme should address the unique needs of the operation in which it will be implemented. It should be integrated into the normal operations, and it should encourage active participation from all stakeholders. "A fatigue management programme should address task- as well as worker-related factors associated with worker fatigue," says Schutte.

Schutte says the causes of fatigue cannot be altogether eliminated but they can be managed. He says it is important to note that employees and management are jointly responsible for fatigue risk management. To facilitate this, Schutte and his team suggests that a sleep contract forms part of the proposed fatigue management procedures.

A sleep contract is an internal company document that reduces fatigue risk by providing a negotiated framework for identifying, reporting and responding to fatigue risk. "The document makes it clear that both employees and employers are responsible for the management of fatigue and states the responsibilities or accountabilities of each party."

The team is currently drawing up a number of guidelines that can be incorporated into the mining codes of practice.

"These guidelines will help the mines manage and perhaps reduce the problem of fatigue in their work environment," says Schutte. – ***Kamogelo Seekoei***

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INTERVENTIONS TO MANAGE FATIGUE

- **Optimal design of shift system and rostering**
- **Ergonomics interventions and taking abilities and limitations of workers into account**
- **Sleep management**
- **Education and training for the successful implementation of fatigue management**
- **Lifestyle interventions**
- **Health screening and counselling.**

IMPROVING COAL BENEFICIATION

TO SUSTAIN SOUTH AFRICAN MINES

Dense-medium fine coal plant under construction at Leeuwpan, Mpumalanga

THE ACCELERATED DEPLETION of coal in South African mines – mainly at the Witbank/Highveld region, an area that has been the main source of coal for decades – and the rising demand for this resource, has made efficient coal beneficiation critical.

Researchers at the CSIR have been involved in various innovations targeted at not only optimising productivity at mines, but also lowering the cost of cleaning coal and still getting the best value coal for local use and for export.

Optimising productivity, retaining jobs and still reducing the cost of mining in this sector have become constant themes. Improved coal beneficiation is one of the ways to achieve this. Coal beneficiation is the process of removing the contaminants and the lower grade coal contained in the raw coal as mined to achieve a product quality that is suitable to the needs of the end user – either as an energy source or as a chemical feedstock.

Johan de Korte, a CSIR researcher and a member of the coal preparation committee of Coaltech, says when coal is extracted, it is mixed with shale and other contaminants from the roof and the floor of the coal seam that are required to be separated from the coal. Research work for industry by the CSIR has contributed to improving the separation methods used in the coal industry.

The pilot dense-medium cyclone plant that was developed by Coaltech and the CSIR and tested at four different collieries, is used for the cleaning of fine coal.

This method proved to be more effective than the conventional methods that were already in use – like spirals – and is now being implemented in Exxaro mines. Other mines are ready to follow suit, says De Korte. The method uses water mixed with magnetite to separate the impurities from the coal and is slightly more expensive but more efficient.

"It has been proven that fine coals can be upgraded to a calorific value of 28 MJ/kg," he adds.

The CSIR undertakes research and development work for Coaltech – a research association with shareholders from various coal mines, including Anglo Coal, BHP Billiton, Xstrata Coal, Exxaro Coal and Sasol Mining as well as other coal consuming businesses such as Eskom.

The aim of Coaltech is to produce services that all these companies can use, thereby helping the South African mining industry remain competitive and sustainable.

"Ultimately, all companies that are part of Coaltech benefit from our research and have the advantage of accessing the technology," explains De Korte.

Other methods developed at the CSIR and other institutions that are part of Coaltech include dry-screening and dry-beneficiation. These processes do not use water and are cheaper than the dense-medium methods. They, furthermore, have a lower impact on the environment.

"Dry screening is not easy but we are getting there. At small screen aperture sizes, dry screening of coal has proven to be problematic but on a full-scale screen in production encouraging results were obtained. Further tests will be conducted," says De Korte.

According to him, it is always better to test new technologies on site because there one can do full scale work and get realistic and accurate results.

Though this process is currently less efficient than the dense-medium process, De Korte says it has a few advantages – making it a potentially viable tool for the mining industry. The first is that it does not use water – a huge advantage considering the drive to reduce the use of water in mines. Another reason is that with this method, pollution of streams are eliminated as no waste slurry is produced. Slurry is a liquid mixture of water and insoluble solid materials such as ore or coal, which is normally disposed of in tailings ponds.

The last benefit of dry screening is that the moisture content of the product coal delivered to the customer remains low, therefore, maximising the heat value of coal.

De Korte says the CSIR is continuing its work to initiate methods that can improve coal beneficiation and help the industry maintain its competitive edge. He says the technology developed in other countries is not always able to cater for South African coal, unless adapted.

"We have to come up with our own effective technology to clean coal because we have a different kind of coal that is more difficult to clean than that of the northern hemisphere," he says. – *Kamogelo Seekoei*

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Van Zyl Brink leads research in the AziSA group, which is drawing up guidelines for South African mines to improve communications underground

REDUCING MINING ACCIDENTS THROUGH

ACCURATE UNDERGROUND COMMUNICATIONS

Accurate information about what is happening underground is rarely obtained in deep South African gold and platinum mines. This is, primarily, because it is difficult and in many cases not practical to collect acquired real-time data from the production end of mining. It is even more difficult to transmit the acquired data to a central data management system on the surface.

THE COMPLEXITY OF acquiring mining data underground and the resulting poor quality of data, means that mining is still done just as it was 50 years ago. "It is still mainly a labour-intensive drill-and-blasting operation. We do not quantify the working environment; the mining process; nor the physical demands placed on the worker," says CSIR researcher Van Zyl Brink.

He says because they cannot quantify these factors, they equally cannot implement better ways of conducting mining. Such quantification will result in optimal safety, healthy and minimisation of mining costs.

A standard and a methodology for mine sensing and control to improve conditions and allow for better decision-making in the mines has been developed at the CSIR.

AziSA was developed as a tool to help the mining industry facilitate data acquisition and underground control through the introduction of a number of standards.

It was developed because existing, identified protocols could not provide what was required. This includes support for low-cost, low-power and wireless networks, as well as organisation and openness.

The principles set out by AziSa will guarantee that accurate measurements are collected. In addition to accurate measurements with adequate precision, data integrity requires that both the time and location of each measurement are known, another functionality of AziSa.

"AziSA means 'to inform' in isiZulu and is intended for the design of systems that will operate in underground mining environments where limited power and communications infrastructure exist," says Brink.

"It should be made clear that AziSA is not a product, but a set of standards that are aimed at improving operations in the mines," he says. Suppliers and end-users of underground monitoring systems are encouraged to adhere to the standards as set out in AziSA.

It is envisaged that AziSA will be adoptable as an open standard, but it is also a compilation of existing open standards. Therefore, connecting these to form the various stages of a network and only adding to the standards when desired functionality cannot be obtained from an existing standard.

The key elements proposed in the AziSA principles include the standardised wireless sensor networks, a data communications system that uses already-installed power line carriers.

The network also includes an open communications protocol for connecting to sensors, getting measurements and controlling actuators and data mining techniques using computational intelligence to purify the input from a vast array of sensors into knowledge that can be used for real-time decision-making.

These guidelines will primarily ensure that the risk of accidents is reduced and will also lower mining operation costs.

The ultimate goal is an open system in which AziSA-compliant sensors could add themselves to a network with the minimum of human intervention. Relatively small systems have been implemented in a number of mines using AziSA principles. These include systems for monitoring waste and ore separation, safety in the workplace and the underground environment. – ***Kamogelo Seekoei***

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Andrea Basola develops 3D technology to experiment with ideas and then makes recommendations for improvement to industry

3D TECHNOLOGY PLAYING A DECISIVE ROLE IN MINES

IN A BETTER WORLD, mine workers do not agonise about going underground every day because of the fear of rock falls. They are not concerned about safety because all the measures and precautions have been adhered to.

In that world, the equipment and machinery used by mine workers do not pose any physical harm to them as these have been adapted, using anthropometric science, to suit the stresses underground. It is a world where the working environment is close to perfect; where technologies are so advanced that seismic events can be predicted. This would translate into the automatic safety of mine workers.

Furthermore, state-of-the-art technology allows for information to be received from the different tools and is transmitted to central communication points underground. These gadgets, used underground, know where they are in the mine and how to function in relation to the rest of the network of data-capturing and warning-signalling machines.

This is a world that the CSIR envisages and works towards through many collaborative initiatives with players in the mining industry. The CSIR's Andrea Basola is one of the researchers who is working hard to ensure that in the future, working in a mine is as attractive and as safe as working in an office.

Basola is part of a CSIR group of researchers responsible for the conceptualisation and development of revolutionary equipment that will not only see the mining sector evolving into a less hazardous working environment, but that will also save lives.

He uses 3D technology to experiment with ideas and then makes recommendations for improvement to industry. These 3D concepts are subsequently converted into real life products that are used in the mines. An example is the trapped miner locator that the CSIR has developed. As the name suggests, this device makes it easier to find trapped miners in accident cases, as it was built to 'hear' or 'sense' through rock.

Basola's group has also created, as part of an AziSA framework, the helmet acoustic sensor (see box). This miniature tool is meant to help miners interpret the sound of the shaft roof after blasting and just before the rest of the miners can go in the tunnel and start mining. Normally the miner will rely only on his own hearing to determine the safety underground. And the interpretation of the sound would be solely based on experience.

"These products are all in the prototype stage and will reach the technology transfer stages soon," says Basola.

Basola says the AziSA framework could eventually create a network of sensors that can communicate with each other and relay information throughout the electrical network in each mine. "Almost like artificial intelligence," he says.

The CSIR is also currently developing the borehole crawler that will help with capturing rock-related data underground for analysis and possible hazard identification.

Basola's research focuses on two aspects of mining: ergonomics and product development. Work is done to develop products, taking into consideration their ruggedness, user interface, configuration and manufacturability.

"While the CSIR ends its involvement prior to marketing, the organisation ensures that its innovations are market-friendly to succeed in commercialisation," he says. Basola has also been responsible for the compilation of guidelines for ergonomics design criteria for mechanised mining equipment and underground locomotives used at platinum mines. In his research, Basola uses anthropometric science to survey South African miners and from the results produces recommendations mines can use.

Anthropometry plays an important role in industrial design and ergonomics where statistical data about the distribution of body dimensions in the population are used to optimise mining equipment and sensors.

"We have also done an ergonomics assessment of possible lower back disorders among drivers of earth moving machinery, which included postural analysis by means of the computer software known as JACK task analysis tools," he says. JACK is used to conduct and analyse research by using 3D environments and anthropometrically scaled digital human models. – ***Kamogelo Seekoei***

The helmet acoustic sensor will help miners determine safety underground

HELMET ACOUSTIC SENSOR

This device, also known as the electronic sounding bar, was developed at the CSIR to improve safety in mines. It is meant to help with decision-making during the inspection process.

