Innovate:

Engineering solutions for health care

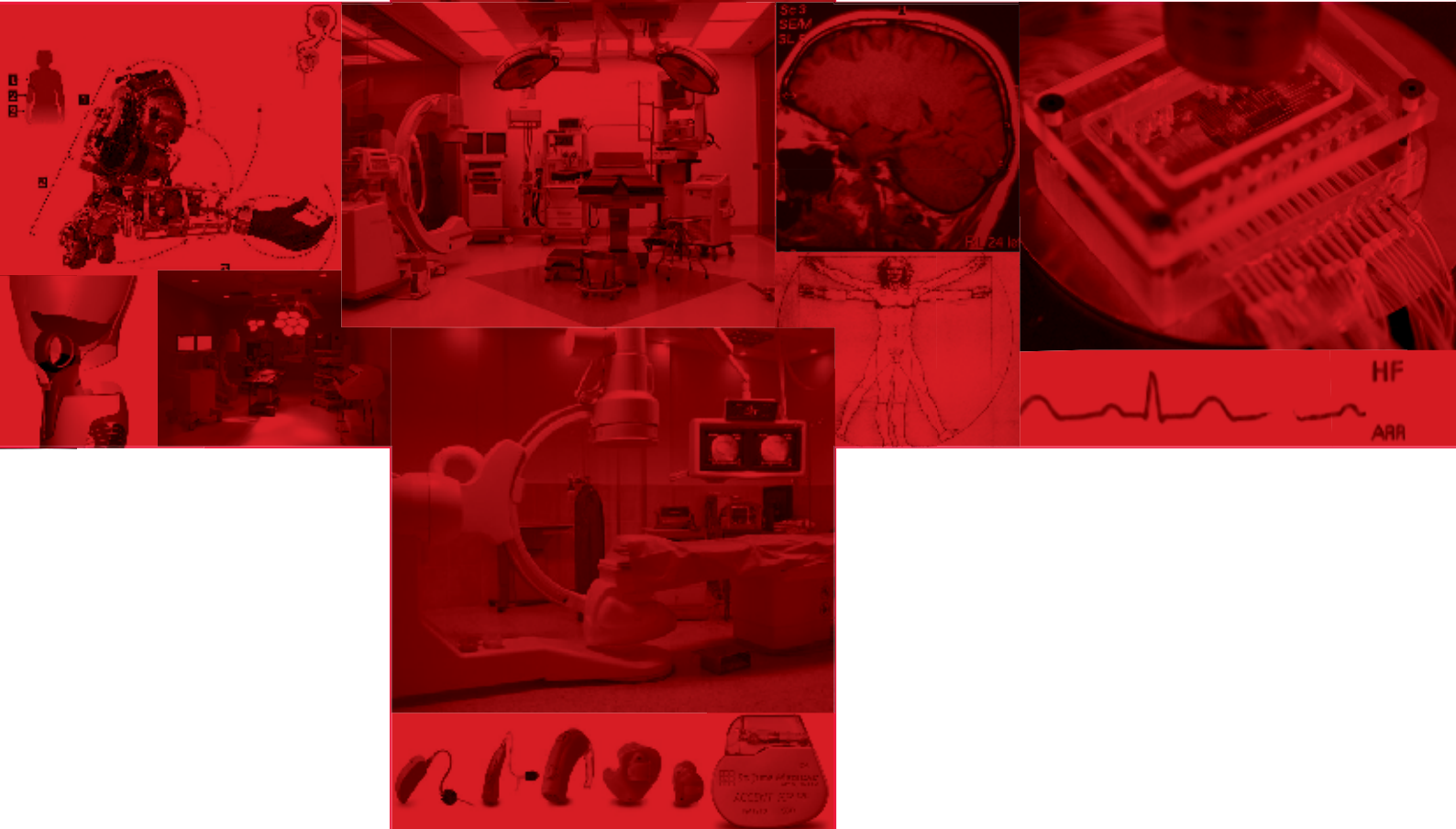## Innovations in the built environment

Faculty news

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On the cover:

Engineering solutions for health care

See feature articles on pages 22 to 41.
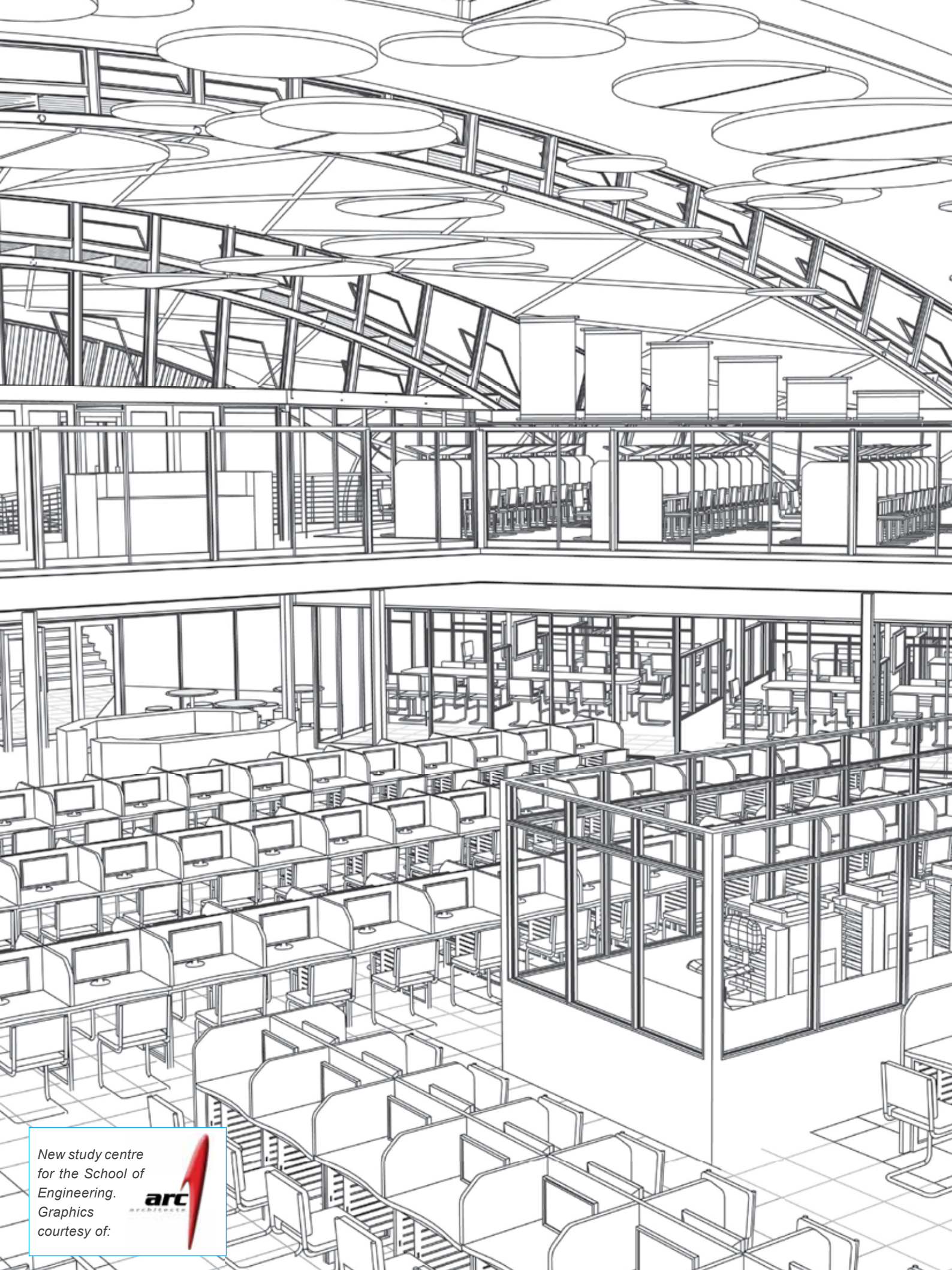
New study centre for the School of Engineering. Graphics courtesy of: **arc**

Content

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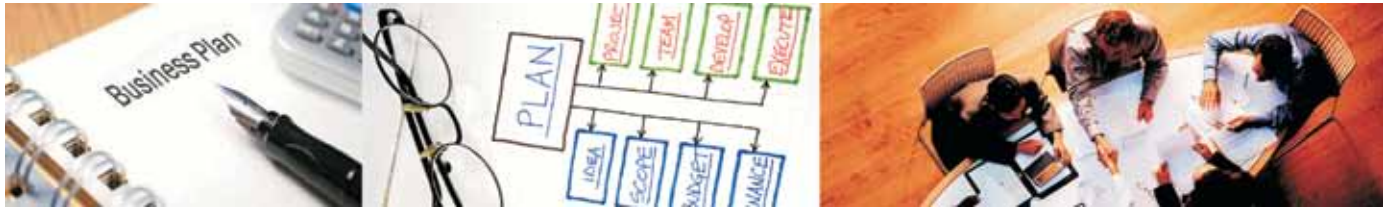
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Should South Africa invest in high-technology R&D?

When we look back at South Africa's success with regard to the development of high-technology systems over the last years, the trend seems worrying. The question to be asked is whether South Africa, as a developing country, should invest large amounts of money in research and development (R&D), or should we rather source knowledge and technology from countries that can afford to develop it.

The closure of the pebble-bed modular reactor (PBMR) in 2010 was obviously a serious point of discussion, especially in engineering circles. During several of these discussions, reference was made to the Rooivalk helicopter project that was also reduced to become nothing more than a small project in its own local industry.

Recently, the development of South Africa's own electric car, the Joule, also disappeared off the radar. The reasons for all of these examples can probably be found in politics, a shortage of funding, the slow pace of progress in development, etc.

Sceptics rightly ask the question about future projects, such as the square kilometre array (SKA), new nuclear generation plants and concentrated solar generation systems. Should South Africa invest large amounts of money in the development of complex, high-technology systems? The intention is not to try to answer these questions here, but an analysis of these case studies would certainly bring interesting perspectives to the table.

The opposite scenario, where South Africa decides not to invest in the research and development of complex, high-technology projects, raises another alarming set of questions.

During the 1990s, policy-makers in South Africa came up with the concept of South Africa as a 'technology colony'. A technology colony is characterised by a low level of activity and investment in R&D, which obviously leads to a high dependence on technology. It also has the implication that intellectual property belongs to foreigners and, along with that, so does much of the decision-making around the commercialisation of technologies.

This is certainly not a future scenario that a country like South Africa would envisage for itself!

The answer for South Africa probably lies somewhere in between. Although it may seem that we do not have the capability to develop and commercialise complex technological systems, we certainly need to invest in the R&D of smaller products, processes and services. In addition, we have to build strong R&D ties with foreign partners, especially where complex technology transfer has to take place. Government and industry see this as a growing priority, which is reflected in various initiatives.

The role of universities and other research institutions is clear. The institutional research themes at the University of Pretoria show a clear commitment towards this important national goal. The Faculty of Engineering, Built Environment and Information Technology, in particular, makes a valuable contribution to the research effort, as is reflected in the articles in this edition of *Innovate*.

In this issue, you can read more about the new initiatives in health technology management, as well as various contributions from researchers in the four schools of the Faculty (Engineering, the Built Environment, Information Technology and the Graduate School of Technology Management).

I trust you will once again enjoy this edition of *Innovate*. ❸

Editor
Tinus Pretorius

Blue Dimension: A new software editor and simulator for cellular automata

Rishal Hurbans

A cellular automaton (CA) is a collection of cells consisting of at least one definite value (or internal state). All cells collectively constitute a world. The cells are classified in types, whereby each cell type is associated with various transition rules that can be applied to the instance cells of that type. These rules are fixed (per cell type) and are applied consecutively to complete a generation of cells throughout a world.

The rules are applied using the cell's current value, as well as the cell's neighbour's current values of the same generation to compute the new value for the next generation.

addressed in one generation of rule processing; therefore the addressing of cells and neighbours must be speedy to lower the latency before the next generation is available for display.
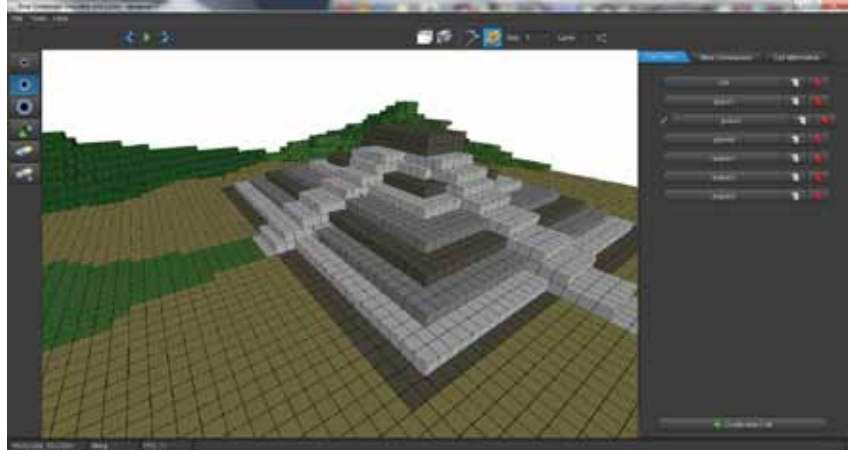
→ *The Blue Dimension simulator and editor cell types.*

On the basis of such rather simple low-level rules on a cellular automaton world, one may observe complex and useful behaviour on a global scale.

The Blue Dimension software system

The Blue Dimension cellular automata simulator and editor had the following main requirements:

- The program should support n-dimensional cellular automaton worlds. It should not only render worlds visually in two or three dimensions, but also use other means (such as sound) to represent higher dimensions that cannot be visualised.
- The program should support heterogeneous worlds: the cells in the world do not need to be of the same type.
- The cells should be addressed efficiently: the cellular automaton worlds that are to be created with the application are potentially large. Millions of cells are

- The program should allow the user to create and edit cell types, author and edit rules, and create and edit cellular automaton worlds by placing cells of various types anywhere in the artificial world.
- The program should allow the user to simulate the cellular automaton in time, based on the rules and initial cell states. A simulation must be able to run continuously until the evolution stagnates or until there is a user-triggered interrupt. Slow step-by-step simulation, which pauses after each new generation, should also be possible.
- The program should allow the user to create cell transition rules in a simple and intuitive manner.

The Blue Dimension CA software supports a five-dimensional world, of which three dimensions can be seen on screen. A fourth dimension is introduced by a concept of 'gravity' to which every cell in the artificial world can be subjected.
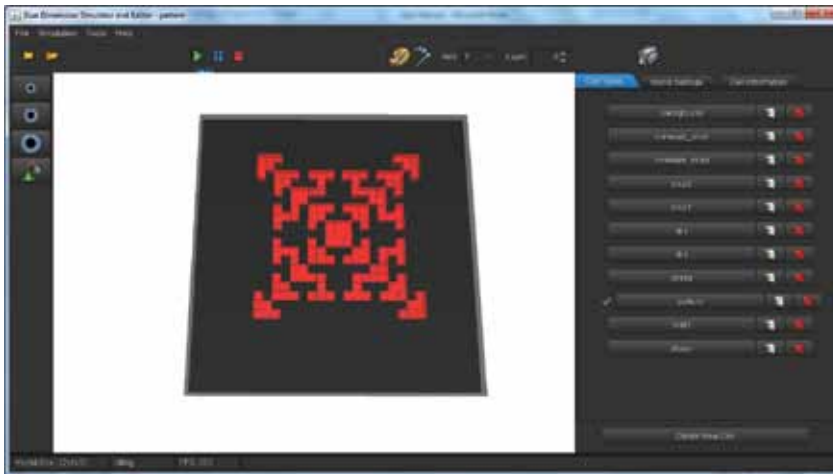
→ *The Blue Dimension simulator and editor pattern.*

A fifth dimension is simulated using summation or average values of the entire world's joint internal state, and this value can then be translated into audible output with varying tones.

Users may play, pause and take snapshots of the world at any time. Snapshot simulations may be saved and reloaded at a later stage and run from that point. Because cellular automaton runs may have very long durations, the save and reload feature is important from a practical perspective.

A new rule definition language was designed to allow a simpler and more intuitive way for lay users to make cell transition rules. The aim of the rule definition language was to not restrict the user to overly simplistic cell types, but to also allow the user to use traditional, explicit referencing of neighbour cells. Furthermore, the language should be sufficiently intuitive for easy learning and applying the tool.

To represent an evolving cellular automaton world efficiently (at high speed), a particular voxel engine

The software supports a five-dimensional world, of which three dimensions can be seen on screen. A new rule definition language was designed to allow a more intuitive way for lay users to make cell transition rules.

```
if  NOT  SUM of all  n                  >           x  AND/OR
         AVG         [n1, n2, ...]       <           x  AND/OR
         MIN                             >=          x  AND/OR
         MAX                             <=          x  AND/OR
         COUNT                           between     x, y
         EXACT                           ==

then self   +- SUM of all  n                  or CONST
            -= AVG         [n1, n2, ...]
            ?- MIN
            /- MAX
            -  COUNT
               EXACT
```

→ *Snippet of the definition language.*

was created. Essentially, the representation engine does OpenGL matrix manipulation, which moved processing of the view from the computer's central processing unit (CPU) to the graphics processing unit (GPU).

Software architecture

The software architecture of the system is a variation of the MVC pattern, which separates the model (M), the view (V) and the control (C) parts of the software system. For M, extensible markup language (XML) files were used, representing a database schema. The controller's main purpose is to run the simulations step by step, whereas the view part consists of the graphical user interface. All components of the system are only loosely coupled for the sake of software maintenance and adaptability.

Applications

The intention with creating the custom applications was to show that the

→ A graphic representation of the software architecture.
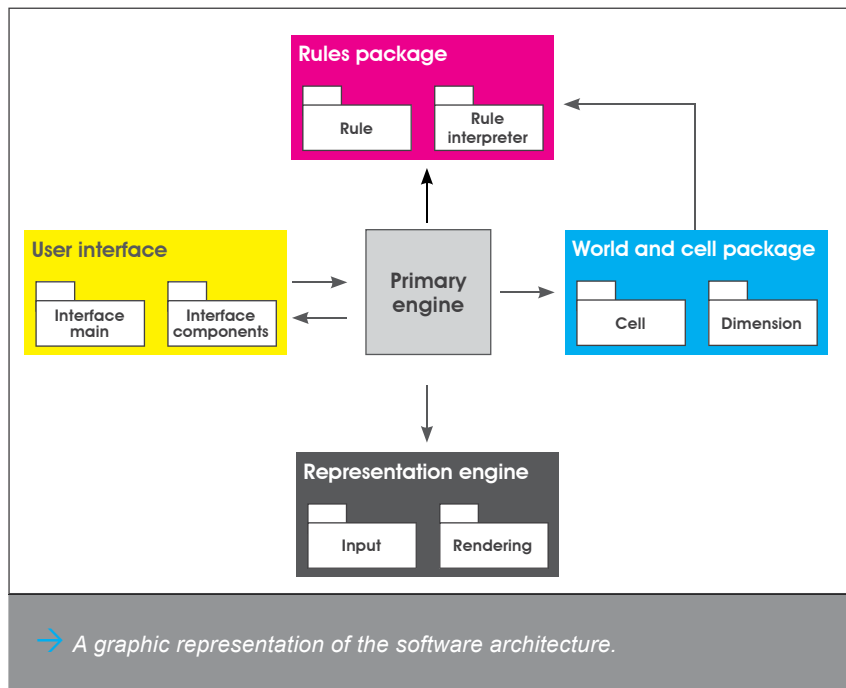
is such an example. This software includes maps of the entire planet in detail with regard to elevation and other useful data related to the land and sea. These features were harnessed and combined with the concepts of cellular automata, using

→ The NASA World Wind map software.

neural networks was applied to the theory of cellular automata. The behaviour of artificial neural networks relies on communication among neighbouring cells. This is also the case (although in a somewhat different manner) for cellular automata. An attempt was made to join these two concepts. It allowed for the construction of a CA program that was able to detect and follow a specific coloured object. This was achieved by capturing frames from a web camera as images, transforming the images to two-dimensional cellular automaton worlds and, finally, applying the cellular neural network rules and mechanisms. The same is done for every frame of the camera. After much training and learning, the program was able to detect the movement of a red ball across the screen in any direction. ☉
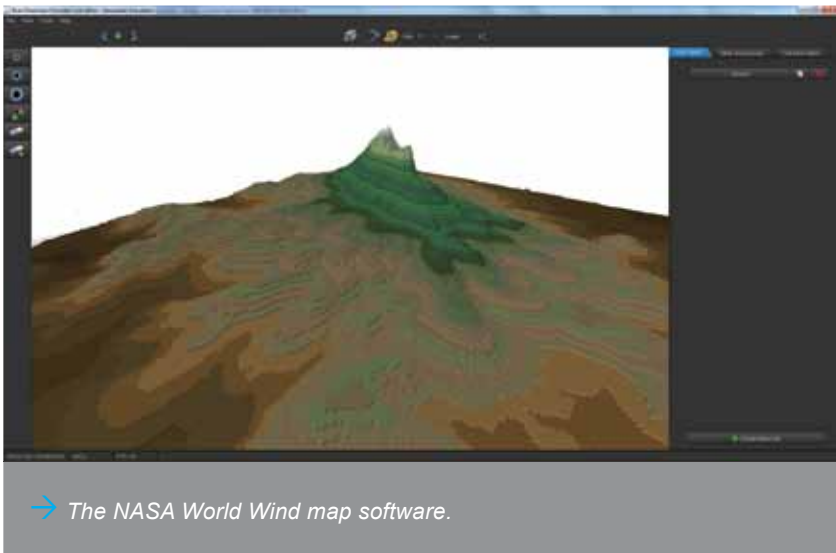
theory of cellular automata has many useful applications, both scientific and otherwise. The implementation of these applications also demonstrates the ease with which external libraries and subsystems can be plugged into the primary cell transition engine.

The National Aeronautics and Space Administration (NASA) World Wind

the new tool. Users are thus able to select portions of the NASA World Wind map and create detailed three-dimensional CA worlds where rules can be applied to simulate scenarios such as floods and fires.

The CA program for shape detection reaches into the field of artificial intelligence. The concept of artificial

Rishal Hurbans is a computer science student working towards his honours degree in the University of Pretoria's Department of Computer Science. His ongoing project on cellular automata is supervised by Prof Stefan Gruner.

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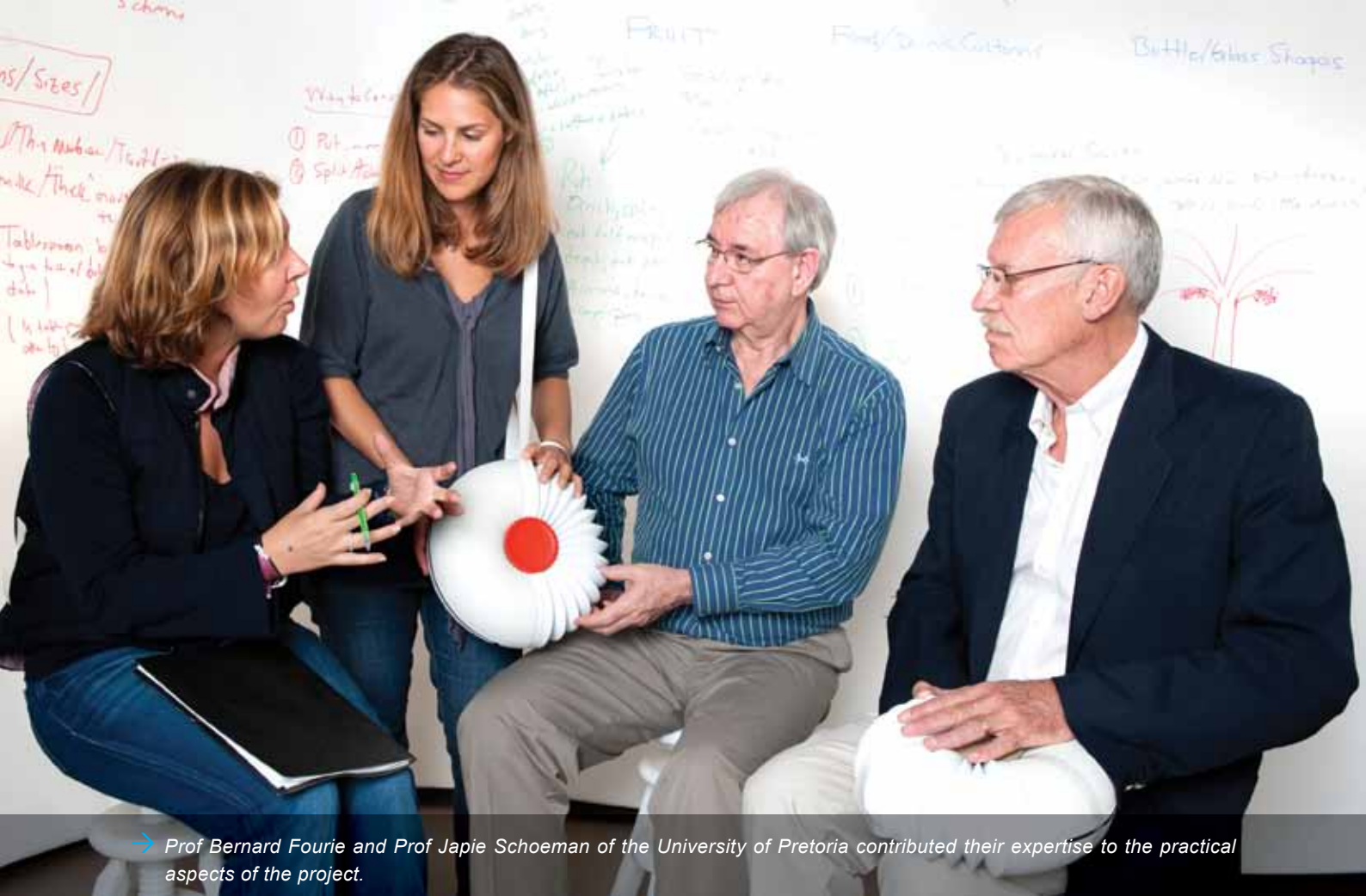
→ *Prof Bernard Fourie and Prof Japie Schoeman of the University of Pretoria contributed their expertise to the practical aspects of the project.*

Harvard and UP find water transport solution

Prof Japie Schoeman

The human body has perfected the art of efficient water transportation through its cells. So why not use the design of a biological cell to find a solution for efficient water transportation in poor rural communities who have limited access to drinking water?

This is exactly what a group of Harvard students have done. With the knowledge and experience of two academics from the University of Pretoria, the CellBag is now being used by members of the Moretele community north of Johannesburg for their daily water needs.

The CellBag comprises two parts that can easily be connected or disconnected from each other: a bendable water bottle that can hold 1 ℓ of liquid and a semicircle-shaped bag in which food can be stored. When these two parts are connected, the CellBag becomes a conveniently sized round 'bag' – one half is the bent water bottle and the other half is the food bag. The circular-shaped bag has a shoulder sling that enables it to be carried effortlessly.

The idea of a bendable water bottle was inspired by the biological cell that can expand and contract as needed. One can also connect a number of bendable water bottles together to carry up to 10 ℓ of water over one's shoulder at once, almost like a long pipe.

The CellBag concept was first envisioned in 2008 by a group of Harvard University students during a course led by Michael Silvestri, under the leadership of David Edwards, Harvard professor and founder of ArtScience Labs. The idea with the design of the CellBag was for it to be used by communities in arid areas around the world to carry water. The Harvard Global Health Institute, together with the Wyss Institute of Biologically Inspired Engineering, sponsored the conceptual development.

Soon afterwards, the CellBag came to life at the Laboratoire (the home of ArtScience Labs in Paris) with the help of the designer Mathieu Lehanneur.[1]

These bags are now for sale in Europe for use by cyclists, hikers, campers and holidaymakers, or just for everyday use. It is in Moretele, approximately 150 km north of Johannesburg, however, that the CellBag is serving its intended purpose. The team from Harvard joined forces with the University of Pretoria's Prof Bernard Fourie, Extraordinary Professor in Medicinal Microbiology, and Prof Japie Schoeman, Associate Professor in Chemical Engineering, to test the use of the product in a South African community.

In Moretele, residents have to walk distances of between 50 m and 1 km to fetch water from a communal supply. They have to fill water bottles and carry them over these distances to their homes for everyday use. Each household uses an average of 50 ℓ of water a day.

In the design stages of the CellBag, ArtScience Labs compiled a questionnaire to ask local residents about their current methods of carrying water to their homes, its storage and quality. This questionnaire was adapted by students of the University of Pretoria to make it relevant to South African conditions.

The residents said that they mostly use wheelbarrows to transport water in 20 ℓ containers from the water source to their houses. This causes back and shoulder problems and general fatigue due to the long

→ *These bags were provided to community members for evaluation.*

1   CellBag: Imitate biology, carry water differently. http://lelaboratoire.org/ CellBag%20Presentation%20EN.pdf.

distances some of them have to walk. The containers are often not properly disinfected. Together with the poor quality of the bulk water supply, this may cause health problems.

After the investigation had been completed, a few of these bags were provided to community members to test their response. The reaction was overwhelmingly positive. One resident who received two strings of water bottles in December 2010 is still using them to collect and carry water from a standpipe to his home, saying it is much more convenient and easy to transport than one 20 ℓ plastic container. The users also indicated that they clean the CellBag or string of bottles diligently once a week with a soapy solution, as recommended.

Following these initial promising results, CellBags were recently provided to 50 schoolchildren from Mashilo-Matsho Primary School, a school in the area, where access to clean drinking water is limited. This trial run will further test the usefulness and acceptance of the CellBag to members of the Moretele community, and as a potential solution to the water transport challenges experienced in many poor rural communities. ☻

The idea of a bendable water bottle was inspired by the biological cell that can expand and contract as needed.
It is in Moretele, approximately 150 km north of Johannesburg, however, that the CellBag is serving its intended purpose.

Innovative results require innovative strategies

Janine Smit

The role played by academia cannot be underestimated in the generation of new ideas. It is these ideas that lead to the chain of events – including research and development – that is so essential for the country's economic development and the wellbeing of its people.

As a research-intensive university, the University of Pretoria acknowledges the importance of providing its students with the support that is necessary to develop into well-rounded individuals who are able to address the needs and challenges of society and the economy.

The socioeconomic development of any country depends on the different parts of the system working in synergy to achieve a common goal. This includes the academic domain. Effective teaching and learning are vital in producing knowledgeable and high-level skilled graduates, and play an important role in the University's endeavour to develop individuals who can think and act innovatively to generate employment and promote economic development.

In an interview with the University's outgoing Vice-Principal responsible for teaching and learning, Prof Nthabiseng Ogude, *Innovate* discovers the innovative strategies that are in place to promote teaching and learning at the University of Pretoria and ensure that the institution is able to deliver well-equipped graduates to the workplace that can respond to the changing demands of the marketplace in the 21st century and beyond.

Prof Ogude, who had been a member of the University's Executive Management since 2006, was appointed as the new Vice-Chancellor of the Tshwane University of Technology from 1 August 2012. At the University of Pretoria, she was responsible for providing strategic direction to undergraduate and continuing education, and

steering these core activities towards local impact and international competitiveness.

The University's strategic initiatives related to teaching and learning at undergraduate level are focused on ensuring quality provision and improving the overall quality of students' life experiences. The aim of these initiatives is to ensure not only equity of access, but also equity of success for all students enrolled in its contact and distance learning programmes.

According to Prof Ogude, universities in South Africa tend to concentrate on the high end of the innovation chain when it comes to developing human capital and generating the knowledge and skills required to address the many

> The University of Pretoria acknowledges the importance of providing its students with the support that is necessary to develop into well-rounded individuals.

challenges related to socioeconomic development. Quality teaching at undergraduate level lays the foundation for postgraduate study and research, which is necessary for the technology and application development that underlies the commercialisation and market development of new tools and practices that will enable South Africa to compete internationally, while improving quality of life on the subcontinent.

While this is crucial and desirable, South Africa also needs to focus on increasing the number of candidates with technical qualifications and widen the base

of technically competent graduates and diplomates, as well as high-level professional qualifications for increased economic development and prosperity. The latter will be Prof Ogude's primary focus at the Tshwane University of Technology.

In terms of her role at the University of Pretoria over the last six years, the crux of teaching and learning activities in the University's Strategic Plan is to deliver independent graduates who fit the profile of a research-intensive university, wherever their future career trajectories may lead. Recognising the importance of supporting students to obtain an initial qualification that can provide critical thinking skills and the foundation for further postgraduate study, and also prepare them for the challenges of the workplace, Prof Ogude highlighted some of the challenges she has been able to address during her tenure at the University of Pretoria in the quest to achieve this goal.

The main challenge facing under-graduate education, as she put it, is the underperformance of the schooling system, which results primarily in mathematical and language proficiency problems that impede learning. It is widely acknowledged that the articulation gap between school and university eventually gives rise to high dropout rates, as well as low pass and throughput rates. This scenario was further complicated by uncertainties around the National Senior Certificate (NSC), which was introduced in 2008. The initiatives that Prof Ogude launched with her colleagues in the academic and support service departments at the University of Pretoria took this state of affairs into account.

Establishing an environment that is conducive to learning

The University of Pretoria has prioritised a number of strategies to ensure that its undergraduate programmes are responsive to the local context and continuously strive for national and international recognition and standing. These include providing an institutional policy environment that is conducive to improving teaching and learning, providing a mechanism for the institutional review of curricula, incorporating graduate attributes in curricula, and sharing and recognising good practice.

Prof Ogude believes in the centrality of an excellent undergraduate programme for a research university, using the rationale that good undergraduate education is a prerequisite for excellence in research by providing a pipeline of postgraduate students and feeding research results into curricula. Undergraduate education therefore has to be managed as systematically as research through the development of appropriate institutional systems, policies, processes and incentives.

Students receive support through various methods of technological innovation. The University's online learning management system, ClickUP, has become an indispensable part of students' academic life. This Blackboard-based learning management system (the latest version has just been implemented), is an online learning environment that gives students access to study guides, learning content and resources, discussion rooms and blogs, notifications, as well as projects and assignments, among many other things. The University has also incorporated a computer-based testing system, which is core to the assessment strategy in some faculties. It is in the process of being replaced by a new system that is better suited to the e-learning system. The systematic review of curricula is enhanced by curriculum mapping software.

An e-resource has also been developed for sharing good practice across the University, particularly, in the challenging area of teaching large classes. This includes a teaching and learning corner with resources for teaching improvement. Investigations into mobile devices for teaching and learning are ongoing.

→ *The academic support of students is crucial to the successful completion of their studies.*

A Senate Committee for Teaching and Learning was established in 2007. To facilitate the work of the Senate Committee, a steering committee for student success was formed in 2008 to develop a concerted approach to improving student success. This committee comprises deputy deans of the University's nine academic faculties, the directors of academic support departments and student representatives. The constitution of this cross-institutional team to address student success was an important breakthrough in modelling a solution to the problem, as it represented an end to working in silos and the need to place the focus on academic issues.

"Good ideas are incubated when students' co- and extracurricula activities are incorporated into teaching and learning," says Prof Ogude. "It is important to focus on the bigger picture, as learning does not only take place in the classroom. Many of the distractions that impact on learning are outside the classroom, and developing

the student as an individual, and ensuring engagement outside the classroom has a major effect on study success."

High academic standards

Teaching and learning committees have been established in each faculty to ensure that all departments adhere to high academic standards. In addition, an instrument has been developed to measure the quality of learning. It includes a student survey and a complementary lecturer survey. Excellence in teaching and learning is promoted and recognised at undergraduate level, and a strategy is in place for the professional development of part-time and full-time academic staff. Three tutoring models, prioritising students at risk, have also been implemented.

Monitoring risks and taking corrective action

Teaching and learning risks are carefully monitored and corrective action implemented to ensure the sustainability of undergraduate

programmes, and the teaching and learning enterprise in general. Strategies that have been implemented in this regard include the incorporation of risks in faculty agreements and the institution of a mechanism to assist in developing and implementing action plans. The implementation of extended programmes is monitored and an institutional support mechanism has been developed for the academic staff members involved in these programmes. This mitigates the risk of inadequately prepared students from the secondary school system and its questionable quality of teaching and learning, which results in an unsatisfactory throughput rate.

Advancing excellence in undergraduate teaching and learning

Following on the firm foundation for improving undergraduate teaching and learning that she established during her first term of office at the University, Prof Ogude continued to focus on advancing excellence in undergraduate teaching and

learning, and benchmarking the University of Pretoria nationally and internationally when she was reappointed for a second term of office in 2010.

According to Prof Ogude, there was a great need for an integrated approach to teaching and learning. This included a greater interface with academic support units, such as Student Affairs, Information Technology, the faculties, and the Bureau for Institutional Research and Planning (BIRAP) at the University, as well as research and community engagement, to ensure the holistic development of graduates.

She subsequently identified the following dimensions that would determine whether the overall student experience would be a positive one:
- The institutional philosophy and orientation to teaching and learning
- The academic readiness of students
- Emphasising academic develop-ment and excellence, and not academic support alone
- Systematically evaluating and measuring all efforts to ensure quantifiable progress

An integrated approach to the holistic development of students

The University of Pretoria's new strategic plan, *University of Pretoria 2025*, was launched in November 2011 to provide the roadmap and navigational markers for guiding the University to achieving the vision and strategic goals it has set for itself for the next 15 years. In line with this plan, the objectives for undergraduate education were geared towards the institutionalisation of a model for student academic development and excellence.

This model, aimed at improving student retention and success at the University of Pretoria, was documented by Prof Ogude and her co-authors in the Department for Education Innovation in an article published in the March 2012 edition of *The International Journal of the First Year in Higher Education*. The model, known as the Student Academic Development and Excellence Model (SADEM), was the result of a concerted institution-wide approach to improving student outcomes at the University of Pretoria.

The motivation for the development of this innovative model for study success was the desire to develop an instrument that would enable the strategic management of student success, enhance a quality undergraduate experience and improve performance indicators.

While several initiatives were already in place at the University to address this challenge, these were primarily housed in faculties, and focused on problems experienced in the classroom. The Senate Committee for Teaching and Learning proposed that initiatives for student success should address the entire student life cycle, from preregistration to graduation. The focus is on the first year. These initiatives should be aligned with the strategic drivers of excellence, diversity, sustainability and relevance.

High-impact modules were identified as a focal point for student success initiatives. These are modules that have a potential impact on performance owing to their large enrolment numbers (more than 200), the fact that they cater for a number of programmes across faculties, because they are associated with academic programmes of national significance, and due to their high dropout and high failure rates.

Lecturers in high-impact modules form a community of practice and meet each semester in an action research cycle. Students in these modules receive comprehensive academic, psychosocial, financial and other support using proven high-impact practices. These include tutoring, supplemental instruction, peer mentoring, academic advice and psychological counselling. These activities are integrated and supervised by faculty-based student advisors in most faculties.

In order to be successful, concerted faculty-based interventions need to be supported by organisational interventions that are aimed at providing an environment

The Student Academic Development and Excellence Model is an instrument that enables the strategic management of student success, enhances a quality undergraduate experience and improves performance indicators.

that is conducive to learning. Institutional, faculty and student readiness projects constitute the input dimension of the SADEM. Institutional readiness initiatives include a teaching and learning charter and ideas for an early warning system; faculty readiness projects include rethinking the educational model and developing resources for large classes; while student readiness projects include collaboration with feeder schools and the design of survey instruments to determine academic readiness, as well as effective mentoring and tutorial support.

Initiatives aimed at developing students' non-cognitive skills encompass issues such as time and conflict management, test-taking skills, and providing psychosocial support to prepare them for optimal learning in the classroom. The emphasis on academic development, on the other hand, entails the development of critical thinking skills, information and computer skills, and writing and reading skills, among other things.

The SADEM acts as a strategic management tool for modelling student success initiatives institutionally, and offers a systematic and systemic approach, supported by resourcing and a performance management system. The key to its success lies in harnessing and aligning existing institutional initiatives for staff and student development around mainstream academic modules or programmes.

Enhancing undergraduate success

The implementation of this innovative model for student academic development and excellence is supported by a framework and implementation plan for an integrated approach to undergraduate education and the holistic development of students, which has been included in the University's Strategic Plan leading up to 2025. The next step is to institutionalise the model and embed and customise it to faculties and departments. Regular quarterly meetings are held with deans, and all faculties understand the value of the model.

The framework provided by the SADEM and the enabling environment that has been established for individual academics to develop innovative methods for teaching and learning will promote the holistic development of students.

Furthermore, the support provided by the Department of Student Affairs ensures that students' non-academic lives are no longer separate from the academic enterprise. This includes support related to academic development (study methods, stress and time

→ *Initiatives are in place to support students to achieve optimal learning.*
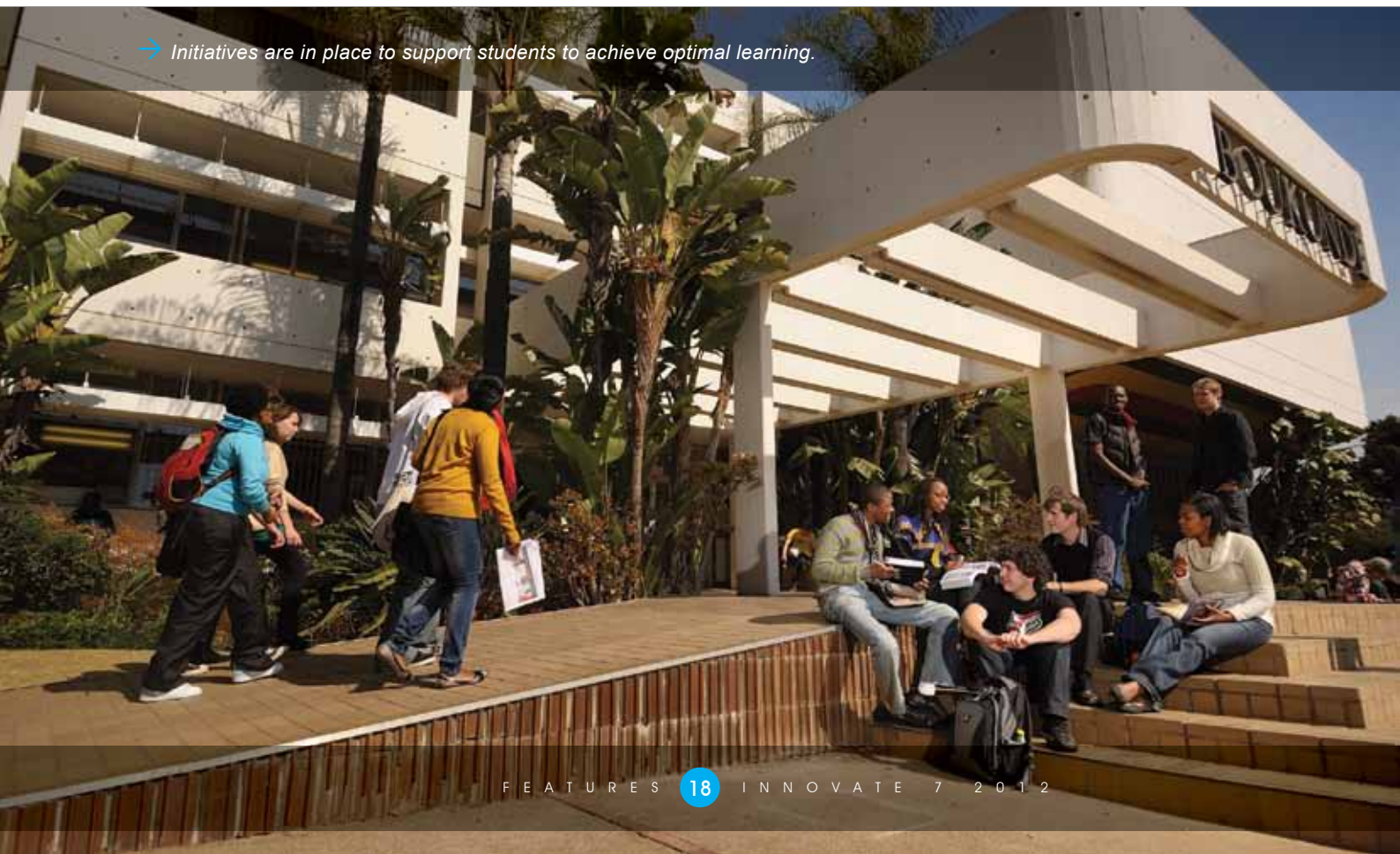
management, and career planning), potential development (conflict management, communication skills, goal setting and problem solving) and individual and relationship counselling (interpersonal problems, stress, depression, eating disorders, life trauma, emotional problems and the development of life skills). The consolidation of a student's academic and non-academic skills contributes to enriching the University's intellectual environment and improving graduate outcomes.

International recognition

There is emerging evidence that the University's academic support model for undergraduate education and its general approach to student success, which targets the whole student life cycle, are unique and effective. Independent evaluations of a paper presented at the 24th International Conference of the First Year Experience reflect on the quality of this work.

The model has also been well received by funders, resulting in the Dell Foundation providing bursaries to a cohort of 50 students from July 2012; and funding from the Kresge Foundation for a conference to be held in January 2013. The proposed joint conference between the University of Pretoria and the Kresge Foundation will serve to position the University nationally and internationally.

This external validation of the University of Pretoria's innovative approach to teaching and learning at undergraduate level reinforces the fact that it is on the right track in its endeavours to develop the intellectual resources that are required to produce well-rounded graduates, populate its postgraduate and research capacity, and contribute to the transformational needs of South Africa.

Profile: Prof Nthabiseng Ogude

Prof Nthabiseng Audrey Ogude was Vice-Principal responsible for teaching and learning at the University of Pretoria since 2006. From 1 August 2012, she is the new Vice-Chancellor of the Tshwane University of Technology.

Prior to her appointment at the University of Pretoria, she was Deputy Vice-Chancellor at the Nelson Mandela Metropolitan University in Port Elizabeth.

She obtained a BSc degree at the National University of Lesotho in 1979, majoring in Biology and Chemistry, followed by an MSc in Analytical Chemistry at the University of Nairobi in 1984 and a PhD in Chemistry at the University of the Witwatersrand in 1992.

She has almost 30 years' experience in tertiary education, 13 of which were in strategic leadership positions. She was the first black woman to hold such positions.

Her research interests are in the areas of science, chemistry education, women in science, higher education policy and academic management leadership.

She is a 2006/07 American Council on (Higher) Education Fellow, a member of several professional organisations, and serves as chairperson and member of a number of university committees, as well as external councils and boards, such as the Council of the University of Botswana, the Judicial Education Institute Council, the National Advisory Council on Innovation and the Higher Education Quality Committee, to name but a few.

During her tenure at the University of Pretoria, she succeeded in consolidating several disparate views on undergraduate teaching and learning into a cohesive whole around the holistic development of students, and provided direction on how the University can develop well-rounded graduates that are attuned to and can operate within both the local and global contexts. She also succeeded in positioning undergraduate education and student success at the University of Pretoria nationally and internationally by delivering presentations at conferences, publishing in international journals and networking at appropriate higher education forums.

Innovate wishes her success in her position as Vice-Chancellor of the Tshwane University of Technology. The foundation that was laid at the University of Pretoria through her involvement in its student success initiatives has provided the impetus for continued creativity and innovation.

IEEE leaders address UP academics on engineering education

Marlene de Witt

Do students really learn effectively through attending lectures? Why are student numbers in engineering, specifically electrical and electronic engineering, dwindling in many countries, and how do we go about attracting students to this field of study? Why do we keep working in silos when disciplines are clearly overlapping? And encapsulating these questions, what is the future of engineering education?

These were some of the difficult questions posed by two of the past presidents of the Institute of Electrical and Electronics Engineers (IEEE) and respected academics during their visit to the University of Pretoria in May 2012.

On 22 May, Prof Michael Lightner, Professor and Chair of Electrical, Computer and Energy Engineering at the University of Colorado and 2012 IEEE Vice-President for Educational Activities, and Prof Leah Jamieson, John A Edwardson Dean of Engineering at Purdue University and 2012 IEEE Foundation President, addressed interested students and staff at the Carl and Emily Fuchs Institute for Microelectronics (CEFIM) on the future of engineering education.

Evolution or revolution?

Prof Lightner, an acclaimed electrical and electronics engineer, predicts that engineering education will be dramatically different in as little as eight years' time, as engineering education is facing pressures for change from multiple sources and the boundaries between traditional fields are fading. More and more people are questioning the effectiveness of the way engineering is currently taught, and major prestigious universities, like Harvard in the USA, have already significantly changed their teaching approach.

Prof Lightner spoke about what he sees as some of the main driving forces behind the evolution in engineering education. The first stems from the question "Why do we teach what we teach?" New computational tools are challenging the definition of basic skills and are demanding changes in theory and laboratory classes to reflect modern engineering practices and needs. He questions why engineering educators are teaching subjects as if symbolic computation and computers do not exist. Even though the traditional methods have some merit, why not use large, real-world examples in teaching instead? Data from real sources allow for new, real-world, authentic problems, which give lecturers an opportunity to engage students to a much greater extent.

Engineering is in many ways embedded within other disciplines, yet engineering schools fail to integrate modules of other disciplines into engineering programmes to expose students to the wide range of career options available to them. Data analysis, microscopy, health informatics, biochips, telemedicine and prosthetics are all fields related to the medical industry, of which engineering forms an integral part. Prof Lightner suggests that it is important to find solutions to integrate differing sets of expertise in engineering courses in order to enrich the learning environment for students.

Prof Lightner believes that while engineering education is evolving, a revolution is taking place in the methods used by some universities to teach engineering. The use of online education offers the possibility of higher efficiency and more personalised learning, and challenges the role of the traditional engineering professor.

Engineering education research

Research that looks at the way engineering is taught and at the philosophy behind engineering as a discipline is a field that is growing into a discipline in its own right. Prof Jamieson is one of a few researchers to be leading research in the field of engineering education.

Engineering education is bringing together decades of experience in teaching engineering with more recent knowledge from education and

social behavioural sciences research, to delve into the critical questions mentioned above. "Engineering education is about good research, good teaching, better learning, and overall it is about change that is based on research," said Prof Jamieson.

She also emphasised another key question: how do we connect engineering education research with engineering education practice? Researchers in engineering education look at change in the profession and how to find new, innovative ways to teach, yet the teaching methods used remain unchanged, because the research findings are not communicated to the lecturers and are not implemented.

A couple of universities or engineering schools in the world now have dedicated graduate programmes in engineering education.

Prof Jamieson said that there are many challenges for researchers in engineering education, as it is an emerging field, but adds that it is an exciting and important research field to enter.

As engineering education departments are being established, new curriculums need to be developed, committees and procedures need to be established, and funding needs to be sourced.

About the academics

Prof Michael Lightner is a Professor and Chair of Electrical, Computer and Energy Engineering at the University of Colorado, Boulder, and is the IEEE's 2012 Vice-President for Educational Activities. Among his many awards are the IEEE's Circuits and Systems Society (CAS) Golden Jubilee Medal (2000), the IEEE's Third Millennium Medal (2000) and

the Distinguished Service Award of the IEEE for Serving as Editor of *IEEE Transactions on Computer-aided Design*.

Prof Leah Jamieson is the John A Edwardson Dean of Engineering at Purdue University, Ransburg. She is a Distinguished Professor of Electrical and Computer Engineering and holds a courtesy appointment in Purdue's School of Engineering Education. She is co-founder and past director of the Engineering Projects in Community Service (EPICS) Programme and is the 2012 IEEE Foundation President. She has been recognised with the Gordon Prize of the National Academy of Engineering (NAE) for Innovation in Engineering and Technology Education, the National Science Foundation (NSF) Director's Award for Distinguished Teaching Scholars and the Anita Borg Institute's Women of Vision Award for Social Impact. ❸

Integrated assessment and management of health care infrastructure and technology

Dr Louwrence Erasmus, Mladen Poluta and Dr Richard Weeks

In many countries, large numbers of people suffer because they cannot access the necessary health care, while the cost of health services annually pushes 100 million people worldwide into poverty, according to a report by the World Health Organization (WHO).

It is universally accepted that all people should have access to the health care they need. However, health care inflation is rising worldwide and countries are continually seeking more funds for health care. Richer countries are struggling to keep up with the rising costs of technological advances and the increasing health demands of their ageing populations, while low-income countries are often resource poor and cannot ensure access to even basic health care services.

There are wide variations in the coverage of essential health care services within countries and even between countries. Unfortunately, amid the rising global demand for essential health care services, 20 to 40% of the resources spent on health care globally are wasted. Common causes of inefficiencies include demotivated health workers, the duplication of services and the inappropriate or overuse of medicines and technologies.

According to *The World Health Report* of the WHO, published in 2006, in Africa 3% of the world's health care workers combat 24% of the global disease burden with less than 1% of the global health expenditure.

Health care in South Africa

In many respects, the health care problems South Africa faces are not different from those experienced globally. In this country, health care services have to be delivered in a resource-scarce environment. Money should not be regarded as a resource, but as a means to acquire resources. The incorrect perception of money as a resource results in the wrong value systems being used for decision-making.

The South African National Department of Health (NDOH) has adopted the following vision for its Human Resources for Health Strategy for 2012: "A workforce developed through innovative education and training strategies and fit for purpose to meet the needs of the re-engineered health system and to measurably improve access to quality health care for all."

In support of this vision, the Minister of Health has signed a national service delivery agreement with the President of South Africa for a "long and healthy life for all South Africans". In this agreement, the Minister and the NDOH commit to the following strategic outputs that the health sector must achieve:

- Increased life expectancy
- Decreased maternal and child mortality
- Combating HIV and Aids and decreasing the burden of disease from tuberculosis
- Strengthened health system effectiveness

To address these priorities, the Minister of Health, in his budget speech in May 2011, announced the re-engineering of the primary health care (PHC) system and the overhaul of the health system. The Minister announced that PHC re-engineering will concentrate on the prevention of disease and the promotion of health. The PHC system will be located in a district-based service delivery model, focusing especially on maternal and child mortality. The Minister has stated that the improved management of health care institutions and health districts will be essential to facilitate the re-engineering of PHC. The commissioning of five flagship academic hospitals was announced as part of the process to re-engineer and strengthen the health system and develop a balanced capacity for health care delivery.

In support of the re-engineering of PHC and the overall health system, National Health Insurance (NHI) was announced and made policy in 2011, with the piloting of the programme in April 2012. The first five years of the NHI will focus on strengthening the health system in the following areas:

- Management of health facilities and health districts
- Quality improvement
- Infrastructure development
- Medical devices, including equipment
- Human resources planning, development and management
- Information management and systems support
- Establishment of the NHI Fund

Quality of health care

In 2001, the Committee on Quality of Health Care in America of the Institute of Medicine of the National Academies proposed six quality criteria for 21st-century health care systems in its report *Crossing the quality chasm: A new health system for the 21st century*.

Health care systems should be *safe* (avoid injury to patients from the care that is intended to help them), *effective* (provide services based on scientific knowledge to all who could benefit and refrain from providing services to those not likely to benefit), *patient-centred* (provide care that is respectful of and responsive to individual patient preferences, needs and values, and ensure that patient values guide all clinical decisions), *timely* (reduce waiting periods and sometimes

THE WHO HEALTH SYSTEM FRAMEWORK

SYSTEM BUILDING BLOCKS   OVERALL GOALS/OUTCOMES

SERVICE DELIVERY

HEALTH WORKFORCE

INFORMATION

MEDICAL PRODUCTS, VACCINES AND TECHNOLOGIES

FINANCING

LEADERSHIP/GOVERNANCE

ACCESS
COVERAGE

QUALITY
SAFETY

IMPROVED HEALTH (LEVEL AND EQUITY)

RESPONSIVENESS

SOCIAL AND FINANCIAL RISK PROTECTION

IMPROVED EFFICIENCY
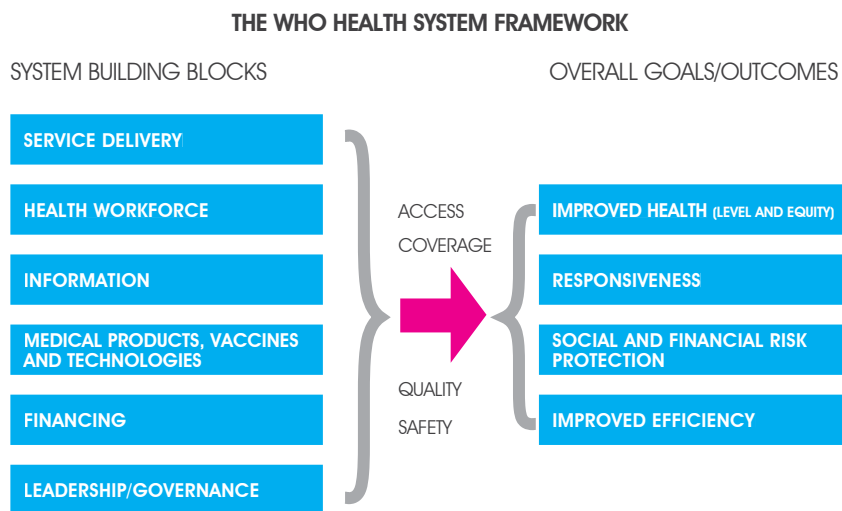
→ *Figure 1: The six building blocks of a health system framework. (Source: World Health Organization, 2007)*

harmful delays for both those who receive and those who give care), *efficient* (avoid waste, including waste of equipment, supplies, ideas and energy) and *equitable* (provide care that does not vary in quality because of personal characteristics, such as gender, ethnicity, geographic location and socioeconomic status).

In evaluating the NHI areas that require strengthening and these six quality aims, the complexity of the subject begins to emerge. Overlap exists between the different areas associated with the NHI without the ontology to treat each independently.

Health care infrastructure and technology

Health care infrastructure and technology (HIT) are important and integral components of the health

care service delivery system. The physical environments in which health services are rendered are constituted by HIT. Quality services can only be provided when physical facilities, installations and equipment are in good working condition to provide a fully functional and operational environment.

Infrastructure and technology make up the visible interface between health departments and the public at large, and it is important that their quality, condition and cleanliness reflect the high standards set by health departments for the provision of health services to a country's people. A clear distinction needs to be made between health care infrastructure and technology.

Health care infrastructure comprises physical infrastructure (buildings, installations, energy sources, water and gas supplies) and logistics and support systems (supply systems, communication, information and transport systems, and waste disposal systems).

Health care systems should be safe, effective, patient-centred, timely, efficient and equitable.

Information requirements for stakeholders in health care systems

Stakeholder	Examples of needs	Data requirements
Government	- Monitoring the health of the nation - Setting health policy - Ensuring that regulatory procedures are working properly - Ensuring that government finances are used as intended - Ensuring that appropriate information and research functions are undertaken - Monitoring regulatory effectiveness and efficiency	- Information on performance at national and international levels - Information on access and equity of care - Information on utilisation of service and waiting times - Population health data
Regulators	- Protecting patients' safety and welfare - Ensuring broader consumer protection - Ensuring that the market is functioning efficiently	- Timely, reliable and continuous information on patient safety and welfare - Information on probity and efficiency of financial flows
Payers (taxpayers and members of insurance funds)	- Ensuring money is being spent effectively, efficiently and in line with expectations	- Aggregate, comparative performance measures - Information on productivity and cost-effectiveness - Information on access to (and equity of) care
Purchaser organisations	- Ensuring that contracts offered to their patients are in line with the objectives the patients expect	- Information on patient experiences and patient satisfaction - Information on provider performance - Information on the cost-effectiveness of treatments
Provider organisations	- Monitoring and improving existing services - Assessing local needs	- Aggregated clinical performance data - Information on patient experiences and patient satisfaction - Information on access and equity of care - Information on utilisation of service and waiting times
Physicians	- Staying up-to-date with current practice - Being able to improve performance	- Information on current practice and best practice - Performance information benchmarks
Patients	- Being able to make a choice of provider when in need - Information on alternative treatments	- Information on location and quality of nearby emergency health services - Information on quality of options for elective care
The public	- Being reassured that appropriate services will be available if needed in the future - Holding government and other elected officials to account	- Broad trends in, and comparisons of, system performance at national and local level - Efficiency information - Safety information

In many respects, the health care problems South Africa faces are not different from those experienced globally. In this country, health care services have to be delivered in a resource-scarce environment.
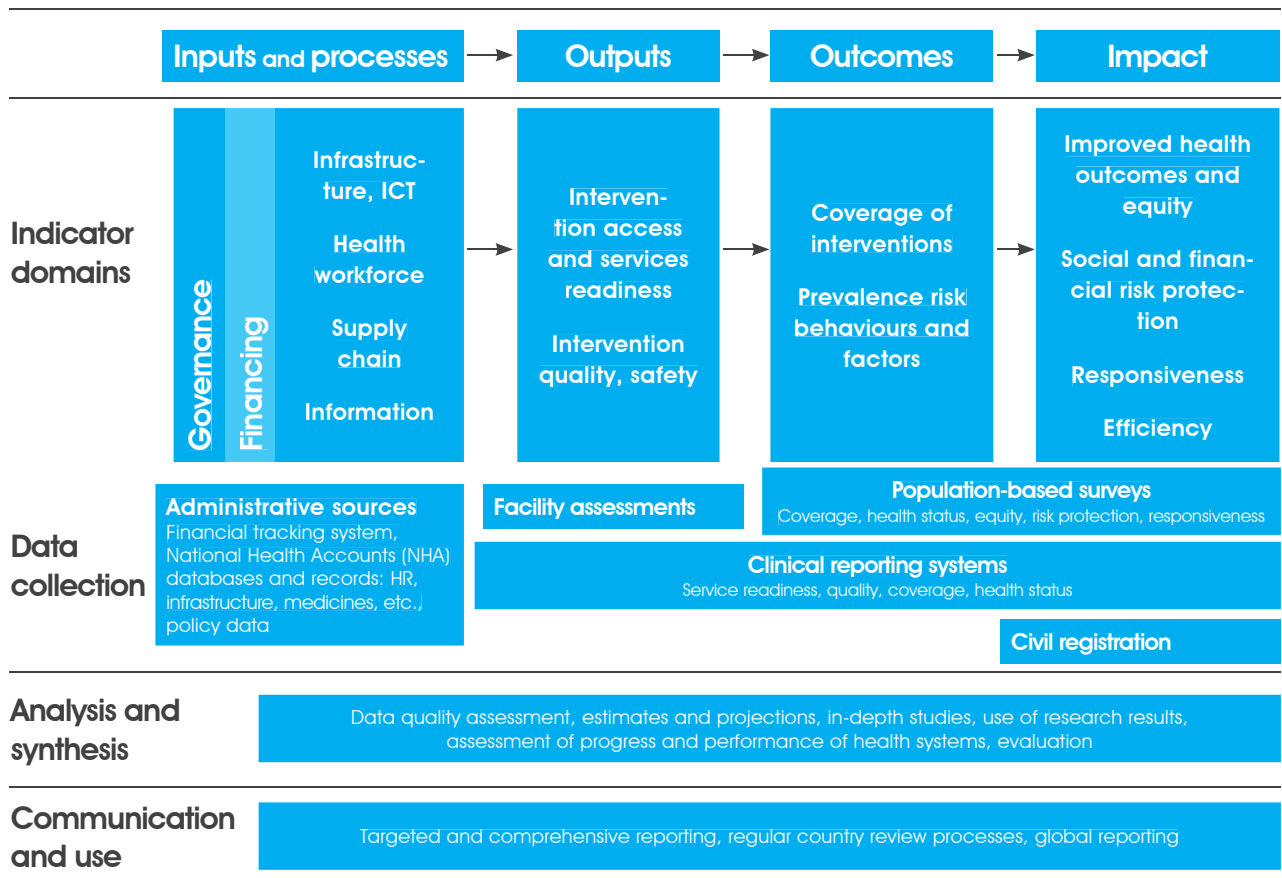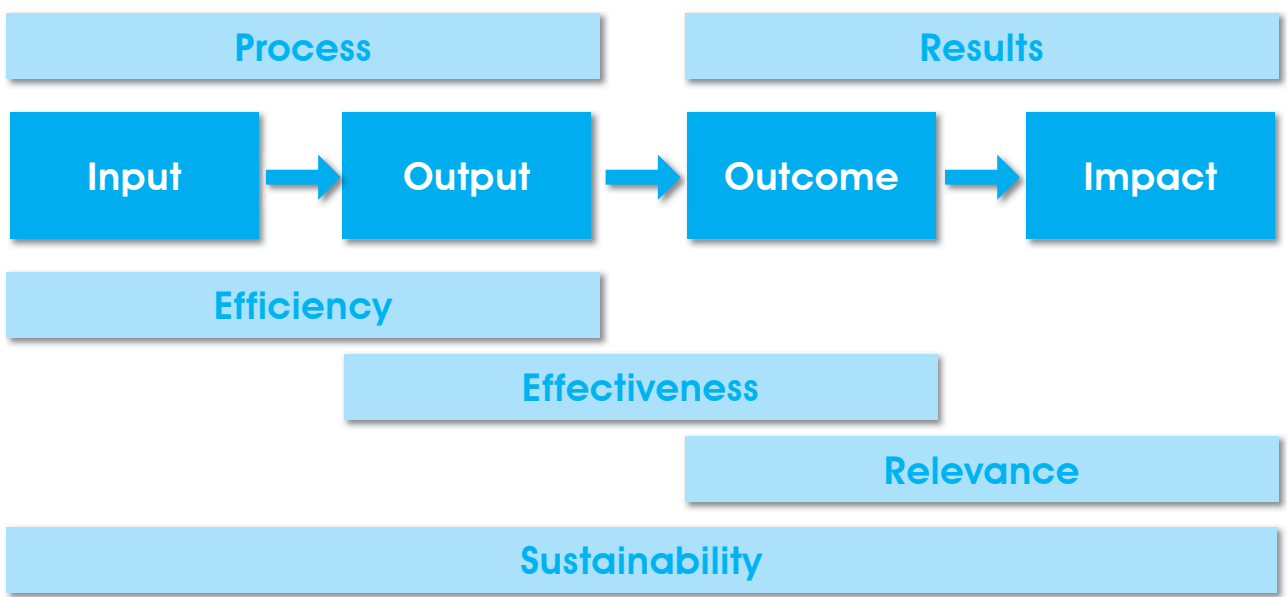
→ *Health care technology comprises the devices, drugs, and medical and surgical procedures used in the prevention, diagnosis and treatment of disease.*

The two components of a health care infrastructure are traditionally part of two different professional disciplines, which require different competencies, and managerial and operational skills. Health care technology comprises clinical devices and has been defined by the WHO as the devices, drugs, medical and surgical procedures – and the knowledge associated with these – used in the prevention, diagnosis and treatment of disease, as well as in rehabilitation and the organisational and supportive systems within which care is provided.

The WHO describes the health system framework as comprising of system building blocks with certain overall goals or outcomes. HIT falls under the building block 'medical products, vaccines and technologies'.

The WHO makes policies and guidelines available on a continuous basis for the planning and manage-ment of infrastructure and technology to member states. The objective of this is to strengthen the capacity of countries to effectively acquire and manage physical health care assets to ultimately facilitate improved health service delivery by optimising the condition and sustainable use of HIT.

A framework for the monitoring and evaluation of the strengthening of health systems was developed by the Global Fund to fight Aids, tuberculosis and malaria as part of a Monitoring and Evaluation Toolkit.

A report published in 2010 by Dr Joachim Nagel and Dr Bastiaan Remmelzwaal, members of the WHO's Advisory Group on Health Technology in 2009, illustrates the relationship between the broader developmental considerations of the framework.

Nagel and Remmelzwaal point out that the definition of performance indicators for HIT is a difficult task.

A major problem is the number of cadres of health care professionals directly or indirectly involved in the many aspects of HIT. On the one end of the spectrum, the technicians and engineers are primarily interested in the tangible outputs of their efforts to acquire and effectively manage a fleet of physical assets. On the other, the interests are mainly on issues around cost-effectiveness and the sustainable impact of HIT on the health delivery system and thus on the patient. The rest falls somewhere in between the extremes and is confronted by multi- and transdisciplinary discussion.

The development of performance measurement in health care systems has rarely been pursued with the requirement of the information users in mind. Performance measurement systems have usually sought to inform a variety of users, typically presenting a wide range of data in the hope that some of the information collected will be useful to different parties. With the diverse information

needs of different stakeholders in health care systems, it is highly unlikely that a single report will be useful for everybody; thus different reports should be generated for different information users in the health care system over the same database. This is a problem that has been addressed many times in systems engineering, especially under requirements engineering, which forms part of the requirements and functional analysis.

The role and importance of HIT in the development of sustainable

it is given. There is evidence that the inappropriate management and deployment of HIT negatively affects sustainability. With adequate planning and management, rapid technology life cycles can lead to health systems that are effective, efficient, equitable and sustainable at every level. To achieve this, it is necessary to employ partnerships between the public and private sector, as well as universities and research institutions.

There is a need for better sharing in the development and use of

national, regional and district level. There is a hierarchy of management training needs in this field, and all of these warrant attention. However, the most neglected problem that should receive high priority in the overall human resource development programme is that of the provision of the education and training that is suitable for key decision-makers at national, provincial and district level. Despite the skeletal framework of a master's programme presented in 1990, no programme had been implemented internationally that was designed to meet the pressing needs of HIT. The problem may be the strictly scientific management approach suggested in the programme, while HIT is a complex adaptive system that cannot entirely be treated with archaic scientific management principles.

As a response to the South African health care challenge, the GSTM is establishing itself as the leading national, regional and global provider of integrated, comprehensive capacity-building and support in the integrated assessment, innovation and management of health care infrastructure and technology.

Health Care Infrastructure and Technology Group

With this in mind, the Graduate School of Technology Management (GSTM) at the University of Pretoria is ideally positioned to support most of the initiatives of the NDOH, with the current expertise, education and training programmes already deployed.

health systems is often not fully understood by policy- and decision-makers, planners and other health care workers, perhaps due to the shortage of documented evidence on the subject. Rapid improvements in technology further accentuate the need for the improved management of all life cycle phases of HIT to better exploit the emerging opportunities and overcome evolving problems. Despite all the accumulated knowledge on the problem and prospective solutions, the tangible progress is very small.

In a report on physical infrastructure and technology published in 1999, the WHO stressed the importance of HIT, which permeates all facets of health care delivery and provides the material framework within which

management tools and impact indicators, and pilot or demonstration projects to promote a better understanding and appreciation of the role and importance of HIT in the health sector.

Management of health and medical care support and technical services

In 1990, the WHO published a position paper to provide the necessary background for discussions around the possible development of an appropriate education strategy for the management of medical technologies.

One aspect of the management problem is the lack of leadership at

The GSTM has leading experts in the areas of technology and innovation management, project management, engineering services management, asset management, sustainable life cycle management and systems engineering, as well as value-added expertise from newly appointed assessment, innovation and management (AIM) HIT expert networks.

The GSTM's services model (based on systems thinking and complex adaptive system principles) can assist, in particular, to address the six priority areas set out by the Minister of Health: the values

and attitudes of staff, a reduction in waiting time, cleanliness and hygiene, patient safety, clinical care and governance, infection prevention and control, and the availability of basic medicines and supplies.

As a response to the South African health care challenge, the University of Pretoria – through the GSTM – is establishing itself as the leading national, regional and global provider of integrated, comprehensive capacity-building and support in the integrated assessment, innovation and management (iAIM) of health care infrastructure and technology, with a non-exclusive focus on resource-scarce health care environments and the African region in particular. The capacity-building and support activities will be driven by the needs of clients and will, in turn, be supported by a dynamic and responsive research programme underpinned by values of excellence, relevance and impact.

The iAIM-HIT programme is uniquely positioned to contribute to six of the seven listed NHI areas by optimally utilising current research, academic and further education offerings in the GSTM, the School of Engineering and the School for the Built Environment in the Faculty of Engineering, Built Environment and Information Technology, as well as the School for Health Systems and Public Health in the Faculty of Health Sciences at the University of Pretoria. Focus areas for the iAIM-HIT programme include the following:

- Responsible and sustainable management of public sector health care physical assets, with a focus on resource-scarce health care environments in the African region
- Supporting – through applied research and targeted capacity-building – the South African departments of Health and

→ *The iAIM-HIT programme positions itself to meet the current and future needs of clients in both the public and private sector.*

Public Works in addressing the challenges associated with the emerging NHI system and the associated effectiveness, efficiency and quality of health care delivery
- Developing HIT-related decision support tools and 'lean' management information systems
- The application of systems thinking and operational research methodologies to health care delivery and related managerial and technology interventions
- The optimisation of the health care technology innovation and technology transfer process
- Developing innovative engineering and architectural approaches to airborne infection control and related capacity-building
- Developing and strengthening health care engineering in the African region

The iAIM-HIT programme positions itself to meet the current and anticipated future needs of clients in both the public and private sector by building cadres of competent practitioners, managers and leaders

in the broad area of iAIM-HIT. In the programme's commitment to assist and support the development of a long-term training and capacity-building strategy for the health care infrastructure and technology sector in South Africa, it is also realised that resources are scarce and should not be wasted. Therefore, based on the principles of efficiency and sustainability, it is essential not to duplicate what is already available. This led to the iAIM-HIT programme taking a strategic decision, in consultation with partners at the universities of KwaZulu-Natal and Cape Town (UCT), to enter the e-health-related capacity-building space. To this end, a draft proposal for a National Centre for e-Health Studies (NCeHS) has been formulated. The vision is that the NCeHS will fulfil the following functions:

- Establish and maintain the national reference model for e-health, based on services science principles
- Create a framework in which stakeholders understand their roles and responsibilities for the e-health studies process to

The broad area of e-health includes the established areas of telemedicine and tele-education, as well as the emerging potential of mobile health.

make optimal use of national resources
- Support an inter- and transdisciplinary research strategy for e-health studies in South Africa and beyond
- Support a human capacity-building strategy for e-health in the public health sector
- Facilitate the exchange of experience and expertise between institutions to maximise national assets for research and human capacity-building in e-health studies
- Define a set of metrics that will measure progress towards the goals of the e-health studies programme
- Assess national and international e-health development trends on an ongoing basis for impact in the NCeHS
- Maintain close ties with all major stakeholders, notably and especially the national and provincial departments of Health

As part of its mandate, the NCeHS will also address integrated planning, appropriate innovation, proper assessment, informed acquisition and the efficient management of ICT for e-health. The broad area of e-health includes the established areas of telemedicine and tele-education, as well as the emerging potential of mobile health (m-health), focusing on the use of mobile technologies, such as cellphones and tablets.

Further opportunities are explored with various schools and departments at the University of Pretoria, the Health Care Technology Management programme at UCT, the Telehealth Department at the University of KwaZulu-Natal, other national and international academic institutions, various national research councils and industry partners. ❸

Dr Louwrence Erasmus, Mladen Poluta and Dr Richard Weeks are associated with the Department of Engineering and Technology Management at the Graduate School of Technology Management (GSTM). Dr Erasmus specialises in sustainable life cycles, systems engineering, and health care infrastructure and technology. Dr Weeks specialises in engineering service science management. Poluta established the Health Care Technology Management (HTM) Programme at the University of Cape Town in 1999. This was the only one of its kind in Africa. He is part of the team that is establishing a comprehensive programme to address the integrated assessment, innovation and management of health care infrastructure and technology at the GSTM.

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University offers new multidisciplinary course for airborne infection control

Airborne infection control is a global concern, more so in countries such as South Africa with high rates of tuberculosis. In addition to this, the lack of specialised training for health care-related topics in the built environment curricula results in low awareness levels and poor technical competence in addressing various issues, such as airborne infection risks.

→ *A visit to the Modimolle multi-drug-resistant tuberculosis hospital in Limpopo.*

To address this deficiency, the University of Pretoria and the Council for Scientific and Industrial Research (CSIR), in collaboration with the Centers for Disease Control and Prevention (CDC) and Continuing Education at University of Pretoria (CE at UP), have successfully launched a multidisciplinary continuing education programme in building design and engineering approaches to airborne infection control.

The course is based on a prestigious Harvard School of Public Health course of the same name. It brings together a body of local and international technical expertise common to the control of human airborne infections, such as tuberculosis (including drug-resistant strains), the H1N1 virus, pandemic influenza and severe acute respiratory syndrome (SARS), with particular reference to resource-constrained settings.

The introduction of this new course establishes an awareness of the role of the built environment in infection prevention and control, as well as a network of committed and interested professionals, together with ample evidence-based practical technical skills to take home good practices for better, safer public buildings in South Africa.

The course, which was presented at the University of Pretoria from 18 to 23 June 2012, was funded by the CDC. It was offered free of charge to 50 professionals, which included architects, engineering practitioners and health professionals actively involved in the design, engineering or operation of public buildings. These professionals are in a position to apply the information that was provided for the benefit of their respective institutions in terms of safer health facilities, public buildings or other congregate settings.

This course addressed control strategies, such as ventilation (natural and forced), the design and use of space, ultraviolet germicidal irradiation (UVGI), filtration and personal protective equipment. The strategies covered were applicable to preventing the transmission of infection in workplaces (including clinics, hospitals and laboratories) and congregate living settings.

Twenty-seven experienced lecturers from the Harvard School of Public Health, CDC, the University of Pretoria, the CSIR, the National Institute for Occupational Health (NIOH), and other domestic and international sources presented papers during the six-day programme. Participants also had the opportunity to engage with the panel of experts regarding a design or engineering solution for airborne infection control.

The course is set to become an annual event, with the next one being planned for 24 to 29 June 2013 at the University of Pretoria. ●

Telemedicine can lower health care costs in Africa

Prof Maurice Mars and Dr Louwrence Erasmus
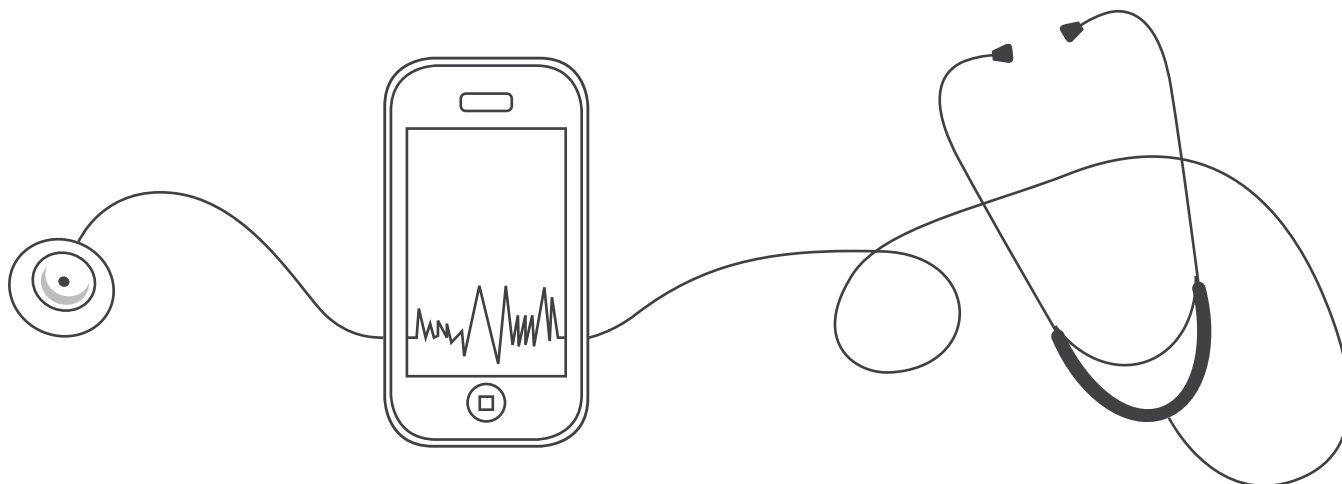
Worldwide, the inflation of health care costs continues with no end in sight. Internationally, telemedicine is used to keep the ageing population out of hospitals and emergency rooms. This could be the answer to Africa's health care woes.

Telemedicine is usually defined as the provision of health care over a distance using information and communication technology (ICT), and includes the provision of health education over a distance. People's health can be monitored in their homes by devices that send information back to a central site by telephone or through the internet. Telemedicine can also be conducted by live interactive video-conferencing, with the patient seeing the doctor face to face, over a distance, with special devices used to assist clinical examination.

Another form is store-and-forward telemedicine, where a photograph is taken of a skin lesion, for example, and attached to an email containing the relevant history, clinical findings and results of special investigations, and sent by a doctor or nurse to another doctor or specialist for diagnosis or a second opinion. Most people have unknowingly practised telemedicine when either seeking or giving medical advice over the telephone.

The health problems of Africa are different from those of the developed world or old economies. Africa carries 24% of the world's burden of disease, and is served by only 3% of the world's health workers, who have access to 1% of global health expenditure. Its population continues to grow rapidly and is expected to nearly double by 2050.

Telemedicine holds great promise for Africa. It can provide rural health care in the most remote areas. All that is needed is a satellite or cellular communication link. This will reduce the long journeys that people need to undertake, sometimes up to days on foot, to get to the nearest health care service point, like a clinic. Telemedicine also increases access to scarce medical specialists in bigger centres and academic institutions.

Through telemedicine, the geographic gap between colleagues is also overcome, as isolated doctors can receive support from their peers at a distance. The severe shortage of doctors can also be overcome by linking several health care facilities serviced by a health care worker to a doctor or doctors allocated to them. Telemedicine provides a platform for the delivery of education by the leading minds in health and medicine to health workers and doctors in the field with minimum disruption to the delivery of health care services. Telemedicine also provides a platform for effectively facilitating research over a large geographic area in a short time.