"After blasting, the group leader has to inspect the area before his team can start mining there. This device provides technology that allows decision-making based on more than (subjective) interpretation linked to experience," says the CSIR's Van Zyl Brink.

The gadget can be attached to the helmet and a double beep and red flash indicate that it is not safe to continue. A green flash results from a positive sound.

The research has now reached the end of the development stage and 20 of these have been distributed in the different mines to be tested and evaluated. "The next stage is for it to be commercialised."

The AziSA beacon will help improve wireless communications in mines

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Main picture: Emmanuel Munyai and Sizwe Ngwenya insert a crane hook into the 500T tensile test machine

Inset: Schoeman Mathipa ensures that a steel wire rope is correctly installed in the 15 MN test machine

TESTING THE LIMITS OF SAFETY IN MINING

The captains of South African industrial and mining sectors have numerous considerations in their day-to-day businesses, not least of which is the safety of their staff and the integrity of their equipment. Checking the safety status of production facilities is a job best left to the experts – and the CSIR's mining and engineering test centre in Cottesloe, Johannesburg. This centre is recognised as a world leader in rope testing, mechanical testing and engineering forensics.

ANDREW PEAKE, the facility's business manager, points out that mining contributes around 6,5% of South Africa's GDP and is the country's largest single private employer. Around 300 000 people descend to the depths of the earth everyday – and their lives are literally held at the end of a steel wire rope. The Cottesloe facility tests these ropes from time to time to assess their breaking strength and general condition.

"Since a rope-related accident in 1904 that cost the lives of more than 40 miners, it has been law for mines to submit the winding ropes that they use in their operations for destructive testing twice a year," says Peake. "An estimated 200 underground mines exist in South Africa, with between 2 300 and 2 500 ropes in use. The deepest shaft in South Africa is close on 3 000 m, and a shaft is the only way in and out for miners from that depth. The steel wire ropes on which the conveyances are suspended are the single link in the mining production chain that keeps them alive."

Steel wire ropes used in mining are purpose-made to order, and each rope has an identification number (called the coil number) used as a reference throughout its life. "This allows us to see where the rope is used and to build a profile of its performance as the years go by," explains Peake. "The history of the rope allows the mine engineer to assess a rope's condition, analyse its performance and ensure that it remains 'fit for purpose'. A small second-hand market for steel wire ropes exists, and when someone is interested in purchasing one of these ropes, we can provide them with information about the rope's history and performance that will be critical in determining the rope's suitability for its intended use."

In the late 1980s a working group was formed with members drawn from the Department of Minerals and Energy (DME), the mining industry, the South African Bureau of Standards (SABS) and the CSIR.

Their objective was to investigate which physical criteria should be used when deciding whether a rope should be discarded. The key criteria identified were

(a) a drop of 10% or more in the breaking force below the new rope breaking force and
(b) a fall in the plastic fraction of elongation of the rope to 0,5% or less.

These findings were subsequently incorporated into SABS standard 0293:1996 and today form the basis of the six-monthly destructive test conducted in the facility's 15 MN testing machine.

"Any fatality is unacceptable. However, the depth, geology, seismicity, temperature and working geometry present formidable challenges to engineers. Against this, the relative safety of travelling to and from the workplace, suggests that winding equipment and the monitoring systems in place such as rope testing, are effective."

Gezani Baloyi examines a steel wire hoist rope for signs of corrosion

"An assessment is also made of the degree of corrosion evident within the strands and on the outside of the rope," says Peake. "As many ropes operate in warm humid shafts, it is inevitable that corrosion will take place. The performance of ropes can vary widely according to the environments in which they are used as well as the work they perform. I've seen 16-year-old ropes that are still performing satisfactorily, while others must be discarded within two or three years."

The largest tensile test equipment in use at the Cottesloe facility is a 15 MN MFL machine that is able to test steel wire ropes with diameters of up to ~160 mm. "The mines send us a 3,5 m length of rope taken from the front end – the section closest to the conveyance – as research has shown that this is the section of the rope that experiences the most stress," explains Peake.

"In preparation for testing, the rope is cut to gauge length, the ends are 'brushed' and end-caps are cast in place. It is then ready to be inserted into the machine. In the test we record the breaking force of the rope and its elongation under load up to the point of failure. Following the test, a rope undergoes examination to assess other factors, including the manner of wire failure, the number of broken strands and the type of wire breakage. All this information is captured and secured on our rope test database. Mines can have remote access to their own information, and the entire database is updated to the DME once a week. The mine then receives a test certificate providing this information along with any recommendations."

The team at Cottesloe endeavours to get results back to the mines within 14 days of receiving the samples, but urgent tests on ropes that may be compromised, or tests on other types of specimens, occasionally scupper their best intentions. "We also test conveyor belts from time to time, as well as railway wagon couplings, chain links and ropes used in the shipping and oil industries."

The fact that so few rope-related accidents take place is a reflection of the effectiveness of regular testing. "Any fatality is unacceptable. However, if you consider the working environment that miners face daily, carving out a new place of work each time they go kilometres under the ground, it is to the credit of all concerned – including the DME, manufacturers, mine engineers, management and the test laboratory – that miners can count on the safety of the cages that take them underground."

The Cottesloe team also conducts a variety of other tests in its mechanical laboratory, which is equipped with 500 ton tensile and 1 000 ton compressive test machines. The mechanical laboratory tests many types of specimens including mine supports, crane hooks and electrical conductors. There is also a rig for the endurance testing of chain blocks.

Despite the best efforts of design engineers, certain components sometimes fail in service. When this happens engineers want to know why, and this is the domain of the engineering forensics laboratory at Cottesloe. Here components are examined and tested to determine the primary cause of failure.

The testing facility at Cottesloe is also the only testing authority accredited by the DME for the functional performance assessment of self-contained self-rescuers (part of the rescue equipment on mines) on breathing simulators.

"Our facility plays a major role in making South Africa's mines safe places to work," says Peake. "The mining environment is a particularly hazardous and challenging one, and as South Africa's most sought-after minerals are so deep below the surface, we are continually pushing the boundaries in our quest to extract it. The services that our facility provides are key to preserving the lives of the men and women who bring our mineral wealth to the surface," he concludes.

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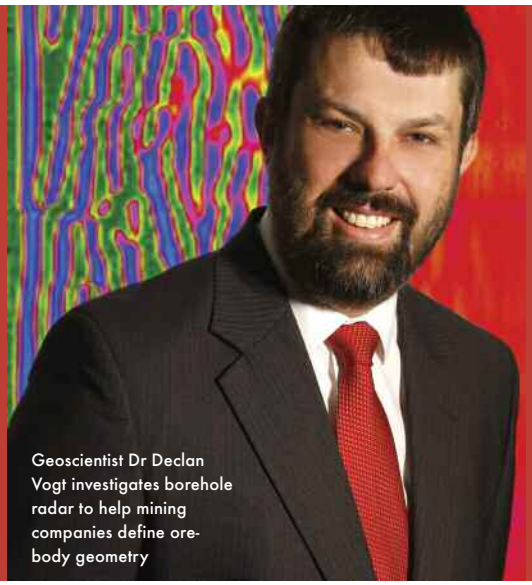


Geoscientist Dr Declan Vogt investigates borehole radar to help mining companies define orebody geometry

CSIR HELPS MINING INDUSTRY MAP OREBODY FOR REDUCED ACCIDENTS

KNOWING THE LAYOUT of a mining reef is an advantage for mining companies as they can make better decisions and anticipate accidents. Knowing in advance the geometry of a gold or platinum reef can help many mining companies avoid accidents or damage to machines that may lead to unnecessary expenses, especially in cases where mechanisation is being introduced.

Borehole radar is one effective way of mapping the shape of underground areas. Borehole radar is an electromagnetic tool that can be applied to assist in the definition of orebody geometry, ideally using routinely-drilled cover and exploration boreholes, although often boreholes are drilled specifically for the technique.

This method is described by CSIR geoscientist Dr Declan Vogt as 'insurance' for the mining industry, especially in questionable areas, such as those mines with potholes or faults in the ground. "Even if a borehole radar survey reveals no problems, that is in itself useful information. It's like car insurance: you pay every month, and most months you don't claim, but you have the peace of mind of knowing that you're covered."

Mining companies may incur an expense to use borehole radar, but in the long run it saves them a lot of money that could be used differently. It also saves time as the mine can make a decision about a fault in the ground or a pothole well in advance.

The CSIR uses its 'homegrown' Aardwolf BR40 radar when doing borehole radar investigations for the different mines.
Vogt says most of the platinum mines on the Eastern Limb of the Bushveld use borehole radar because they have so many faults that not knowing the lay-out of the ground could be costly.

The CSIR developed the Aardwolf BR40 application in 2001 after a Swedish system proved unable to handle the conditions in South African mines, particularly the heat.

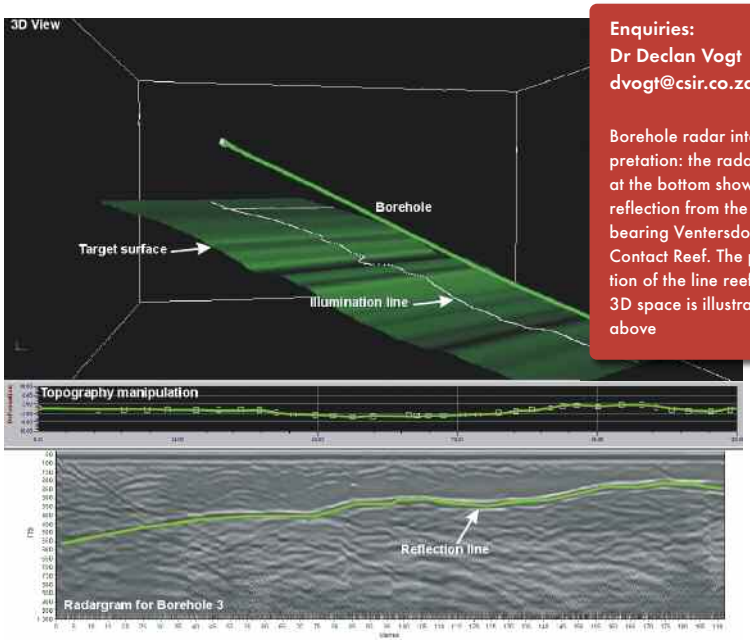
"Radar can only see through certain rocks but the host rocks for gold and platinum in this current are very good for radar, so we do work mainly for those companies," explains Vogt.

Successful trials of borehole radar for delineating reef horizons on South African gold and platinum mines led to the development of the Aardwolf BR40 borehole radar system, specifically for routine application in those environments.