Africa has yet to embrace tele-medicine. Poverty and civil unrest have left most African countries with poor infrastructure. Fixed telephone line penetration is 1.5% and, as fixed telephone lines provide most internet access, internet penetration

in sub-Saharan Africa is only 4.5%. Bandwidth is both limited and expensive. Fixed-line broadband penetration is 0.1% and the cost of a monthly broadband subscription and 1 GB of data exceeds the average gross monthly income per family in 22 African countries. Mobile phone penetration is now in the region of 32%. One may see this as the solution to connectivity, but costs remain high.

Poor countries have small budgets and even smaller health budgets. The governments of 20 African countries budget less than US$20 (about R160) per capita per annum for health. This amount includes the costs of ICT for health purposes.

Thirty-one African countries have fewer than 10 doctors per 100 000 people. In comparison, Germany has 240 doctors for every 100 000 people, Italy has 370 and Norway has 380. Telemedicine is seen as a solution to the shortage of doctors in Africa. However, something that is often forgotten is that telemedicine adds additional steps to the normal workflow of already overburdened doctors and nurses at both the sending and receiving sites.

International telemedicine across borders will be required to help overcome the shortage of doctors. Such a service will need enabling policies and legislation. However, African policy-makers have been slow to grasp the potential of telemedicine. None of the policies published by the African Union, the New Partnership for Africa's Development (NEPAD) or African health ministers mention e-health, m-health, telehealth, ICT for health or telemedicine. Very few African countries have either an e-health or a telemedicine policy or strategic plan, and this will continue to obstruct the uptake of telemedicine.

Not only is there a shortage of doctors to treat patients, there is also

Not only is there a shortage of doctors to treat patients, but there is also a shortage of doctors to teach and train new doctors and specialists.

a shortage of doctors to teach and train new doctors and specialists. It is not uncommon for medical schools, and indeed countries, to have no specialists in some disciplines.

E-learning in the health sector has been one of the most successful uses of telemedicine in Africa to date. Some of the examples include the following:

• The Resau en Afrique Franco-phone pour la Telemedicine Project, based at the Hopitaux Univesitaires de Geneve, which involves 15 West African countries
• The African Medical and Research Foundation (AMREF) Project to raise the qualifications of 40 000 nurses in Kenya
• The video-conferenced post-graduate training programme of the University of KwaZulu-Natal in South Africa

What is needed now is a telemedicine awareness campaign among health workers in Africa and international support for low-bandwidth clinical telemedicine across borders.

It will require an international effort to resolve issues related to licensing and liability. Furthermore, one should not lose sight of the necessary skills to manage and maintain the technology that enables the successful functioning of telemedicine.

In an effort to address the above issues, the Graduate School of Technology Management at the University of Pretoria is collaborating with the Department of Telemedicine at the University of KwaZulu-Natal and

the Health Technology Management Group in the Department of Human Biology at the University of Cape Town. This multi- and transdisciplinary approach to finding a solution in resource-limited settings by using telemedicine is currently unique.

The first project on which the three partners are currently working is the development of courses for health care workers, based on the current offering of modules at the respective institutions. ❸

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Health care management:
An e-health perspective

Dr Richard Weeks

The first phase of the implementation of the National Health Insurance (NHI) system is now a reality and a host of challenges will need to be addressed to achieve the objective of universal coverage and access to patient-centred, quality health care.

According to an article that appeared in *Sunday Times* on 25 March 2012 ('Public hospitals in Gauteng sick and tired'), the current situation is described as one where "hospitals are under siege as doctors, nurses and patients battle with broken equipment, a shortage of linen, medicine and food, flooded theatres and no telephone lines". Add to this scenario the critical shortage of health care professionals and utterly exhausted doctors, nurses and medical interns, and the challenges assume a newfound reality.

It is within this context and the noble vision of achieving universal access to quality health care services for all South Africans that the potential role of electronic health (e-health) systems needs to be analysed. The concept of e-health embodies a significant spectrum of technologies, including health care informatics, mobile health (m-health), e-prescriptions, electronic medical records (EMR), telemedicine and similar technologies often cited with an electronic or 'e-' prefix.

The concept 'technology' includes the health care service delivery systems' infrastructure. Two key value streams exist within this context: primary or preventative health care and medical care (diagnostics, therapy and rehabilitation). The important aspect that should be noted is the emphasis that is placed on services, as opposed to products. The latter would essentially entail the supply of medication and the acquisition of physical devices, such as wheelchairs.

The following components support or underpin the services value stream: technology component, business systems (financial, asset, risk and maintenance management) and human resources. These are collectively depicted in Figure 2 (the systems health care perspective). Figure 1 could, in fact, be overlaid onto Figure 2 to reflect the technological system.

Notably evident in the two models are the systems' interrelationships, such as the human resources or people dimension that is common in both figures.

The reason why electronic technology is considered so important in the health care framework is because of the prevailing shortage of health care services professionals and the ability of this technology to enable these professionals to be more effective in their delivery of preventative and health care services to the community.

A critical shortage of medical doctors could hamper the successful implementation of the South African government's NHI strategy. The focus therefore needs to be on how to use scarce resources more effectively by using the appropriate technology.

The health care element of the technology model is one of limited resources and the need for increased efficiency and resource utilisation through the application of technological systems in order to improve service delivery to all South Africans. In this sense, the deployment of e-health systems embodies governance, clinical health care and education frameworks. The foundation for the governance framework is an electronic medical records system that forms the backbone of routine health management systems.

Within the clinical framework, telemedicine, decision support and mobile electronic systems, in particular, are important issues. In a widespread and diverse geographical environment, continuing education implies the need for distance education systems that are best delivered by means of electronic media. An e-health perspective to health care management takes the governance, clinical and education aspects of health care into consideration.

E-health systems

The Bill and Melinda Gates Foundation provides a five-stage categorisation of e-health maturity. South Africa is currently at the stage where traditional district health information systems are being migrated to electronic storage and reporting. The journey to the final stage of a fully comprehensive and integrated national information system will form an essential component of the country's e-health strategy.

One of the challenges the health care community will face on this journey is the need to establish national standards that will ensure systems integration and interoperability. To this extent, an office of health standards compliance has been established.

A further constraint that needs to be overcome is that of connectivity and bandwidth, as the various provincial and district health care facilities are widely dispersed in rural settings that are not all that well integrated into the national internet network. Access to an intranet ICT infrastructure that enables digital imaging transfer, such as that associated with picture archiving and communication systems (PACS), will not only enhance the EMR system, but also the clinical medical diagnostic and treatment systems. PACS imply the digital processing, archiving, transfer and display of image data across boundaries. This gives new meaning to mobile health (m-health) systems, as it brings together health care professionals from varying fields of specialisation to provide patients with a seamless, integrated service.

Converting a traditional paper-based and film-based radiology practice from an analogue system to a completely digital one is, however, not merely a 'plug and play' activity. Not only does the technology change bring with it changes in technical systems and infrastructure; it also brings a very fundamental change in the way things are done. It changes the culture of the facility concerned. This brings into focus the third component of the technology concept, namely the human resources or people dimension.
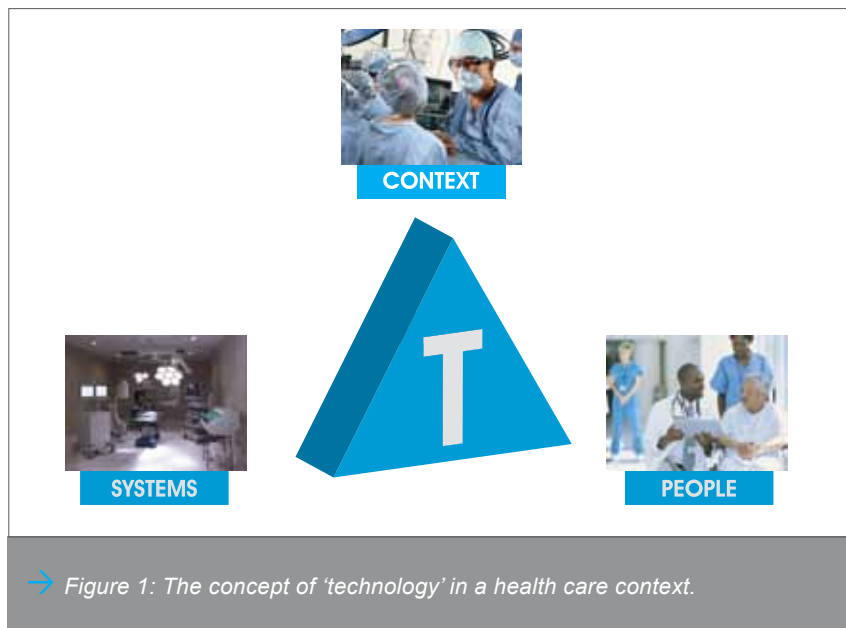
Figure 1: The concept of 'technology' in a health care context.
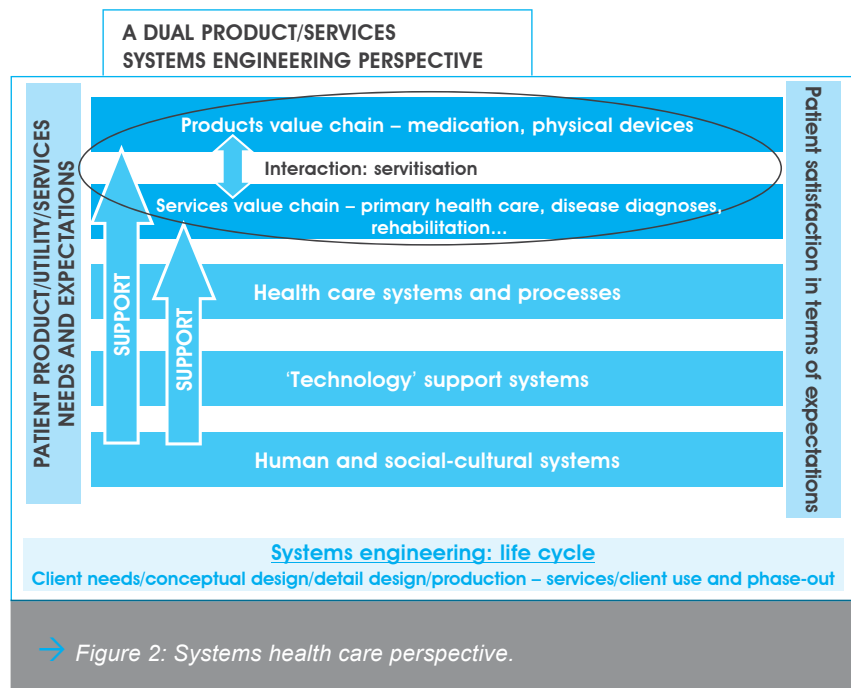
Figure 2: Systems health care perspective.

A national e-health infrastructure and EMR system necessitate the introduction of a patient identification system. Ideally, such a system could be linked to a national electronic identity system that could encapsulate not only marriage, firearm and driver's licence particulars, but also the health care-related information of citizens. The issue of confidentiality in such an interconnected system needs to be taken into consideration. It is, however, hardly a technological constraint, as similar security and confidentiality issues exist in the financial industry. It follows that innovative solutions that have been developed in this industry can be applied to a national e-health system. Diverse health care ICT systems currently exist in the private sector, but many are linked to medical aid systems from a financial systems perspective. When establishing an NHI dispensation, consideration needs to be given to how these systems will be integrated with those of the public sector. This again raises the issue of interoperability and national standards.

A legal regulatory framework is without doubt a very definite challenge that will need to be addressed when

→ *IT is used to deliver medical information from one location to another.*

(clinical), moving to aggregated data (performance and utilisation), knowledge-based data (planning and decision support) and comparative community data (policy development). It has been suggested that the integration and assimilation of EMR information need to become a reality of life for health care professionals. Capturing, organising and presenting medical information will need to be done in a way that will enable greater efficiency and resource utilisation.

E-health and telemedicine

Telemedicine has been defined as the use of information technology to deliver medical services and information from one location to another, and includes medical care delivery, consultation, diagnoses and treatment, as well as the education of patients and staff. Such a definition resonates with the systems health care perspective presented in Figure 2.

The deployment of telemedicine to address the shortage of health care professionals could be achieved by means of the 'teleconsultation' room, situated at more remote district hospitals and clinics. A typical consultation room of this kind is depicted in Figure 3. The purpose of the facility is to link health care professionals from diverse disciplines with each other in situations where, during the examination of a patient, the diagnosis is complex and difficult, or where a second opinion is required.

Such a facility avoids the patient's transfer and referral to a regional or more specialised hospital facility, saving both the time and cost of transportation. There is a need for video-conferencing

establishing a national e-health system. Not only are privacy and security issues at stake, but so are issues that relate to the services that health care professionals provide. One such issue is medical consultation taking place across national boundaries between health care professionals that are registered in one country, but not in another. It could even be contended that pure technological considerations are not the major constraint in implementing an e-health system, but rather the peripheral legal and human resources difficulties.

Closely linked to the EMR system from an e-health perspective would be an electronic pharmaceutical

information and prescription system. The value of the EMR system is the ability to integrate the health-related information of patients from diverse sources. The information system needs to be viewed as a continuum, beginning with patient-specific data

There are already too few specialists to train doctors in specialities and subspecialities. E-health, through the use of distance education, telemedicine and computerised health information systems, is seen as a possible solution to this problem.

e-health packages at clinics and regional and district facilities that will facilitate interaction between health care professionals and provide patients with medical services remotely.

The same facilities can be used for continuing education programmes for health care workers. E-education has been described as being videoconference- or web-based. However, despite the obvious advantages of telemedicine, its uptake has been very low because of challenges related to capacity development. The use of telemedicine in clinical practice requires some form of training and capacity development for the practitioners involved and it is at this point where e-education has an important role to play.

There are already too few specialists to train doctors in specialities and subspecialities. E-health, through the use of distance education, telemedicine and computerised health information systems, is seen as a possible solution to this problem, but there are few practitioners who are trained in e-health.

The people aspect of e-health technology

Over the years, health care professionals have grown accustomed to documenting and storing patient information in paper-based documents and filing systems. An interview with the manager of a large private sector clinic revealed that, while the institution had acquired a state-of-the-art EMR system, most of the doctors still made use of a paper-based system. The EMR system was essentially used for billing purposes and for forwarding accounts to medical aids.

Changing the way we do things is deemed to be an organisational culture issue, and traditionally the logic of culture change, based on scientific management principles, is inherently flawed. Developing mission and vision statements of telemedicine will hardly change the well-entrenched values, norms, beliefs and related cultural artefacts that act as perception and behavioural determinants.

An alternative perspective is that of organisational culture as a complex adaptive system, where culture is seen as being emergent in nature and not static. Within a health care context, static systems are those where the system is practically dead and no longer functioning. In contrast, human cultural systems are alive, vibrant and constantly evolving in relation to changing contextual conditions and system adaptation. The question is therefore one of why e-health technology has not been readily adopted by health care professionals.

A research study undertaken to investigate physicians' perspectives of health information technology revealed that six out of ten physicians feel that electronic health care records have not improved either diagnosis accuracy or treatment planning. Private sector doctors also cited the cost of EMR versus a perceived low return on investment as a constraint in the adoption of such systems in private practice. The research study revealed that only two out of ten doctors provide online scheduling

Teleconsultation Room

Physical assessment
- Integrated diagnostic system efficiency

Thermometry
- Fast, predictive oral thermometry
- Technology and innovation leader in category

Vital signs monitoring
- Automated spot-check and continuous vital signs collection
- Simple, fast, easy-to-use range of devices

Cardiopulmonary
- Aggressive development of ECGs
- Full range of PC-based connected devices

Figure 3: The teleconsultation room. (Source: Eshwari, 2012)

or the downloading of test results and the use of e-health as a private health care communication system. The use is thus extremely low among physicians. The reasons most cited by doctors as being barriers to the meaningful use of health information technology are cost and workflow disruptions. If medical practitioners view an e-health system as something that adds an additional workload with little real benefit, the already overworked and exhausted doctors are hardly likely to change their existing behaviour patterns.

The training of health care professionals in e-health care systems entails having to take them out of the workplace (hospitals and clinics). In light of the shortage of staff at these facilities, this places an extra burden on the remaining staff. The training programmes therefore have to be designed in such a way that they will cause as little disruption to health care service delivery as possible. The skills required for implementing an e-health system are therefore best dealt with through distance education, which permits the trainees to complete the modules where and when they

find appropriate time. This will imply that the people concerned will need to be convinced of the value of the training and use of such systems. Currently, the University of KwaZulu-Natal offers videoconference and e-learning courses. Staff at the receiving institutions who have completed these courses can then act as mentors.

While the focus is generally on the health care professionals who will need to implement and manage the systems, thought also needs to be given to the availability of ICT professionals, who play a very fundamental role in establishing and maintaining the systems. The ICT skills that are required for such a project are also in short supply and there is a large demand for ICT skills within a wide range of service sectors, such as the financial sector.

The technologies themselves are subject to innovative changes and applications in the health care industry. As major new, innovative technological advances are made, the breakthrough technologies will require a fundamental review of prevailing practice. This is particularly

evident in the m-health sector. The ICT technical specialists and the health care professionals often do not understand each other's work, resulting in significant challenges when project managers attempt to put the infrastructure in place to support and manage the new technology.

Conclusion

E-health technologies have the potential to improve health care service delivery to the broader community. In order to implement the technologies, however, a number of challenges will have to be addressed. These include network access and bandwidth, staff training, and – above all – the formulation and implementation of a new management strategy. A key consideration in the formulation of this strategy is the emphasis on creating a culture that is conducive to e-service delivery at the various facilities that will be affected by the system. The e-health technology framework presented in Figure 1 could serve as a point of departure for developing an e-health strategy that will support the implementation of the NHI initiative.

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Mobile post-training support for data capturers in a health environment

Machdel Matthee and Jacobus Liebenberg

The Basic Routine Health Information System for Data Capturers (HISDC) Project was initiated by the National Department of Health (NDOH) in 2008 to address the need for data capturers to improve data quality in public health facilities in South Africa. The so-called 3 535 project aims to train 3 535 unemployed youths as data capturers over a period of three years. The HISDC Project also supports the Expanded Public Works Programme (EPWP), a government initiative aimed at drawing a significant number of unemployed people into productive work – in this instance, young matriculants.

The NDOH awarded the tender for the 3 535 project to a collaborative team comprising the Health Information Systems Programme (HISP), the Health Systems Trust (HST) and Continuing Education at University of Pretoria (CE at UP). The training programme involved 21 days of full-time training at the Hammanskraal service centre of the University of Pretoria for groups of approximately 140 learners at a time. The training covers computer literacy, health information systems, data management, as well as the District Health Information System (DHIS) and Electronic Tuberculosis Register (ETR.net) software.

After completing their training, learners were transported back to their rural and urban health facilities to assist with data management, including data capturing, records management and any other administrative tasks relating to the monitoring and evaluation of health data at their facilities. This is done for the remainder of their one-year internship.

Mobile post-training support

As part of the agreement between the client and the service provider, post-training had to be provided. Initially this support was done telephonically and a share call facility was set up for this purpose. In addition, the service provider offered mobile post-training support as an 'add on' to the helpline support originally specified by the department. Mobile support was done via the Mobile Learning Engine (MLE). Linked to this was a targeted SMS service. For the project implementation, the MLE client was renamed MOBI and adapted by changing icons and adding functionality. The mobile support option was provided because South Africa has an extremely high mobile phone penetration (above 95%).

MOBI offers trainees the opportunity to access the content that has been covered during the course, as well as frequently asked questions (FAQs), post questions, send messages to each other and create message groups.

The current state of the project

Due to a lack of funding, an estimated 900 students still need to be trained. During the past four years, the project has been monitored by the stakeholders, as well as researchers in the departments of Informatics and Information Science in the University's School of Information Technology. Several areas of interest were identified and investigated.

Telephonic vs mobile support

The telephonic helpline came into effect in January 2009 and the last call was received in May 2010. The helpline was discontinued because of its underutilisation. The line was seldom accessed, despite the fact that it provides immediate gratification as opposed to the mobile platform where answers are provided asynchronously.

Trainees seem to prefer the mobile environment because of the mobility of the support and fear of direct contact.

When the trainees left their health facilities, they were just interns, but after a rigorous 21-day training programme, they returned as data capturing experts. The feedback received on the training course proved to be quite helpful in understanding their local situations.

In a questionnaire completed by the delegates after their return to the workplace upon conclusion of the course, about 27% of the trainees mentioned problems with resources. This included access to computers, suitable software, fax machines, printing facilities, proper furniture and buildings. Another problem related to their managers or supervisors – either the lack of mentoring or the problems
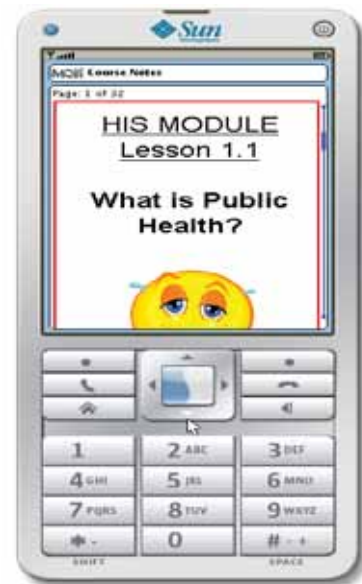
→ *Choices offered to trainees by MOBI, typical FAQs available and the learning content.*

that their 'new' job description were causing. The lack of communication with colleagues, supervisors and the department was also mentioned.

During the 21-day training, a powerful support system was established that involved the trainees and their relationships with each other, the provider and to some extent the client (NDOH). Compared to this, the local support at the clinics with their limited infrastructure and resources, of which the local telephone/landline is part, has little to offer. By contrast, each mobile device, having already been 'activated' on the MOBI network during the training, presented a powerful link to the post-training support set up by the provider. Indeed, each mobile was intrinsically personal, always available. This implied continued participation in and membership of the learning community, which was established during the training.

This is not to say that the MOBI platform does not have any flaws: it is text based, has limited interactivity, no synchronous communication and is quite difficult to use in terms of communicating via text. Yet these limitations are not enough to weaken its role in the post-training support network. Apparently, what it offers is sufficient.

Transformation of the mobile system

The mobile system was designed in a specific way. It was set up as a post-training support technology with specific aims – but the trainees use the technology in unexpected ways. For instance, the FAQ section became a forum not only for course- and training-related questions, but for employment issues, issues related to working conditions and personal issues. As a result, the training provider had to adapt the interface and split the FAQ section in two. One relates to training issues and the other to general and employment-related questions.

This now has further implications. The original system did not require any input from the client (NDOH). As a result of the trainees' influence, the system has now changed to the extent that a mechanism needs to be set up to enable feedback to the client on issues that are raised on the platform that have nothing to do with the training provider's mandate and even find ways of having the client respond.

The network that has been established became more than a post-training support system with a focus on content and learning. For the trainees, it became a general information and communication tool. Trainees are

dispersed all over the country. They do not have a single unified voice, but by becoming their spokesperson, the training provider is able to present a unified voice on their behalf, indicating the value that the mobile support platform has for them.

It is clear that using mobile technology successfully in a developing learning environment has very little to do with users having high levels of technical literacy. From the research, it is quite clear that most trainees would not qualify as digital natives, yet they embraced the technology. ❷

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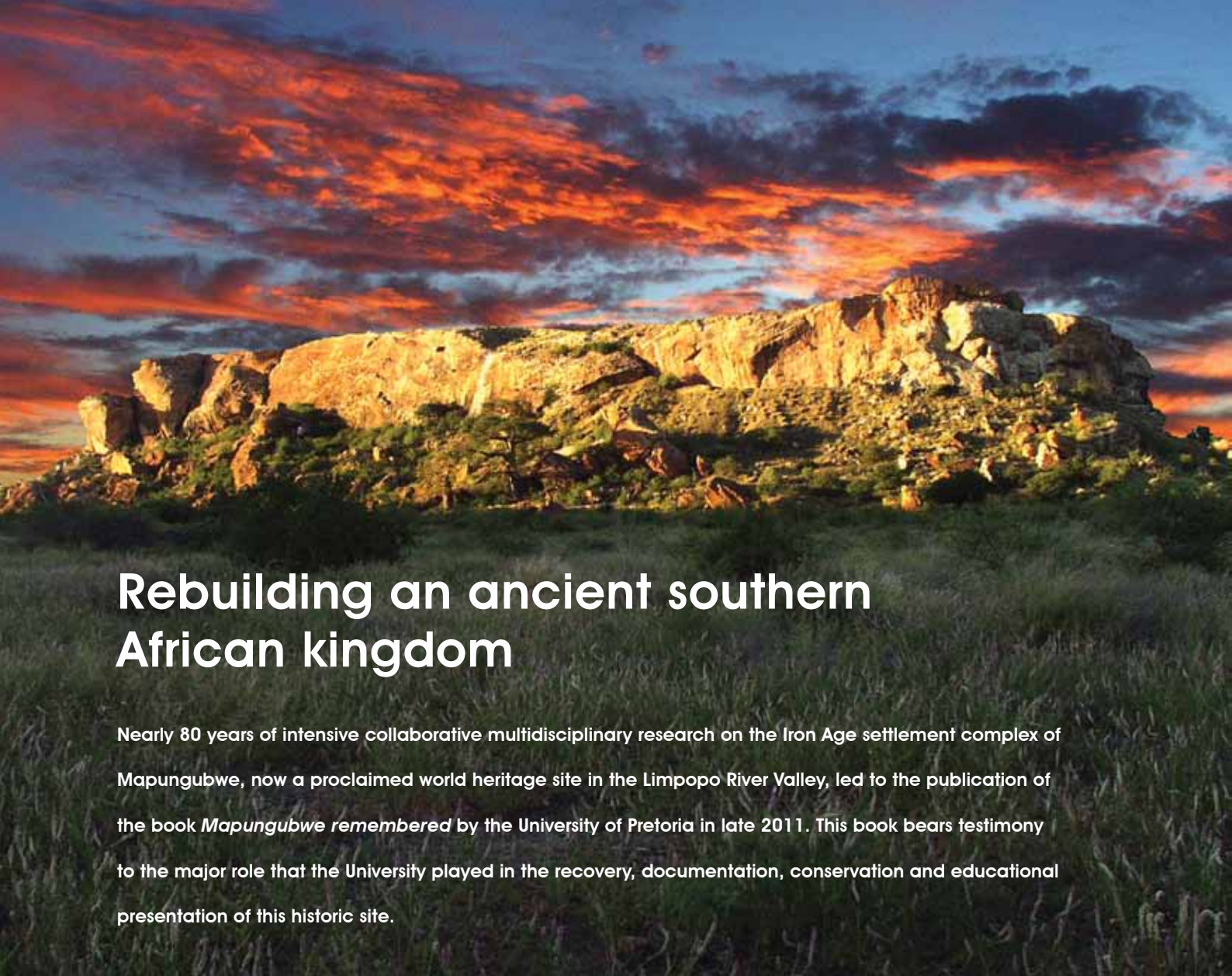
Rebuilding an ancient southern African kingdom

Nearly 80 years of intensive collaborative multidisciplinary research on the Iron Age settlement complex of Mapungubwe, now a proclaimed world heritage site in the Limpopo River Valley, led to the publication of the book *Mapungubwe remembered* by the University of Pretoria in late 2011. This book bears testimony to the major role that the University played in the recovery, documentation, conservation and educational presentation of this historic site.

Researchers in the School for the Built Environment made significant contributions to the book and are continuing with their ethno-architectural research for the digital reconstruction of traditional settlement patterns and African architecture at Mapungubwe and other sites.

Mapungubwe Hill lies on the border between South Africa, Zimbabwe and Botswana on the farm Greefswald in the central Limpopo River Valley. For centuries, it had no significant meaning for anyone, apart from being part of the beautiful natural Limpopo landscape. This was until 1933, when a young man who had stumbled upon gold treasures on the hill called the University of Pretoria to the site. This led to the discovery of the capital of an ancient African Iron Age kingdom and another similar capital nearby, known as K2 or Bambandyanalo.

When the inhabitants of Mapungubwe Hill abandoned this African capital towards the end of the 13th century, they left a wealth of evidence of an ancestral southern African society behind – clay pots, and various objects and tools made from iron, copper, gold, glass and natural materials.

After the discovery of the treasure of Mapungubwe, the University of Pretoria established the Greefswald Archaeological Project, now known as the Mapungubwe Archaeological Project. Over the years, researchers from various disciplines worked on unlocking the history of the site and have jointly gathered a legacy of public and scientific knowledge of the Mapungubwe Cultural Landscape.

As archaeological research efforts on the site progressed, Mapungubwe was recognised as one of the best Iron Age sites in the country and one of the most important cultural heritage sites in Africa. In 1995, South African National Parks (SANParks) declared Mapungubwe

For centuries, Mapungubwe had no significant meaning for anyone, apart from being part of the beautiful natural Limpopo landscape. This was until 1933, when a young man who had stumbled upon gold treasures on the hill called the University of Pretoria to the site.

and the surrounding landscape as the Mapungubwe National Park (initially known as the Vhembe-Dongola National Park). In 2000, the University of Pretoria opened the Mapungubwe Museum on its Hatfield Campus with a display of selected artefacts from the University's Mapungubwe research collection. In 2003, the Mapungubwe landscape was declared a United Nations Educational, Scientific and Cultural Organization (UNESCO) world heritage site.

Ancient architectural remains

Of particular interest to the School for the Built Environment is one of the key features of the Mapungubwe site: the remains of the traditional African architecture that was revealed throughout the archaeological excavations at Mapungubwe and K2.

During the excavations, researchers found architectural features dating back to between 1000 and 1300 AD. At K2, researchers found remains of a homestead complex with structures such as groups of different round pole-and-daub structures or huts, including large structures thought to have been sleeping huts that had an inner wall surrounded by an outer wall; medium-sized single-walled huts that were in some cases used for storage, one of which contained an elephant tusk; and small granary huts.

In the Mapungubwe settlement area, researchers found architectural features such as stone walls and stone steps, small stone platforms, pole-and-daub huts and gravel floors, as well as the remains of ceramic vessels and figurines, metal artefacts, trade glass beads and other cultural objects. A large number of different gold objects were found on top of and surrounding Mapungubwe Hill.

This, in addition to remnants of grain seeds in burnt granary huts, the skeletal remains of domestic animals and remnants of manure in a kraal-like structure, provides valuable information about the lifestyle and agricultural activities that these communities practised.

In spite of the time lapse of approximately 700 years between the settlement of Mapungubwe and the current kingdoms in the Limpopo region, and despite the diversity of languages spoken in the region, researchers realised that there seemed to be remarkable similarities between the subsistence and settlement traditions of the existing Sesotho- and isiVenda-speaking communities that still reside in the region today and the ancient architecture and objects found in the Mapungubwe area.

This inspired researchers in the Department of Construction Economics to embark on an interdisciplinary study to formally research the cultural heritage landscapes and architecture of the communities that currently live in the Limpopo region in relation to the structures found at Mapungubwe and K2, and to use the similarities they uncovered to digitally reconstruct this ancient southern African kingdom.

Ethnographic analogy

Over the past few years, researchers from the University of Pretoria have been working closely with Thovhele MPK Tshivhase, the king of the Tshivhase kingdom of the VhaVenda at Sibasa in the northwestern part of Limpopo, together with his Royal Council, as well as with Kgosi TJ Maleboho, king of the BaHananwa of Blouberg in the northeast of Limpopo and his Royal Council, to gather information on their cultural traditions.

Image courtesy of Eloff (1979).

Image courtesy of Van der Waal (1977).

Image courtesy of Eloff (1979).

Image courtesy of Huffman (1974).

Image courtesy of Fouche (1937).

Image courtesy of Cunningham and Terry (2006).

→ *Two circular stone structures (above left) were excavated at the summit of Mapungubwe Hill in 1934 and seem to be similar to the stone structures that local communities have used until recently to support woven granary storage baskets in Lesotho (above right).*

Image courtesy of Meyer (1998).

→ *Some large stone stamping rocks with a semi-circular wall (above left) were found at Mapungubwe. This is thought to be part of a threshing floor on which the Mapungubwe people threshed and stamped dried grain, like the Shona-Ndau people in Mozambique were doing in the 1900s (above right).*

→ *Numerous bangles and golden anklets or leg rings were found as funerary ware on K2 and particularly on the summit of Mapungubwe Hill (above left). People in the Limpopo region today still manufacture similar objects for cultural use, such as the metal anklets that form part of the ceremonial dress of Venda girls (above right).*

The ancient architecture and objects found in the Mapungubwe area inspired researchers in the Department of Construction Economics to study the architecture of the communities that currently live in the Limpopo region and to use the similarities they uncovered to digitally reconstruct this ancient southern African kingdom.

Digital reconstruction

The research into the relationship between the Mapungubwe architecture and traditions, and the traditions and features of the surviving tribes in the area is ongoing. The kings of the communities are providing valuable insights into the project, passing on traditional knowledge that can be used to explain the cultural and architectural remains at the Mapungubwe and K2 sites.

The Department of Construction Economics is now using the data collected over nearly 80 years of research, together with oral data from the kings of the local tribes, combined with different authors' published ethnographic records of similar ethno-architecture elsewhere in southern Africa, to digitally rebuild Mapungubwe.

The aim of this interdisciplinary project is to create a 3D video that takes the audience through the digitally reconstructed, historic capital of Mapungubwe. The sleeping huts, granaries, stamping blocks, threshing floors and other main structures will be digitally 'rebuilt'.

The cultural and agricultural features of the settlement, as well as the games they were thought to have played, will be reconstructed to create and add detail to the reconstructed settlement.

This will serve as an excellent educational tool for tourists and local residents, and could be used to train the tour guides that work at the site. Such a project was successfully completed and implemented for Thulamela in the Kruger National Park.

The oral traditions of the kings of the tribes will play a major part in ensuring that the digital reconstructions are as accurate as possible. Recording their culture and traditions will supplement the digital reconstruction of the heritage remains of Mapungubwe. These community leaders are grateful for the opportunity to have their own communities' heritage officially recorded and conserved for future generations. The researchers are looking into obtaining intellectual property rights for some of the discovered features, so that these communities' ancestral legacies can be legally protected. ⊕

Mapungubwe remembered

In August 2011, the University of Pretoria published *Mapungubwe remembered*, a 300-page book that celebrates the almost 80 years that the University invested in excavating, discovering and documenting the ancient life of the inhabitants of K2 and Mapungubwe.

The book was compiled to serve as a remembrance and research legacy; a tribute to the former inhabitants of this unique Iron Age settlement – considered to be the most important Iron Age site in the southern hemisphere; a reference work for students, researchers and anyone interested in the history of Mapungubwe; and lastly to tell the story of the University's involvement in the discovery and documentation of this site. It contains a special chapter on Jerry van Graan's recollection of how he and his father ventured into the Limpopo River Valley in search of the graves and treasures that they truly believed were waiting to be discovered.

Mapungubwe remembered is a collection of articles written by 20 authors who have been intimately involved in the research into the discovery and documentation of Mapungubwe over the years. Each of the articles provides the authors' personal views and inputs regarding their respective research fields and involvement in the Mapungubwe project.

→ *The digital reconstruction of the Iron Age settlement of Thulamela in the Kruger National Park.*
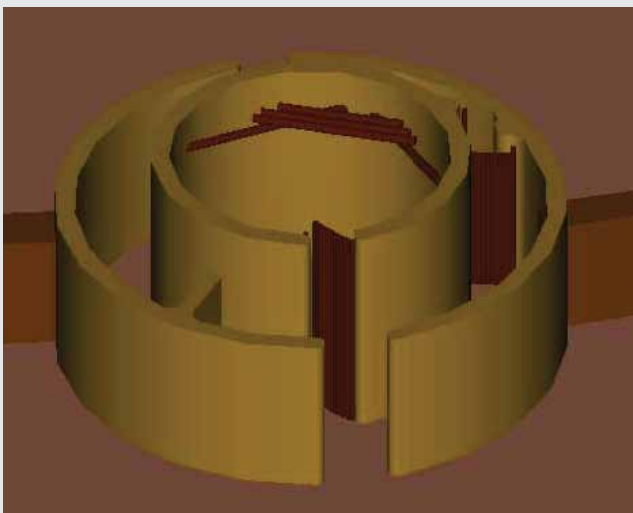
→ *A representation of the double-walled structures found at K2 that are thought to have been sleeping huts.*

→ *A maize storage hut that was digitally reconstructed, based on the trenches with poles found in the Mapungubwe area and the storage huts that can still be found in communities in the Limpopo region today.*

Tuks gets stuck in the mud

Tuks engineering students shine at US Baja competition

It is now official: the design of the CSIR TuksBaja team's off-road Baja vehicle is world-class. The team, comprising 10 Tuks engineering students, travelled to Portland in the USA in May to participate in the annual Society for Automotive Engineers (SAE) International Baja: Oregon, which is one of the largest of the six SAE Baja competitions held in the world. Although they did not win the overall competition, the Tuks team beat 76 other teams from across the USA and various other countries to win the Best Design Award.

The SAE Baja is an international competition in which university engineering students design small off-road cars, each having the same engine, in order to compete against other universities at Baja events. The teams get judged on the car's design, manoeuvrability, ability to climb over rocks and hills and its acceleration performance. They also compete in an endurance race on an off-road track. There are currently six SAE Baja competitions in the world – three in the USA and one each in Korea, Brazil and South Africa.

The South African Sasol Baja is held around October each year and has been organised by UP since the inception of the competition in 1996. The Council for Scientific and Industrial Research (CSIR) TuksBaja team has won the design category of this competition among local universities many times.

The TuksBaja team arrived in Portland, Oregon in the USA on 26 April as the only South African team among 77 entrants from across the world. This is the second time the TuksBaja team has competed internationally in the USA, the previous time being in 2007.

The SAE Baja Oregon officially started on 2 May when judges did engine checks on all the vehicles. "During the engine check, the judges inspect your vehicle according to very strict rules to make sure that it has in no way been modified. All teams compete with exactly the same engine, a standard 10 horsepower engine provided by Briggs and Stratton," says Wietsche Penny, captain of the CSIR TuksBaja team.

On 3 May, cars were judged according to safety standards. "Here we picked up a few minor problems because of the difference in interpretation of the rules between South Africa and the USA, so we had to do some welding and changing on the spot, but we managed to fix what was needed," says Penny.

Prof Schalk Els, faculty advisor for TuksBaja, says it gives students vital experience to compete in international competitions like the SAE Baja Oregon: "They get international exposure, it measures our international competitiveness and exposes us to different challenges, ideas and cultures."

"What makes this win so much more rewarding is the fact that most of the other teams have much larger budgets and more resources available to them to build their vehicles. We have won the design category in the South African Sasol Baja many times, but this award gives us the reassurance that we really are moving in the right direction. It was really great to learn that our design is up to standard worldwide."

The team also had to do a 'sales pitch' as the first official event in the competition: "Each team gets five minutes to 'sell' their vehicle to the panel of judges. You have to convince them that your vehicle is the best one to manufacture at the most affordable price, and answer any questions that the panel may have." Brett Kent was the TuksBaja team's salesperson at this event and helped his team to achieve 11th place in this part of the competition.

The 2012 CSIR TuksBaja winning design

The second event was the design competition, where judges evaluated all design aspects of each vehicle and asked the team members about their design of certain elements. The Tuks team was very surprised when its name was read out as the winner of the category.

What separated Tuks from the other teams was the fact that they designed their own dampers and hub reduction gearboxes for the vehicle, while all the other teams in the competition bought these. "We design these elements of the car ourselves, because we believe that it is better engineering practice to design, manufacture and test all components, so that a solution can more readily be developed in the shortest and most inexpensive

manner, instead of buying components off the shelf, which is effectively a guessing practice," Penny says.

The team does not build the entire vehicle from scratch each year. Instead, they work towards optimising the design of the vehicle in terms of its gearbox, strength, gear ratios, shock absorbers and any other aspects that were identified during a competition that could be improved. The Tuks team has been designing and manufacturing its own dampers since 2005 and has been working continuously on optimising the design.

The drivetrain setup of the TuksBaja vehicle is another unique feature that distinguishes it from other teams. Off-road vehicles will typically have a single driveshaft coupled with a central gearbox, where all the transmission occurs. However, the transmission of the TuksBaja vehicle is split up into numerous driveshaft and gearbox assemblies. The vehicle incorporates a Polaris continuously variable transmission (CVT) that mounts directly onto the Briggs and Stratton standard 10 horsepower engine. From this, a 3:1 reduction is used to increase torque and transmit the power to the hub reduction gearboxes. Here, yet another final 3:1 reduction ensures that the vehicle delivers a maximum of 642 Nm of

torque on the driven wheels at an engine speed of 2600 rpm. The team has done numerous tests on the Polaris CVT to ensure that it takes care of all the transmission of the vehicle without the driver having to change gears.

The roll cage of any SAE Baja vehicle is subjected to very strict rules and is strongly enforced by the safety inspectors. The TuksBaja vehicle features Chromoly tubing that is laser-cut from computer-aided drawings to perfect lengths and profiles, and then expertly tungsten inert gas (TIG)-welded. This Chromoly roll cage has never failed during a roll, crash or jump and can protect the driver from all foreseen hazards that are associated with the sport.

Practical stages

After the euphoria of winning a category, the Tuks team had to prepare for the practical part of the competition that started on 4 May. It was held at the Washougal track just north of Portland.

On this day, the teams had to participate in a number of performance events on an outdoor, rough-terrain track that tested the vehicles' ability in acceleration, hill climb and rock climb, as well as manoeuvrability. The teams got two attempts at each of these events.

It is here that the TuksBaja team experienced its biggest fallback in the competition. The terrain and weather in Portland was not at all what the team expected; therefore the tyres were completely unsuitable for the wet, muddy conditions on the Washougal track.

"We tested every single important aspect of the vehicle in preparation for the event, but the tyres were the one thing we just did not think about.

The biggest lesson we learnt from our participation in this Baja was to carefully research and check the small things of the car, like the tyres, as well."

The main event of the Baja took place on 5 May in the form of a four-hour endurance race at the Washougal track. Teams had to complete as many laps as possible within four hours, on a muddy track littered with obstacles such as logs, mudbaths and riverbeds with cobbles.

Again, the tyres were the Tuks team's big downfall. Because the traction on the tyres was inefficient, they had to lower the pressure, but this led to the tyres slipping off the rims a few times. "We fared very well in the first two hours. We were one of the frontrunners in the race, but then the tyres started giving us problems," said Penny. The team was, however, very satisfied with the fact that, apart from the tyres, the vehicle experienced no other problems or technical difficulties throughout the entire race.

The CSIR TuksBaja team finished 29th overall in the competition.

Future plans

When the team returned from the USA, they turned their attention to preparing for the South African Sasol Baja to be held at Gerotek just outside Pretoria in mid-October. They also went on a recruitment drive at the University to get first-year engineering students to join the team.

"It is important for us to find first-years to join the team so that we can ensure that they are properly prepared to take over when the current senior team members graduate," says Penny. All students in the Faculty may apply to join the team; not only mechanical engineering students.

Prof Els has big hopes for the team in future competitions. "Our team has proven to be a worthy contender at international competition level. It certainly ranks among the world's best Baja teams in terms of mechanical design and manufacturing, leading the way with innovative ideas and implementing these extremely well. The team already has plans in place to test different tyres, especially on wet and muddy terrains, and should be much better prepared for this challenge in future. Ending in 29th place overall, despite totally unsuitable tyres, shows that the potential is there, and with the experience gained, we can take another positive leap forward."

Prof Els adds that the experience of sending the team to compete in the USA is so rewarding. "We will have to think of a very good reason why not to send them there again next year." 🔵

The CSIR TuksBaja team would like to thank the following sponsors:

AFRIT
BPW
CSIR
UP (University Relations)
Faculty of Engineering, Built Environment and Information Technology
A&R Engineering
Investmech
Carab Technologies
Briggs & Stratton

Team members of the 2012 CSIR TuksBaja team:

Wietsche Penny (Captain)
Rian Lauwrens (Vice-captain)
Nico Bouwer (Driver)
Brett Kent (Driver)
Eugene Havenga
Tokologo Komana
Leshanti Raj-Gopaul
Joachim Stallmann
Janco Viljoen
Malcolm Vosloo
Prof Schalk Els (Faculty Advisor)
Carl Bekker (Substitute Faculty Advisor)

Stirring the urban pot: The nature and future of mixed housing in South Africa

Dr Karina Landman

There has been a greater call for mixed housing developments all over the world since the beginning of the 21st century. Whether it is characteristic of the growing trend of New Urbanism, in support of creating more diverse places, or part of a larger movement towards more sustainable neighbourhoods and cities, urban planners and designers have increasingly proclaimed the need for mixed housing.

Leading the way in the UK, planners and designers have advocated the many benefits of mixed housing developments. These include their positive social impact, the potential for interaction between different social spheres and income groups, reduced negative area effects (for example, low aspirations and low-level crime), a mix of students from various backgrounds in the local school, attracting and supporting a higher level of services, providing for a change in household composition in one neighbourhood and the creation of additional employment opportunities through higher disposal income in the area.

Many studies have highlighted the positive contribution that mixed housing can make towards more sustainable human settlements.

As a result, a growing number of countries (including the USA, Canada, the UK, the Netherlands, Australia and New Zealand) have adopted planning and development policies that include a focus on mixed housing.

South Africa is no exception. In line with these planning trends, and especially in an attempt to readdress the patterns of spatial fragmentation and separation in South African cities, current planning policies highlight the need for greater integration. Government's housing plan (commonly referred to as *Breaking New Ground 2004*) specifically emphasises the need for mixed or integrated developments to allow more people greater access to a wider range of socioeconomic opportunities in closer proximity to their living places.

In reality, however, South Africa faces a number of context-specific challenges in the implementation of mixed housing, such as the tradition of separation and segregated development, and high levels of insecurity that may impede interventions that are focused on greater integration and diversity.

The interpretation of what is meant by a 'mixed development' can vary, based on the type of mix, whether housing or tenure types, a mix of income groups or a larger sociospatial mix through all of the aforementioned, including a mix of social groups and land uses. People often use these concepts interchangeably, including mixed tenure, mixed income and mixed communities. In addition, mixing can take place on different scales, at one site and/or in an entire larger urban neighbourhood.

Mixed developments vary greatly in South Africa and comprise a mix of housing or building types, tenure types and land uses, accommodating a mix of income and social groups. As is the case internationally, projects differ in size and scale, ranging from smaller projects such as Brickfields and Carr Gardens to medium and larger projects on very large sites, for example, Wonderpark, or an entire neighbourhood, such as Cosmo City, Pennyville and Olievenhoutbosch in Gauteng.

Take, for example, the Brickfields development in the inner city of Johannesburg. The entire complex comprises 345 units of various sizes, including bachelor units, one, two and three-bedroom and live-and-work units. There are also 21 commercial units. The precinct consists of a mix of building types, including a number of four or five-storey walk-ups and two nine-storey tower blocks.

Another good example is the Wonderpark Estate in the north of Pretoria.

South Africa faces a number of context-specific challenges to the implementation of mixed housing, such as the tradition of separation and segregated development, and high levels of insecurity.

The mix in unit types, size and tenure options also provides opportunities for a mix of income groups to invest in developments.

This development offers 1 480 units, which include bachelor units, as well as one, two and three-bedroom units. The units vary in size from 33 to 80 m^2 and are arranged in different building types, including two and three-storey walk-ups.

Contrary to existing fears, mixed housing projects do not embody the stereotypical image of European low-income public housing estates or 'matchbox' low-income housing developments in South Africa. They often include vibrant environments that offer a range of on-site amenities and facilities in close proximity to other urban facilities.

The Wonderpark Estate, for example, is within walking distance of the Wonderpark Shopping Centre, various restaurants and fast-food outlets, the Akasia Hospital and clinic, municipal offices and the offices of the Department of Home Affairs. It is also in close proximity to the Rosslyn industrial area, George Mukahari Academic Hospital, Medunsa, Tshwane University of Technology and various crèches, and primary and secondary schools.

Another example is Pennyville, which is located south of Roodepoort in southwestern Johannesburg. It lies along New Canada Road just south of the major railway line that connects the Johannesburg CBD with Soweto.

The project is close to a major shopping centre (the Highgate Centre) and industrial areas. On-site facilities and amenities include sports facilities, schools and a crèche. This enhances greater access to a range of socioeconomic opportunities.

Mixed housing developments are not only restricted to large metropolitan areas in Gauteng, but also occur in the rest of the country, for example, Amalinda in the Eastern Cape (Buffalo City Municipality) and Thornhill in Limpopo (Polokwane). Amalinda is a small development of 598 units with a range of unit and building types. These include two, three and four-storey walk-ups with one, two and three-bedroom units between 31 and 52 m^2 in size.

Thornhill is a much larger development that consists of different precincts, each with its own character in terms of layout, building types and unit sizes. Thornhill Estate comprises 1 100 households and a clubhouse with a swimming pool, tennis court, squash court, gymnasium and entertainment area, as well as numerous landscaped walkways to all its residents. The village has 188 one-bedroom bachelor units and one and two-bedroom townhouses for rental purposes. Fairview offers 141 simplexes in two and three-storey walk-ups. The Willows comprises 73 units of two to three-bedroom townhouses and 1.5-bedroom lofts.

Mixed housing projects also accommodate different housing models and tenure types. The Pennyville project is expected to deliver 2 800 housing units, of which 1 400 would be RDP houses (subsidised by the government), 1 000 credit-linked units (to be purchased by financial institutions and leased or sold) and 400 apartments for rental accommodation (to be owned by the Johannesburg Social Housing Company – JOSCHO). This illustrates the mix of tenure accommodated in

Pennyville, including private ownership for very low-income households (through subsidised RDP houses), private ownership for low to middle-income households (through affordable credit-linked housing) and rental social housing units.

Cosmo City is another good example of a mixed housing development with a mix of house types, tenure types and land uses, providing opportunities for a range of income groups. The development consists of four housing and tenure types: 5 000 fully subsidised units, 3 000 partially subsidised (credit-linked) units, 3 300 fully bonded houses (market-rate housing) and 1 000 social housing apartments for rent. The different housing types offer the opportunity for a mix of tenure, ranging from owned to rental units.

The mix in unit types, size and tenure options also provides opportunities for a mix of income groups to invest in the development. This can vary from smaller projects that incorporate a smaller range of income groups, to large projects that accommodate a much wider range of income groups, such as Cosmo City.

Based on a household survey conducted as part of a larger project on medium-density mixed housing in 2008, a large portion of the respondents (35%) earned less than R2 500 per month, 16% earned between R2 501 and R5 000, 19% earned between R5 001 and R10 000, and 22% earned between R10 001 and R20 000.[1] Few of the respondents (8%) earned a household income of over R20 000 per month. This probably includes professionals residing in the market-rate housing. Yet, it remains very significant, given the wide range of mix in the development.

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1   *The survey sample included residents from RDP, credit-linked and market-rate houses.*

→ The Brickfields development in the inner city of Johannesburg comprises 345 units of various sizes.

→ The Pennyville development, located south of Roodepoort in southwestern Johannesburg.

Based on subsequent household surveys conducted in 2010, slightly less than 40% of the respondents in Thornhill earned between R10 001 and R20 000 per month, with just more than 40% earning more than R20 000 per month. Mixed housing projects are not restricted to projects that include lower and middle-income households. They also include upmarket developments such as Melrose Arch in Johannesburg. The development has 11 blocks with mixed land uses and a variety of housing units (one, two and three-bedroom units) and tenure types (ownership and rental). According to the household survey (2010), more than 90% of the residents earned more than R20 000 a month.

Mixed housing is slowly starting to stir the urban pot and is allowing greater integration and diversity in South African neighbourhoods and cities. However, in spite of the positive signs, it is not yet part of South Africa's mainstream housing development and it remains to be seen whether it will become one of the preferred models for the majority of people in the country. In order for mixed housing to become a preferred model, the following three aspects will need attention:

- The general perception of mixed housing developments in the country needs to change, and the general awareness of successful projects needs to increase to bring about a change in mindset in the broader society. Due to South Africa's tradition of segregated development, people need to be convinced that mixed develop-

ments can offer great benefits in a vibrant environment. A positive image of existing and new mixed housing projects therefore needs to be created and advocated.

- People need to feel safe and secure to invest and reside in mixed housing projects, especially in a country with high levels of crime and the associated fear of crime.

- The realities of the urban housing market need to be borne in mind. It is necessary to carefully consider the viability of different housing models and price ranges in a single development. One could therefore mix a certain range in one development, such as low income and middle income (for example, Brickfields and Pennyville) or middle income and higher income (for example, Melrose Arch). Very few projects will, however, be able to achieve the wide range of income groups accommodated in Cosmo City.

Stirring the urban pot in South Africa through mixed housing necessitates creative thinking in terms of different housing models, tenure and unit types, aesthetic and pleasing environments, design for safety and grouping, and thresholds of different income groups.

Acknowledgements

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Dr Karina Landman was previously employed at the CSIR, where she coordinated a large project on medium-density mixed housing in South Africa (2007–2009). Since 2009, she has continued research in this area at the University of Pretoria. Her research includes work carried out by a number of honours and master's students in 2010 and 2011.

Revealing the nano-world to understand an age-old process

Dr Heinrich Badenhorst

The University of Pretoria is a world leader in ultra high-resolution scanning electron microscopy. Students in the South African Research Chairs Initiative (SARChI) Chair in Carbon Materials and Technology are using this cutting-edge equipment to peer deep into the structure of carbon materials. They are revealing new aspects of what was thought to be a well-understood and mature subject: the combustion of graphite. By linking their observations of tiny particles and minute structures to innovative models, entirely novel descriptions of the material's behaviour are being created. This work promises to lay the foundation for a much broader understanding of exactly how carbon burns.

Ever since the Palaeolithic cavemen ignited those first flames of fire almost 800 000 years ago, man has striven to harness its amazing power. Combustion is the impetus behind nearly every aspect of our lives – from the cars we drive and the electricity we use in our homes, to the traditional braaivleis that makes our weekends so special.

Despite all the research that has gone into understanding this relatively simple reaction between carbon and oxygen, much is still disputed. This is partially due to the myriad of complex carbon structures that exist. The problem is further complicated by impurities in the material, which can both inhibit and amplify the reaction. A first look at the carbon surface already reveals numerous phenomena. Graphite was chosen as a simplified carbon structure for the initial modelling in this research.

As can be seen in Figure 1, the planes of hexagonally bonded carbon atoms give graphite a characteristic layered structure. This layered structure, along with several other aspects, is revealed in the image. The figure shows that the edges of the graphite are lightly dusted with tiny white particles. These particles inhibit combustion, leading to the development of characteristic edge features. One can also see large droplets of catalyst particles. These catalysts drive the combustion in a multitude of ways, but over time they agglomerate into larger particles and become relatively inactive.

Initially it was thought that all graphite materials were similar, but closer investigation revealed large differences between natural and synthetic materials. For example, the synthetic materials were found to be far from ideal and much more liable to attack by oxygen, leading to some very complex structures, as illustrated in Figure 2.

Only natural graphite exhibited the pristine edges (Figure 3) with the characteristic 120º angles that are indicative of the underlying crystal structure. In addition, the natural material was found to contain inclusions of impurities. When these were evaporated under extremely high temperatures, the beautiful, underlying layered structures of the flawless graphite crystals were revealed.

Close inspection of the graphite particles showed several noteworthy microstructures. As the particle is combusted, these structures develop and grow, controlling the rate at which the material burns. Based on this observation, several representative structures for the behaviour were proposed and simulated using a probability-based finite element mesh. This allowed the progression of the microstructure throughout the reaction to be predicted, as shown in Figure 4,

> Despite all the research that has gone into understanding this relatively simple reaction between carbon and oxygen, much is still disputed.

which could ultimately be linked to real experimental data.

When the edges of the partially combusted natural graphite flakes are examined, the effect of the catalytic impurities are clearly noticeable. The edges are completely degraded and highly erratic as the catalyst particles have created random channels in the graphite. In some cases, the catalyst particles cut fissures into the graphite, which created tiny fjords (each less than one tenth the width of a human hair), as can be seen in Figure 5.
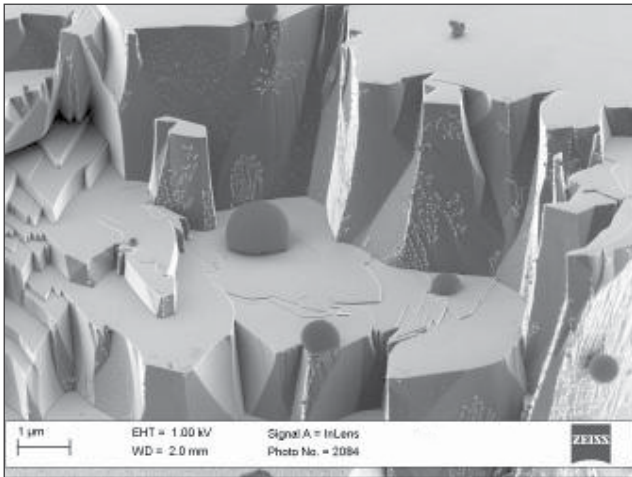
Figure 1: Surface effects on graphite.
   (Winner: Carl Zeiss Nano-image Competition)

Figure 2: Synthetic graphite structures.
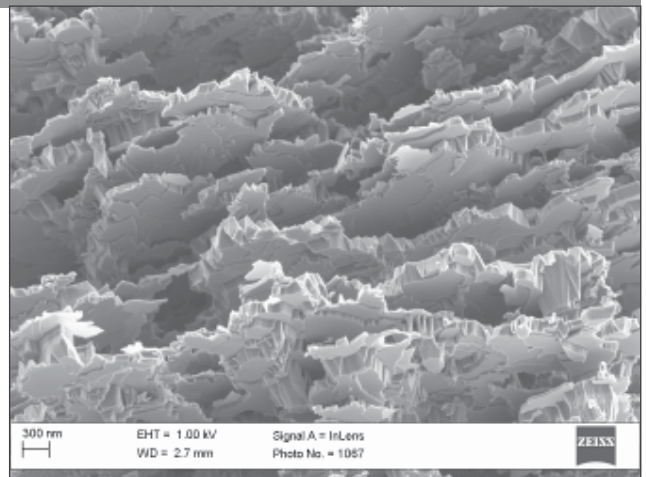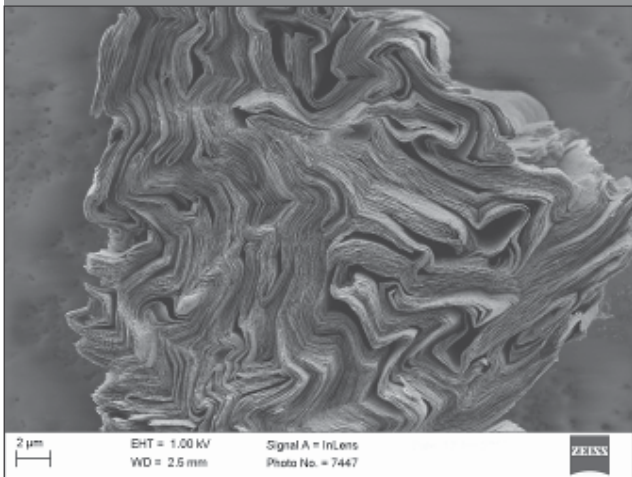
Figure 3: Natural graphite structures.
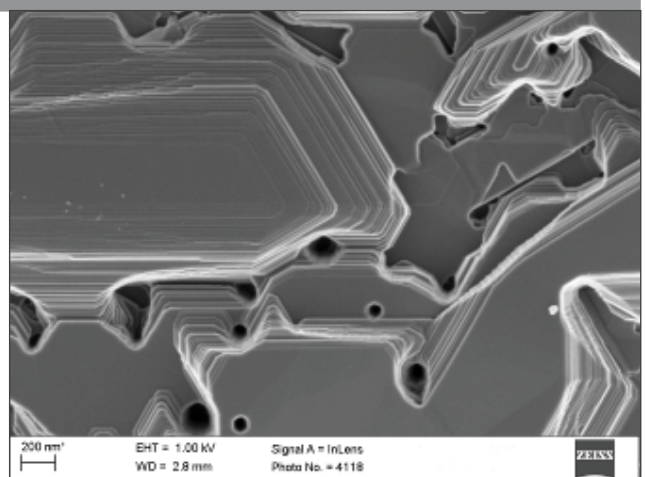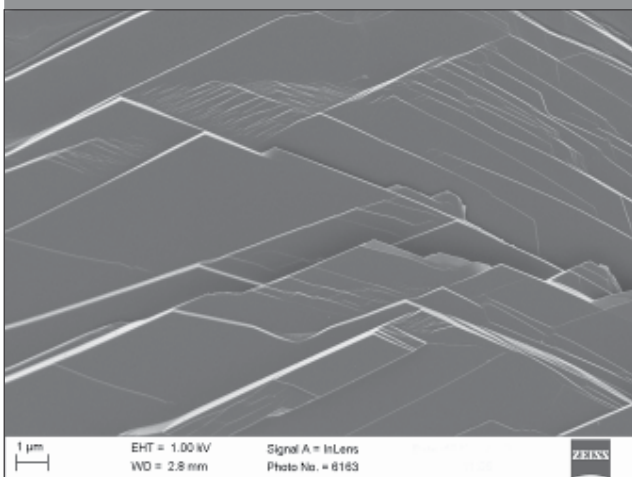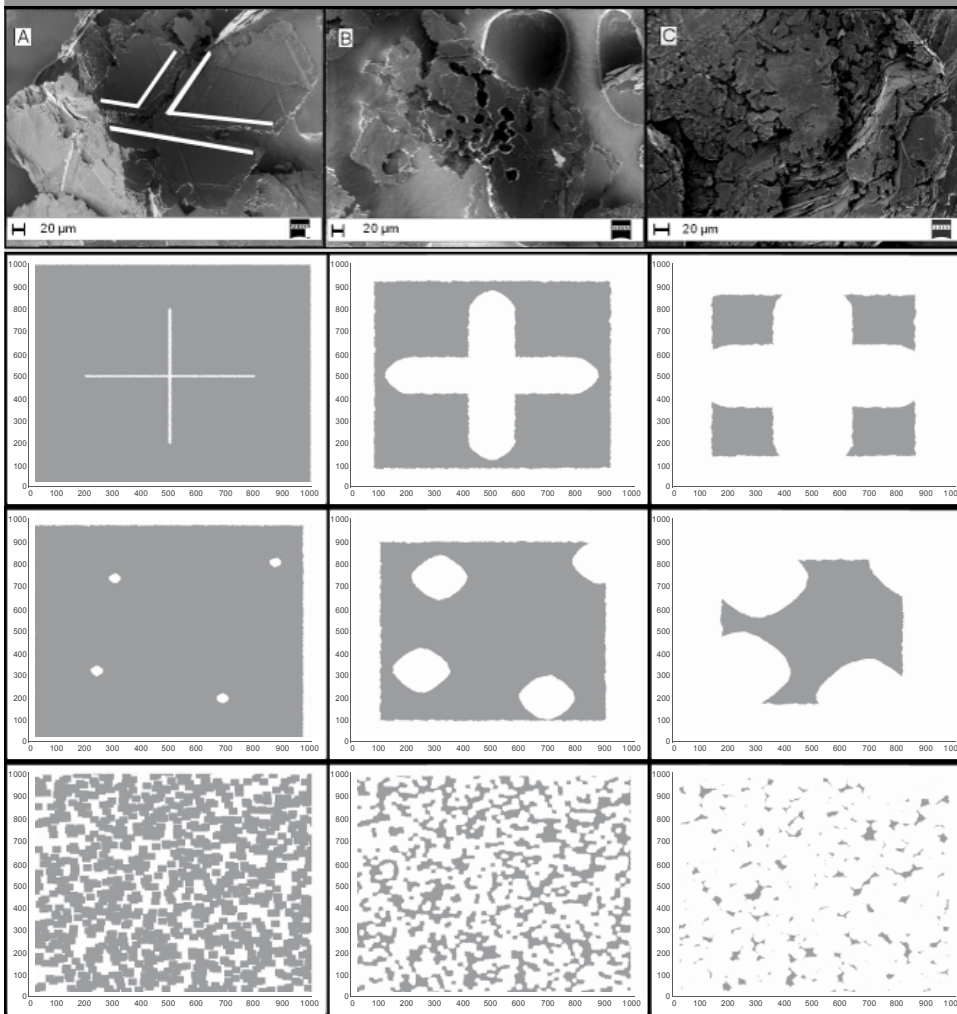
The particles that cause these effects are extremely small. In most cases they are in the order of a few hundred nanometres, which is about the same size as an average virus particle.

industrial applications aimed at modifying the combustion behaviour of carbon materials. If successful, the new materials will open doors to a wide range of new high-temperature applications for carbon materials. ℹ
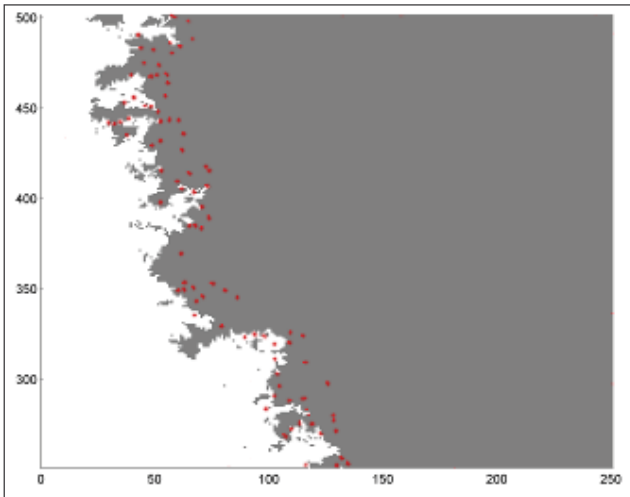
The particles that cause these effects are extremely small. In most cases they are in the order of a few hundred nanometres, which is about the same size as an average virus particle. By studying the wide variety of behaviours these particles exhibit, a general representation of the catalytic action can be formulated. This was incorporated into the aforementioned simulations to account for the effect of the catalysts on the measured reaction rates (Figure 6). The red dots represent individual catalyst particles that trace random channels through the graphite.

Finally, the influence of the particles that inhibit combustion had to be considered. These particles block the attack of oxygen, shielding subsequent layers from attack. This leads to the formation of distinctive saw-tooth-like edge structures, as can be seen in Figure 7. The pinnacle of

each structure represents a single inhibiting particle, protecting the entire formation. In some cases this leads to the creation of tiny caves. Within them, minuscule stalactites and stalagmites are visible. It is incredible to imagine that these formations are one thousand times smaller than a single strand of human hair.

All of these phenomena could not have been observed without the exceptional resolution of the modern electron microscope facilities at the University of Pretoria. By incorporating all three of these effects into a single model framework, a coherent foundation has been formulated to study the combustion of a variety of carbon materials. It is hoped to expand this work in the future to include a far wider range of carbon allotropes and impurity behaviours. This work has already borne fruit in the form of several
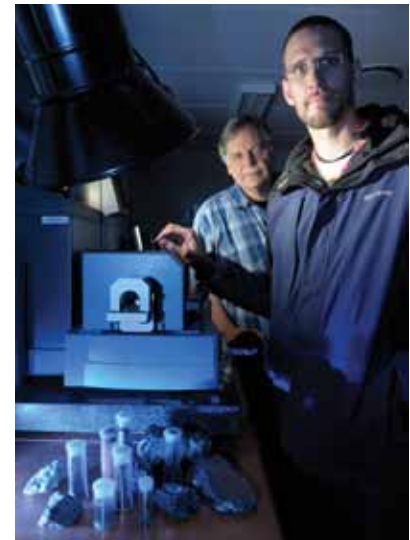
Dr Heinrich Badenhorst (front) *recently completed his PhD in Chemical Engineering and will soon be taking up a research fellowship at the University of Pretoria. His interests centre around all forms of carbon materials, with a particular focus on surface, structural and kinetic phenomena.*
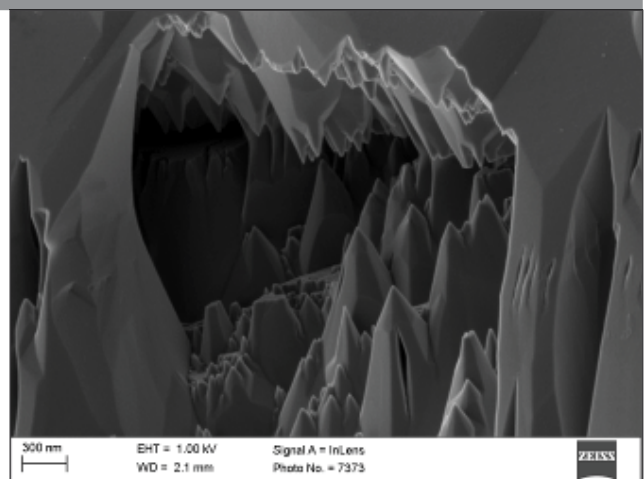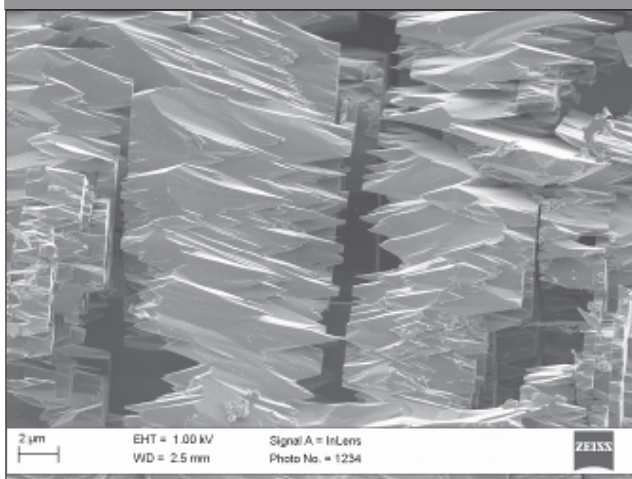
Education and training in automotive component manufacturing

Prof Jasper Steyn

The Graduate School of Technology Management (GSTM) has long identified the importance of research on technological innovation in the automotive manufacturing industry, with the aim of contributing to industry practice and government policy. In the domain of global trade, the value of the international trade of vehicles and automotive components contributes the dominant proportion of the manufactured goods category (more than one third of the total value traded). Automotive manufacturing is also the largest manufacturing subsector in South Africa, largely due to generous government support, driven by the need for socioeconomic benefits, particularly in respect of the creation of advanced technology jobs.

Having been around for more than a century, the automotive industry is a primary example of a mature industry with many well-established multinational corporations, strong power relationships and leading-edge technologies. Competition for business among global players has grown to extreme levels. This has made it even more important to upgrade via innovation to defend and grow market share, with technology-based innovation at the forefront.

One would expect education and training to be the key enablers to achieve technological innovation, as technology-based innovation requires managers and employees to understand the new technologies that are emerging in their field of business.

To explore how this dynamic plays out in the South African automotive component manufacturing industry, a survey was conducted in industry to obtain information on the level of education and extent of innovation and training for innovation. The purpose of the survey was to gain an improved understanding of how education and training can enable the technological innovation capability of firms in the automotive component manufacturing industry. Better understanding of how this works should enable firms to make more effective choices in acquiring the resources they need for innovation. It should also enable government to plan its support for

innovation and for education and training more effectively.

The study was planned in collaboration with researchers at the University's Gordon Institute of Business Science (GIBS) and Lund University in Sweden. The latter linkage provided the benefit of information on data obtained in the automotive component manufacturing industries in India and China via a study using the same questionnaire, financed by the Swedish Research Council.

For the South African study, members of the National Association of Automotive Component and Allied Manufacturers (NAACAM) were approached. NAACAM represents the largest number of automotive component manufacturers with the most employees in the sector.

For the South African survey, 75 responses were obtained, while 190 responses were obtained for China and 272 for India.

From a comparison between the average education levels for companies in South Africa, China and India (see Table 1), it is evident that India and China have a much higher percentage of staff with higher levels of education than South Africa does. This is consistent with the much higher level of own design that is required for own original equipment manufacturer (OEM) brands that is prevalent in India and China.

Table 1: Proportion of employees according to level of education

Education level	Average percentage of staff so educated		
	South Africa	China	India
Technical education/training	19%	46%	41%
University degree	5%	44%	30%
Graduate studies	2%	10%	12%

From the total responses, it is evident that innovation is fairly evenly spread between the various categories (see Table 2), with approximately two thirds of respondents indicating improved processes and more than half indicating improved products and services or improved organisational methods. When compared with the data from China and India, it appears that South African manufacturers, together with their counterparts in China, fared comparatively worse than those in India on product innovation in both products and services. South African manufacturers reported notably higher levels of innovation in improved manufacturing methods.

In general, the levels of innovation reported are much closer between South Africa, India and China than education levels. In the context of the high own OEM brand activity in China and India, innovation in South Africa – being tailored to follow the requirements of multinational OEMs and component parent companies or licensors – appears to require lower education levels. The comparatively higher level of innovation in improved manufacturing methods in South Africa can be attributed to new OEM model introductions, rather than own initiative in gaining increased business.

The survey also compared training (as an innovation activity) in South Africa to that in China and India (see Table 3). Companies in South Africa are much more dependent on international training, which is consistent with their dependency on multinationals.

As can be expected, the profile of the level of education and the kind of training that automotive component manufacturers use in South Africa correspond to the dependency of the industry on innovation driven by multinational corporations.

Proclaimed government aspirations of greater competitiveness, increased sustainability and decreased dependency on government incentives would require higher-level skills and better local training opportunities, judging from the education level profiles and training locations in India and China, where these aspirations have been achieved in greater measures. On average, typically double the proportion of technical educated and trained staff would appear to be needed, and at least five times the proportion of university-level educated staff. ⊖

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Table 2: Innovation type

		Percentage of respondents involved		
		South Africa	China	India
Product	Improved goods	49%	48%	63%
	Improved services	32%	36%	52%
Process	Improved methods of manufacturing	61%	40%	34%
	Improved logistics	35%	34%	14%
Organisation	New internal management practices	55%	54%	54%
	New organisation of external relations	28%	26%	12%

Table 3: Training locality per country

	Percentage of respondents involved		
	South Africa	China	India
Local	28%	24%	79%
Domestic	16%	32%	12%
International	32%	2%	2%
Total	76%	58%	93%
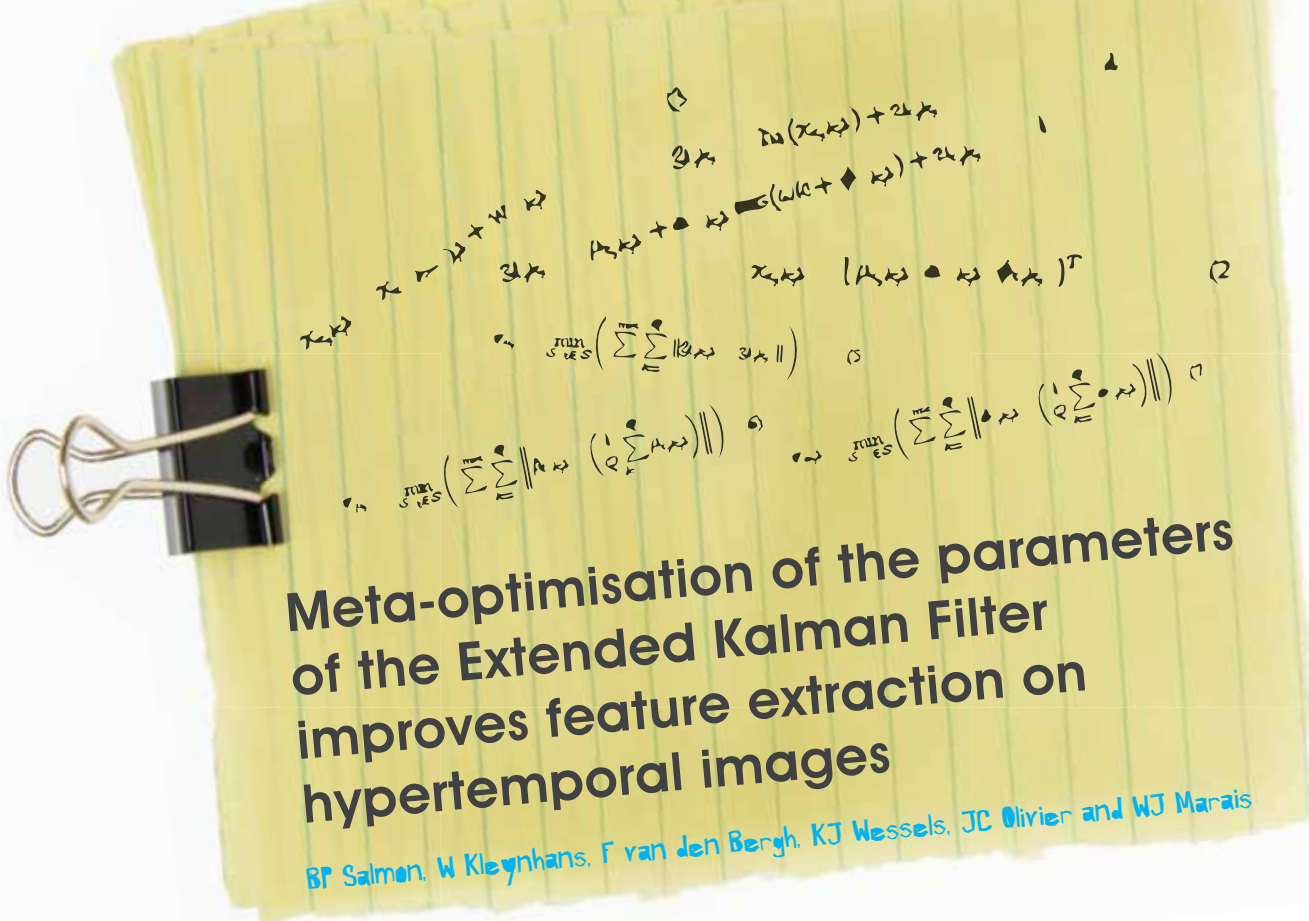
Meta-optimisation of the parameters of the Extended Kalman Filter improves feature extraction on hypertemporal images

BP Salmon, W Kleynhans, F van den Bergh, KJ Wessels, JC Olivier and WJ Marais

The reliable surveying of land cover and transformation has always been a key area of interest to the remote sensing community. The increase in the human population is one of the major contributors to settlement expansion, with several studies showing that anthropogenic activities have transformed more than a third of the earth's surface. Gauteng is of interest, as it is the fastest-growing province in the country, housing more than 10.5 million people. Reliable knowledge of land cover is a critical tool in the effective allocation and management of the environmental resources.

Satellite-based sensors are widely recognised by international and local agencies as a cost-effective method of acquiring periodic, systematic information of the earth's land surface. Land cover is defined as the physical composition of material on the surface of the earth, while land use is a description of how the land is used for socioeconomic purposes. Monitoring land cover is of great importance as this guides regulatory bodies on how to best utilise a country's resources without putting the environment at risk.

Two types of land-cover changes are usually investigated: land-cover modification and land-cover transformation. Land-cover modification is caused by internal changes within a particular land-cover class. These changes affect the current state of the land-cover class, but do not change the land-cover class, such as seasonal variation of natural vegetation. Land-cover transformation of a particular geographical area involves change from one land-cover class to another. Hypertemporal acquisition strategies of satellite-based sensors allow the construction of time series, which enables one to distinguish between these two types of land-cover changes for improved land-cover classification.

In a study conducted by researchers at the University of Pretoria and the Remote Sensing Research Unit of the Meraka Institute at the CSIR, time series were extracted from the first two spectral bands (red and near infrared wave lengths) of the MODerate-resolution Imaging Spectroradiometer (MODIS) land-surface reflectance product and were modelled as a pair of triply modulated cosine functions. A meta-optimisation approach was proposed for setting the parameters of the non-linear Extended Kalman Filter (EKF) to rapidly and efficiently estimate the internal state-space variables for the pair of triply modulated cosine functions.

This meta-optimisation approach uses an unsupervised algorithm to search for improved parameters over an appropriately defined manifold, using spatial and temporal information. Performance of the new method was compared to other applicable methods.

The state-space variables estimated by the EKF were then used as feature inputs to cluster the time series into different land-cover classes. Clustering is an unsupervised method used for grouping unlabelled objects into a set of categories. The algorithm used in this work was the K-means algorithm, which is usually used as a benchmark for

other algorithms. The proposed method was evaluated on a 285 km^2 study area in Gauteng, comprising mostly areas of natural vegetation and human settlements. The time series in the validated study area was verified using visual interpretation of SPOT images to map areas of no change in land-cover type during the study period for the temporal component of the analysis. The classification accuracies obtained by using the meta-optimisation method improved by more than 7% when compared to other methods.

The method was then applied to the entire province. A silhouette graph is a graph-based approach used to determine the number of clusters that should be used by the clustering algorithm without any human supervision. The optimal number of clusters in Gauteng for the K-means algorithm was calculated to be five clusters using the silhouette graph. The formed clusters were evaluated by a human operator and grouped into either human settlement or natural vegetation areas.

Roughly 23% of the province's total area of 19 676 km^2 was classified as settlements by the clustering algorithm.