The trials showed that the instrumentation met its performance specification. "The radar is robust enough for routine work underground and is easy to use. It has proved to be remarkably reliable. "

The radar design has a transmitter that sends pulses into the underground rock and a receiver that collects the pulses reflected back from interfaces between different rock types. The transmitter and receiver are located in the same borehole. The reflected radar waves that are recorded are then processed and interpreted.

Vogt concludes that the borehole radar is a useful addition to the 'toolbox' of the mining geoscientist because it can give information about the reef plane along a line, rather than the single point information about the reef given by a borehole. – ***Kamogelo Seekoei***



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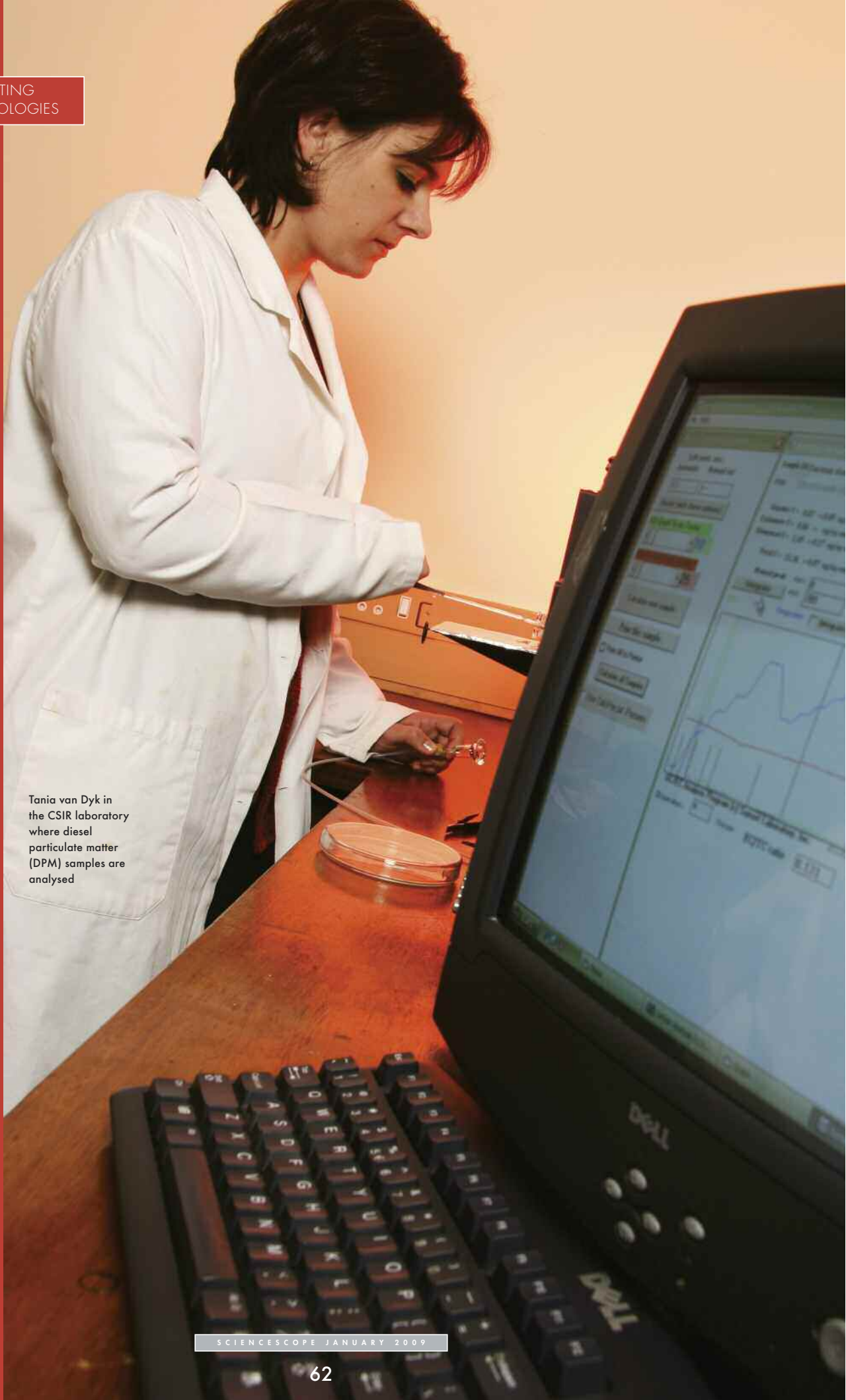
Borehole radar interpretation: the radargram at the bottom shows the reflection from the gold bearing Ventersdorp Contact Reef. The position of the line reef in 3D space is illustrated above



Tania van Dyk in the CSIR laboratory where diesel particulate matter (DPM) samples are analysed

MINE AIR

INSPECTING MINE AIR FOR DIESEL EMISSIONS THAT CAUSE LUNG CANCER

The laboratory equipment used to analyse diesel particles

THE CSIR IS INVOLVED IN VARIOUS RESEARCH PROJECTS HELPING THE MINING INDUSTRY TO IMPROVE ITS HEALTH GUIDELINES AND SAFETY MEASURES UNDERGROUND.

CSIR researcher Tania van Dyk says in 2006, at the request of the mining industry, her research group analysed samples of diesel exhaust emitted from trackless equipment from the platinum mining industry. The group investigated the extent to which these emissions contained health-threatening diesel particulate matter (DPM).

In mines, diesel-powered equipment is a constant feature and is often operated by humans. The equipment includes front-end loaders, haul trucks, roof bolters and tractors, to mention a few.

With an increasing use of diesel equipment in the confined space of underground workings, the limiting of mine workers' exposure to DPM is vital to ensure good health. Diesel particulate matter is the particulate component of diesel exhaust from diesel vehicles, which includes diesel soot and aerosols such as ash particulates, metallic abrasion particles, sulfates and silicates. When released into the atmosphere, DPM can take the form of individual particles or chain aggregates.

Exposure to diesel particulate matter has been linked with acute short-term symptoms such as headaches, dizziness, coughing, nausea, light-headedness, and difficult or laboured breathing. Long-term exposure can lead to chronic, more serious health problems such as cardiovascular disease, cardiopulmonary disease and lung cancer.

For these reasons and also because the international mining community had set standards to control the levels of diesel emissions in the mines, the local mining industry requested the CSIR to investigate the extent of the problem.

The research was solicited despite the fact that there was, and still is, no legislation guiding local mines on the safe levels of diesel exhaust permitted underground.

The aim of the research was also to determine how big the diesel emission problem was and to make recommendations on how to limit worker exposure.

"Our study indicated levels exceeding the internationally acceptable standard of diesel emissions," says Van Dyk. She says the CSIR is one of few institutions in the country that have a facility to analyse for diesel particulate matter.

Subsequent to these findings, the CSIR made a number of recommendations that the mines could use to reduce the problem. "Though the research was completed in 2007, we still do DPM studies for the mining industry from time to time," says Van Dyk.

"During our research we also learnt that diesel with lower sulphur content produced less emissions than diesel with the normal sulphur content," she says. Some mines are already implementing and benefitting from these guidelines. – ***Kamogelo Seekoei***

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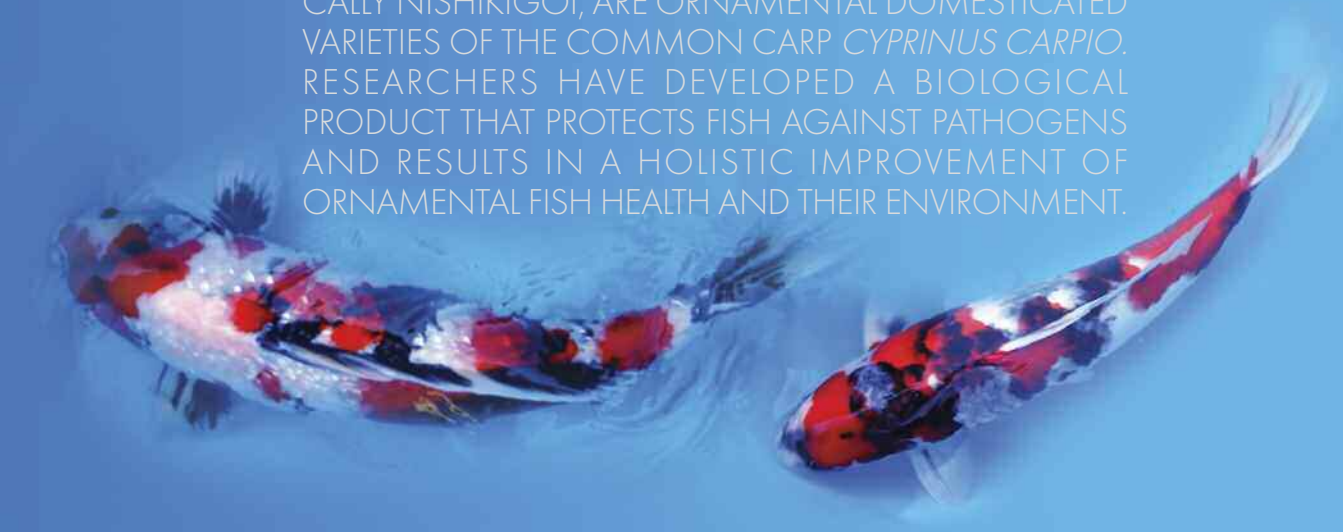
NOVEL ORNAMENTAL FISH PROPHYLACTIC:

FROM CONCEPT TO MARKET

SPRINGTIME OR ULCER DISEASE IS A COMMON ILLNESS AFFECTING KOI FISH. KOI, OR MORE SPECIFICALLY NISHIKIGOI, ARE ORNAMENTAL DOMESTICATED VARIETIES OF THE COMMON CARP *CYPRINUS CARPIO*. RESEARCHERS HAVE DEVELOPED A BIOLOGICAL PRODUCT THAT PROTECTS FISH AGAINST PATHOGENS AND RESULTS IN A HOLISTIC IMPROVEMENT OF ORNAMENTAL FISH HEALTH AND THEIR ENVIRONMENT.



THE SENSITIVE IMMUNE SYSTEMS of Koi are easily weakened by parasitic infections and changes in their environmental conditions. Pathogenic bacteria infect weakened fish, resulting in diseases such as haemorrhagic septicaemia and ulcerative ethyrodermatitis. Strategies focused on reducing pathogenic microbial load and the concentration of waste metabolites such as ammonium, nitrate and phosphate are an essential component of ornamental fish husbandry.

In January 2004, with about R5 million funding from BioPAD, Raj Lalloo, at the CSIR and his team of process bioscientists initiated a three-year project to look into the development of a biological agent to add value to the ornamental fish industry.

"Chemical treatments are an option but are costly, environmentally harmful and result in enhanced resistance of pathogenic organisms. Biological treatment is an emerging alternative because it offers potential for the reduction in the concentration of pathogenic bacterial species and waste metabolites, resulting in a holistic improvement in fish health," explains Lalloo.

According to Lalloo, during the early 2000s the market required a prophylactic against ulcer disease that does not contain chemicals or antibiotics, that improved water quality, prevented algal blooms and a product that could remain stable along the supply chain to the end-point of use. The product was also expected to enhance general health and growth of the aquatic species and reduce organic load to prevent clogging of the filtration systems used in reticulated aquaculture.

"The culture of fish in intensive reticulated systems results in waste accumulation, disease proliferation and negative environmental impact," he explains, but this practice is growing to satisfy the global demand for fish protein.

Lalloo and his group are experienced in the transfer of technology into process and product development and technology packages for commercial applications. The group tapped into that knowledge and focused on improving environmental conditions to find the best solution for this niche-market. "Our primary research aim was to isolate, select and evaluate *Bacillus spp* as a potential biological agent for the enhancement of water quality in the culture of ornamental fish," adds Lalloo. Experiments with *Bacillus spp* proved an inhibitory effect on pathogen growth and decreases in concentrations of waste ions. The bacterium was sourced from natural environments in Gauteng.

The resultant product prototype was evaluated *in vitro* and *in vivo* using actual fish.

"Studies showed that spores of *Bacillus spp* have an advantage over vegetative cells because they remain stable for long periods, can be formulated into useful commercial products, are widely used as biological agents, possess antagonistic effects on pathogens and are naturally ingested by animals," he says.

Next followed the true test – applying the product in a commercial context. The technology was subsequently licenced to BaoBio Holdings and packaged under the same name. In addition to the South African market, the product is distributed as far afield as China, Australia and European Union countries while it is under-going further tests in the United States.

The product range has been expanded to seven offerings that purify pond water, boosts biological activity including treating specific fish ailments.

"We've so far had a positive response to the product and are currently selling about 4 000-5 000 units per annum. Some of our other products have been tested for the veterinary market. This is expected to take off in 2009," reveals Tracey Gardiner, the marketing manager.

Lalloo also added that the project allowed the training of several students and resulted in four publications. The first generation technology resulted in royalties to stakeholders and the expansion of this technology into edible aquaculture will have a significant impact on fish availability in developing countries. – ***Asha Speckman (with additional information from en.wikipedia.org)***

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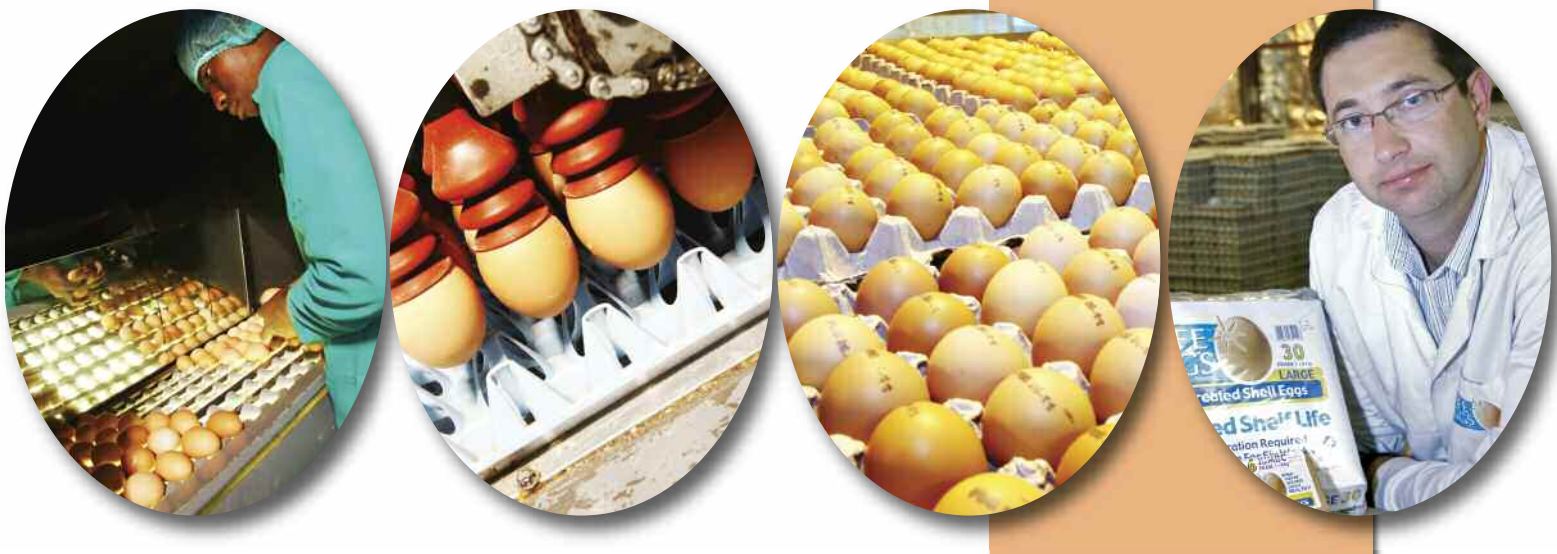
THEN... Annali Jacobs, a researcher, demonstrates the pilot plant

THE BIRTH OF A SAFER EGG IN SOUTH AFRICA

NOW... The commercial pasteurisation plant consists of a series of machines working in tandem

In November 2005, the CSIR put South Africa on the map with regard to food safety when a research consortium led by its bioscientists successfully developed a novel pasteurisation system. This system primarily employs microwave technology to greatly reduce the risk of *Salmonella enteritidis* infections acquired from eggs and resulted in the first sales of pasteurised, whole shell eggs in South Africa.



According to business manager, Ewerd Ras (top right), the Safe Eggs range will expand nationally and internationally

A RESEARCH CONSORTIUM was formed with financial support from the South African Innovation Fund. Food scientists and microbiologists at the CSIR, sensory evaluation experts at the University of Pretoria, design engineering experts from Delphius Technologies and commercial experts from Eggbert Eggs, pooled their knowledge to produce a home-grown success story.

The researchers and industry partners developed a system that harnesses microwave and dry heat technology. The initial concept consisted of a rolling bed of eggs, with eight lanes. The eggs were heated to an even temperature varying between 54 and 58 degrees Celsius, depending on the oven power and exposure time settings. A novel microwave cavity design was developed in order to prevent overheating of eggs. Infrared sensors were used to monitor egg processing quality control; giving an indication of the egg shell temperature of each individual egg, which highly correlated with egg internal temperature. Egg internal temperatures were measured using optic fibre technology.

Target temperatures for processing were determined based on inoculating *Salmonella enteritidis* in known quantities into the eggs, and determining survival rates after heat exposure. Specific challenges regarding egg temperature distribution, inoculation methods and ensuring repeatable results suitable for quality control, had to be overcome.

Microwave heat absorption is affected by various parameters, of which weight distribution and egg shape are the most important. Specific challenges linked to the variability of size, shape and weight of eggs had to be addressed, as current egg classification standards were not specific enough to allow for a narrow range of heat absorption.

Studies comparing the effects of the pasteurisation system on the levels of *Salmonella enteritidis* indicated that the CSIR-developed process contributes significantly to whole egg safety.

According to the project leader, Dr Corinda Erasmus, the primary aim of the research was to design and develop an effective pasteurisation system to produce raw eggs free from *Salmonella enteritidis* and other Salmonella contaminants with the same sensory and functional properties as untreated eggs.

"The secondary aim," says Erasmus, "was to have a dry pasteurisation system to replace the need for dipping eggs in water as a heat transfer medium." Treating eggs in water results in additional challenges such as destruction of the natural protective wax layer on egg shells, and contamination of the egg contents by water leaking into the shell's porous structure.

Prior to the CSIR-developed method of microwave pasteurisation, there were only two other established egg pasteurisation methods in the world. Water-based pasteurisation is an innovation from America while the Europeans created steam pasteurisation. Apart from water pasteurisation causing egg damage, the handling of heated water and steam also poses a human safety risk.

Safe Eggs (Pty) Ltd currently holds the exclusive worldwide rights to the patented technology previously sub-licenced to Eggbert Eggs, a large commercial egg distributor. Since January 2008 the company has been owned by entities not directly supplying other eggs to the market. It is focusing exclusively on growing sales of pasteurised shell eggs.

According to Ewerd Ras, business manager for Safe Eggs, the plant based on the outskirts of Pretoria channels about 60 000 eggs through the 42 minute per load process per day. Major retail groups such as Spar and Checkers have incorporated the Safe Eggs range into their product lines. The eggs have an extended shelf life with no refrigeration required.

"The consumer response has been good. South Africans are not very health conscious yet, but that too seems to be changing," says Ras. The first batch of pasteurised eggs were introduced to Western Cape consumers in November 2008. The Innovation Fund, managed by the National Research Foundation, is considering financing the addition of a smaller, automated and updated version of the pasteurisation machine while there is talk of making this technology available to farmers in the future.

According to Fanie Marais, contract research and development manager at the CSIR, the technology has already been patented in the European Union with other international patent applications pending. "The current royalty stream is about R100 000 per annum, but the project has significant growth potential for 2009 and in the longer term," he says. – ***Asha Speckman***

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TECHNOLOGY IN SUPPORT OF THE FOOD INDUSTRY

ANALYSES CONDUCTED AT THE ACCREDITED FOOD AND BEVERAGES ANALYSIS LABORATORY OF THE CSIR IN CAPE TOWN ARE FUNDAMENTAL TO THE SUCCESS OF THE SOUTH AFRICAN FOOD INDUSTRY.

SANAS (South African National Accreditation System) accreditation ensures analytical methods used by the lab, and the results achieved from the analyses, are traceable to international standards. Regular internal and third party audits are conducted by independent quality representatives to measure compliance with the ISO17025 standard.

The current lab evolved from the Fishing Industry Research Institute (FIRI), started in 1947 by the fishing industry in collaboration with the CSIR. This institute was controlled and funded by the fishing industry. The current laboratory, which still has strong links with the fishing industry, is destined to expand into a centre of excellence in a variety of food analysis areas. Lab manager André Munian's previous experience includes being a chemical analyst, research scientist and technical manager.