In conclusion, it was demonstrated that improved features can be obtained by using the information within a spatio-temporal window. The proposed unsupervised feature extraction method was not dependent on acquiring a labelled training data set. It was shown that with proper selection of the initial state parameters, observation noise matrix and process covariance matrix, the cluster separation of EKF-derived features could be improved.

The algorithm described in this article can be optimised by adjusting the temporal length of the spatio-temporal window to ensure that it takes cognisance of short-term inter-annual climate variability and adapts to longer-term trends in climate. The features extracted using the EKF can also be applied in combination with a variety of other machine-learning algorithms. 🌐
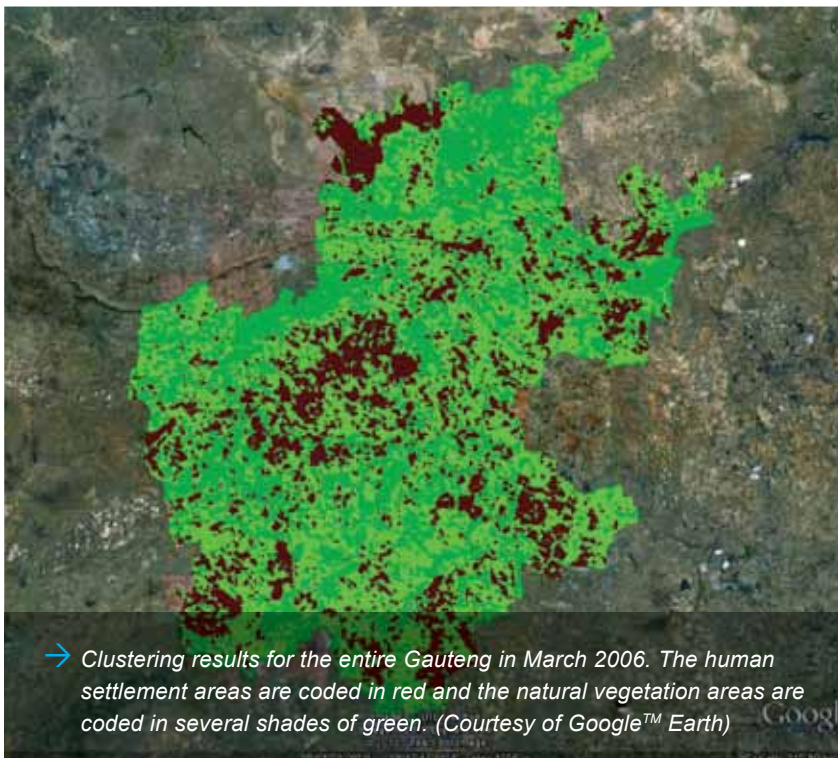
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→ *Clustering results for the entire Gauteng in March 2006. The human settlement areas are coded in red and the natural vegetation areas are coded in several shades of green. (Courtesy of Google™ Earth)*

→ *A rural dwelling in the KwaZulu-Natal Midlands.*

Using ICT4D to make a difference in Tugela Ferry

Dr Marita Turpin and Kirstin Krauss

In Tugela Ferry, a remote town in the KwaZulu-Natal Midlands, researchers in the Department of Informatics at the University of Pretoria made a significant contribution to the wellbeing of a Zulu community by effectively and sustainably implementing information and communication technology (ICT) according to the community's needs. The project formed the basis of the doctoral research of two lecturers in this department and produced valuable new insights into research in the field of ICT for development.

Information and communication technology for development (ICT4D) is a research area in information systems that is concerned with the application of ICT to improve socioeconomic conditions in developing countries. The first era of ICT4D is associated with the expansion of the internet in the 1990s, and is characterised by the establishment of telecentres. Many of these telecentres failed. This drew attention to concerns such as sustainability, scalability and impact evaluation. The current rapid diffusion of mobile telephony throughout Africa presents new opportunities, and the reach of mobile phones into remote areas can be used to support service delivery, educational initiatives and mobile payments, to name but a few.

One of the concerns of ICT4D is that of using appropriate technology. Many failed initiatives have been characterised by initial enthusiasm around high-tech applications, which could not be sustained in the long run in terms of maintenance, unreliable internet access and electricity infrastructure, among other things. Other risk factors include local ownership and the ability of

ICT4D practitioners to address real needs, as opposed to implementing their own pet projects. Added to this, the communities that may benefit most from ICT4D initiatives are not necessarily accessible to ICT4D researchers and practitioners because of geographical, language and cultural barriers.

In South Africa, with its high inequality rate, high levels of poverty and unemployment, and the large urban-rural development divide, there are many challenges around socioeconomic development, community empowerment and the improvement of the human condition. These same challenges could be viewed as opportunities for local ICT4D researchers and practitioners, who want to make a difference using ICTs.

A group of ICT4D researchers from the Department of Informatics at the University of Pretoria were in the fortunate position to have gained entry into a remote, rural community that is not generally accessible to outsiders. Here they could scope and implement an ICT4D project.

→ *The town of Tugela Ferry.*

→ *The view from a household in Tugela Ferry.*

The Tugela Ferry community

Tugela Ferry is the administrative and business centre of the Msinga district deep in the KwaZulu-Natal midlands. Msinga is the heartland of the amaZulu. Herding animals is the primary economic activity and the area is mostly unsuitable for crop farming, except for some plots along the Tugela River.

Tugela Ferry has a very limited, basic infrastructure. A tarred road connects the town to the national road network. Four out of every five households in the district do not have access to electricity or running water, have no sanitation facilities and no means of transport. The adults in the poor households are largely illiterate and do not speak English. Their subsistence livelihoods have become inadequate as a means to sustain them, and as there are virtually no formal employment opportunities in the area, social grants in the extended family have become the major source of income. The prevalence of HIV/Aids and tuberculosis (TB) in the community, with the associated social, physical and financial burdens, is among the highest in the country.

The implication of the remote dwellings of the majority of the people is that they are not within reach of institutions outside their community. This is because their households are not accessible by car and outsiders cannot interact with them if they do not speak Zulu.

Tugela Ferry is a community of extremes. In contrast to the difficulties described above, a number of very successful, community-owned initiatives have been established since the 1990s. These were largely in association with the Rock of Life Church, a local Christian mission, and include initiatives such as the Khayelisha Care Centre (KCC), the Lobethal Independent School and the Philanjalo Hospice.

The KCC provides an integrated care programme for orphans and vulnerable children in the community. This includes a day crèche, a residence, assistance with the placement of children in foster care and a feeding programme to ensure that there are no street children in the town.

The Lobethal Independent School was founded in 1994. Due to the realities

has maintained a 100% pass rate since its first matric class in 2001 and it is considered to be one of the best schools in the region.

The Philanjalo Hospice will deliver humanitarian support in the form of a holistic care programme for Aids and TB patients when the mandate of the national Department of Health comes to an end. It also does groundbreaking research on drug-resistant TB in partnership with two American universities. While the mission is small in terms of the number of staff members, its influence is widely visible in the Msinga district.

UP partners with Tugela Ferry

During a visit to the Department of Informatics at the University of Pretoria in August 2008, a representative from the KCC in

The implication of the remote dwellings of the majority of the people is that they are not within reach of institutions outside their community. This is because their households are not accessible by car and outsiders cannot interact with them if they do not speak Zulu.

that face the impoverished community, the school cannot afford to pay teachers market-related salaries. As a result, many of the school's teachers are volunteers or former learners who are mentored by senior staff members. Despite these difficulties, Lobethal

Tugela Ferry presented the community's information technology-related needs.

The people of Tugela Ferry required IT literacy training for a number of reasons: it would enable school

leavers to get jobs and it would provide teachers with the skills they needed to process marks and prepare test papers. KCC administrators would be able to manage donor funding and the centre's feeding programme, and nurses would be able to keep better track of patients' medication schedules.

This visit marked the beginning of a long-standing partnership between the Department of Informatics and some of the institutions in Tugela Ferry.

Funding obtained from the United Nations Educational, Scientific and Cultural Organization (UNESCO) enabled the Department's initial involvement in the community. This funding provided the assistance that was needed to establish and maintain a computer centre at Lobethal Independent School, where teachers and other care workers received IT literacy training. Some teachers also completed a train-the-trainer programme, which enabled them to present courses to the nurses at the local hospital.

In 2010, a local businessman was identified who had the vision to

establish and manage a computer training centre, whereby training could be made accessible to the larger community. The Department of Informatics facilitated the process of setting up the training centre early in 2011. To date, 58 local people have received training at the centre, compared to the 34 that the University staff managed to train. Since the town has virtually no internet access apart from a handful of slow and costly dial-up modems, internet literacy and the opportunities associated with it were not pursued as part of the ICT4D initiative.

An opportunity for ICT4D research

The Department of Informatics was in a privileged position to have gained access to a remote, rural community that is not generally accessible to non-Zulu speaking people. In the process, they were provided with a unique opportunity to do ICT4D research.

The two lecturers who utilised the opportunity to do their doctoral research in Tugela Ferry are Kirstin Krauss and Dr Marita Turpin.

Krauss was the primary driver and outsider champion of the project. In partnership with several key community members, he has been involved in many aspects of community engagement and ICT4D that have evolved since the inception of the project. This involvement includes being part of how the project was initiated, and watching it gain momentum, observing relationships with teachers and key community members develop and mature, and witnessing key community members being empowered through ICT and train-the-trainer initiatives. The ICT training slowly progressed to become sustainable and community owned. In the process, Krauss's role evolved from that of project initiator to that of implementer, mentor and guide to community members, who acted as local visionaries and champions.

Krauss's research focused on two specific aspects of community engagement. The first dealt with the issue of community entry and specifically how an outsider should approach ICT4D research and practice in rural communities. The second aspect dealt with the difficulties and realities involved in introducing, interpreting and aligning the ICT4D artefact (such as ICT4D policy and training) in rural communities in South Africa. His choice of methodological approach was firstly based on a desire to affect change and emancipation in the community of Tugela Ferry. Secondly, it illustrated the desire to make a research contribution that

"I wanted to do something good and meaningful with my research and at the same time uplift the people I interacted with in a way that is also ethical and truly emancipatory."
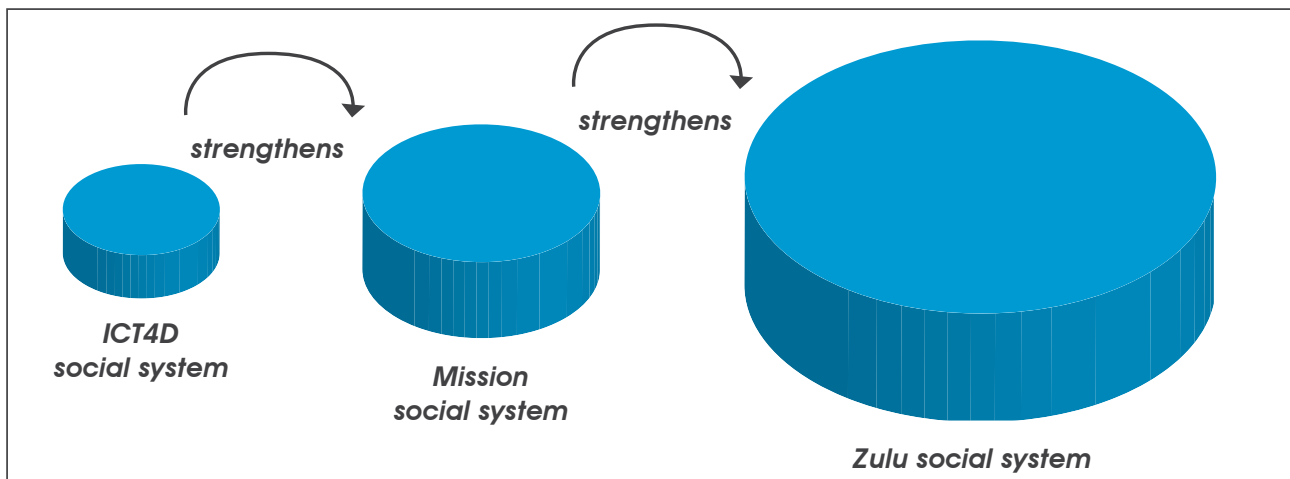
was practically relevant. "I wanted to do something good and meaningful with my research and at the same time uplift the people I interacted with in a way that is also ethical and truly emancipatory."

Dr Turpin was interested in studying the impact of the ICT4D intervention on the socioeconomic development of the larger community in the Msinga district. One of the key challenges in ICT4D is that the contribution of ICT to development is difficult to describe and assess. This is particularly true when one looks beyond the immediate context of an ICT4D project to its impact on the larger social system of which the project forms part.

Dr Turpin realised that the problem could benefit from a systems approach. Systems thinking is concerned with the performance of the entire system when changes are made to part of the system. Systems thinking recognises that the performance of a subsystem relative to its own goals does not necessarily lead to the increased performance of the larger system. Systems approaches are seldom used in the field of ICT4D and appropriate ways to describe and assess a social system are lacking. Dr Turpin's study contributed theoretically and empirically to the social systems body of knowledge in ICT4D. A social systems framework was developed, based on structuration theory and autopoiesis. The framework was

attractive because it provided a way to describe and assess the sustainability and state of development of the total system.

A concern with the ICT4D project was that it was primarily aimed at mission caregivers rather than the wider and more needy Zulu community. The wider community was not accessible to the ICT4D team, and IT training was too remote from their subsistence livelihoods to be a feasible or appropriate endeavour. In her empirical study, Dr Turpin indicated the contribution the mission's systems could make to the sustainability and socioeconomic development of the wider Zulu social system (see Figure 1). She also found evidence that the IT training strengthened the mission as a system, which enhanced the mission's ability to serve the Zulu social system. In this way, the ICT4D project contributed to the wellbeing of the wider Zulu community.

Conclusion

The success of the project can be attributed to a combination of factors. These include the ICT4D team's application of appropriate and culturally sensitive community entry principles, working under the close guidance of key community members whose locally established authority and leadership positions were respected, sensitivity to the community's expressed needs and requests throughout the project, mutual openness to and participation

in cultural practices, and ethical research practices and self-reflexivity throughout.

As far as possible the ICT4D team avoided an attitude of simply feeling sorry for the people and their suffering, while cultivating untested assumptions about their position and role, such as the following: "Because we are developed, empowered and educated, we know and could prescribe, without reflection and questioning, how to do ICT4D and how to develop the people." Rather, it was acknowledged that by understanding their own role, limitations and needs, and remaining open to unexpected local innovation, they could continue to create and support ICT4D that is relevant and truly emancipatory.

The ICT4D team took comfort in the fact that even though they were not in a position to directly interface with the majority of the Zulu speakers in the Msinga district, they could indirectly contribute to the wellbeing of the community by helping to strengthen existing local socioeconomic development initiatives. ❸

Dr Marita Turpin is a senior lecturer in the Department of Informatics at the University of Pretoria, and Kirstin Krauss is currently completing his PhD in the same department.

An innovation translation perspective of future Web 2.0 design trajectories

Dr Rennie Naidoo

A number of authors have recently argued that the web is entering a second phase in its evolution – Web 2.0. They claim that this phase is being marked by recent applications and services that enable more social collaboration – so-called 'social software'. When the previous dot-com certainties about a collaborative and interactive workspace exploded, it was perhaps fair to assume that some of the eminent diffusion theories went with them. Overestimations about the social impact of this collaborative and interactive workspace – during the now branded Web 1.0 era – was not due simply to 'irrational exuberance', as our rational proponents would lead us to believe. What is certain and still relevant is that a fresh direction of enquiry is needed to more fully understand technological innovations, such as Web 2.0.

An alternative way of conceptualising the Web 2.0 design challenge is to view these applications and services as a socio-technical phenomenon. Web 2.0 has both technical and social merits, and it might be appropriate to try to overcome the distinction between the technical and the social to improve our understanding of their implications. This lack of understanding of the socio-technical features by practitioners and academics may partly account for our failure to have made better predictions of Web 1.0's adoption and use in the previous era, and the recent protracted uptake of Web 2.0 technology applications and services in some contexts, as well as the surprising emergence of others.

A key feature of actor-network theory (ANT) is the perspective of the social world that shows it to comprise of heterogeneous networks that form actors. All phenomena are the effect or the product of heterogeneous networks. ANT does not accept any form of reductionism, either technological or social, that splits the technical from the social and supposes that the one drives the other. It states that there is no reason to assume, a priori, that either objects or people in general determine the character of social change or stability.

As such, ANT supports analytically treating objects and people in the same way; non-humans and humans together form the heterogeneous networks. This is best explained by means of an example. In our day-to-day lives, we are influenced by a wide range of factors: social and technical factors, as well as political and historical factors. For example, when using social bookmarking online, we are influenced by our research interests, previous peer collaboration experiences, bandwidth or accessibility conditions and the usability of the bookmarking application itself.

ANT presents the translation concept to describe the variety of ways in which actors actively seek to interest others in supporting the construction of a claim (in this case about Web 2.0), enrolling them directly or indirectly in a coalition dedicated to building a fact or a machine. The subprocesses of creating actor networks consist of
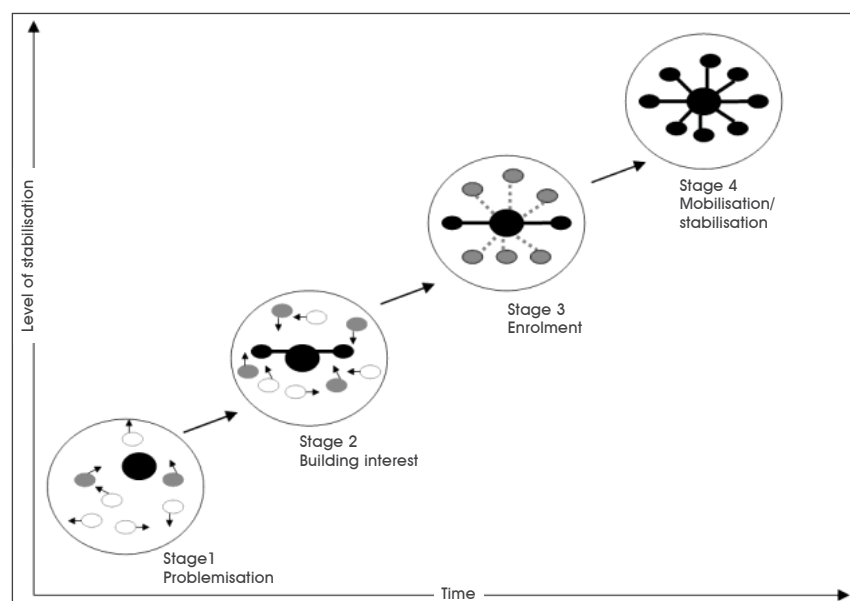
→ *Stages in the subprocess of creating actor networks.*
(Source: Adapted from Callon, M, 1986)

> However, unexpected uses or trajectories may develop, leading to a new perspective on what the technological innovation does and what it is expected to do.

four major stages: problematisation, building interest, enrolment and mobilisation.

The model uses the notion of weak ties (depicted by broken, thinner, disconnected lines) and strong ties (depicted by darker, connected lines). Whereas actors during the earlier stages, such as problematisation, are characterised by fragmented alliances and instability (weak ties), they are progressively locked into alliances through the process of translation, whereupon they come together and the network stabilises (strong ties). The depiction of the orderly sequence of the translation subprocesses allows us to construct an understanding around the sequence of events that led to the outcome of a Web 2.0 implementation.

ANT views Web 2.0 design largely as an emergent process initiated and guided by actors, such as designers, vendors or managers (agenda setters), with specific interests. Their agendas are enacted through processes of translation. The subprocesses of translation are used to enrol dissidents who oppose the new agenda. By inscribing the agenda in material artefacts, actors enable material artefacts like Web 2.0 services and applications to assume the role of actors in the network; that is, they stand in for the agenda setters. However, unexpected uses or trajectories may develop, leading to a new perspective on what the technological innovation does and what it is expected to do.

The translation process describes the emergent outcome of technology meeting social practice. This analytical framework can demonstrate the powerful role human and non-human elements of Web 2.0 and related socio-technical systems can play in a long and heterogeneous network. An ANT analysis can provide a detailed description of the way in which the internet, open standards and applications such as blogs, wikis, multimedia-sharing services, content syndication, podcasting and content-tagging services interact in a social, economic and cultural context.

By transcending the undue importance bestowed upon human agency, ANT provides a technique for grasping the ways in which social establishments diminish or stabilise. At the outset, a few actors typically gather and mobilise the support of influential actors (both social and technical) and decision-makers to accomplish their vision of transforming conventional social practices via the use of a technological innovation. Over time, ANT demonstrates how the design and implementation of technology emerges from the many unplanned negotiations and mediations with human and non-human actors, and not from some perfectly executed grand plan. In this way, ANT can perhaps provide an understanding of the limitations and opportunities of Web 2.0 applications in an increasingly socio-technically rich practice.

Different conceptions of the internet will emerge as more 'facts' about Web 2.0 are produced over time and actors reflexively alter their stance. ANT can be very effective at teasing out those socio-technical relations that must be explicated in order to come to terms with the role of web technologies, together with human actors, in constituting contemporary society.

Importantly, using an ANT perspective, the web is never complete or final. That is to say, if the web would remain fixed, stable and uncontested, it would not be translated and would likely die. In the case of Web 2.0, the web is consistently being reinvented by both designers and users. To carry on its march, further translations are needed. What these translations will be, only time will reveal. ⊖

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Separating Ta and Nb using a dry process

Andrew Pienaar

When Anders Ekberg gave the chemical element tantalum (Ta) its name in 1802, he could not have begun to guess how apt the name would prove to be. Tantalus, being the son of Zeus, may have been divine, but this did not make his life any easier. Now seen as the embodiment of temptation without satisfaction, he was doomed to eternally want and never receive, because of his behaviour, which was frowned upon by the Greek gods.

Not only are Ta and Nb found in the same minerals, they are also from the same group in the periodic table and have similar ionic sizes.

Encountered in many minerals of the columbite family, tantalum recovery has for decades perplexed chemists and mineralogists. Tantalum is used in electronics for its high capacitance-to-weight ratio and for many of its other advantages, including its reluctance to leak electrical charge. As a capacitor, tantalum forms part of many modern must-have items, such as cellphones, gaming consoles and automotive electronics.

Niobium (Nb), on the other hand, was named after Niobe, daughter of Tantalus. This element may not share the same glamour as tantalum, but is very useful in its own right and can be alloyed with steel to produce super-strength materials.

As the names of these elements have already alluded to, they are related in many ways – often to the frustration of anyone interested in the recovery of either one.

Not only are these metals found in the same minerals, they are also from the same group in the periodic table and, because of a phenomenon called lanthanide contraction, have similar ionic sizes.

Several efforts have been made to separate these two metals from their ores over the years, but with varying degrees of success.

Current industrial recovery and scientific research focuses on a process called liquid-liquid extraction. Using this method, the metal-containing ores are dissolved in an aqueous hydrofluoric acid solution. After all the metal has been dissolved, tantalum values, which are more soluble in organic phases, are extracted into an organic solvent, such as octanol or methyl isobutyl ketone (MIBK).

Organic solvents such as these are hazardous to work with and can cause harm through inhalation or exposure to the skin. They are also possibly carcinogenic. Now add hydrofluoric (HF) acid to this already dangerous mix and one has an accident waiting to happen.

Aside from these short-term dangers, the storage and disposal of HF-containing organic solvents are equally problematic. Is it then perhaps possible to use hydrofluoric acid without having it in a liquid phase?

The other possible option is to use hydrofluoric acid in gaseous form. Gaseous hydrofluoric acid is very corrosive, so one needs to be cautious when working with it. Its high polarity, however, allows the gas to be easily captured onto a solid scrubbing material, such as alumina.

Can the gaseous hydrofluoric acid be used for separation?

The metal values of niobium and tantalum in mineral ores are in oxide form. When these oxides are exposed to anhydrous gas-phase HF (AHF), they are converted to oxyfluorides (MO_xF_{5-2x}). These oxyfluorides are distinguished by the fact that they either decompose or volatilise at temperatures that are significantly different for niobium and tantalum analogues. Capitalising on this property, it may be possible to separate and purify these metals based on a thermal separation process.

First, as with liquid processes, the ore gets concentrated. The concentrate is then exposed to AHF at low temperatures to convert it to oxyfluoride form. The unreacted HF is either cycled back or scrubbed out, and the oxyfluorides are separated on the basis of their different volatilities. This cycle can be repeated or modified to include a hydrolysis process that converts oxyfluorides back to oxide values.

So, will it work? Quite possibly! This technique has been demonstrated by using the pure metal oxides, and is now being tested on ores.[1] By changing from a wet to a dry process, separating the oxides of tantalum and niobium may be a more elegant alternative to current industry practice. Unlike the unfortunate Tantalus, the recovery of tantalum may have a happy ending after all. ❸

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1   *Patent Cooperation Treaty (PCT) application number: PCT/IB2011/051408.*

RED in architecture: An ecotropic approach

Prof Roger C Fisher and Nicholas J Clarke

The teaching of sustainability is an important aspect of the methodology of the Department of Architecture at the University of Pretoria. It forms an important part of what the department wishes its students to 'think, feel and do'.

The introduction of the Sustainable Building Assessment Tool (SBAT) implies that sustainability is nothing more than good and appropriate design. A design that has good fit with its brief is strategised around the essence of the problem and responds in a resource-efficient way that is self-evidently sustainable. This has led to the use of the term **resource-efficient design** (RED).

In the School for the Built Environment at the University of Pretoria, RED is not only presented to students in architecture, but also to students in interior and landscape architecture.

Think

Ecosystemic thinking is an approach that has emerged from the field of psychology, particularly as it is reflected in the writings of Jordaan and Jordaan. In South Africa, it has a long tradition and can probably be traced back to Smuts' holism and evolution (2006) and John Phillips' biotic community (1931).

To think ecosytemically is to think of systems as nested, each as part of a larger system; made up of subsystems, which in turn form part of a suprasystem. These subsystems can develop properties that are emergent and thus uniquely properties of the suprasystem and not found in the subsystems. One can thus speak of the ecology of building materials as biologists would use and understand the term, and see each element as part of a larger whole that impacts on other subsystems and suprasystems. It is proposed that design that has such a fit should be termed 'ecotropic' rather than 'green' or 'sustainable'.

The idea of emergence in systems originates from the thinking and writing of Ilya Prigogine and Isabelle Stengers, popularised in their book

Order out of chaos (1984). Central to their thinking is that while the universe may be an entropic system, embedded within it are events that display neg-entropy. Within these systems, order emerges from chaos. These systems display emergence where the emergent properties are more than the sum of their parts. They therefore display acquired characteristics that cannot be predicted from the characteristics of the constituting subsystems.

While it may seem obvious that all things are natural, and so subject to natural law, as an idea it does not resonate naturally with human thought. We are used to thinking in dualities. If we are of nature, we do not have to become more natural, rather, perhaps, we reflect more deeply on our own nature. Even when well embedded in theory, the designer tends to revert to a thinking of a 'natural world' – in opposition to that of the 'cultural'.

Longer-term strategies rather than immediate goals are important.

We have deliberately endeavoured to broach this dichotomy of thought by introducing the term 'biophysical' for all where human activity is not dominant, as opposed to 'cultural' where human activity dominates. Both of these are embedded as subsystems in so-called 'nature' and are consequently considered as natural. Any activities that undermine the persistence of any of these systems must therefore be considered 'natural', even when destructive. Industrial ecologies are considered as systems in the built environment, and so, when designed for, might contribute to the larger whole through
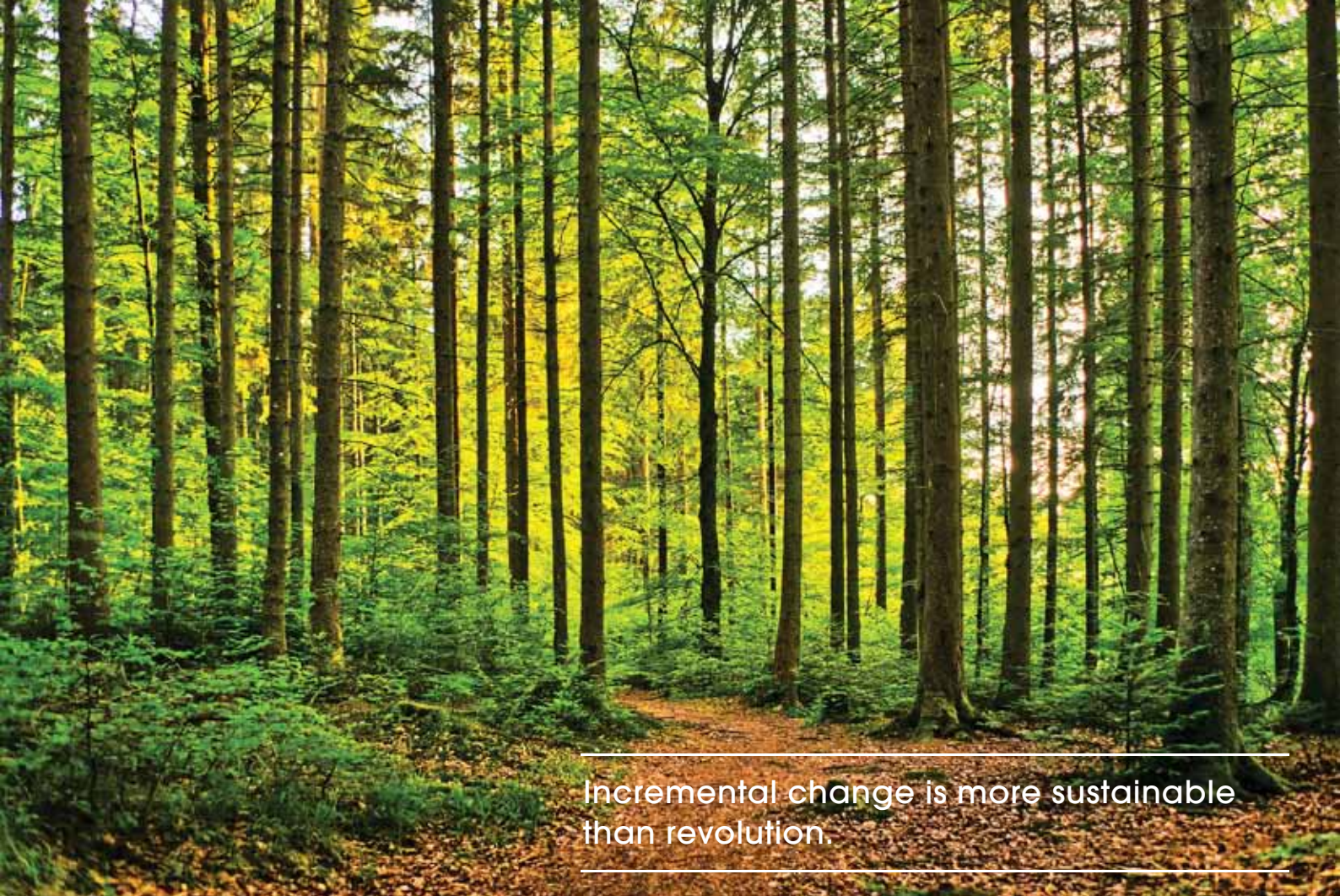
Incremental change is more sustainable than revolution.

the emergence of unpredictable properties at the urban scale.

Fridjohn Capra's *The web of life* (1996) introduces the student to many concepts that are useful when thinking about sustainability. They are concepts that come from the natural order, such as autopoiesis, homeostasis, iteration, emergence and generative processes.

In the analysis of systems, there are quantitative as well as qualitative aspects. What we value cannot necessary be quantified and that which is quantifiable is not necessarily valuable.

The last 40 years has seen an exponential growth in our ability to predict or model complex problem sets through the aid of computing. Students are exposed to these contemporary tools and are expected to understand their use in iterative processes – a process of feedback, evaluation and adaptation. Computing is not the only way of quantification and more 'primitive', but intuitive

tools are also presented and used to ensure that scholars develop a core personal understanding of issues such as solar shading and the forces of air movement. Computation, while being extremely useful, also has the potential for fascinating the mind, thereby dominating the design process and steering the final design towards a purely technocratic solution.

The obverse – that which is not measurable is not necessarily valuable – is a much more difficult aspect to teach, since it is dependent on developing an empathetic understanding of need. Such understanding necessarily requires life experience, something that cannot be taught in a classroom. Here it is important to expose students to real problems with real people who have real needs. Exposure to this is sometimes disturbing to students.

In analysis, we focus on the social, which is qualitative with quantitative aspects; economic, which is quantitative with qualitative aspects;

and environmental, which is the balance of the qualitative and the quantitative.

Students are encouraged to engage with the biophysical as a resource and inspiration in design resolutions. This engagement with the larger 'site' includes aspects ranging from the tangibles of cultural palimpsest to intangibles such as the dimension of time. Projects aim at creating an awareness of the biophysical, not only in the possibilities this might hold for the designer, but also in the impact that the biophysical will have on buildings. Steward Brand's *How buildings learn* (1994) forms an integral part of this process.

Where there is fit between context and design response, there is fitness. The idea of 'fitness' is again a biological concept as, for example, in the notion of 'survival of the fittest'. The idea of design as something that has 'fit', requires a deep understanding of the context in which the designer is working, for only through a full understanding of the

context can the determining aspects that characterise the design solution be identified.

Feel

Sustainability is the attempt to harness our understanding of the natural order and natural laws so as to be able to spend more time as a species on earth. This involves personal sacrifice, which is a moral issue. A new mindset requires a change in the ethical standards by which we have come to judge our successes.

Essential to our thinking is empathy. Many students, by virtue of their backgrounds, are unaccustomed to engaging with the diverse aspects of the culturally and economically disparate realities of a Third World, and so direct contact is important. Empathy can only be engendered through engagement. It is only through empathy that appropriate design responses can be found that 'fit'.

By finding 'fit', professionals in the built environment not only allow for current 'fitness', but also for future growth. This fit should be 'loose' enough to allow for this growth and, with an embodied energy, high enough to make it valuable and low enough to allow for change.

Students are required to strategise around the problematiques of a specific location and generate strategies for development that react as nested systems with loose enough fit to adapt over time as new eventualities emerge, but with enough rigour to energise them for long-term impact. The designer may not always be present at the realisation of the design intent. Hence it is an imperative that the residue of this realisation is seen as acting as catalyst and stimulus for the actualisation of the intended change.

Small change is valuable.

Building on the thinking and work of Nabeel Hamdi, we believe that small interventions that impact on systems by gradual evolution and that do not upset social hierarchies are more likely to succeed and catalyse change. As is evident in Hamdi's *Small change*, it is the act of enabling that produces results, not the act of providing results that can never make allowance for growth. As Schumacher states in *Small is beautiful*: "In practice all prediction is simply extrapolation, modified by known 'plans'… As a matter of fact there are no rules; it is just a matter of feel or judgement… what can you predict?"

Students are lead to realise that no single solution exists to the multifaceted problems designers are confronted with in the real world. Engagement means allowing for emergence. No intervention is too small, but can easily be too large. The critical intervention requires the necessary minimum, even though this may seem simple. Buildings that are tightly bound by the requirements of the programme are more likely to fail or soon become redundant, other than those that have a loose fit. Programmatic design leads to rapid obsolescence. Form does not follow function, fitness follows fit.

Decision-makers must know how to modulate their involvement as designers in the process and know when to approach specialists for design solutions. The complexity of the biophysical environment, as understood from a holistic perspective, requires an input from the full range of diverse talents that is available in society and cannot be resolved through the limited responses of any one person. The implication is that the designer,

as 'master', is superseded by the designer as catalyst and facilitator. Design is not merely a product, but is a moderator of the environment.

Do

Design responses are seen as part of those ecologies of the built environment that are emergent, so that the designer is not only delivering a product, but is plugging into and optimising processes. In the feed-through cycles of resources, design should optimise the retention and delay and minimise the production of waste. Cradle to cradle, rather than cradle to grave.

All solutions are presented as hypotheses that are tested through modelling. Thereby design solutions are presented as the optimisation of the essence of the problem. Designs are expected to be optimal, appropriate and applicable. When designing, the programme of a brief must be seen as facilitating the design response. But if "buildings learn", it is also important to take long-term strategies into account as a resource in the design response. The designer has the obligation to enrich the brief, seeking out opportunities for 'double-functioning' elements and the 24/7 cycling for uses.

Interventions should be 'long life, low energy, loose fit', a concept coined as title to a Royal Institute of British Architects (RIBA) probe into the long-term use of buildings as announced by the RIBA president, Alex Gordon, in 1972.

Waste must be seen to offer opportunity. Design is currently often form-driven, with the intrigue of how the computer can generate complex

form and feed-through to fabrication. Our feeling is resonant with that of Papanek when he says: "modern technology is beginning to give mankind a chance to return to the interactive… [to become] relevant to a society of generalists, in other words, designer planners".

Design should rather be generative where the responses to each of the diverse problems that inform the design thinking are investigated independently so as to realise optimal resolution. Through iteration and convergence, the design process achieves an optimal resolution to the problem.

It must be borne in mind that the inherent qualities of each facet are but a subsystem of the emergent design that needs to be tested as a whole. An example in simple terms addressing aspects of the SBAT:

a sphere has the lowest surface area to volume, but in terms of efficiency of planning and adaptability of use it is the most inefficient, particularly as the complexity of use increases. It may be an ideal form as a hut, but probably not a hospital.

Iteration

RED is an acquired discipline that can be learnt, but not schooled. It is an attitude, underpinned by skills and not a skill in itself. It does not obviate the need for a designer or suggest that design can be left to computers. However, it does highlight the use of computers and computation as aids to informed decision-making, as well as the need for other inputs by those skilled in their particular areas of expertise. Design should not be an end in itself, but the privilege and obligation society offers those so talented. ⊖

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The embracing of the forces of nature in design lends to the aesthetic experience.

Image behaviour in international engineering projects

Dr Dongdong Jiang and Prof Leon Pretorius

There are many factors beyond the control of managers that could determine the success or failure of a project, especially an international development project. In the era of globalisation, the project manager of an international project needs to understand key concepts in cross-cultural management and project management. Research conducted on the differences between South African and Chinese project managers, particularly with regard to 'face' or 'image', casts some light on this challenge.

A combination of exploratory and comparative research, employing surveys, was used to explore the cultural differences between Chinese and South African engineering and construction project managers on 'face/image' behaviour and the effects of this behaviour on five project management activities: project communication, negotiation, conflict resolution, contract process and team-building. 'Face/image' is a critical cultural issue for achieving project success in the Chinese community, because it represents prestige, respect, dignity and social status. Although the questionnaire was based on Chinese culture, South African project managers were asked to participate in order to illustrate differences where applicable.

Culture is a critical factor in international project management

Different projects should be managed in different ways. For a project to succeed, the people involved "should not only learn and practice its tools and techniques, but also learn, internalise and practice its work-related values/beliefs". The project management environment for international development projects is much more complicated than the environment for domestic projects in industrialised countries, since international projects face uncertainties caused by host country conditions. Research on international construction in China determined that cultural differences are a critical factor that can actually affect the outcome of an international project. For an international project manager, understanding key concepts in cross-cultural management and project management is a basic requirement.

Academics state that it is an immense challenge to define 'culture'. From an observational point of view, the central elements of any culture can be classified into two groups:

- Observable elements that constitute 'surface culture', such as customs, dress, dining, technology, arts and behaviour
- Hidden elements, called 'deep culture', such as values, beliefs and systems of thinking

In an article in the *International Journal of Cross-cultural Management*, Ronald Fischer of the Victoria University and the Centre for Applied Cross Cultural Research in Wellington, New Zealand, points out that culture has two key characteristics. It is a collective phenomenon, and it is learned or transmitted genetically. According to him, "culture is passed on through socialisation processes within specific groups, which require communication of key symbols, ideas, knowledge and values between individuals and from one generation to the next".

Chinese culture

China has a history of 5 000 years with specific outstanding cultural characteristics. The following typical Chinese behaviour relating to 'face/image' that may impact on international project success was identified:

- Directly commenting on or rejecting others' opinions will make them lose 'face/image'.
- Saving others' 'face/image' is critical to maintaining harmonious Guanxi (personal relationship).
- 'Face/image' is more important than profit in some cases.
- One should strive for one's own 'face/image' to be recognised and save others' 'face' at the same time.

Research

The research project, which compared Chinese and Western concepts of relationships in construction project management work, focused specifically on the extent to which Western project management ideas

The difference between Chinese and Western concepts of relationships will affect the successful conclusion of a project.

have been supported by the Chinese culture. A total of 75 Chinese and 65 South African project managers were identified on the basis of their project management experience to participate in the survey. The research had the following objectives:

- Identify typical Chinese 'face/image' behaviour.
- Establish how Chinese 'face/image' behaviour affects engineering project management activities.
- Conduct comparative research on Chinese and South African project managers with regard to 'face/image' behaviour.
- Develop a systematic framework for the modelling, analysis and management of intercultural 'face/image' behaviour in international project management.