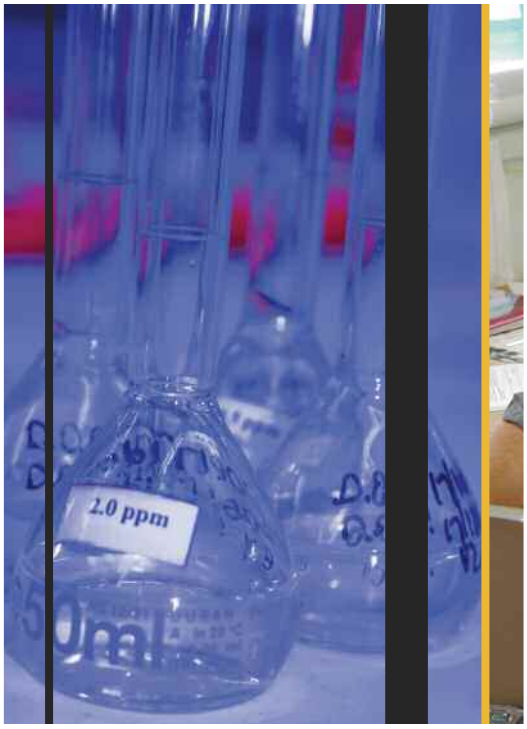
The food and beverages analysis lab provides chemical analytical services to external customers in both the public and private sectors. "Some of our key activities involve quality evaluations for export requirements (fish, shellfish and other foods and beverages), the compilation of nutritional profiles (primarily for labelling purposes), and biotoxin testing in shellfish and other foods," explains Munian. The laboratory is the only one of its kind in southern Africa equipped to test for marine bio-toxins in shellfish products in support of the shellfish monitoring programme.

QUALITY EVALUATIONS FOR EXPORT REQUIREMENTS

"Primarily fish and shellfish, but also other food products, exported to the European Union (EU), legally require analytical tests for contaminants," comments Munian. The South African Bureau of Standards (SABS) administers these compulsory food specifications on behalf of the Ministry of Trade and Industry, with the CSIR performing the food sample analysis for the SABS. "Metal contaminants found in fish are linked to the pollution of our oceans and tuna caught off the South African coastline is regularly tested for mercury," he says.

Histamine tests to detect human allergic reactions to fish are mostly performed on tuna in this CSIR lab. "Histamines in fish can cause allergic reactions in humans, ranging from mild skin discomforts to nausea, vomiting and diarrhoea," explains Munian. Seafood contains high concentrations of non-protein nitrogen and is highly susceptible to spoilage and deterioration caused by autolysis (the process of self-destruction of a cell or tissue through the action of enzymes) and growth of the *post mortem* microbial population.

The lab does total volatile basic nitrogen (TVB-N) analyses to provide an index on the decomposition of fish to manage the freshness of fish products. Peroxide value (PV) analyses are also done to measure rancidity in fish and fish products. Histamine and heavy metal analyses are prerequisites for fish exports from South Africa to the EU.



Andre Munian, laboratory manager, and Fikree van Niekerk (opposite page), project leader

BIO-TOXIN TESTING

"As the only lab in southern Africa to analyse bio-toxins in aqua-cultures, our work is undoubtedly of national importance to public health and the South African shellfish industry," says Munian. The lab also offers its expertise to Namibia. The most common tests performed on aqua-cultures include testing for paralytic shellfish poisoning (PSP), which can cause paralysis of the lungs in humans and could be fatal; diarrhoetic shellfish poisoning (DSP), which causes diarrhoea and is mostly found in Namibian aqua-cultures – although DSP was recently also found in aqua-cultures on the west coast of South Africa – and amnesiac shellfish poisoning (ASP) associated with red tide, which causes vomiting and diarrhoea and also neurological symptoms in severe cases.

NUTRITIONAL PROFILING

"Nutritional labelling and food safety are a novel section of our lab," remarks Munian. Analyses performed are used for commercial food labels and include fatty acid profiling (mono-poly-unsaturated, saturated, trans fatty acids) and fibre analyses (dietary, crude, soluble and insoluble), including work on fructo-oligo-saccharides (FOS), a naturally-occurring fibre found in unprocessed fruits and vegetables that promotes gastrointestinal wellness.

"This is the only laboratory in the country that has done work in the measurement of FOS and resistant starch (RS). These two components are responsible for many health benefits associated with dietary fibre," he says.

This section of the lab provided ground-breaking input for the draft legislation on food labelling in South Africa.

Specialised equipment used includes:

- An atomic absorption spectroscope (AAS) used for the detection of cadmium and lead; with the attachment of the vapour generation atomisation component (VGL), the AAS can also read mercury
- A gas chromatograph (GC) used in the analysis of cholesterol and fatty acid composition
- High-liquid performance chromatography equipment (HPLC) used in the analysis of histamines and ASPs
- Inductively-coupled plasma (ICP) equipment used in the analysis of cadmium and lead, and several other heavy metals.

The 15 staff members all have qualifications in food technology and analytical chemistry. Negotiations for research collaboration with the Cape Peninsula University of Technology are in the final stages and the vision of expanding food safety analyses seems set to become a reality soon.

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CSIR AND ARMSCOR SET STANDARD FOR VEHICLE

LANDMINE PROTECTION

BY DAVID REINECKE

VEHICLE LANDMINE PROTECTION RESEARCH AND VALIDATION TESTING THAT IS LOCALLY INDEPENDENT, AND GLOBALLY RELEVANT AND RECOGNISED, WILL EFFECT INTERNATIONAL COMPETITIVE ADVANTAGE AND ACCEPTANCE. THE CSIR OFFERS COST-EFFECTIVE, WORLD-CLASS EXPERTISE IN THIS FIELD.

While South African defence personnel are providing only peace keeping support in areas such as Burundi and the Democratic Republic of Congo, their military vehicles are likely to travel in areas with buried landmines. Driving in a vehicle that can offer a degree of protection, provides safety and some comfort to occupants. Hence the importance of military vehicles with landmine protection as a design feature.

Military vehicle acquisition programmes normally require that any product offered must have its landmine protection level independently verified in accordance with an internationally-accepted test standard.

South Africa currently applies two open (accessible, within reason, by all stakeholders) test standards for vehicle landmine protection: the South African and NATO test standards, called RSA-MIL-STD-37 Issue 3 and AEP-55 Volume 2 Edition 1. South Africa was the first to issue an open test standard in 2000; Issue 3 signifies that it has been updated three times. The NATO test standard was issued in September 2006.

THE NATIONAL AUTHORITY TEAM

The CSIR's landward sciences research area, in partnership with ARMSCOR, is the South African National Test Authority with respect to vehicle validation testing. Validation testing is different from certification testing in that the latter is more expensive as it requires a very specific, fully-equipped vehicle.

The CSIR is responsible for executing independent validation tests that include all planning, management and technical activities as well as the final report. As such, the CSIR is the custodian of the test standard and the equipment required to execute validation tests, while ARMSCOR is responsible for the verification of the test item and compliance to the test standard and test instruction.

STANDARDS TEST METHODOLOGY: STEP BY STEP

The inputs and sequence required for validation testing are specified by RSA-MIL-STD-37. The validation of the test item involves physical inspection and the evaluation of the protection systems and levels offered. This presentation by the supplier includes computational modelling and test results.

The first step is the verification of the test item and its suitability for blast testing. This is important as the equipment used for these tests is extremely expensive and should be protected as far as possible. The test item should, therefore, be able to withstand the test charge.

The next step is the drafting and approval of the test instruction by the test team.
A large number of preparations need to be done prior to the test. For instance, all the surrogate charges are to be manufactured and checked, which includes non-destructive testing and ratification by ARMSCOR. All the test equipment and facilities are prepared and the human response equipment is drop tested. These results are compared to previous data as a benchmark to ensure that the test equipment is functioning correctly.

These data are diverse and are primarily based on Hybrid III crash test dummies instrumented to measure landmine blast effects.

SIIMA

High-speed video images of blast

Time 0

Time 0.3 milliseconds

Time 2.4 milliseconds

Time 4.5 milliseconds

Other equipment parameters are external and internal (inside the test item) high-speed video, pressure, acceleration, strain and displacement. An important aspect is that all transducers used for measurements must be synchronised with the detonation, ensuring the 'same time' baseline to enable comparable and correlated data. This emphasises the importance of pre-test preparations.

The two test standards require different approaches. For AEP-55 Volume 2 tests, soil pits are filled with new soil and compacted. The soil characteristics are tested for density and moisture content prior to the test and adjusted to meet the requirements. RSA-MIL-STD-37 tests at the CSIR Detonics, Ballistics and Explosive Laboratory are conducted with a dynamic cone penetrometer (used for measuring the penetrating power of radiation) for consistency.

Once the test set-up is approved, an initial booster test using approximately 200 g of explosive is executed to ensure that all equipment is functioning and that all critical human response parameters are being measured.

Additional booster tests are conducted prior to the main test. This cautious approach is required because validation tests are by nature destructive; the test items are expensive to manufacture; and it is crucial that data be captured correctly.

After the booster test, the main test is executed with the specified surrogate charge. Only once the test area is declared safe, is the test team allowed forward and are the required test data downloaded and analysed. This verifies that all required data have been captured and assists the team with the damage inspection. All items destroyed or damaged are recorded along with the crater dimensions.

Vehicle damage assessment is a requirement of the AEP-55 Volume 2 tests. On completion of the damage assessment, the test item is either removed or repaired by the supplier at the range; these tests do not require the team's presence during the repair process.

A full reparability evaluation in the presence of and in conjunction with the responsible defence force personnel is a requirement of RSA-MIL-STD-37 tests. The test item is removed and repaired offsite with the test team present.

After the repairs, the test item is inspected and verified as safe to continue by the test team. All repairs executed are recorded and a second test is conducted.

Subsequently, the test data are reviewed and all critical parameters are compared to other measured data to verify the results and ensure that there are no anomalies between measurement equipment. It is important that visual (video and inspection photographs) and other data, such as pressure or force, correlate.

The compilation, review and finalisation of the test report follow next. RSA-MIL-STD-37 test data are evaluated and recommendations are made to improve and enhance the survivability and reparability of the vehicle. After the report is approved and the item has passed, the RSA-MIL-STD-37 officer in ARMSCOR requests the organisation to issue validation test certificates. AEP-55 Volume 2 tests are not strictly independent and recommendations are not mandatory.

FUTURE RESEARCH

Current testing standards are not perfect and require constant research and updating to ensure that the best possible methodology is used. Some criteria, such as those used for the lower limb, are heavily disputed and are typically the main criteria that vehicles fail.

The CSIR's landwards sciences experts form part of the NATO Research and Technology Organization's panel Task Group 148, responsible for updating AEP-55 Volume 2 test standards and developing AEP-55 Volume 3. The latter is the test standard for protection levels of vehicles against improvised explosive devices (IEDs). As part of this NATO initiative and in response to future research requirements, scientists are researching the effects of blast IEDs on vehicles. This is primarily focused on scaled testing but will be further developed to update RSA-MIL-STD-37.