The results of the research identified significant differences between Chinese and South African project managers in their 'face/image' behaviour with respect to three project activities. However, during the project contract process and project team-building, there seemed to be no significant difference between their 'face/image' behaviour.

With regard to the effects of 'face/image' behaviour on project management activities at sub-behaviour level, it seems that during

project communication and conflict resolution, 'face/image' is important for Chinese and South African respondents. They do not like to lose 'face/image' in project communication and conflict resolution activities.

Commenting directly on or rejecting others' opinions to make them lose 'face/image' during the project contract process is another variable that should be noted. It was rated the lowest by both Chinese and South African respondents. Communicating directly with little concern for the 'face/image' of one's counterpart in the project contract process attracted remarkable consensus from both groups. However, commenting directly on or rejecting others' opinions to make them lose 'face/image' during project communication was rated highly by Chinese respondents, but very low by South African respondents. Chinese project managers have much greater consideration for the 'face/image' of others than South African

project managers during project communication. It seems that 'face/image' is not that important to South African project managers during project communication.

With regard to the effects of 'face/image' behaviour on project management activities, the mean of the score for 'face/image' behaviour of Chinese respondents was much higher than that of South African respondents. This can be interpreted as Chinese project managers regarding 'face/image' in the five identified project management activities as much more important than their South African counterparts. However, both groups believe that 'face/image' is not a critical factor in the project contract process.

Finally, the results of the research were used to determine whether there is any difference between the ways in which the two groups rate the effects of each behaviour on the five project activities. A significant level of 0.05 was selected (95% confidence that the difference is not due to chance). Generally, the finding was that there are significant differences between Chinese and South African project managers' 'face/image' behaviour with regard to project communication, project negotiation and project conflict resolution. These differences could have a negative impact on project management activities, and could thus lead to problems. Chinese project managers consider the 'face/image' to represent prestige, respect, dignity and social status, while South African project managers do not seem to care about Chinese project managers' 'face/image' during project communication, negotiation and conflict resolution. Some difficulties may arise in the project management activities of international engineering

The research project, which compared Chinese and Western concepts of relationships in construction project management work, focused specifically on the extent to which Western project management ideas have been supported by the Chinese culture.

→ *A conceptual model for managing cultural differences.*
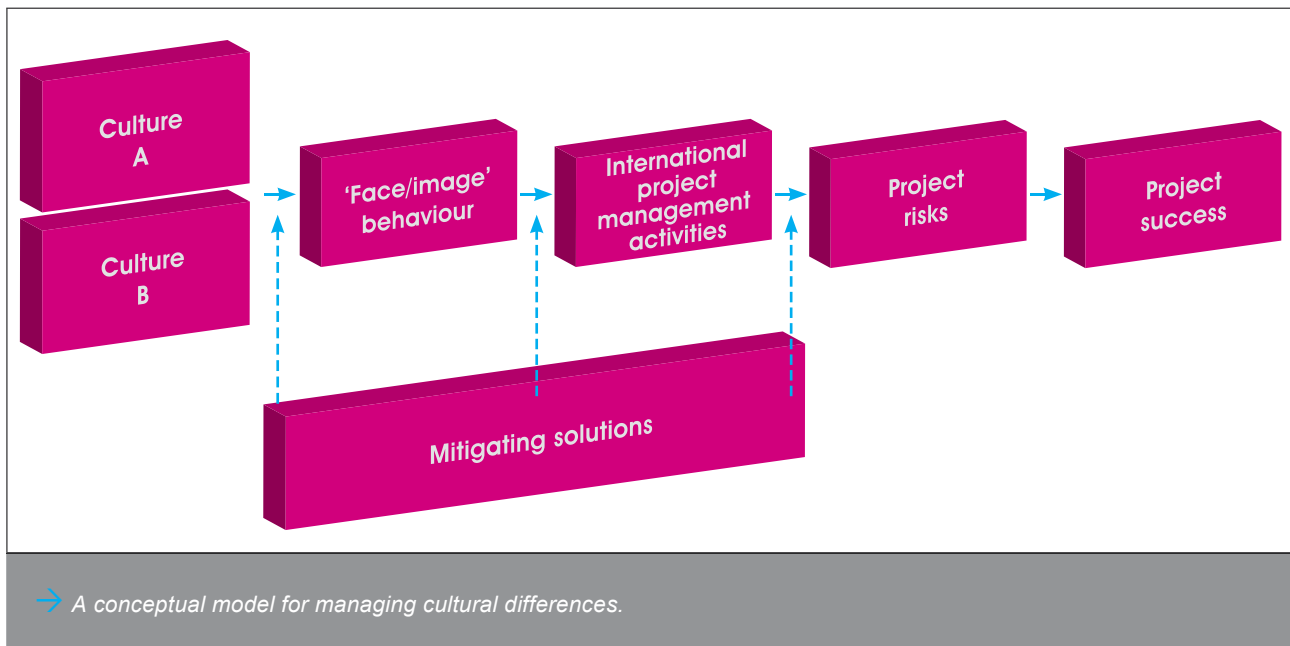
teams because of cultural differences. However, Chinese project managers seem to realise that South African project managers do not have the same concept of 'face/image'.

Conceptual model

A conceptual model was developed based on the results, which illustrates the relationships that are identified in the literature as the key relationships between 'face/image' behaviour in international project success. The model also shows the relationships between the components and the proposed solutions that can mitigate the negative effects of 'face/image' behaviour. This conceptual model gives a clear image of the path along which 'face/image' behaviour affects project success.

As there are significant differences between Chinese and South African project managers' 'face/image' behaviour regarding project communication, negotiation and conflict resolution, these activities may create potential risks, such as misunderstanding each other, unsatisfactory negotiation results and new conflicts during project conflict resolution. A recommendation was made that practical considerations should be based on the knowledge that project management is not universal, but culture-sensitive. ❽

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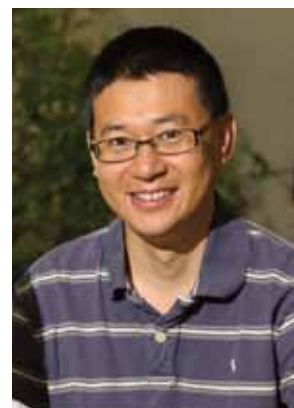
Dr Dongdong Jiang is a senior researcher at the University of Pretoria. He obtained his PhD in Engineering Management on the topic of cross-cultural research in international project management.

Can electronic product reliability be predicted?

Albertyn Barnard, an alumnus of the University of Pretoria and chair of the Reliability Engineering Working Group of the International Council on Systems Engineering, received a silver award for a presentation delivered at the International Applied Reliability Symposium (Europe) held in Warsaw, Poland, in March 2012.

This symposium provides a forum for reliability and maintainability practitioners in industry and government to discuss their success stories and lessons learned regarding the application of reliability techniques to meet real-world challenges. Barnard's presentation examined the question of why one cannot predict electronic product reliability.

According to Barnard, who provides consulting services in systems and reliability engineering in the defence, nuclear, aerospace, utilities and commercial industries, an accurate prediction of the field reliability of an electronic product during the development stage is highly desirable. Reliability prediction methods (and standards) have been developed and applied for many years, and some 'new' standards are constantly introduced. However, when these methods and standards are carefully analysed, they all seem to be based on misleading or even incorrect assumptions.

The implication is that a product is reliable if it does not fail, and that this failure-free state can only be achieved if failure is prevented from occurring. If that is the case, what is required to prevent failures? Firstly, engineering knowledge to understand the applicable failure mechanisms. Secondly, management commitment to mitigate or eliminate failures. The proactive prevention of failure should be the primary focus of reliability engineering, and not reactive failure management or failure correction.

What is reliability prediction?

Reliability prediction is performed during the product development stage, and attempts are made to estimate field reliability. This activity is entirely different from the quantification (or measurement) of reliability during operations.

There are three different approaches to electronic product reliability prediction:

"All failures in electronic equipment can be attributed to a traceable and preventable cause, and may not be satisfactorily explained as the manifestation of some statistical inevitability."   – Norman Pascoe, 2011

What is reliability?

There are two fundamental concepts in reliability engineering. Firstly, that failures are caused, and secondly, that failures can be prevented. Based on these fundamental concepts, and applying common sense to real-life experience, reliability can be defined as the absence of failures, while reliability engineering can be defined as the management function that prevents the creation of failures.

- **Reliability prediction based on published failure data:** This method consists of the calculation of the failure rate for each part in the product (typically as a function of operating temperature). This failure rate is then modified according to factors related to the intended operating environment, the quality of the part or the complexity of the part. These part failure rates

are summed to obtain a product failure rate.

- **Reliability prediction based on practical test:** This method consists of subjecting one or more products (typically prototypes) to a practical step-stress accelerated life test. Analysis of failure data is performed to determine both the time-to-failure distribution and the life acceleration factor. Estimated field reliability is then obtained by extrapolation to the expected 'use' conditions.
- **Reliability prediction based on physics-of-failure:** This method, which was originally developed from research to understand fundamental failure mechanisms, is based on detailed root cause analysis of field or test failures. The knowledge gained from physics-of-failure can then be proactively applied to prevent similar failures in new products.

Why electronic product reliability cannot be predicted based on published failure data

Reliability prediction based on published failure data (also known as standards-based prediction) is usually an exercise in futility.

Reliability prediction based on practical tests and physics-of-failure is much more valuable. However, this is not without its limitations.

If it is possible to predict failures, why not rather prevent failures?

An accurate prediction of reliability implies knowledge of the cause of the failure so that it could be eliminated. If one can predict reliability, that means that one knows what will fail in future. Therefore, why not prevent it from occurring at all?

"Some well-known documents, such as Mil-Hdbk-217 and derivatives of it, treat all flaws as being precipitated by temperature alone, which is completely erroneous."

– Gregg Hobbs, 2000

Reliability prediction is contrary to proven wisdom by quality and reliability gurus

Edwards Deming wrote: "Avoid numerical goals. Alternatively, learn the capabilities of processes, and how to improve them." Philip Crosby explained that 'zero defects' is an asymptote (continuous improvement), and Ralph Evans wrote: "The ultimate goal of reliability engineering is surely not to generate an accurate reliability number for the item."

Since all failures are caused by people, why allocate failure rates to parts?

Product failures are primarily caused by errors by design and production personnel, and are generally not caused by defective parts. These errors are due to human nature, and the complexity of engineering. Therefore, why do we allocate failure rates to parts?

Many parts do not have a property such as 'failure rate'

Many items do not have a property such as 'failure rate' (a wine glass, for example, will last forever unless somebody breaks it). Similarly, many electronic parts do not have inherent failure rates, but part failure may be caused by mechanical failure mechanisms, such as environmental conditions specific to the product. Examples include vibration (inferior mechanical design) and temperature (inferior thermal design).

Parts with 'failure rates' may have insignificant failure rates during their useful life

Many electronic products are replaced by customers due to technological obsolescence (for example, computers), and not due to wear-out of parts.

Failure may be caused by software

How does one predict embedded software reliability? Available methods are typically based on the complexity of the software, and the number of faults found during testing. However, most prediction methods conveniently ignore software reliability. This is surely inadequate, since most modern electronic products contain one (or many) microcontrollers.

The failure rate of a product is not the sum of the failure rates of its parts

An assumption frequently made in reliability prediction is that the product consists of parts in a series configuration (parts count prediction). This assumption is seldom valid. Furthermore, electronic products may fail due to interaction and integration of good parts (without individual part failure).

All part failures do not have 'constant failure rates'

Many reliability prediction methods assume that the time-to-failure

→ *Printed circuit board of an electronic product.*

is exponentially distributed. This assumption is seldom valid, since product failure may be caused by wear-out (fatigue). In fact, many engineers are unaware that mean time between failure (MTBF) should not be used as an indicator of expected life.

Life acceleration factor may be invalid

Mil-Hdbk-217F (and similar databases) assumes an exponential relationship between failure rate and operating temperature, also known as the Arrhenius relationship. Research has shown that this may be invalid for solid-state electronic parts, since the great majority of electronic parts do not suffer from physical or chemical degradation.

Reliability prediction results are frequently unrelated to real-life observations

Due to huge differences in predicted and observed reliability values, companies have proposed modifications to Mil-Hdbk-217F in an attempt to improve the reliability prediction.

Conclusion

Reliability prediction of an electronic product using published failure data is based on many misleading and incorrect assumptions. Many other reliability engineering analyses and test methods should rather be used to identify potential failures modes during development.

For example, part derating analysis can be used to identify electrically or thermally overstressed parts, and highly accelerated life testing (HALT) can be used to identify a range of design and production weaknesses.

Once identified, these potential failure modes can then be corrected prior to full-scale production.

Dr Richard Feynman, Nobel Prize-winning physicist, once said: "It does not make any difference how smart you are, who made the guess, or what his name is – if it disagrees with real-life results, it is wrong. That is all there is to it." This statement may also be applicable to reliability prediction based on published failure data. ❷
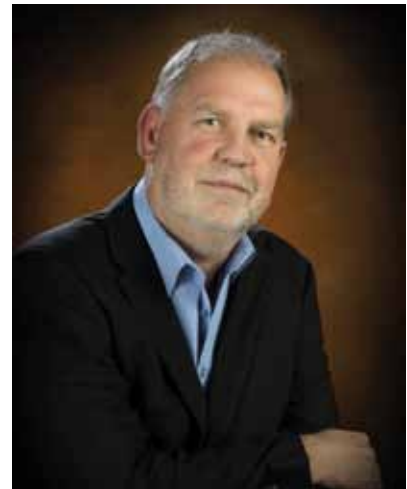
Albertyn Barnard received the MEng (Electronics) and MEng (Engineering Management) degrees from the University of Pretoria. He provides training in reliability engineering to industry postgraduates. He has been a member of the management committee of the South African chapter of the International Council on Systems Engineering (INCOSE) for a number of years, and established the INCOSE Reliability Engineering Working Group in 2011. He is currently leading this international working group, which focuses on reliability engineering from a systems engineering viewpoint.

On forensics: A silent SMS attack

Neil Croft

Research conducted in the Information and Computer Security Architectures (ICSA) Research Group in the Department of Computer Science at the University of Pretoria has been investigating how one would forensically obtain evidence of a silent SMS attack. Both at a network and handset level, what evidence is present that indicates that such an attack has taken place? Using an anti-forensic network configuration may render it impossible to gather any evidence of a silent SMS attack.

The mobile station (MS) is the mobile phone or mobile network-compliant device. The MS provides access to the network and consists of mobile equipment (ME) and a subscriber identity module (SIM) card, which is connected to an ss7 network. The short message service (SMS) message, sometimes simply referred to as a text message, is a store-and-forward service, in other words, short messages are not sent directly from sender to receiver, but always to an MS via an SMS centre (SMSC). Message delivery is 'best effort', so there are no guarantees that a message will actually be delivered to its recipient, but delay or complete loss of a message is uncommon. If delivered successfully, the SMS message is usually stored on the recipient's SIM card under user data.

How are silent SMS messages sent?

The ME or handset must acknowledge receipt of the short message, but may discard its contents. Such an SMS is useful, in particular, for the police services to send an application-generated SMS to detect the presence of a mobile handset without the intended party knowing about the request. The Short Message Peer-To-Peer Protocol (SMPP) is a telecommunications industry protocol for exchanging SMS messages between SMS peer entities or applications and SMSCs. It is often used to allow third parties to submit, at an application layer, SMS messages using protocol data units (PDUs). Data exchange is synchronous, where the sender must wait for a response to each PDU (data packet) either being sent immediately or asynchronously (where the receiving and sending of PDUs are executed independently making use of buffers and timers, while adhering to throughput limits). The protocol is based on pairs of request and response PDUs exchanged over the

Open Systems Interconnect (OSI) layer 4, which is a Transmission Control Protocol (TCP) session. PDUs are binary encoded for efficiency.

Using the SMPP, an SMS application system, called the External Short Message Entity (EMSE), may initiate an application layer connection with an SMSC over the TCP or Internet Protocol (IP) or x.25 network connection and may then send short messages and receive short messages to and from the SMSC. An EMSE is capable of manipulating the sender identity or originator of the message using the SMPP. This is commonly referred to as number masquerading. Using international mobile number formatting, messages are sent globally between mobile networks.

What are stealth SMS messages used for?

One can locate a user by identifying the three antennas (base stations) closest to the mobile, and then deduce (using triangulation) the location by the speed it takes the signal to make the return trip. In other words, location can be approximated by simply using the signalling layer of the mobile network. The mobile handset updates its presence periodically on the network, but when a subscriber moves, this information is not necessarily updated immediately. By sending a silent SMS, the handset is forced to update its location information on the network. A network authority may perform a silent SMS attack for the sole purpose of better tracking a subscriber. Using this approach without the subscriber's knowledge gives a more accurate account of the subscriber's movements.

Is information available as to whether silent SMS messages are being used for location purposes? This question was answered at the 28th Chaos Communication Congress

in Berlin, Germany, in 2011 where it was allegedly confirmed by a member of the Minister of the Interior that the German police and German intelligence services had sent an average of 440 000 stealth SMSs over the last year.

How can evidence be extracted to show that an attack occurred?

Although there are indeed a number of ways to manipulate and ultimately malform an SMS PDU, two common examples can be showcased. The first is simply a change to the data coding scheme in the message headers when creating the SMPP submit_sm PDU request. The second is to affect the scheduled_delivery_time and

A stealth SMS allows a sender to send a message to another mobile without the knowledge of its owner. The message is discarded from the handset without a trace. This is not only problematic for privacy, but from a legal perspective too.

validity_period by setting the delivery time to a date in the past and/or by making the message valid for an extremely short period of time, again when creating the SMPP submit_sm PDU request. In both instances, when tested across several SMPP gateways, messages did not arrive on the handset. Successful delivery receipts for these silent test messages were received corresponding to the original message ID.

A stealth SMS allows a sender to send one message to another mobile without the knowledge of its owner. The message is discarded from the handset without a trace. This is not

only problematic for privacy, but from a legal perspective too. It is unclear by definition if such messages form part of communication, since no content is delivered. This is convenient for some, as such surveillance technologies are not governed by legal frameworks designed to manage the inviolability of telecommunications. This legal vacuum allows members of the police and intelligence services to reactivate inactive suspects (subscribers) and improves geo-location information.

What information is available to the forensic investigator?

A silent SMS is the only practical method to immediately update location information when the subscriber is constantly moving, but the handset is not in use. Thus, silent SMS is a valuable tool for investigation, which when ordered by a judge for a specific case in some countries, might even violate the fundamental right to a subscriber's protection of privacy.

The use of silent SMSs to trace subscribers is no doubt a contentious issue. However, the focus of the research conducted was to examine the data available for extraction during a forensic investigation.

It was found that there is very little data available for extraction by a forensic investigator. This is typically due to the nature and configuration of existing mobile networks and capacity constraints. At a network level, one may only infer the existence of an attack through an analysis of the

number of messages received. Only by using rudimentary techniques, with the mobile device in hand, can a forensic investigator confirm (through radio interference) the existence of a continual stream of inbound network data. Likewise, only through the installation of an application, whose sole purpose is to intercept SMS messages at a mobile operating system level, is one able to extract silent SMS data. It is evident that through some network configuration and handset security settings, no forensic data is available to the investigator. ⊖

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The role of satellite remote sensing in detecting anthropogenic land-cover change

Brian Salmon and Dr Waldo Kleynhans

The wellbeing of the environment is one of the major factors that contributes to sustainability. The United Nations General Assembly's discussion on sustainable human settlements concluded that countries' local governments need to plan, implement, develop and manage human settlements. It was further stated that the local government needs to manage existing settlements and prevent the establishment of any new unplanned settlements.

The ability to determine where new settlements are formed, ties directly with the United Nations Millennium Development Goals. The United Nations proposes a systematic development of sustainable cities for newly formed settlements. The South African government incorporated this vision into its local policies by focusing on service delivery to these newly formed settlements, as human settlement expansion is currently the most pervasive form of land-cover change in South Africa.

Anthropogenic changes to natural land cover are being driven by a need to provide water, food and shelter to more than seven billion people. Unfortunately, these changes have a major impact on hydrology, biodiversity, climate, socioeconomic stability and food security. Changes in land use contribute to human impact on the climate as we are changing the natural rate of exchange of carbon dioxide between the atmosphere and the terrestrial biosphere, for example, huge stocks of carbon are released as a result of deforestation.

Remote sensing is the science of obtaining information on an object or area without being in contact with the object or area under investigation. Remote sensing imagery has proven to be a valuable tool in the effort to monitor land cover globally.

The most pervasive form of land-cover change in South Africa is human settlement expansion, which commonly occurs in areas that are covered by natural vegetation. Determining where and when new settlement areas are developed is beneficial not only from an environmental, but also from a socioeconomic point of view.

Determining when and where these types of changes occur has historically been done on an ad hoc basis by means of the visual interpretation of aerial and satellite imagery. Coarse resolution satellite data provide frequent observations (daily or multi-day composites) of land surface conditions at regional to global scales and are thus an attractive option for regional-scale change detection. When considering current change detection methods in literature, the majority of methods are based on multi-date high resolution data (in most cases only two images are used) for change detection that fails to exploit the valuable temporal components (for example, phase or frequency modulation) of the signal that is driven by seasonal changes in land surface phenology.

For South Africa, two major land cover mapping efforts were made to produce a land-cover database in 1994 and 2000, referred to as the South African National Land Cover (NLC) Database 1994 and NLC 2000 datasets respectively. These datasets were used to determine a change map by comparing the class labels for each pixel. Unfortunately, the 1994 and 2000 versions of the NLC were compiled using very different methods. The NLC 1994 had a minimum mapping unit of 25 ha, and contained 31 land-cover classes, whereas the NLC 2000 had a minimum mapping unit of 2 ha, and contained 45 land-cover classes.

Converting these classes into comparable pixel sizes and land-cover classes was not a trivial task, taking into consideration that the original classification accuracy of the land-cover datasets were 79.4% and 65.8% respectively. The production of a highly accurate land-cover change map using this post-classification change detection approach proved challenging. Both of these maps took several years to complete. Subsequently, it was preferable to map land cover by provincial governments on an ad hoc basis through private companies using a variety of methods.

Since land-cover classification methods have not been standardised, reliable
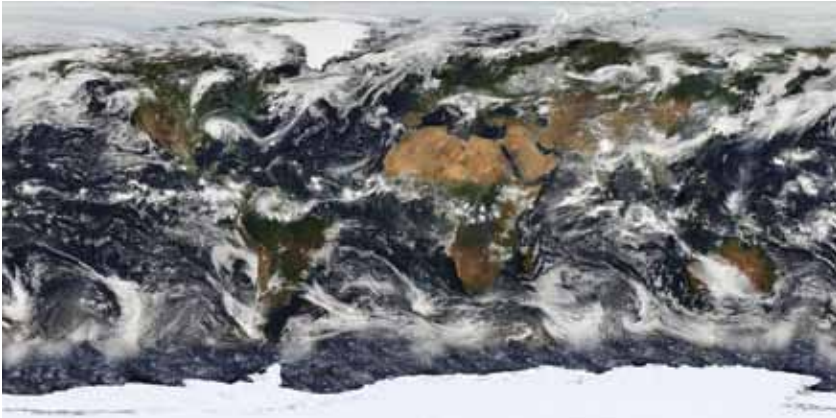
comparison between land-cover maps has not been possible. The Landsat-based land-cover mapping efforts relied on single-date imagery, acquired at a range of different dates for the entire area. This resulted in considerable seasonal variability between images, which hampered multi-spectral land-cover classification. It follows that a need exists for automated change detection to reduce operator dependence and enable large datasets to be processed frequently.

Since 2008, a team of researchers at the Meraka Institute's Remote Sensing Research Unit (RSRU) at the Council for Scientific and Industrial Research (CSIR), in collaboration with the University of Pretoria, has been actively doing research on how satellite-based remote sensing data could be used for automated land-cover change detection using machine learning and signal processing methods.

The hypertemporal time-series analysis approaches used by the RSRU explore the time domain of satellite images and capitalise on seasonal dynamics to characterise land cover and land-cover change using repeatable and standardised methods that can be applied over large areas. It proved to be very effective in detecting anthropogenic land-cover change, and numerous algorithms have been developed, published and presented internationally.

A recent paper presented at the flagship Institute of Electrical and Electronics Engineers (IEEE) Geoscience and Remote Sensing Symposium 2011 conference was awarded best paper and the team was presented with the award at the IEEE Geoscience and Remote Sensing Society 2012 conference held in Munich, Germany, in July 2012. ⊕

Quickbird images taken in 2002 (left) and 2007 (right). (Courtesy of Google™ Earth)

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Implementing open source software to conform to national policy

Lizette Weilbach

Lizette Weilbach, a senior lecturer in the Department of Informatics in the University of Pretoria's School for Information Technology, recently had the honour of receiving the Highly Commended Award of Emerald Group Publishing at the Group's Literati Network Awards for Excellence 2012. Weilbach's paper on implementing open source software was published in the Journal of Systems and Information Technology.

This paper reported on some of the findings of the case study research she completed for her PhD thesis, under the supervision of Dr Elaine Byrne. Her research interest is related to information technology (IT) change management and the social context of IT. The case study on which she reported in the article was executed in one of South Africa's government departments, and helped her to illuminate on how an imperative government policy, such as the new South African policy on open source software, which seems to compel all government departments to migrate from proprietary software (PS) to open source (OS) software, has impacted on the nature and implementation process of a new Open Source Enterprise Management System (EMS). The internal alignment of the divergent voices in government indicated that the organisational environment, change management strategies and technology need to be aligned.

Change management in the information and communication technology (ICT) environment presents a number of challenges. One of the effects of globalisation is that the new form of business operates in a networked economy, largely facilitated through ICT. It follows that ICT development, together with deployment and supporting policies, takes place in this fiercely contested globalised political economy. Furthermore, the rate at which change occurs rises with these globalising effects, and organisations are continually experiencing change processes, many of which are externally imposed.

This case study explored two main aspects of the change process. The first was the impact of the national open source policy on government departments, with the accompanying externally imposed change of mission, vision and values. The second was how the government department changed its internal work processes and information systems to comply with that policy. These two aspects are intertwined.

Alignment of the organisation's mission, values and objectives with the proposed technological innovation and change management models emerged as a necessary condition for managing change. However, what emerged as a more challenging issue was whether internal organisational changes could be aligned with contentious national policy imperatives.

> One of the effects of globalisation is that the new form of business operates in a networked economy, largely facilitated through ICT. It follows that ICT development, and deployment and supporting policies take place in this fiercely contested, globalised political economy.

Several information change management models have been developed to gain a broader understanding of change management in a complex environment. As each change context is unique, process-oriented theories encourage an enabling rather than a controlling approach to managing change. One such model is the Improvisational Change Model of Orlikowski and Hofman, which was published in the *Sloan Management Review* of 1997. This model is based on two major assumptions: change is an ongoing
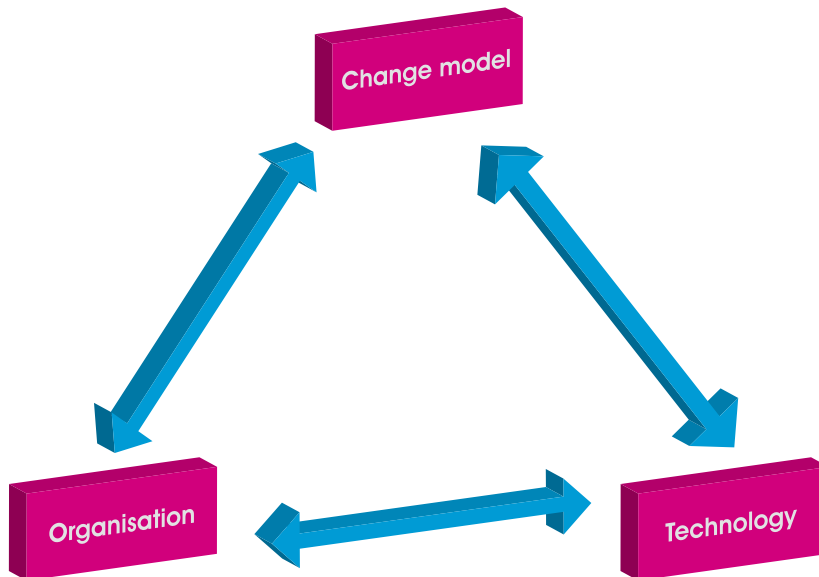
process; and not every technological and organisational change can be anticipated in advance. This model is ideal for situations where it is difficult to determine the exact changes that will occur when implementing new technology and where it is consequently difficult to determine the impact of these changes on the specific organisational context.

The key dimensions referred to in this model are technology, the organisational context and the change model (see Figure 1). It is important to note that the alignment of these three dimensions requires explicit and ongoing assessment and modification.

When trying to make sense of the complex environment in which IT change takes place, it is important to analyse the human and social environment in which the IT is implemented to facilitate its adoption, use and integration in a socially responsible manner. The social factors present in the human environment include people, organisations, groups,

tasks, environments and technology. These contexts should be viewed as a collective that is tied together by a human environment.

Based on the case study, the researcher found that in order to implement an open source ECM system in a government department, it was important to recognise that changing from a PS to an OS system was an ongoing process. It was also found that the allocation of specific resources to the change process (such as the PS ECM specialist) without the alignment of the three key change dimensions indicated in Orlikowski and Hofman's improvisational change model meant that the change was difficult to implement.

As users found it difficult to put the training into practice, the PS ECM specialist acted as a 'champion' for the project and one could deduce that his dedication and support contributed immensely to the achievement of the end result. When asked to compare the new system to the old one, and to

elaborate on the new system's ease of use, it was clear that the users had not worked with or even seen most of the new system's functionalities. This raised a concern, as one of the aims of the pilot project was to determine whether the new system would be considered a sufficient replacement of the old PS.

The technology (OS ECM) was therefore found to be aligned with government's Free and Open Source Software (FOSS) Policy, but there was a clear lack of internal alignment within the organisation in terms of attaining a shared vision. The technology and the change management strategy were also not aligned. The system was, however, implemented across the entire government department. The fact that the PS ECM specialist was a dedicated resource to provide ongoing support for the ongoing change process, could have contributed to this.

Many of the challenges raised in the case study were common oversights mentioned in change management literature. However, what made this case different was that one of the main challenges arose from the alignment of internal organisational change with a national policy that did not seem to have the full support of the agency that was tasked with implementing it.

Specifically, some of the recommendations for government practitioners emerging from this case study were as follows:

- Compose a formal change management strategy and plan before embarking on similar projects. This means ensuring alignment of the vision of the department, other participating government agencies or departments, and the users with the national vision.
- Be sure to have a project champion.
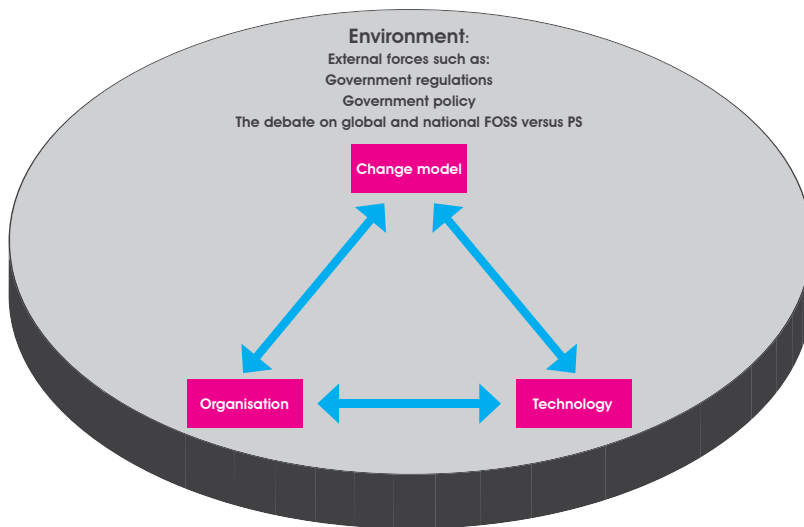
→ Figure 2: Adjusted improvisational change model. (Adapted from: Orlikowski and Hofman, 1997)

- Study the organisational culture and politics of all participating institutions and agencies to gain an in-depth understanding in order to act wisely.
- Gain an understanding of the relevance of the new system to the users, users' knowledge and perceptions of IT and their attitude towards management before embarking on such a project. This understanding should inform the change management plan.

On a theoretical level, models can increase one's understanding and reveal how one can 'cultivate' the human environment in which technology is to be implemented. However, the process of developing an understanding of how national policy was developed and the rationale for it is important.

An addition to or expansion on Orlikowski and Hofman's model was to include a fourth element, indicating the external forces in the environment – such as government regulations, government policy, and

the debate on global and national FOSS versus PS – may highlight the need for this external alignment, and also prevent the focus on internal alignment only.

What emerged from this case study was a caution that there is not a sole voice in government. The internal dynamics and differences of government departments are inadequately understood. Alignment of the different rationalities that exist in a multilevelled and multisectoral institution is necessary for the alignment of the organisation, the change management strategy and the technology.

An awareness of the social context of the organisation and the environment in which technology is to be implemented might at least provide an understanding of what the contention is about, if not the solution on how to address it. ☻

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Management framework for people, processes and places in the virtual workplace

Dr Ilse Geldenhuys, Prof Carina de Villiers and Prof Trish Alexander

A study conducted by three researchers at the University of Pretoria explored how virtual workers executed their activities through the use of technology, the type of business processes supporting them and the challenges experienced. The proposed framework for the management of people, processes and places in the virtual workplace was subsequently derived.

The framework aims to represent the relationship between the people, processes and places components in the virtual workplace, thus providing a management framework that supports the virtual workplace. These three components have been incorporated into management, technology and practice components, thereby providing a framework based on the relationship between people, processes and places.

The newly developed framework is discussed based on the management, technology and practice components (based on people, processes and places). The relationships identified and discussed include business process maturity, understanding of the difference between business process management and business process improvement, governance, support structure, the integration of business process tools and the feasibility of the infrastructure. The framework thus provides structure to the management of people, processes and places in the virtual workplace.

Management

The management areas of attention identified during the research relate to business process maturity, understanding business process management, active change realisation and establishing an enabling culture and support structure. Following on the aforementioned people component is the process portion related to management. The process portion has a correlation with business process maturity, understanding business process management and the business process support structure. The virtual workplace has specific management challenges, as the workplace is off-site or remote and sometimes outside the borders of the country. The places component focuses on establishing an enabling culture, the types of virtual workplaces, the types of work appropriate to the virtual workplace and infrastructure requirements.

The management challenges related to the management of people, processes and places in the virtual workplace have a multiple relationship, thus emphasising that the components cannot be viewed in isolation. This connectedness is evident in the establishment of an enabling culture, understanding business process management, the need for a business process support structure and infrastructure feasibility.

Technology

The technology component of the framework is covered as an essential part of the virtual environment. As part of the people component, streamlined network accessibility, the need for integrated business process tools and the use of social networks were identified as areas requiring attention. The process portion of technology relates to process technologies, such as single-source and process support, including data integrity. Technology supporting the virtual workplace relates to the feasibility and sustainability of infrastructure and has a bearing on the management component. The technology component's challenges relate to
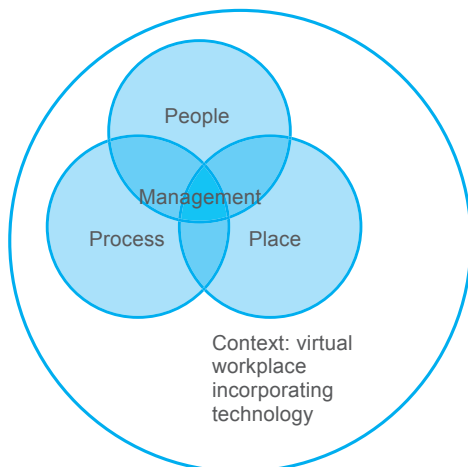
> The virtual workplace has specific management challenges, as the workplace is off-site or remote and sometimes outside the borders of the country.

COMPONENTS OF THE VIRTUAL WORKPLACE

Management | **Technology** | **Practice**

PEOPLE	**PEOPLE**	**PEOPLE**
• Determine business process maturity • Create an understanding for business process management • Active change realisation • Establish enabling culture • Establish business process support structure • Involve right resources • Develop skilled resources • Retain skilled resources	• Determine streamlined network accessibility • Determine standardised integrated tools • Use of virtual work tools and social networks	• Create an understanding for business process management • Develop skilled resources • Encourage clear communication

PROCESS	**PROCESS**	**PROCESS**
• Determine business process maturity • Create an understanding for business process management • Establish business process support structure • Sustainability of business processes	• Establish single source • Determine computer-supported processes • Integrated business process tools • Ensure data integrity	• Integrated business process management tools • Need for business process tool licences • Need for business process governance • Need for business process change control

PLACE	**PLACE**	**PLACE**
• Establish enabling culture • Virtual workplace • Determine types of work • Feasibility of infrastructure	• Feasibility of infrastructure	• Feasibility of infrastructure • Help desk support

Virtual

→ *Management framework for the components of the virtual workplace.*

People

Management

Process   Place

Context: virtual workplace incorporating technology

→ *Management, people, processes and places in the context of the virtual workplace.*

streamlined network accessibility and establishing an integrated, single source of information that is accessible from remote locations. There is a connection between people, processes and places, again emphasising that this topic cannot be viewed in isolation.

Practice

The third component of the management of people, processes and places in the virtual workplace is practice, and follows the central theme of identifying relationships. Creating an understanding of business process management, developing skilled resources and having clear communication were identified as important areas within the people component.

The process portion includes process technology, licensing and governance requirements, while the places portion includes feasibility of infrastructure and help desk support as identified. The practice portion discussed the need to understand business process management and addressed the need for business process governance and a standardised business process methodology. The relationship between business process management tools, licences and the help desk support is evident. ✛

Dr Ilse Geldenhuys has a BCom degree and an MBA. Her PhD focused on research in the virtual workplace.

Prof Carina de Villiers was head of the Department of Informatics at the University of Pretoria from 2000 until 2011. She is currently a full professor in the department.

Prof Trish Alexander is an associate professor in the Department of Informatics. The use of computer-mediated communication by virtual teams is one of her research interests.

Adding vanadium to improve the ductility[1] of niobium-containing steels

Dr Kevin Banks, Dr Alison Tuling and Prof Barrie Mintz

Dr Kevin Banks and Dr Alison Tuling from the University of Pretoria's Department of Materials Science and Metallurgical Engineering, in collaboration with Prof Barrie Mintz of the City University, London, are the most recent recipients of the International Vanadium Award for their research into high-strength low alloy (HSLA) steels.

Their work, documented in a research paper entitled 'Influence of V and Ti on hot ductility of Nb-containing steels of peritectic C contents', dealt with the widely reported issue that the presence of niobium (Nb) reduces hot ductility in some steels, which can result in transverse cracking of slabs during straightening at the end of the continuous casting operation. This work demonstrated (in laboratory simulations) that the addition of vanadium (V) to a titanium-niobium (Ti-Nb) microalloyed steel can help increase the ductility in the critical temperature range at which straightening takes place. This was confirmed under full-scale steel production.

1 Ductility is the ability of a material to undergo permanent deformation through elongation without fracturing.
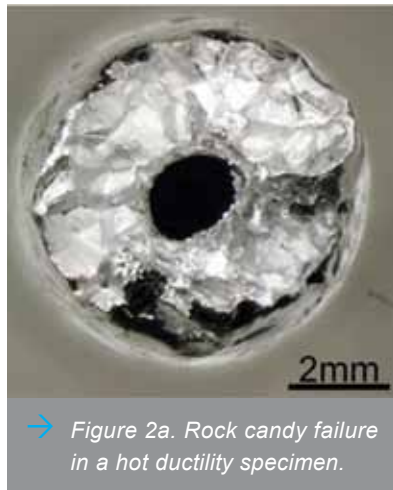
Since the early semi-industrial pilot plants that were developed after World War II, continuous casting has become the route to follow in large-scale steel production. Over 90% of the steel produced in the Western world is now produced in this way. The molten steel (see Figure 1) is poured into a vertical, water-cooled copper mould. The steel is removed from the bottom of the mould in a continuous slab. On exit, the steel must be bent and unbent to orientate the slab in the horizontal for ease of handling (cutting, transport, etc). In the unbending/straightening zone (750–1 000 °C), the steel is particularly vulnerable to cracking, as a number of important metallurgical interactions occur.

The transverse cracking that occurs is detrimental to downstream quality, as these cracks result in either poor surface quality or poor edge quality after further processing and must be mitigated by scarfing or trimming. This contributes to the cost of production and loss of yield.
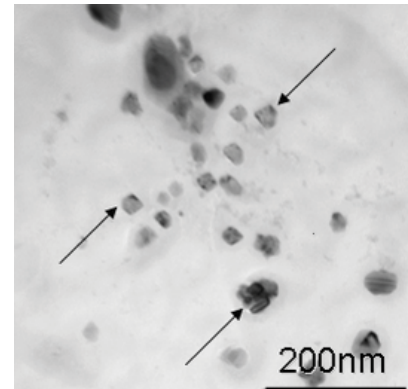
The cracking mechanism can be studied in the laboratory using

Adding V to the Ti-Nb-containing steels resulted in significantly improved ductility with reduction in area values at 800 °C in excess of 45%.

→ Figure 2a. Rock candy failure in a hot ductility specimen.

→ Figure 2b. Vanadium-free steel showed copious carbonitride precipitation (15–23 nm) at the γ-grain boundaries, as well as some finer precipitation within the grains, which causes such failures (Ti-Nb steel).

thermomechanical simulation. The 'hot ductility test' has been established to predict transverse cracking.

The authors used a sophisticated thermal profile in the hot ductility technique to study peritectic carbon steels with varying levels of the microalloying elements Ti, Nb and V, as well as considering the effect of nitrogen levels.

Peritectic carbon (C) steels are difficult to cast, even without microalloy additions, as the grain size during unbending is inevitably large and causes a weakening of the steel, making it more vulnerable to cracking during the strain applied during unbending. The addition of the microalloys adds complexity to the casting of these steels. If these elements form fine carbonitride precipitates, they strengthen the steel so as to force the unbending strain to a small region adjacent to the grain boundaries, where the plasticity is quickly exhausted and fails in a rock candy-like fashion (see Figure 2a).

However, what the present work showed is that certain combinations of the microalloys produce differing amounts and sizes of precipitation and thus the additions strongly influence the propensity for transverse cracking (see Figure 2b).
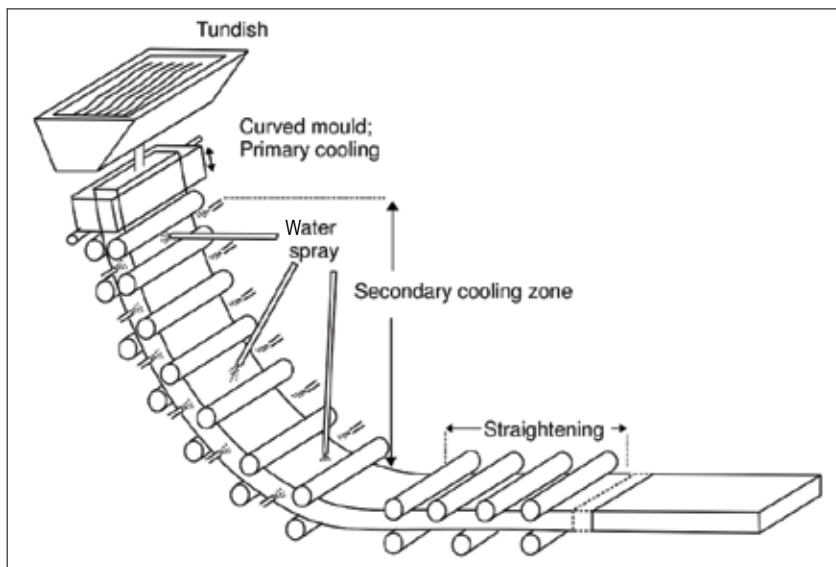
→ Figure 1: Schematic representation of a continuous casting machine.
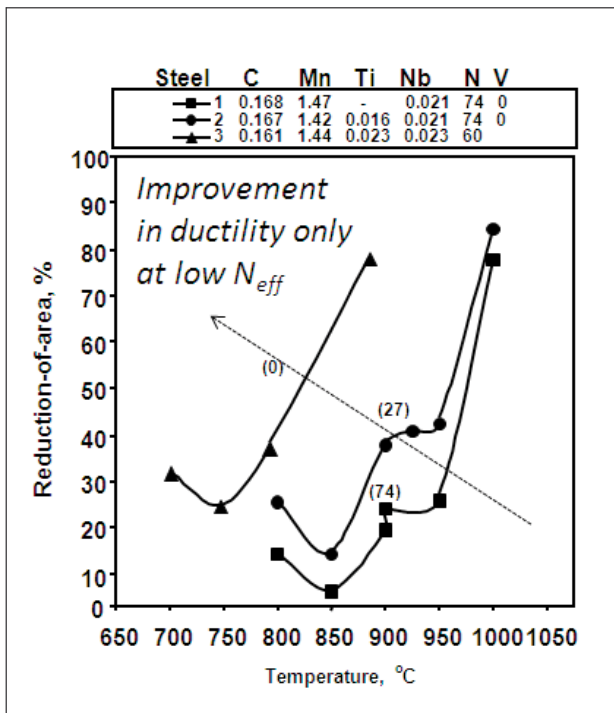
Figure 3: The influence of Ti on the hot ductility of 0.165% C- and 0.02% Nb-containing steels. The numbers in parenthesis are the N_{eff} x 10–4 values (the N available in the solution after the Ti has combined with the N).

Figure 4: Influence of V on the hot ductility of Nb-containing Ti steels. Open symbols are for the V-containing steels and closed symbols are for the V-free steels. The ductility improves with the addition of vanadium.

Influence of Ti on Nb-containing steels within the peritectic C level

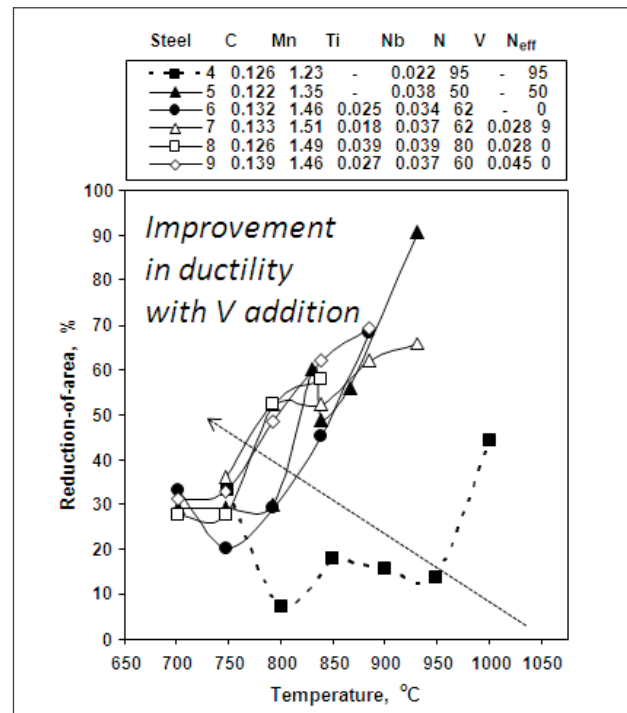Nb-containing steels are notoriously difficult to cast so that the likely increased precipitation from both Nb and Ti might be expected to produce even worse ductility. If all nitrogen (N) is combined as Ti-rich compounds, then precipitation of Nb can only take place at temperatures below those used for normal straightening. It is then likely that the N left in solution, after combining with the Ti, will dictate the hot ductility. This nitrogen, N_{eff} (the N available in the solution after the Ti has combined with the N), is then able to precipitate out as carbonitride in a fine detrimental form on deformation and so control ductility. The less N available for forming Nb (carbon or nitrogen), in other words, the higher the Ti-Nb ratio, the better the ductility will be.

Figure 3 indicates that as the N_{eff} value decreases from 0.0074% to 0, the ductility improves. However, in some industrial processes where high N is unavoidable, Ti additions are not sufficient to avoid transverse cracking.

Influence of V on the hot ductility of Nb/Ti-containing steels within the peritectic carbon range

When V, Nb and Ti steels were examined (see Figure 4), it was shown that the V-Nb combination (open symbols) gave better ductility than the V-free steels, 4–6 (solid symbols).

The cause of the improvement was shown to be the few coarser precipitates observed in the V-containing steel and lack of

This improvement was due to a decrease in the fraction of fine particles, and in accordance with this better ductility, transverse cracking of industrial slabs was avoided.
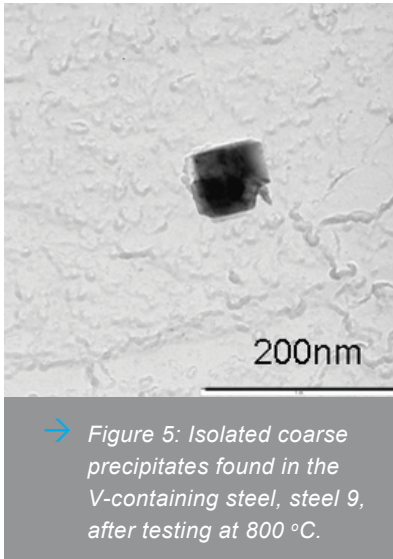
fine V-containing precipitates, as indicated in Figure 5, which provides a comparison to the copious Ti-Nb precipitation (15–23nm) in the Ti-Nb steel (Figure 2).

In the present instance, no V-containing precipitates were observed, presumably because of the presence of Ti, all the N being combined with the Ti or as Ti-Ti precipitates. All the V is therefore probably in solution and able to retard the precipitation of Nb, resulting in the absence of the finer detrimental carbonitride precipitation that occurs in the V-free Ti-Nb-containing steel leaving only the coarser Ti-Nb precipitates that are formed with the slow cooling prior to deformation.

This result is in accordance with previous work where stress relaxation tests confirmed that the Nb addition to the V steels delays

→ The winners of the International Vanadium Award (from left): Prof Barrie Mintz, Dr Kevin Banks and Dr Alison Tuling.

the onset of Nb-V carbonitride precipitation, which is in accordance with the work of Akben et al, published in *Acta Metallurgy*.

The V addition therefore behaves in a very similar, beneficial manner as the steel would behave, whether it contains Ti or not. Finally, something that is very important from a commercial point of view is that whereas transverse cracking was observed in the Ti-Nb steels in this C range, the addition of V was found to eliminate this problem. ●

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For titanium-containing steels, an under-cooling cycle needs to be introduced in order to use the hot ductility results to predict transverse cracking behaviour.

Predicting the buckling length of compression chords in prefabricated roof structures

Prof Walter Burdzik and Prof Nick Dekker

In South Africa, timber-trussed roof structures supporting concrete tiles have for many years often been braced solely by diagonal braces. Failures have shown that the diagonal brace was inadequate for larger span roofs, and the use of diagonal bracing has subsequently been limited to spans of less than or equal to 10 metres.

When designing the compression chords of a timber truss in a braced roof, South African National Standards (SANS) 10163:1 (2003) recommends a minimum effective length for out-of-plane buckling of no less than 15 x b, which is 540 mm for a 36 mm-wide member. This effective or out-of-plane buckling length of the top chord was later assumed to be equal to the spacing of the trusses.

With the availability of PC-based packages that can perform three-dimensional buckling analyses, it is useful to investigate the validity of using the effective length equal to the truss spacing, and then also the 10 m limit on span for roofs braced by diagonal braces.

Since the introduction of computer-based analysis programs for timber roofs, the pre-processing and post-processing parts of the software have changed and improved to the extent that the designer is no longer aware of the design process, even though forces, displacements, sizes and assumed effective lengths may be printed for checking by a competent person.

Loads are calculated from the layout and these are applied to a two-dimensional analysis of the truss, even though a timber roof structure is a three-dimensional problem constructed of a brittle material with limited ductility in the connections.

Limited ductility can be a problem in cases where construction errors have been made and force-fitting is applied. Assumptions are made about the member sizes and sometimes also about the connector plate stiffness for an initial analysis. More often than not, a centreline analysis using beam elements is used and the forces obtained in this way are used to size the members in accordance with SANS 10163: Part 1 (2003) or Part 2 (2001).

At this stage of the design, assumptions are made about the type of bracing to be used, as well as the effective or buckling length of the compression chord that would result from using that specific type of bracing. Many believe that the effective or buckling length of the top chord is equal to the spacing of the battens. This assumption would perhaps be correct if the tiles could be relied on to supply diaphragm action, and if the battens were rigidly connected to the compression member. In such a case, any further bracing would only be required for erection purposes. Diaphragm bracing by the tiles will initially be active, but with time, the friction between the tiles seems to break and movement occurs. This eventual movement of the tiles has led to the failure of roofs.

The assumption of the buckling length equal to 15 x b, with b = 36 mm, may not be a problem when the spacing of the trusses is equal to

Limited ductility can be a problem in cases where construction errors have been made and force-fitting is applied.

640 mm, as is common in Australia, but could become a problem where the spacing of the trusses is as much as 1 050 mm, as is often found in South Africa. The minimum slenderness of Le/b = 15 was later changed by the South African Institute for Timber Construction to an in-house rule, which suggests an effective buckling length of the spacing of the trusses (750 mm to 1 050 mm).
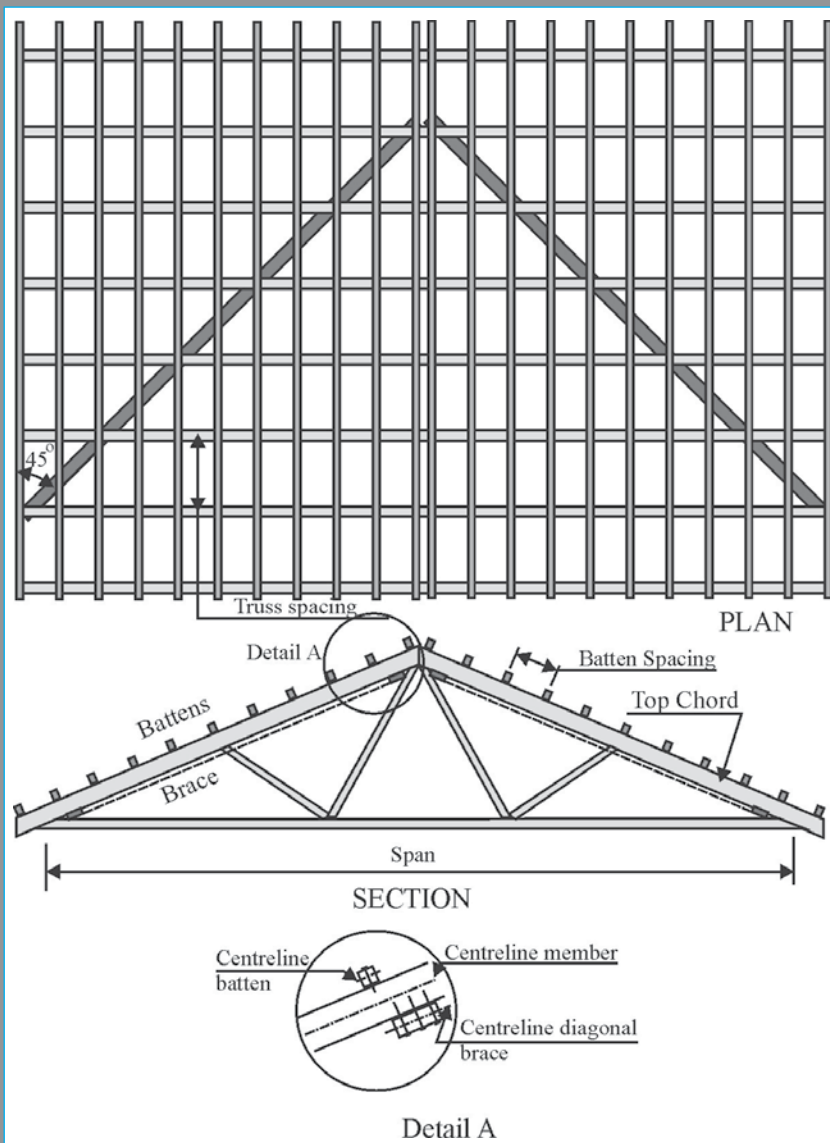
→ *Figure 1: Positioning of diagonal braces.*

It is believed that a blanket rule such as effective length = 15 x b or even buckling length equal to the spacing of the trusses may not be conservative, as the buckling length depends on the boundary conditions, the stiffness of the bracing and the method of transferring loads once buckling is initiated.

For small-span timber trusses (up to 10 m), a diagonal brace is the norm in South Africa. As the limit on the span for the use of a diagonal brace is less than 10 m, only the 10 m

and 7.5 m spans were investigated. Timber sizes for 10 m span roofs would typically be 36 mm x 111 mm top and bottom chords, with 36 mm x 73 mm web members. When bracing a 10 m-span trussed roof, a 36 mm x 111 mm timber member is fixed to the underside of the compression chords and runs at about 45° when seen in plan. Three 100 mm long nails are used to fix the brace to the underside of the top chord (Figure 1). Maximum spacing rules are used to ensure that trusses are not too far from the brace. Battens, the smallest nominally being

36 mm x 36 mm, are placed on top of the compression chord. These are then fixed to the compression chord with one 75 mm long nail.

A study was conducted to investigate diagonal bracing and all forms of bracing that are currently used by the South African timber roof truss industry. Although this investigation was a theoretical exercise and could not be validated by test results, it can be concluded that a three-dimensional buckling analysis is an acceptable way of determining the buckling length of a compression chord in a timber roof structure. Buckling and finite element analyses are widely used for many structural systems and materials, as the analyses are based on theories that have historically been proven to work for structures.

Effective length factors in simple lattice structures

The effective length factor is used to adjust the actual unrestrained length of a compression member to account for prevailing boundary conditions. Many software packages use a default out-of-plane effective length factor of 0.85, implying some form of rotational joint restraint by adjacent members. This is only possible where adjacent members have high out-of-plane bending or torsional stiffness and are themselves not compression members that could buckle. Some design codes specify effective length factors for compression members in lattice trusses.

Boundary conditions that influence the degree of restraint exercised on a compression member are not merely a function of connection details and continuity, but are influenced by the capacity of adjacent members at the node. Consider the example of a simple lattice truss with a constant section (Figure 2), where lateral supports are provided at seven nodes. The compression chord is divided into
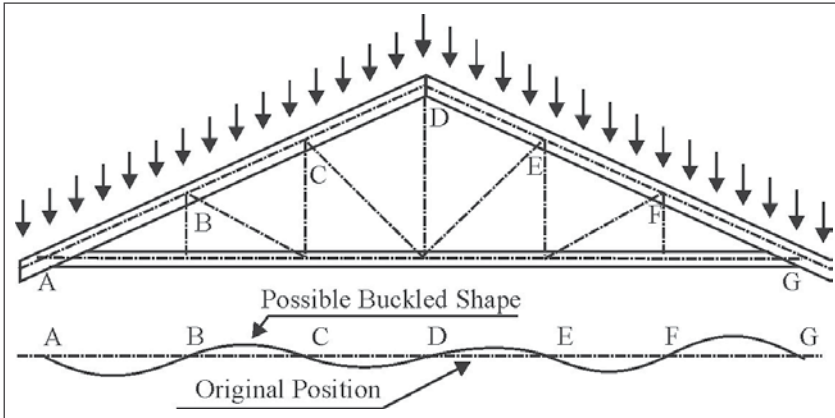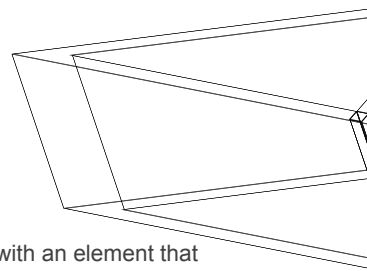
→ Figure 2. A possible buckled shape of the top chord.

equal portions. The basic principle that the buckling load is unique shows that an effective length factor of less than one for a particular member is consistent with an effective length factor of greater than one in the adjacent members, albeit with a smaller force.

Stiffness of connectors

When a stiffness matrix method with beam elements is used to analyse a structure, there are a number of ways of modelling the connection between, for instance, the batten and the top chord. One of the methods is the use of a spring as a connector. This, however, does not adequately address the possible rotation of the top chord, as the chord, the spring and the batten are in the same plane. Rotation of the chord will then 'soften' the stiffness of the connection. If a beam element analysis is applied to the three-dimensional model, it would be better to model the nail with an element that has the same bending stiffness as the transverse stiffness of the nail in double curvature, than to use a spring. The spring will not have the necessary eccentricity to allow the torsional displacement of the chord.

To illustrate how the connection 'softens' with relative rotation between two connected members, two analyses were undertaken (Figure 3).

In the first analysis, the eccentricity between the centreline of the battens and the compression element was taken into account, with the nails being modelled by bending elements. No account was taken of the possible lower shear modulus of the compression member. A buckling load factor of 174 and an out-of-plane buckling length of 622 mm resulted. In the second analysis, the member was analysed using shell elements with springs connecting it to the battens. The spring stiffness was reduced until the same buckling factor (174) was obtained as in the first analysis. The spring stiffness that was
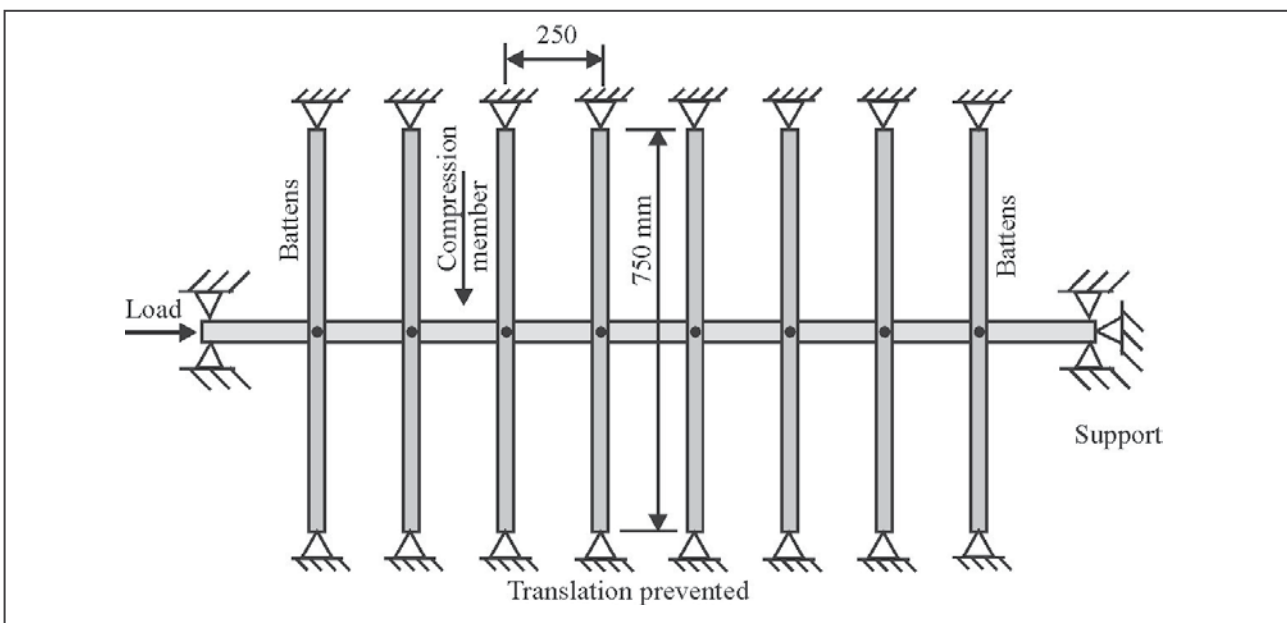
→ Figure 3. Theoretical set-up to investigate softening of the stiffness of the connections between battens and the braced member.
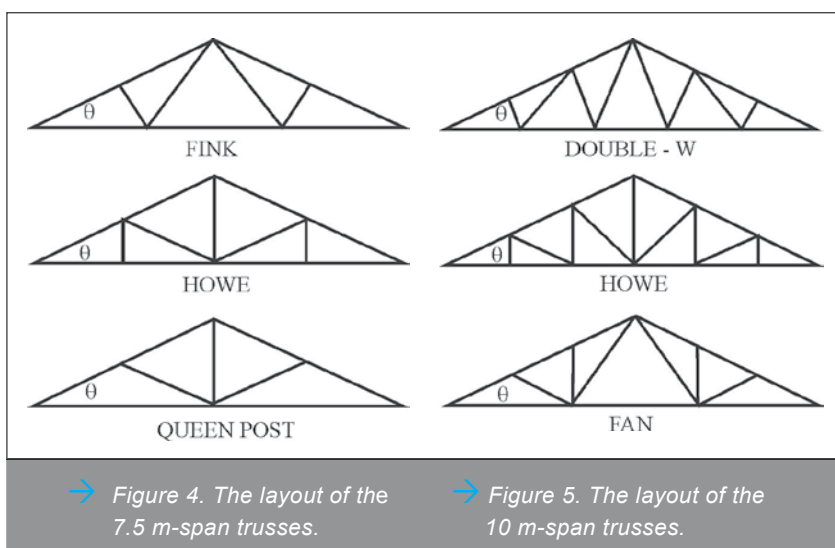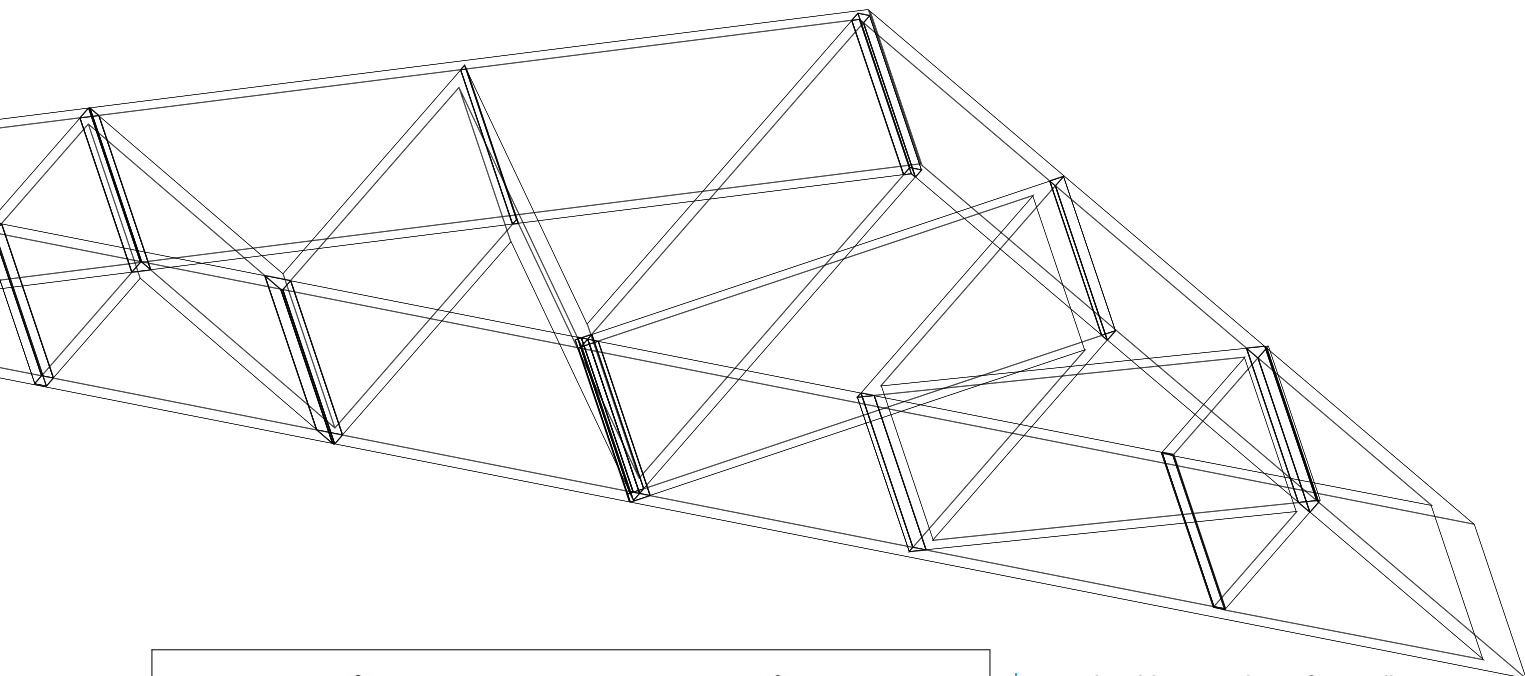
→ Figure 4. The layout of the 7.5 m-span trusses.

→ Figure 5. The layout of the 10 m-span trusses.

required to achieve this was 267 kN/m and no longer 800 kN/m. This shows that, when using shell or plate elements that are connected to the bracing battens by way of springs, great care should be taken, as it may result in misleading answers.

Shear modulus and analyses

The shear modulus of South African pine is accepted to be about equal to MOE/13. In order to demonstrate the principles discussed above, a commonly available PC-based analysis package (Prokon) was used to calculate the effective length factors of the top chord of gable-to-gable timber-trussed roofs with spans of 7.5 m and 10 m and pitches of 17.5°, 25° and 35°. The batten spacing was taken as 262 mm and 305 mm respectively in order to simplify the input of the truss and batten geometry. Only the tile weight and the self-weight of the timber were used to determine

the buckling length of the top chords, as the buckling is a long-term problem, rather than a problem that occurs only when imposed load is applied, as imposed load will increase the friction between the tiles, leading to bracing by diaphragm action. Tile mass was taken as being 55 kg/m^2, although the actual mass is not that important, as the buckling analysis is only used to calculate buckling lengths.

The different configurations were used to ascertain whether the configuration would play a significant part in the buckling length of the compression chord.

In all cases, the top and bottom chords were assumed to have dimensions of 36 mm x 111 mm, with web members being 36 mm x 73 mm with a 36 mm x 111 mm diagonal brace, although in practice the top and bottom chords may be 36 mm x 73 mm and the diagonal bracing
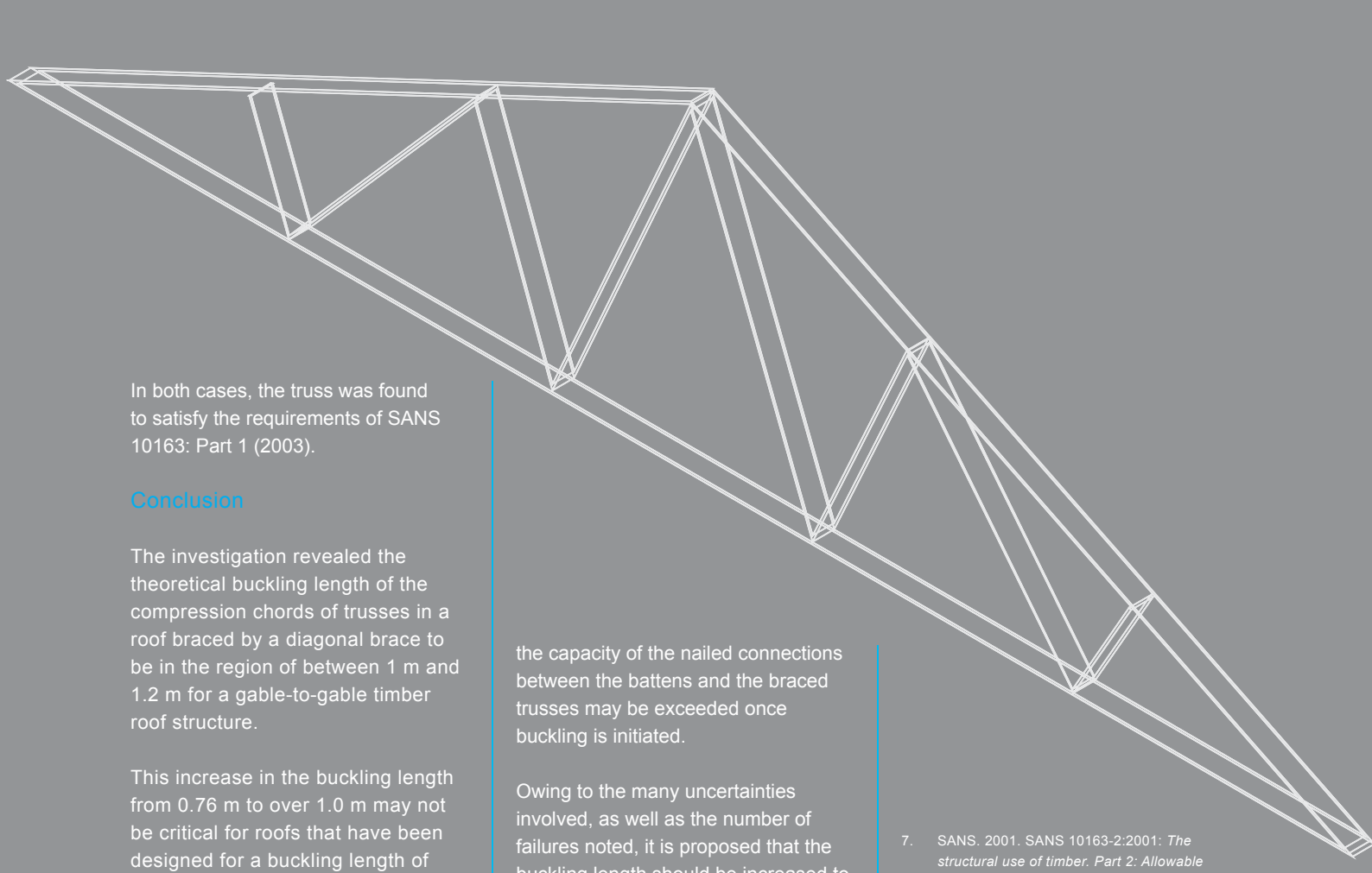
member 36 mm x 73 mm for small-span roofs.

A full-span complete roof was analysed to ascertain the buckled shape of the roof so that a half-structure, with the correct boundary conditions, could be analysed. From the buckled shape, one can deduce that the apex moves as the brace is flexible and it then becomes apparent that one cannot assume an inflection point at the apex. This then makes it possible to define the boundary conditions for a structure where only the half-structure is investigated. If the half-structure with the correct boundary conditions is used, it simplifies the input and speeds up the analyses of the various truss layouts and spans.

When comparing the results of the analysis for the different configurations, it is clear that the actual buckling length exceeds the purlin spacing by a factor of between 3.8 and 4.4. The error caused by centreline modelling was undertaken, as it was assumed that the difference in the buckling factors for the different layouts would be insignificant.

Ultimate strength of trusses

To see whether the theoretical increased buckling length would negatively influence the design of timber trusses, one of the 7.5 m trusses and one of the 10 m trusses were used to illustrate the code requirements between using the effective buckling length based on the truss spacing and the theoretical buckling length of 1.2 m.

In both cases, the truss was found to satisfy the requirements of SANS 10163: Part 1 (2003).

Conclusion

The investigation revealed the theoretical buckling length of the compression chords of trusses in a roof braced by a diagonal brace to be in the region of between 1 m and 1.2 m for a gable-to-gable timber roof structure.

This increase in the buckling length from 0.76 m to over 1.0 m may not be critical for roofs that have been designed for a buckling length of 0.76 m, or the spacing of the trusses, as the imposed load is very seldom applied to the full roof.

Furthermore, the imposed load would increase the friction between the tiles, perhaps leading to diaphragm bracing. The 30% shortfall in capacity should not impact significantly on the probability of failure of the compression chords, provided that the integrity of the connections between the trusses and the battens is maintained.

Ignoring the lack of torsional stiffness of the top chord has a small effect on the buckling length obtained from the analysis. This may not be true for sections that have a greater depth (149 mm and 225 mm). However, a centreline analysis that neglects to consider the distance between the centrelines of the brace, the chords and the battens is shown to underestimate the theoretical buckling length by a dangerous margin, possibly leading to unsafe member sizes.

The buckling analyses and calculations would appear to justify limiting the span of trusses that are braced by a diagonal brace to less than 10 m, as

the capacity of the nailed connections between the battens and the braced trusses may be exceeded once buckling is initiated.

Owing to the many uncertainties involved, as well as the number of failures noted, it is proposed that the buckling length should be increased to 1.2 m or 30 x b for timber-trussed roofs that are braced solely by diagonal bracing. Perhaps there should be two interaction equations for checking the lateral buckling strength of the roof trusses. The first check should be to ascertain whether the truss strength is adequate for permanent load with the increased buckling length, and the second for total load, with the buckling length, however, reduced to 15 x b. 🔵

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Prof Walter Burdzik is a professor in the Department of Civil Engineering at the University of Pretoria. He has been involved in timber research and structural timber design for the past 30 years, and runs one of the few recognised timber-testing facilities in South Africa. He is also involved in all the SANS committees that write the South African timber design codes and specifications that have to do with wood-based structural products.

Prof Nick Dekker spent most of his professional career with the BKS Group, where he was responsible for the design of a wide range of structures. In 1996, he co-founded the practice Dekker & Gelderblom and was appointed as a professor in Structural Engineering at the University of Pretoria. He received an NRF rating for his research in 1997.

Launch of University of Pretoria's new energy research initiative

As a research-intensive university, the University of Pretoria believes that it can make a positive contribution to the economic and social development of the country. Its research agenda is focused on a number of carefully selected themes, on which proven capacity exists within the University, and which build on the work of excellent researchers and research leaders. This has led to the establishment of a number of institutional research themes (IRTs), one of which is the IRT on Energy.

→ *Celebrating the official launch of the IRT on Energy were (from left): Prof Anton Ströh (Dean: Natural and Agricultural Sciences), Prof Tinus Pretorius (Director: IRT on Energy), Prof Cheryl de la Rey (Vice-Chancellor and Principal), Malcolm Fawkes (Senior Manager: Generation Learning Faculty, Eskom) and Prof Roelf Sandenbergh (Dean: Engineering, Built Environment and Information Technology).*

A study by the University's Institute for Technological Innovation found that the University was the most prolific publisher of energy research in South Africa from 1997 to 2007. This led to the establishment of the University's Institutional Research Theme on Energy (IRT on Energy).

The IRT on Energy was designed to recognise and foster excellence in research, and is aimed at enhancing multi- and transdisciplinary research that cuts across faculties to strengthen the University's reputation as one of South Africa's leading research universities. The IRT will coordinate the research being done in a number of faculties and partner institutions, which focuses on topics that are relevant to South Africa's future energy security. Such a focused and concerted research effort is necessary to ensure that the country succeeds in achieving the goals of government's Integrated Resource Plan of 2010 (IRP2010).

In order to develop an appropriate strategy for the IRT on Energy, the IRP2010 was evaluated, together with other government energy policies and strategies. The main goal of the IRT on Energy is to concentrate on research related to electricity generation, transmission and distribution. A number of selected research subthemes include energy production (with the emphasis on clean coal, nuclear and renewable energy), energy distribution (smart grids and energy storage), energy optimisation, advanced materials, energy policy and economics, and ensuring a sustainable environment.

With the newly established IRT on Energy at the University of Pretoria, excellent opportunities have been created for the development of research capacity at postdoctoral level. Different academic departments, especially in the faculties of Engineering, Built Environment and Information Technology, and Natural and Agricultural Sciences will collaborate in the new energy research initiative. Collaborations will also be established with local and international organisations, universities and industrial partners. ◑

Trevor Manuel urges engineers to plan for change

South Africa's engineering community has an important role to play in the implementation of the change that is necessary to improve skills, upgrade infrastructure and enhance the nation's innovative capacity. During the annual Hendrik van der Bijl Memorial Lecture, Minister Trevor Manuel, Minister in the Presidency for National Planning and Chairperson of the National Planning Commission (NPC), identified some of the challenges that need to be addressed to eliminate poverty and reduce inequality by 2030.

→ *Minister Manuel emphasises that the ownership of the implementation of change should be shared by government and the private sector.*

The Hendrik van der Bijl Memorial Lecture is an annual event that is presented jointly by the University's Faculty of Engineering, Built Environment and Information Technology and the South African Academy of Engineering (SAAE). It is delivered by a prominent personality under the general theme of the role of engineering in society. This lecture is of particular significance to both the University of Pretoria and the SAAE as Dr Van der Bijl was the Chancellor of UP from 1934 to 1948 and he made a huge contribution to the industrial and scientific development of South Africa. The first Hendrik van der Bijl Memorial Lecture was delivered in 1963 by Dr MS Louw (who represented Sanlam), and ever since, these lectures have been delivered by eminent persons who have made their mark in South Africa.

The most recent lecture, which was presented on 1 August 2012, was attended by more than 100 academics, students, engineers and alumni of the Faculty of Engineering, Built Environment and Information Technology. Other distinguished guests included Prof Cheryl de la Rey,

Vice-Chancellor and Principal of UP, Bob Pullen, Chairperson of the SAAE, and Prof Roelf Sandenbergh, Dean of the Faculty of Engineering, Built Environment and Information Technology.

In the lecture of Minister Trevor Manuel, entitled *The role of the National Planning Commission as catalyst for the development of South Africa,* he elaborated on the NPC's responsibilities. These include developing a long-term vision and strategic plan for South Africa. The Commission also plays an advisory role in policy implementation.