The scientifically instrumented impulse measuring apparatus (SIIMA) was developed to research comparatively various parameters that affect blast loading (i.e. the pressure/force and impulse applied). It enables the landmine threat to be characterised and surrogate mines to be developed and qualified. SIIMA takes all close field explosive effects into account in measuring the total blast impulse of a charge. Current areas of research are the effect of the steel pot vs. buried charges (a repeatable scientific representation of the mine), the depth of burial and the effect of moisture content in the soil on the blast impulse and ultimately, the vehicle.

Although extensive research has been executed about blast effects on human beings, no standard surrogate or test method has been developed for validating demining and personal protective equipment systems for explosive disposal. The results of this research can be used to validate current pressure criteria and enable protection systems to be developed for blast pressure. This is of particular importance to IED testing and injury criteria.

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HEAVY VEHICLE SIMULATION LEADS TO IMPROVED ROAD NETWORKS

THE HEAVY vehicle simulator (HVS) is a road-testing machine that simulates the damage caused by heavy traffic to road structures.

This accelerated pavement testing facility was developed and upgraded by the CSIR and its technology and commercialisation partner, Dynatest, over the past four decades. The facility simulates the traffic-associated deterioration of a road over its design life (usually 20 years) in as little as three months.

The HVS is essentially a high-tech field laboratory often used on real in-service road structures. It uses unique instruments to measure and analyse the engineering performance of the road structure and individual material layers. This enables the prediction of the long-term performance of new road materials and designs, as well as the optimisation of road designs, through the testing of trial sections well ahead of their implementation in practice, thus saving costs and avoiding expensive failures.

The South African National Road Agency Ltd (SANRAL), Gautrans, the Cement and Concrete Institute (C&CI) and the CSIR started a concrete research programme in 2003 to address the current shortcomings in the South African mechanistically-based concrete pavement design manual. To date, four different studies have been completed with the HVS facility. The outcome of this research has been so successful that SANRAL has put out tenders for a full-scale rehabilitation project on major freeways using a specialised rehabilitation method after the validation using the HVS.

The application of labour-intensive construction techniques is of special relevance to South Africa. The HVS programme has investigated road building techniques constructed in this way since 1997.

The HVS has had a significant impact on the development of pavement engineering over the past four decades, resulting in significant savings in road building and rehabilitation costs.

The international HVS programme has generated foreign income of more than R200 million for South Africa over the past 15 years.

Internationally, the CSIR is recognised as one of the global leaders in road design and pavement performance evaluation.

The success of South Africa's HVS research programme has led to the export of the technology platform and equipment to China, Finland/Sweden, India and the USA. By April 2009, a total of 10 HVS units will be in operation worldwide.

The international HVS programme has generated foreign income of more than R200 million for South Africa over the past 15 years. – *Hilda van Rooyen*

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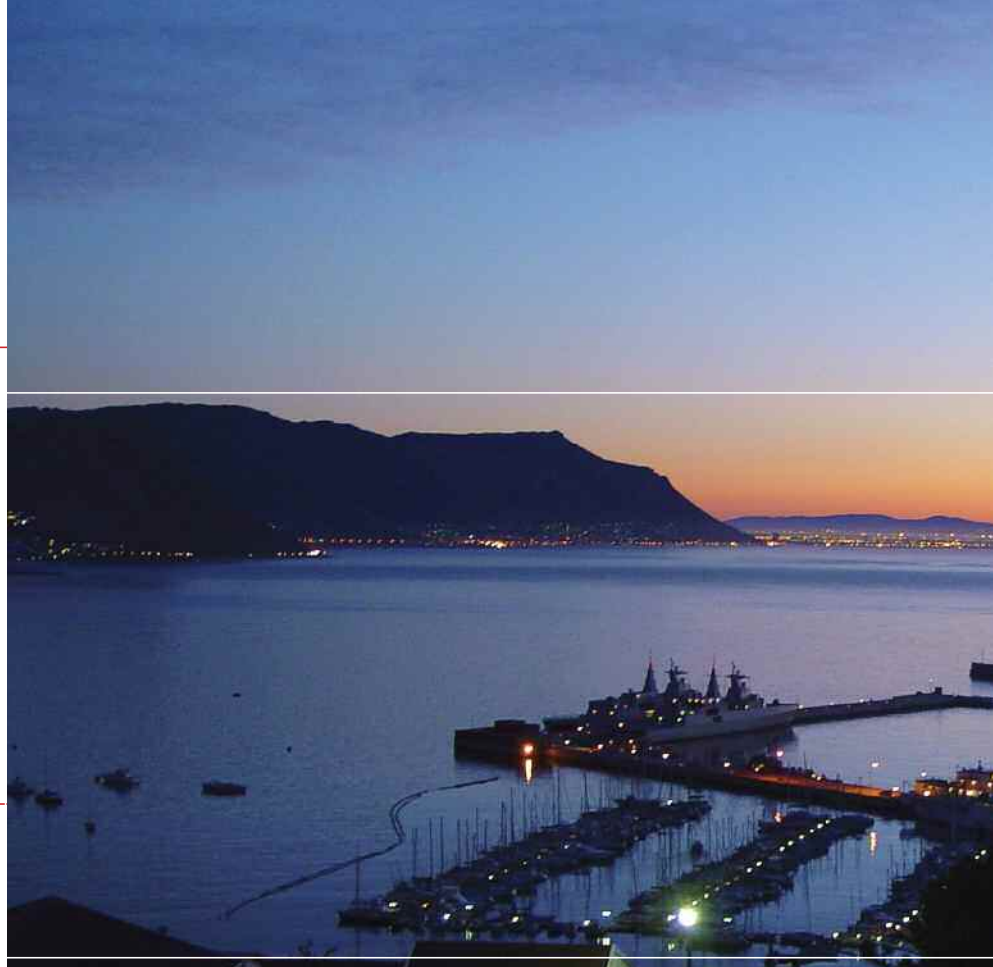
SUPPORTING PROUDLY SOUTH AFRICAN RADAR INNOVATIONS



THE CSIR'S RADAR EXPERTS CONTINUE TO SUPPORT THE SOUTH AFRICAN NATIONAL DEFENCE FORCE (SANDF) AND LOCAL INDUSTRY WITH PROUDLY SOUTH AFRICAN INNOVATIONS INCLUDING MILLIMETRE WAVE TRACKING RADARS, RADARS ON THE SOUTH AFRICAN NAVY'S NEW VALOUR CLASS FRIGATES, AND A NEW CLASS OF PERSISTENT, WIDE AREA SURVEILLANCE RADAR INNOVATIONS.

THE OPTRONIC RADAR TRACKERS (ORT) onboard the South African Navy's new frigates are proudly South African in all aspects – researched, developed and manufactured in South Africa.

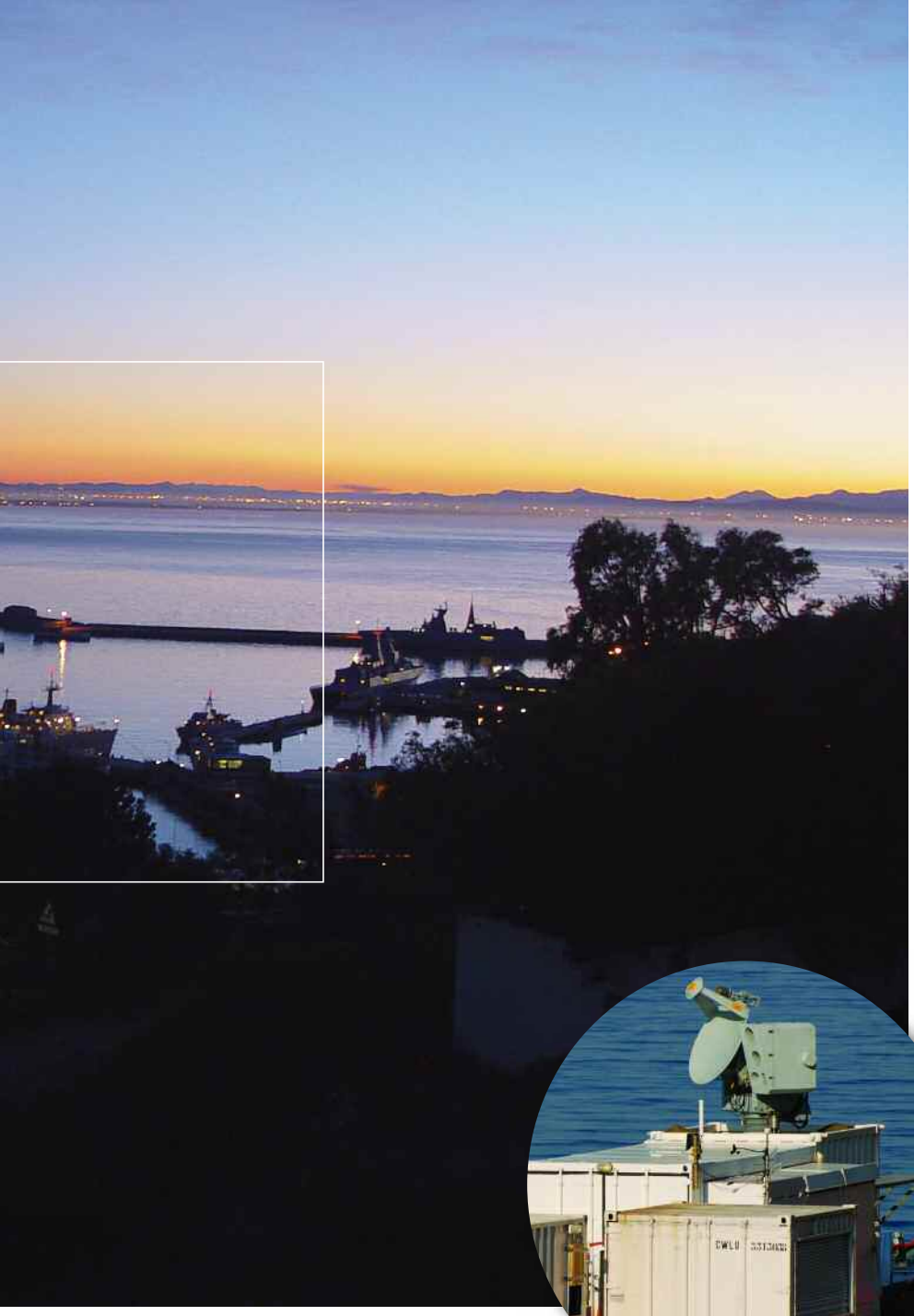
These trackers are based on pulse Doppler radar technologies that were designed and developed by the CSIR. The ORT products were developed and manufactured by Reutech Radar Systems (RRS). RRS also ensured their successful integration on the SA Navy's Valour class frigates. (See http://www.rrs.co.za/products/tracking-systems.html for more information).

RRS was established in 1987 to become a South African radar system house. Its first radar development project was a search and acquisition radar for a mobile air defence system. The CSIR started developing tracking radar technology in South Africa during the early 1980s. The CSIR's Francois Anderson says Armscor then contracted RRS to industrialise "some of the technologies we developed here". "We transferred millimetre wave, monopulse tracking radar technologies to RRS during the early 1990s. Based on this it developed a short range, millimetre wave optronics radar tracker, designated the ETS 2200 that was later offered to the South African Army's Ground Based Air Defence Formation," he says.

In the mean time, the CSIR developed pulse Doppler radar technology during the 1990s on a technology development project funded by the South African Department of Defence (DOD). The technology was demonstrated by means of a bread board radar under laboratory conditions.

"Later during the 1990s, the Navy commissioned the CSIR to perform a detailed study into radar concepts that could meet the stringent requirements for tracking systems for its proposed fleet of new frigates." The Navy, says Anderson, concluded that South African tracking radar technology was mature enough to include in its system concept and placed a contract on RRS to develop the required trackers with the support of the CSIR. Due to the short delivery times required by the SA Navy it was not possible to perform a full technology transfer to the RRS. The latter, therefore, subcontracted the CSIR to design, develop, build, test and deliver the wide band monopulse antennas and pulse Doppler signal processors required for the ORTs, based on RRS's product specifications.

The ORTs were integrated and tested by RRS, then integrated on the ships and started entering their operational deployment phase in 2006 after passing their factory, harbour and sea acceptance tests. These radars now



form part of the self defence systems of the ships. They are capable of acquiring and tracking airborne threats such as sea skimming missiles out to the radar horizon. "They form part of the eyes of the ship," he says. "The tracking systems provide highly accurate and real time information about airborne and surface targets, day and night and under all weather conditions."

"One of the major advantages of developing and producing these trackers locally is that the system design authority is now local, making it possible to upgrade the trackers as new requirements are developed. In addition, the ORTs were fitted with some of the most advanced suites of electronic countermeasures (ECCMs) to protect them from interference by enemy jammers. These types of measures are usually considered very sensitive by exporters of radar systems and are often disabled in the export versions of their products."

Another advantage of the local development and production of the ORTs, according to Anderson, was that a high percentage of the R350 million development and production contract was spent in South Africa, creating jobs and resulting in taxes returning to the South African fiscus. However, the greatest benefit arguably lies in the further investment in the knowledge economy in defence electronic systems established during the previous 25 years in South Africa. This strengthened the elements of a South African industrial cluster in modern radar systems, which is now starting to establish itself in some international, competitive niche markets.

Early on in the development programme of the ORTs, the decision was made to follow a spiral development process with stage gates between subsequent baselines of the system. This approach is made possible by the extensive use of digital waveform generators, signal processors and data processors in the ORTs, allowing very substantial improvements to be integrated over time without having to make extensive modifications to the hardware baseline of the system. To gain maximum advantage from this approach, the joint Navy, DOD Technology Management, Armscor, industry and CSIR team agreed to the following:

- Establishment of a Tracker User Workgroup (TUW) consisting of members from all five these parties that meet regularly. The objective is to review experiences with the operational systems as well as changed employment conditions and user requirements. Based on this, the TUW establishes a prioritised task list of changes and additional functions required of the ORTs.

- The DOD allocates funding to acquire a containerised pulse Doppler radar laboratory that can be used to

FOLLOWING THE SUCCESSFUL DEVELOPMENT OF PULSE DOPPLER TRACKING RADAR TECHNOLOGY, THE CSIR IDENTIFIED AN IMPORTANT NEW REQUIREMENT FOR A RADAR-BASED INNOVATION IN SOUTHERN AFRICA.

develop and verify upgrades to the sensors of the ORT and validate and accredit them for operational use during tests under realistic operational conditions.

- The DOD continues funding the research and development team at the CSIR to make use of the above inputs and resources and continue with the advanced development of prioritised functions to the required technology readiness levels. Having passed the validation tests they are transferred to RRS, the design authority of the ORTs. RRS then takes responsibility for integration, testing and release back into service of the upgraded operational systems on board the Navy's ships.

Anderson says that this plan was implemented and is still being followed today. The radar laboratory was jointly developed and built by RRS and the CSIR. It was named MECORT and came into full service during 2007. Since then, it has already been deployed three times near the sea in the Cape Peninsula. In between deployments it is also used for R&D tasks from its permanent base on the CSIR campus in Pretoria.

One of the important improvements developed at the CSIR and tested in MECORT is a new technique to measure the elevation angle of a low flying target over the sea, such as a sea-skimming missile. This technique was proven to improve the elevation angle measurement accuracy of measurements contaminated by reflections off the sea by as much as 10 times. This was measured during tests where low flying jet aircraft were used to simulate sea skimming missiles flying towards MECORT. Another important objective of the continuing development programme is to develop ECCMs against new types of interference and jamming that may be encountered under operational conditions.

The ORT type trackers have other applications apart from those of the Navy. In a study performed for the South African Army's Ground Based Air Defence Formation it was found that many of its requirements for the

"WE INTEND TO CONTINUE WITH RADAR RESEARCH AND DEVELOPMENT AT THE CSIR AND WANT TO SUPPORT RRS AND OTHER SOUTH AFRICAN INDUSTRIES ACTIVE IN THE GENERAL FIELD OF RADAR AND ITS SUBSYSTEMS TO BE WORLD-CLASS EXPORTERS OF RADAR RELATED PRODUCTS," SAYS ANDERSON.

tracker of a next generation air defence system can be satisfied by a radar very similar to the ORT. Should it decide to acquire such a radar locally, it would further stimulate and strengthen the South African radar capability and its value to the country.

Following the successful development of pulse Doppler tracking radar technology, the CSIR identified an important new requirement for radar-based innovations in southern Africa. These are integrated real time sensing systems capable of sensing, detecting, tracking and classifying multiple entities of interest over broad areas (tens to hundreds of kilometres), over long periods (one to three weeks), with relatively short update periods (one to ten seconds) and in all weather conditions, day and night. The aim of such systems would be to provide rich information to commanders in command and control centres tasked with ensuring national security. This should greatly enhance their situation awareness and thereby provide them with an edge in decision-making relative to the criminals, rebels, bandits and other negative forces threatening national security. Important applications are foreseen to be the security around major events such as the 2010 FIFA Soccer World Cup, air, land and sea borderline protection and peace keeping operations in Africa. The CSIR embarked on this programme, dubbed AwareNet, during 2004.

It is expected that the AwareNet programme will establish persistent, ubiquitous surveillance technologies on which a number of South African innovations in this general field of applications can be based. "Some initial research phase outcomes are already being contracted for transfer and use in radars developed by industry for overseas clients.

"We intend to continue with radar research and development at the CSIR and want to support RRS and other South African industries active in the general field of radar and its subsystems to be world-class exporters of radar related products," says Anderson.
The concept of an industrial cluster (or Centre of Competence as foreseen by the Department of Science and Technology) was taken a step forward in January 2008 when Armscor, the CSIR, the Institute for Maritime Technology (IMT), the universities of Stellenbosch and Cape Town as well as industry partners RRS and Denel Dynamics, established an organisation called the South African Radar Interest Group (SARIG), to define and manage the development of a radar cluster in South Africa. "This capability in radar research, development and production is quite unusual for a developing country," he says. "Our aim is to develop a South African cluster of related organisations interested in collaborating with each other to develop and produce radar-based innovations that will prove to be effective and competitive worldwide." – *Mzimasi Gcukumana*

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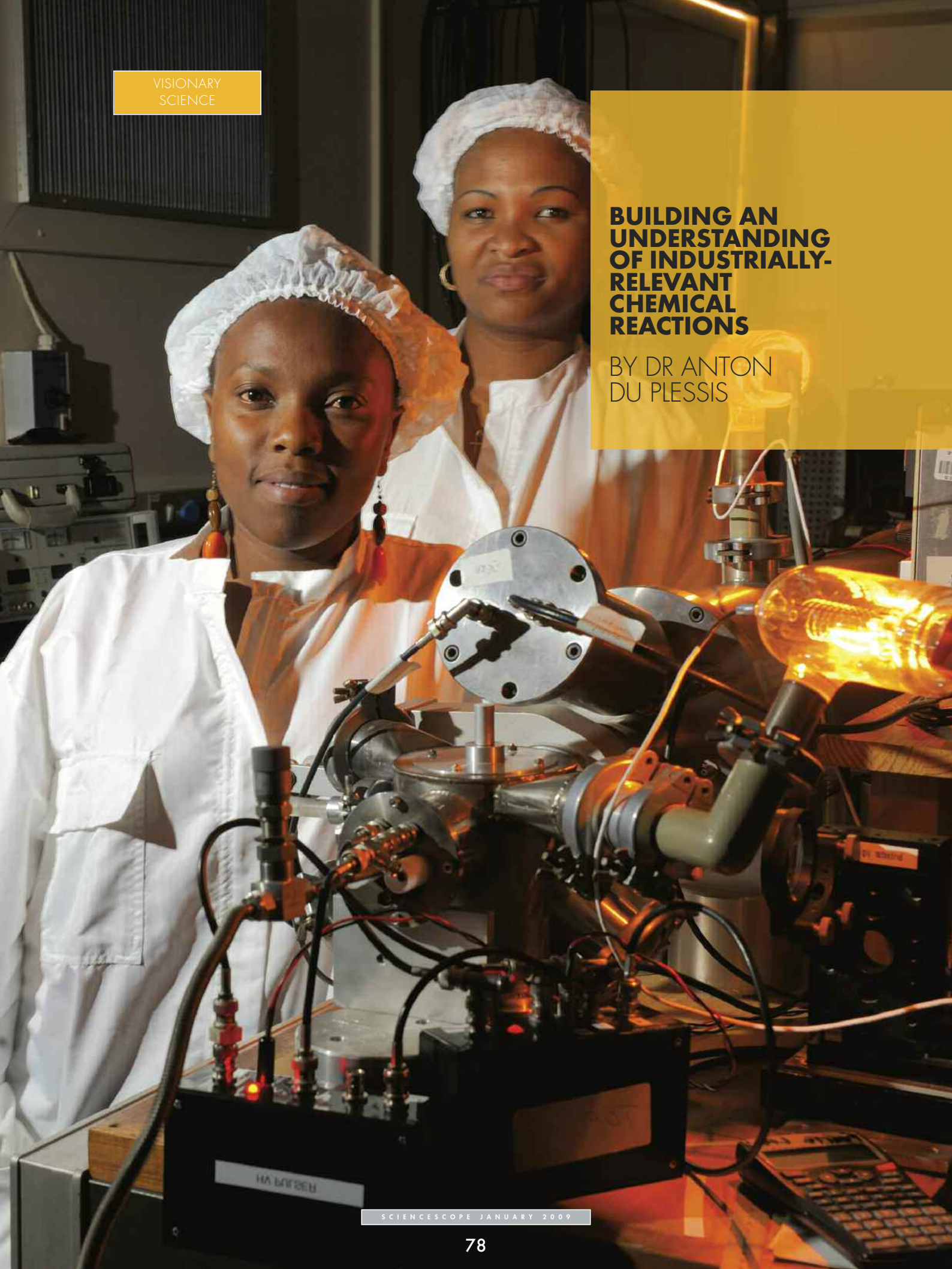

BUILDING AN UNDERSTANDING OF INDUSTRIALLY-RELEVANT CHEMICAL REACTIONS

BY DR ANTON DU PLESSIS

FEMTOSECOND SCIENCE:

THE NEXT FRONTIER

FEMTOSECOND LASER SCIENCE is one of the fastest growing research fields in laser science today. It is a field of research and technology utilising state-of-the-art laser systems delivering extremely short pulses with high peak intensities, in particular pulses in the femtosecond regime. Over the past ten years, these lasers have gradually become commercially-available, which has resulted in an upsurge in this field of research. One femtosecond (fs) is equal to one millionth of a billionth of a second (10^{-15}s). This is an extremely short unit of time: small molecules typically take a few hundred femtoseconds to complete one vibration. This is exactly one of the advantages of such short pulses; they are so short that they can be used to measure extremely fast processes, down to the femtosecond regime where no other time-resolved techniques exist.

In 2007, the CSIR established a femtosecond research group; and a versatile amplified femtosecond laser system was installed.

The CSIR uses the characteristic of the short temporal duration of femtosecond laser pulses to measure extremely fast biological and chemical processes. A technique called pump probe spectroscopy is used to measure absorption changes in liquid samples as fast as 150 femtoseconds, a first of its kind in Africa. Another major advantage of this technology is the extremely high peak powers that are obtained using these short pulses – allowing for a wide variety of interesting and novel applications.

For example, the technique of laser induced breakdown spectroscopy, which is an established laser spectroscopic technique for measuring trace quantities of elements in any material down to the parts-per-million (ppm) level in real time and without sample preparation, is made even more sensitive and accurate when using femtosecond laser pulses. One of the many advantages of this laser is the low mass ablation rates making precision sampling and depth profiling a reality. This is currently an active field of research in the femtosecond laboratory and forms part of a project for an industrial client, measuring trace metal concentrations in thin layers as a function of depth into the layer. This cannot be performed with other techniques without sample preparation and in a non-contact measurement setup.

Other active fields of research include laser ionisation time of flight mass spectroscopy, laser ablation and micromachining, and laser pulse shaping and diagnostics. This research is currently being undertaken in a combined effort to make a long-term impact in this exciting field and in particular in coherent control, but also to make an impact in the short-term by applying this technology to specific industrial problems.

Using femtosecond laser techniques, one can actually control chemical and biological reactions, a technique called coherent control. This is made possible through the coupling between frequency and time by the Heisenberg uncertainty principle. Applying this principle to, for example, 100 femtosecond laser pulses implies that these pulses must have a wavelength bandwidth or 'spread' of about 10 nanometres; entirely different from typical laser sources that are monochromatic (very narrow wavelength spread). This characteristic of femtosecond lasers makes it possible to excite molecules at exactly the same time but into adjacent excited energy levels, which is called a coherent excitation or wavepacket. Such a wavepacket after excitation coherently vibrates in the excited state and may then be manipulated further into an ionised state, a dissociating state or some other process can be initiated. By changing the laser pulse parameters and timing of subsequent pulses it actually becomes possible to control molecular processes. In principle, this means that chemical reactions may be controlled, for example a reaction that can produce either product A or B may be controlled to produce selectively more of A or more of B by simply changing certain laser parameters in real time. For example, in a chemical deposition process generating thin layers of material, the deposition process could possibly be improved in real time by coherent control techniques.

According to CSIR Interim Group Executive, Dr Thulani Dlamini, "The CSIR has seen the potential of this new technology and intends making an impact by becoming a world leader in niche application areas of femtosecond science. Our research is already looking at building an understanding of industrially-relevant chemical reactions and novel approaches to materials processing."

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Dr Kevin Wellington investigates multiple uses for an emerging class of enzymes found in fungi, plants and micro-organisms

GREEN CHEMISTRY: PROMOTING AN ENVIRONMENTALLY-FRIENDLY INDUSTRY

IN THE AGE OF A GREEN REVOLUTION AND EFFORTS TO SLOW THE EFFECTS OF GLOBAL WARMING AND CLIMATE CHANGE, THE INDUSTRIAL SECTOR IS CHALLENGED TO PLAY ITS FAIR SHARE IN PRESERVING THE EARTH AS WE KNOW IT.

Laccases are a class of enzymes that are gradually attracting interest for their potential in health and environmental research.

Dr Kevin Wellington, a CSIR bioscientist, is conducting novel research into the application of these enzymes in organic synthesis reactions to replace environmentally-unfriendly chemical oxidants. This could eventually go a long way in changing the effect of industry, especially the chemical and pharmaceutical industry, on the environment.

Laccases are defined as copper-containing oxidase enzymes found in plants, fungi and micro-organisms. Wellington is sourcing laccases from fungi for his study. "Laccases are internationally popular for bioremediation. Much research has been done to look at possible applications but I have not yet heard of it used in industrial organic synthesis applications," he says.

In addition to developing 'green' methods of synthesis, he is investigating the use of laccases as reaction catalysts to access compounds with anti-bacterial, anti-cancer and anti-tuberculosis (TB) activity – work that began in 2007. Wellington is modifying selected first-line TB drugs in an effort to circumvent resistance to these drugs by adding a part that has never been added before.

"The basis for our research is to provide answers to our questions: 'What can we do with laccases – can we use them to replace conventional chemical oxidants? Can we, through the use of laccases, access compounds with some pharmaceutical value? At the CSIR our aim is to eventually synthesise compounds that can be further developed to achieve enhanced activity against TB and cancer," he explains.

So far positive results have been obtained with regard to anti-cancer activity. "We had some success in the screening conducted in the cancer screening laboratory at the CSIR. Laccase products also inhibit the growth of some non-pathogenic bacteria, however, we need to do further studies to determine the cytotoxicity of these compounds."

According to Wellington, some very specific traits give enzymes an edge over chemical oxidants. Enzymes are substrate and region-specific and can be used at room temperature; reactions performed with enzymes require no or less organic solvent; enzymes are natural and if one has to dispose of them, are environmentally-friendly while chemical oxidants are often not.

Wellington maintains that research into laccases is very much visionary. "In terms of its applications it's more academic at this stage. The broadening of its applications, particularly in organic synthesis, is relatively new." – *Asha Speckman*

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A NOVEL, PLANT-BASED RABIES ANTIBODY IN THE PIPELINE

Dr Ereck Chakauya is masterminding the establishment of a new pharmaceutical company for the production of plant-based pharmaceuticals

HUMAN OR EQUINE BLOOD PLASMA has for generations sufficed as the major source of rabies immunoglobulin (RIG), a passive immunisation antibody administered in combination with a vaccine to rabies victims. Critical shortages of donor blood countrywide and common outbreak of rabies threaten the supply of this vital antibody. This spurred CSIR plant biotechnologists to investigate a promising alternative harvested from plants as well as the blueprint for a new pharmaceutical company.

Plants have been the source of many therapeutic proteins to treat diseases such as cancer and are lucrative natural factories for the production of health molecules due to their similarity to human cells and yeasts, among other reasons. They read the same genetic code and can assemble, fold and secrete complex proteins while offering the pharmaceutical industry one of the trendiest and economical options to grow safe, pure and highly efficacious therapeutics.

According to the National Bioproducts Institute, the sole manufacturer and supplier of RIG, stocks of its anti-rabies product, Rabigam, reached critical shortage following outbreaks of rabies in KwaZulu-Natal, Mpumalanga and Limpopo. Not only is rabies a problem in South Africa, it is also a challenge to Indian and Chinese health authorities, explains Dr Ereck Chakauya, who manages the CSIR's project.

"Statistics produced in 2008 reveal that about 450 000 cases and 50 000 laboratory confirmed deaths are reported per annum in mainly Africa and Asia. More than 10 million people worldwide are vaccinated annually against rabies. The scope of this disease is growing, however, due to poor human health systems, inadequate prevention regimes and limited infrastructure for *post mortem* and laboratory analysis. In Africa especially, it is estimated that the number of human fatalities from rabies may be 20-100 times higher than reported," says Chakauya.

Rabies is a viral disease occurring in mammals and is usually spread through the bite of a rabid animal. If not treated immediately, it can infect the central nervous system, institute inflammation of the brain and ultimately result in death.

In mid-2008 the CSIR made a breakthrough when experiments to produce an antibody in plants against rabies passed several tests in the laboratory.

"Our *in vitro* data suggested that the plant-made monoclonal antibody neutralises most rabies strains," reveals Dr Rachel Chikwamba, the principal investigator. Samples were subsequently forwarded to the collaborative partner for trials in animal models.

Antibodies are naturally occurring molecules that bind to and neutralise antigens and are classified as either polyclonal or monoclonal. The latter antibody is programmed to recognise and neutralise specific antigens.

"In South Africa, this is the first attempt that we are aware of to make the antibody in plants. The concept has been tested in laboratories overseas with one currently in phase two clinical trials. What makes the CSIR work unique is that we use a novel monoclonal antibody donated by the World Health Organization on a humanitarian basis through our affiliation to the international Pharmaplanta Consortium," he explains.

The CSIR generated genetically modified tobacco plants expressing the anti-rabies antibody using *Agrobacterium tumefaciens*, a bacterium commonly used to introduce genes into plants.

According to Chakauya, monoclonal antibodies are one of the fastest growing classes of therapeutics with 200 products in clinical evaluation and many more in preclinical development. Worldwide, the market is expected to reach $49 billion by 2013, owing to a growth rate of 11,5% annually. In Europe alone the monoclonal antibody market is guestimated to grow at a combined growth rate of 34,1% to $11,4 billion by 2011, mainly fuelled by the need for safe and effective treatment alternatives to autoimmune and inflammatory disorders.

The CSIR plans to contribute to this market through the establishment of a spin-off company, GreenPharm, which will initially focus on supplying the antibody to the South African market. This, according to Chakauya, also promises to become a reality.

– Asha Speckman

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