The overarching goal of the National Development Plan, which was presented to President Jacob Zuma on 11 November 2011, is to eliminate poverty and reduce inequality by 2030. Some of the main challenges identified in the plan are poverty and inequality, division, resources and education, social protection and community safety. In the same way that Hendrik van der Bijl faced various challenges to effect development years ago, South Africa has to deal with a number of issues to facilitate development in all

spheres of society in order to achieve the abovementioned goals.

The two most critical issues that should be addressed in order to reach these goals are to increase employment and improve the quality of education. A capabilities approach is needed, which entails enabling people and giving them the capability to find employment and improve themselves through education. This can only be done by upgrading skills and infrastructure. Minister Manuel emphasised that these were necessities.

South Africa has enormous skills deficits, and the basis of upgrading skills is education. The five basic themes around which the improvement of education, and thus skills, will be built are the following:

• Lay a solid foundation for higher education, which means prioritising early childhood education.
• Build a properly qualified, professional, competent and committed teaching, academic, research and public service core. Educators should update their skills and qualifications regularly.
• Build a strong and coherent set of institutions for delivering quality education, science and technology innovation, training and skills development. Schools should adhere to infrastructure standards.
• Expand the production of highly skilled professionals and enhance the nation's innovative capacity.
• Create an educational and national science system that serves the needs of society. A stronger emphasis should be placed on the teaching of literacy, mathematics and science, and increasing the numbers of African and female postgraduates.

Infrastructure promotes inclusive growth and is essential for development, which means that the basic systems (water, electricity and telecommunications) must be improved. More specific infrastructure developments proposed in the National Development Plan and mentioned by Minister Manuel are the upgrading of informal settlements on suitable land, the extension of the rail network and coal lines, the development of new water schemes and a water conservation plan, the development of renewable energy and the responsible exploitation of natural gas for energy purposes, the decommissioning of coal power stations and the installation of fibre-optic networks.

In conclusion, Minister Manuel remarked that experimentation was fundamental to finding solutions. Every country and situation have unique circumstances and textbook solutions cannot be simply applied to all similar situations. It is imperative that everyone is involved in the development of the country, and that public-private partnerships drive the process. The involvement of engineers would be to plan for effecting change. ❸

More on Hendrik van der Bijl

Hendrik van der Bijl was born in Pretoria in 1887 and studied at the Victoria College (which would become the University of Stellenbosch). He continued his studies overseas, specialising in electronics. In 1920, he joined the South African government as Technical Advisor, and laid the foundations for the development of South African industry. He established and became the Chairperson of Eskom, Iscor and the Industrial Development Corporation.

The foundations for the industrial development of South Africa were laid by Hendrik van der Bijl, the scientist, industrial leader, engineer and entrepreneur. His achievements have been recognised locally and internationally.

→ *At the annual Hendrik van der Bijl Memorial Lecture were (from left): Prof Roelf Sandenbergh (Dean: Faculty of Engineering, Built Environment and Information Technology), Prof Cheryl de la Rey (Vice-Chancellor and Principal), Bob Pullen (Chairperson: South African Academy of Engineering) and Minister Trevor Manuel.*

UP acquires the largest geotechnical centrifuge in the southern hemisphere

The University recently established itself as the leader in the field of geotechnical research when it acquired the largest geotechnical centrifuge in the southern hemisphere and opened a dedicated Geotechnical Centrifuge Laboratory in the Department of Civil Engineering. This move is set to greatly expand the University's research programmes, promote collaborative research, and attract more postgraduate students to enter this important field of study.

Soil-structure interaction and its associated problems is an aspect of civil engineering that is essential to understand. Sinkholes, bursting pipes and soil analysis for construction are just some of the issues that fall under the theme of geotechnical research. One can use computer models to simulate or model soil-structure interaction problems, but without a centrifuge this is a difficult and sometimes not-so-accurate task.

The University's new state-of-the-art centrifuge, only the second geotechnical centrifuge in Africa, will therefore greatly enhance research efforts into geotechnical problems. The centrifuge was installed in a heavily reinforced concrete chamber (for safety reasons) and was officially unveiled on 13 June 2012.

A geotechnical centrifuge is used to accelerate small-scale soil models through high accelerations, thus creating a realistic stress distribution within the model that corresponds to the full-scale situation. For example, a model with a scale of 1:50 needs to be accelerated to 50 times the earth's gravity, or 50 G. This is necessary because realistic soil behaviour in the model will only occur at the correct stress level.

The instrument acquired by the University is classified as a 150 G-ton instrument, meaning that it is capable of accelerating a model weighing up to 1 ton, to 150 times the earth's gravity. The centrifuge model platform measures 0,9 m x 0,8 m with unobstructed headroom of 1,3 m. The radius, measured from the centrifuge axis to the model platform, is 3 m. This means that at an acceleration of 150 G, the model can travel in a circular track at 240 km/h.

Existing and planned research programmes

One UP research programme for which this centrifuge will be used is the study of dolomitic sinkholes, a problem often encountered south of Pretoria and on the West Rand. The University wishes to study the effects of these sinkholes on various foundation types and structures. Scope also exists to investigate sinkhole rehabilitation methods. New sinkholes open up regularly in the Centurion area and need to be closed quickly to limit danger to the public.

Another common problem in civil engineering is one that relates to urban water distribution systems. Such systems often rely on large diameter, thin-walled, buried pipelines. The stability of such pipes, when buried in trenches or under fill embankments, requires further research. The University is investigating to what extent the load imposed on these pipes by the ground can cause deformations on the pipes, and how this pressure influences the stability of the soil-pipe system.

The machine will also enhance the Department of Civil Engineering's seismic investigation techniques, which were developed at the University to measure the small-strain stiffness of soil by means of seismic methods. These techniques are now used routinely by many consulting engineers in the design of foundations. However, the correct compressibility that should be used in the calculation of foundation settlement is yet to be researched.

To answer this question, a project has just commenced at the University to model the placement and loading of a foundation in the centrifuge. During this process, small-strain stiffness and model foundation settlement will be measured.

During the construction of the Gautrain viaduct through Centurion, large-scale surcharge trials were carried out to measure the compressibility of the dolomitic soils on which the viaduct had to be founded.

The back analysis of the settlement that was measured during these trials was a complex undertaking that required many assumptions to be made. The behaviour of the surcharge loads will now be modelled in the geotechnical centrifuge, which will entail settlement and soil compressibilities being measured and compared. This may have important applications for future projects when construction has to be carried out on dolomitic soils.

In addition to these examples of how the geotechnical centrifuge will be used in the field of civil engineering, the centrifuge can also be used for research in mining engineering, geology, mechanical engineering and other fields where large accelerations have to be applied to models or components. It therefore has the potential for great collaboration across various departments and disciplines.

Although the primary purpose of the centrifuge will be for research, the University will also make the equipment available to companies who would like to carry out the testing of physical models for commercial purposes.

Funding

The new Geotechnical Centrifuge Laboratory and procurement of the machine were co-funded by the National Research Foundation (NRF) through the Research Infrastructure Support Programme (RISP), and the University of Pretoria, thanks to the hard work and dedication of Prof Elsabe Kearsley and Prof SW Jacobsz of the Department of Civil Engineering.

In addition to the support received from the NRF to acquire the centrifuge, the University has received remarkable support from industry to create the infrastructure necessary to safely house the instrument in a heavily reinforced concrete chamber.

The Department of Civil Engineering would like to express its gratitude to the following companies for their tremendous support:

- Design of reinforced concrete chamber: Jones & Wagener (Pty) Ltd, Consulting Civil Engineers
- Design of electricity supply: Claassen Auret Incorporated
- Design of the cooling system: Spoormaker & Partners Incorporated
- Construction and steel reinforcement: Stefanutti Stocks Holdings Ltd
- Special shuttering: PERI South Africa Formwork Scaffolding Engineering
- Concrete: Lafarge South Africa Holdings (Pty) Ltd ⊖

Prof Elsabe Kearsley is Head of the Department of Civil Engineering at the University of Pretoria.
Prof SW Jacobs is the manager of the Geotechnical Centrifuge Laboratory.

Xstrata establishes research chair in Centre for Pyrometallurgy

The Centre for Pyrometallurgy in the Department of Materials Science and Metallurgical Engineering established a second research chair in February 2012 with the financial support of industry partner Xstrata plc. This chair will focus on research in pyrometallurgical modelling.

The Centre was established in 2009 when Anglo American established the Anglo American Chair in Pyrometallurgy. With the establishment of this chair, the company stipulated that its main purpose would be to address the shortage of academic resources, maintain quality tertiary tuition in pyrometallurgy, and meet core teaching outcomes specified by the Engineering Council of South Africa (ECSA).

As part of the conditions of the establishment of the chair, Anglo American suggested the establishment of a Centre for Pyrometallurgy supported by industry and government. The Centre for Pyrometallurgy in the Department of Materials Science and Metallurgical Engineering therefore became a reality on 30 May 2011.

The key aim of this Centre is to bring the Pyrometallurgy Group at the University of Pretoria and the South African pyrometallurgical industry closer together. It aims to strengthen communication, cooperation and support between academia and industry, and to further develop expertise in pyrometallurgy. Other objectives include the delivery of high-quality manpower in pyrometallurgy and the execution of internationally competitive applied research of interest to UP's industry partners.

It was envisaged that the Centre for Pyrometallurgy would eventually consist of a number of industrial chairs associated with different subdisciplines of pyrometallurgy and that close cooperation between the different chairs would take place, as strong overlap exists between the different subdisciplines. The Anglo American Chair mainly supports the teaching drive of the Centre (undergraduate, postgraduate and in-house courses). However, other research focus areas in the Centre include the various subdisciplines of pyrometallurgical processes, refractory materials, waste materials and modelling, which will each be associated with an industrial chair.

The Xstrata Chair in Pyro-metallurgical Modelling is the second of these envisaged chairs. It was officially inaugurated by Mick Davis (Chief Executive Officer, Xstrata plc) on 21 February 2012. The inauguration was combined with a workshop on pyrometallurgical modelling offered by experts in the field.

Effective modelling of pyro-metallurgical processes can help gain a better understanding of an existing process, plan design improvements and develop new processes. It can aid in predicting how the process will respond to operational changes, and help estimate certain parameters of the process (some of which could be very complex to measure). Predictive models that will be developed in this group will be verified with experimental measurements and plant data as far as possible.

The modelling of metallurgical processes is an interdisciplinary

> The key aim of this Centre is to bring the Pyrometallurgy Group at the University of Pretoria and the South African pyrometallurgical industry closer together.

field of study, which can also advance cooperation with other metallurgical disciplines, such as minerals processing, and also lead to closer association with the departments of Mechanical and Aeronautical Engineering, and Electrical, Electronic and Computer Engineering. Through the Xstrata Chair, the Centre now has the opportunity to further develop its capability in the modelling of pyrometallurgical processes, not only in the thermodynamic modelling of processes, but also in kinetic, heat and fluid flow, and financial and multiphase modelling.

The first student projects, in which the skills of thermal modelling, economic modelling and multiphase modelling are developed, were started in 2011. These projects include an investigation into the effect of cooling conditions on the quality of platinum group metals (PGM) converter matte, multiphase modelling of the raw material granulation process and green bed permeability during the sintering of iron ore, the economic modelling of a ferrochrome furnace, the modelling of thermal profiles in a furnace wall, the evaluation of the degree of mixing within a converter process by using physical and computational fluid dynamics (CFD) modelling, and the development of a generalised mass, energy and thermal profile model of a typical chromite ore sinter belt process.

The Centre for Pyrometallurgy currently comprises four members: Prof Andrie Garbers-Craig (Director), Prof Johan de Villiers, Markus Erwee and Robert Cromarty. With the signing of the agreement between Xstrata South Africa and UP for the funding of the research chair, another three-year contract position has been secured. It is anticipated that the incumbent will join the Centre in due course. ☻

→ *Unveiling the plaque at the launch of the Xstrata Chair in Pyrometallurgical Modelling are (from left): Prof Roelf Sandenbergh (Dean: Engineering, Built Environment and Information Technology), Mick Davis (CEO: Xstrata plc), Prof Cheryl de la Rey (Vice-Chancellor and Principal) and Andile Sangqu (Executive Director: Xstrata South Africa).*

→ *Mick Davis (CEO: Xstrata plc – sixth from left) and Andile Sangqu (Executive Director: Xstrata South Africa – third from right) with staff and students from the Centre for Pyrometallurgy. Staff include Prof Andrie Garbers-Craig (front row, fourth from right), Prof Johan de Villiers (front row, second from right), Robert Cromarty (front row, extreme right) and Markus Erwee (back row, middle).*

Eskom specialisation centre enhances research

Prof Stephan Heyns

Over the next five years, the University of Pretoria (UP) will benefit from a unique opportunity to enhance and reinforce its current interdepartmental research programme in physical asset management and establish a core of expertise in this field in South Africa. This is due to the fact that the University has been chosen to host the Specialisation Centre in Plant Asset Management of the Eskom Power Plant Engineering Institute (EPPEI).

Eskom recently established the EPPEI to produce highly skilled engineers at postgraduate level in eight broad specialisation areas at South African universities. UP accepted the offer to host the specialisation centre and signed the agreement with Eskom in January 2012.

This contract will see Eskom supporting a full-time professor, a senior lecturer and an administrative position at UP over the next five years. The funding will also allow the University to engage a senior researcher from a developing university for the contract period.

The new centre at UP will develop and present a range of courses, including specialised physical asset management-related courses, that will support the EPPEI. In addition, UP will supervise and mentor master's and doctoral research students and develop collaborative research programmes with South African and foreign universities, original equipment manufacturers, as well as foreign utilities proposed by Eskom.

The Department of Mechanical and Aeronautical Engineering at the University of Pretoria has a well-established presence in the field of plant asset management, which has grown tremendously ever since Eskom started supporting research in vibration-based diagnostics and prognostics through its Tertiary Education Support Programme in January 1999. Over the years, this has led to a significant body of research in the field of vibration-based condition monitoring and maintenance.

Research focus areas include vibration monitoring under varying load and speed conditions, gearbox vibration monitoring and vibration modelling, and monitoring on large electrical machinery. A finite-element model was developed to model and understand the dynamic behaviour of large electrical generators and to devise appropriate monitoring strategies.

The research programme was enhanced in 2010 when two senior lecturers in maintenance engineering were appointed with the support of Anglo American, Eskom, Exxaro and Sasol. These positions are focused on reliability and maintenance practice, as well as condition-based maintenance.
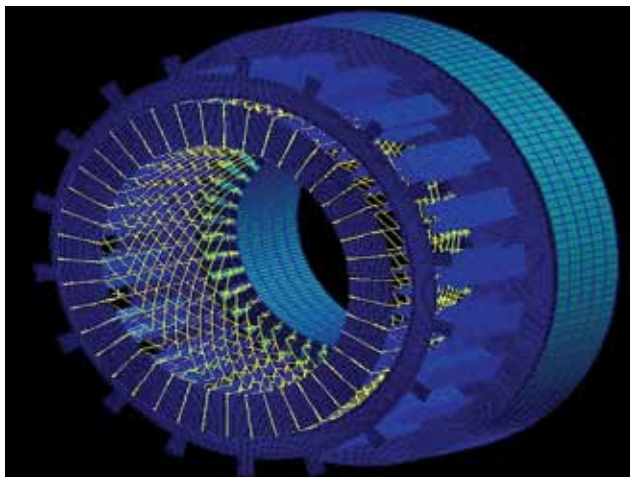
→ *A finite-element model.*
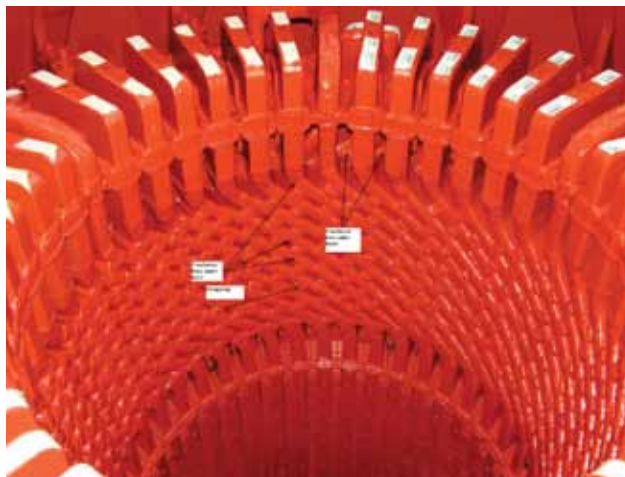
→ *The end windings on a typical large electrical generator.*

They strongly reinforce the new plant asset management programme.

The programme is well supported by the Sasol Laboratory for Structural Mechanics, which was established in the early 1980s and has been actively developed ever since. This laboratory now has excellent testing and analysis capabilities and a very good infrastructure for specialised laboratory investigations on rotating machinery, as well as a unique fatigue-testing capability. In addition, the laboratory features a strong field measurement capability for in situ investigations on, among others, mills, generators, fans and gearboxes at power stations.

While the new centre will be hosted by the Department of Mechanical and Aeronautical Engineering, there are various other entities at UP with significant expertise in plant asset management. These include the Graduate School of Technology Management and the Department of Industrial and Systems Engineering. This positions UP very strongly in the field.

The support from EPPEI provides the University with an excellent opportunity to enhance and reinforce the current research programme. While the UP team has always had a strong focus on addressing real problems, the scale of operations can now be expanded to include a broader understanding of the entire plant life cycle. In addition, more attention can be given to integrating traditional technical focus areas, such as fatigue analysis, vibration-based condition monitoring, vibration signal analysis, finite element analysis and experimental modal analysis, with fields such as reliability, statistics and financial modelling.

Worldwide, there is a great need to integrate these disciplines for the optimisation of life cycle performance. It is therefore believed that the new specialisation centre will contribute to the establishment of a core of expertise that will play a significant role in improving plant asset management practices in South Africa and abroad. ❸

Prof Stephan Heyns is a senior lecturer and Head of the Division of Structural Mechanics in the Department of Mechanical and Aeronautical Engineering at the University of Pretoria.
Dr Barend Botha and Dr Coenie Thiart are senior lecturers in the same department.

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Study centre for the School of Engineering

The School of Engineering has embarked on a growth strategy over the last decade in view of the shortage of engineering skills in South Africa. This resulted in a significant increase in engineering student numbers.

The creation of additional teaching and research facilities for the School of Engineering was supported by the University and the Department of Higher Education and Training, resulting in the construction of the new Engineering 3 Building and Parkade on the Hatfield Campus. This development provided additional lecture halls, laboratories, an access road and entrance, as well as parking for a thousand cars.

The study centre is a vital part of the School of Engineering's strategy to increase the success of engineering students by providing facilities to support learning and especially groupwork. Such a facility has become a necessity due to the complexity of the lecture timetable and the changing demographic profile of students. There are many students who travel far on a daily basis and who do not have adequate facilities for study or groupwork at their homes or on campus.

The development of the study centre, situated immediately west of the Engineering 1 Building, was financially supported by Xstrata and the Anglo American Chairman's Fund. The contract for the project was allocated to Robenco Construction. Work on the project started in April and is scheduled for completion in May 2013. Progress on the project may be viewed at http://web.up.ac.za/building.

The study centre will accommodate 758 students in the following configurations on two levels: On Level 3, there will be 252 individual workstations accessible to students on a first-come basis. There will also be 30 conceive, design, implement and operate (CDIO)-type venues where groups of seven students may work in a private cubicle equipped with a table and flat screen. These venues will be reserved through a computerised booking system.

On Level 4, there will be 296 seats without workstations.

The study centre is situated at the old entrance to the Engineering 1 and Engineering 2 buildings off University Road, which was closed when the new entrance to the parkade was opened. A new 'drop off and go facility' will be constructed at the old entrance, which will be convenient for dropping off or picking up students in a safe environment adjacent to the study centre.
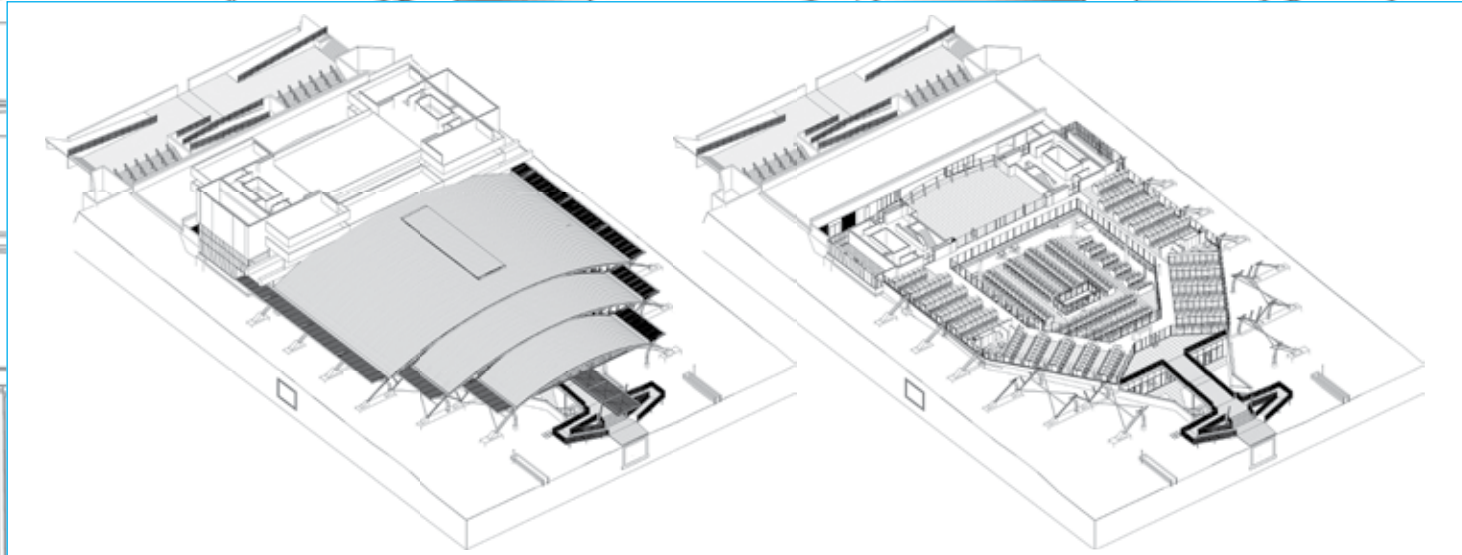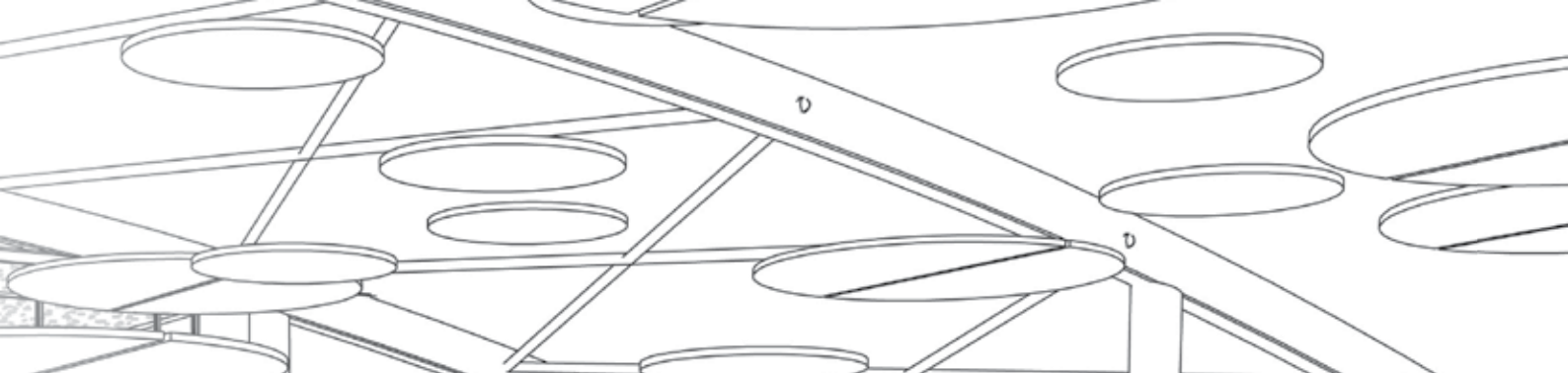
→ *Level 6 cut away (left) and Level 4 cut away (right) of the new study centre as designed by ARC Architects.*

Graphics courtesy of:

African Centre of Excellence for Information Ethics established

Coetzee Bester and Rachel Bothma

Information ethics is a descriptive and emancipatory discipline dealing with the study of the changes in the relationship between people and the world due to information and communication technologies. Information ethics in Africa provides a unique platform to build an information and knowledge society driven by critical reflection on ethos and values within the African context. It addresses opportunities and challenges unique to the development of African societies.

The African Centre of Excellence for Information Ethics (ACEIE) was established in the Department of Information Science at the University of Pretoria on 17 May 2012. This was the culmination of a series of activities and events by various stakeholders involved in information ethics.

In 2007, a group of international academics in the fields of information technology, philosophy and politics came together to form an academic network to do research on information ethics. This network was formalised, and is now known as the African Network on Information Ethics (ANIE).

At approximately the same time, the rollout of broadband capacity in South Africa and Africa resulted in information being more readily available. The recent and ongoing construction of various submarine network cables, such as SEACOM, directly contributed to the expansion of the broadband capacity on the African continent, thereby making more information available to more people at greater speeds.

The growth in communication and information management capacity contributed significantly to the development and management of e-skills, e-governance and information ethics, and the challenges related to these matters.

The ANIE identified a gap in the academic representation of the African continent on the global stage, specifically pertaining to information ethics, and therefore started organising events to stimulate research on information ethics in Africa. Similarly, because it is a new field of research and study, it was found that students were not properly introduced to information ethics and did not fully understand the concept, purpose and practice of this field.

The result of these activities and international collaboration has led to a partnership with the South African national Department of Communications, the United Nations Education, Scientific and Culture Organization (UNESCO) and various universities across Africa. The Department of Information Science took the lead and formed an integral part of the conceptualisation and negotiations between the parties. Finally, this collaboration contributed to the establishment of the ACEIE, and the Department now hosts the Centre.

> The growth in communication and information management capacity contributed significantly to the development and management of e-skills, e-governance and information ethics.

The purpose of the ACEIE is to formally reflect on the activities and history of information ethics in Africa. Furthermore, this reflection should contribute to research on the topic and allow networking with other academics in the field.

One of the main objectives of the Centre is to develop a curriculum to teach information ethics in Africa. During the first three years, the ACEIE will develop a curriculum structure and implement the content at universities in Africa. A group of more than 30 international

academics are working together on this pilot project.

According to a formal memorandum of agreement between the University of Pretoria and the South African national Department of Communications, signed on 15 December 2011, the ACEIE was conceptualised and will further fulfil the following functions:

- Support the establishment of other ethics centres in Africa through the African Ethics Research Centre Network
- Convene, coordinate and handle the administration of the ethics conference, and follow up the implementation of the conference resolutions
- Facilitate the hosting of ethics awards ceremonies in collaboration with other partners
- Focus on research and training in information ethics

- Develop short courses for government officials in the nine provinces of South Africa
- Encourage information ethics workshops, where academics and practitioners can exchange their knowledge and enhance the practical dynamics of information ethics
- Function as a centre where research interests can converge

to endorse key proposals concerning information ethics and its application in African societies, governments and institutions
- Maintain its collaborative relationships with UNESCO, the E-skills Hub, hosted by the Department of Informatics, and its host, the Department of Information Science ✪

The purpose of the ACEIE is to formally reflect on the activities and history of information ethics in Africa. Furthermore, this reflection should contribute to research on the topic and allow networking with other academics in the field.

UP honours British philanthropist and interior design expert

Raymund Königk

The University of Pretoria conferred an honorary doctorate in Architecture on the person who has had an enormous influence on the discipline of interior design since he entered the profession in the 1950s. Sir Terence Orby Conran (81) is a designer, a restaurateur, an entrepreneur, the author of numerous books on interior design, the founder of the Design Museum and a businessman. Most importantly of all, he is a philanthropist who made the discipline of interior design accessible worldwide.

Sir Terence Conran is the son of Christina Mabel (neé Halstead) and the South African-born Gerard Rupert Conran (a businessman from East London). He was born in Kingston-upon-Thames on 4 October 1931. It could be said that his career started while he was still in school. Being in a school where academic study was combined with practical, physical activities, he started designing furniture at a young age. While teachers in the 1940s encouraged pupils to learn hard so that they would not "end up working in factories", Sir Terence did not see anything wrong with the idea of being a factory worker, creating things.

The man who is said to have had the biggest impact on the contemporary British lifestyle enrolled at the Central School of Arts and Crafts in 1948, but was later advised by his tutors to leave the course to join the architect Dennis Lennon to design the interior of a princess flying boat for the 1951 Festival of Britain.

Sir Terence founded Conran and Company in Notting Hill, London in 1952. The practice specialised in furniture making, but also received commissions for complete designs. After working in the basement of a restaurant washing dishes as a young man, he got the idea of opening a restaurant without any chefs. So, his first restaurant, The Soup Kitchen, was born in 1953, founded to supplement his furniture enterprise, selling only soup (made in a large cauldron) at cheap prices.

He did not give up on designing and in 1956, at the young age of 25, he opened his own furniture store in which he could sell his modern furniture at affordable prices, making a contemporary lifestyle available to the average person. He later opened the first Habitat shop in London, which grew to become a revolutionary furniture store across the UK and later worldwide. It sold affordable, modern furniture and both local and international household goods. In the 1980s, Sir Terence expanded the Habitat shop into a group of companies to include various chain stores.

In 1956, Sir Terence established The Conran Design Group. He was involved in, among others, redesigning

London's Michelin House, which he turned into a restaurant. In the 1990s, he played a major part in the regeneration of the Butler's Wharf area of London.

In 1982, he opened The Boilerhouse in the basement of the V&A Waterfront to showcase and celebrate design. This collection grew to such an extent that it moved out of the basement of this museum in 1988 into a new premises in Shad Thames to become the Design Museum that is still there today.

Sir Terence received his knighthood from Buckingham Palace in 1983. He is also a fellow of the Chartered Society of Designers and winner of the Minerva Medal (the society's highest award). He was awarded the Prince Phillip Designer of the Year Award by the British Design Council and is a *Commandeur de l'Ordre des Artes et Lettres*, France.

His other later successful business ventures include creating the Conran Octopus Publishing Company, having the Conran Shop spread around the world, establishing the Conran Restaurants group in the 1990s, and publishing around 30 books.

Sir Terence was the Design Indaba Keynote Speaker in South Africa in 2003.

Honorary doctorate

The University of Pretoria decided to bestow the degree PhD (honoris causa) upon Sir Terence Orby Conran in recognition of his significant and original contribution to the discipline of interior design. He is specifically honoured for his direct contributions to interior design, his design activism, his contributions to the literature and for his management and corporate contributions.

Sir Terence advocated the use of a multidisciplinary approach in design – a model that is still followed by the Department of Architecture at the University of Pretoria today. His holistic design approach, where location, environment, architecture, materials, interior design, light, space, product and graphics connect as if chosen by 'one pair of eyes', is a major and original contribution to interior design where the concept of design distribution plays such an important part in the design process.

Sir Terence was meant to receive his honorary doctorate at the April 2012 graduation ceremony, but due to ill health could not travel to accept his degree. He received his degree at a TuksAlumni function in London on 21 August 2012. ❸

→ *Sir Terence received the PhD (honoris causa) at a special TuksAlumni function held in London on 21 August 2012.*

House Onderstepoort now houses record-breaking solar water heating system

Marlene de Witt

→ *The aim of the upgrading project at Onderstepoort was to make the new facilities as energy-efficient as possible.*

House Onderstepoort, the student residence on the University's Veterinary Science campus, will now save almost 700 000 litres of water and produce 450 less tons of carbon dioxide per year. This is after the University acquired a world-class solar water heating system for the residence complex during a recent upgrading project.

The upgrading formed part of a R90 m project, which commenced in May 2010. The University's Faculty of Veterinary Science is the only one of its kind in South Africa. With the new facilities and accommodation that were added adjacent to the existing residence, it can now accommodate 604 students.

As part of the upgrading project the University aimed to make the new facilities as energy-efficient as possible. One of the measures taken to achieve this goal was the installation of a solar water heating system on the new carport. With a total collector surface of 672 m^2, it is the biggest glazed installation in southern Africa. The system, installed by Holms and Friends (formerly Omnibus Engineering), avoids the production of 450 tons CO_2 and will save 600 980 litres of water each year.

"The savings are remarkable, the system is fully functional and it is a pleasure to watch in action," said Alec Blackhall, Manager: Residence Affairs and Accommodation at the University.

Pretoria North, where Onderstepoort is situated, falls within the Northern Middleveld climatic region, which is characterised by its distinct rainy and dry seasons. Temperatures show a large daily variation and strong solar radiation is prevalent. This led to the decision to install SUNDA PG2.0-F/G flat plate collectors instead of the costlier, but more efficient, vacuum-tube collectors.

Some 336 two-metre^2 collectors were installed on top of the carport and rooftops. Three collectors were connected in parallel, and two parallel 'strings' were then connected in series to get a total thermal length of 12 metres. The total capacity of the installation, 430 kWh, could produce 404 700 kWh of electricity a year.

One central feeder tube transports the warm water to a building

constructed next to the carport to house the heart of the system: two giant 20 000-litre water storage tanks, an expansion tank, membrane expansion vessels (totalling 5 400 litres) and seven external heat exchangers, among others.

The water heated by the solar panels is stored in the buffer tanks. Through external heat exchangers (that is, exchangers not housed in the tanks themselves), a different continuous freshwater supply is warmed and distributed to the individual residences. This results in an indirect loop system, which automatically complies with health standards without having to manage a major maintenance programme, since it will never be used for human consumption. It is, simply, the 'working fluid' of the system.

The water is distributed through pump-circulation, via 40 mm diameter heavily insulated pipes. These are mounted on steel frame structures to reach each residence building. A safety measure has been put in place for those periods when the system is not in use; for instance, over the December holidays. During that time, the system could get extremely hot and the water can expand, sometimes even reaching a gaseous state.

Merely using open expansion vessels would result in having to continually top up the working fluid, which could lead to corrosion and contamination of the system. Therefore membrane expansion vessels were used for the project. These, and all other components for the system, are 'Made in Germany' quality and are directly imported or locally produced. Normal grid-connected electric heating serves as a back-up for the system. ❸

→ *The residence facility at Onderstepoort will save almost 700 000 litres of water and produce 450 less tons of carbon dioxide a year.*

While the full consequences of climate change are unknown, what is certain is that neither the planet nor humanity will be able to adapt in time, unless the process can be halted by developing new technologies to generate alternative and renewable sources of energy.

The threat of rapidly rising electricity prices for energy-intensive users

Is South Africa at a tipping point when it comes to electricity prices and the supply of electricity in the mining industry? This was the question posed by Mike Rossouw, Executive Director of Xstrata Alloys, who was the guest speaker at an industry discussion presented by the Pretoria branch of the Southern African Institute of Mining and Metallurgy (SAIMM) that took place at the University of Pretoria in April 2012. The topic under discussion was the threat of rising electricity prices and low security of supply on the South African mining and metallurgical community.

A tipping point refers to the moment of critical mass; the threshold; the boiling point. Within the mining and metallurgical community, the threat of rising electricity prices is creating a situation where there is "all load and no traction", which could translate into no jobs if not managed correctly. Electricity prices and supply are currently seriously threatening growth. The South African government's position on developed economies' climate change policy, carbon tax and the issue of nationalisation might translate into new labour laws that come with even more transformation and increased taxes.

Ultimately, South Africa is entering a terrain where electricity prices will either 'make' or 'break' projects. If electricity prices rise to an unmanageable rate, the mining industry, together with other energy-intensive users, will not continue to implement subsidies and pay other taxes. Unfortunately, imports from other countries that are in direct opposition with South Africa's own markets, such as the ferrochrome imports in China, further inhibit growth, even though South Africa potentially has more of the resources available than other countries. While the National Energy Regulator of South Africa (NERSA) approves costs and returns recovered from tariffs, the average cost per voltage has risen too fast (and continues to rise) and is too high to be considered an affordable price path. If the price rises inconsistently and is too high, industry demand will shrink and then collapse.

However, if the price of electricity is too low, new generating capacity cannot be funded. The price needs to be established at a cost-effective level that will also support the build level. In contrast, if the price is too high, marginal energy-intensive sectors will shut down, sectors that have been targeted for job growth will shrink or stagnate, competition in certain energy-intensive sectors will not be viable, and the balance of payments and GDP will shrink.

It is important to take cognisance of the fact that there are a number of levers that can be used to balance funding and affordability, but these need more robust modelling and analysis to inform concrete decision-making. These levers include asset depreciation, capital expenditure (CAPEX) and rate of return, independent power producer (IPP) purchases, and levies and taxes. At all times during the process of finding a solution, the shortfall in the operating margin must be considered, lest the overuse of assets be to the detriment of the consumer.

Another fundamental challenge for the energy-intensive users' group is that there is currently not enough energy to sustain the South African economy. There are increases in the risk of forced outages due to maintenance that is long overdue, and there are shortfalls in the daily operating margin that are too high and too frequent. It is imperative to increase emergency reserves from 1 220 MW to 4 220 MW to merely sustain the current economy. Additional reserves need to be identified, and more projects need to be created.

From the supply side, the following projects have already been identified:

- Municipal generation
- Additional capacity from the medium-term power purchase programme
- Short-term local and cross-border independent power producers
- Regional gas options
- Solar photovoltaic cells
- Coal quality improvement
- Non-Eskom peaking generation
- Standby customer generation (for example, shopping centres)
- Additional demand market participation (large customers)

From the demand side, the following programmes have been acknowledged:
- Demand response
- Power buy-back

- Voluntary energy conservation schemes (additional)
- Emergency demand market participation
- Mandatory demand management participation (DMP) through regulations

Furthermore, nuclear power stations, gas turbines, and hydro power are all controversial, but worthwhile options that need to be analysed further if the economy is to grow in the future.

Rossouw concluded that now, more than ever, every stakeholder that is affected in some way by this energy crisis needs to communicate and work together as one team.

One of the tenets of the SAIMM's mission is to bring the mining and metallurgical fraternities, research and education personnel, and students together in one organisation; and to judiciously anticipate the needs of members. By hosting industry-specific discussions around pertinent issues, the collective generation of creative solutions is increased. It is the hope of the entire industry, of which SAIMM – and by extension the Department of Mining and the Department of Materials Science and Metallurgical Engineering at the University of Pretoria – is part, that a vibrant solution to the energy crisis will be reached shortly. ✪

Mike Rossouw *is an alumnus of the University of Pretoria. He has over 30 years' experience in engineering, and has occupied general and executive management positions in the gold, manganese, titanium, platinum and chrome mining, and mineral beneficiation sectors. He is currently the executive director of Xstrata Alloys, and was previously a non-executive director of Zimplats. He also served a term of five years as the government-appointed, independent director of NERSA.*

Securing carbon finance to promote energy efficiency

Prof Ciska Terblanche

Carbon financing, when implemented and managed correctly to ensure early income from energy-efficient projects, holds significant advantages for South African businesses. South Africa, in particular, has a lot to gain, as energy-efficiency projects in this country can contribute hugely to successful carbon finance projects.

Carbon finance provides a means to mitigate the risks posed by climate change, as it offers financial encouragement to organisations to implement measures to reduce their greenhouse gas emissions.

Conventional generation methods that are used to provide electricity are some of the main reasons for South Africa's global contribution to emissions being fairly high in comparison with other countries. This contributes to the popularity of energy-efficiency projects in the country, because of the large amount of CO_2 that can be offset.

Typically, reducing 1 MW of electricity will result in a CO_2 reduction of approximately 1 ton, which is among the highest amounts in the world. Emission reductions can also be generated to reduce product-specific energy consumption (ton of CO_2 per ton of product).

Many organisations experience problems with the way carbon financing is currently being implemented. Equity finance is usually provided initially, with certain carbon finance benefits being generated in the second year of implementation of the project. A carbon component for a project is a time-consuming process and the emission reduction can only go through the auditing process and generate a real income after implementation.

This is problematic for most organisations, as the aim is to move carbon finance to the beginning of the project, so that income can be generated sooner, making projects more appealing. This concept is called 'selling carbon forward'.

Various basic principles can be applied to sell carbon reductions forward. These include the following:

- The potential volume of carbon reductions that a project may deliver over a certain period of time is quantified upfront.
- A view is taken by a financier or carbon buyer on the carbon market up to a future point in time.
- A price structure for the carbon reductions is negotiated between the parties, taking into account all risks associated with the project, the market, etc.
- The price of carbon reductions sold forward is discounted to account for the risks associated with the project.

Usually the financier has a back-to-back agreement with a carbon trader to purchase the carbon reductions once they realise.

Considering the risks

There are risks associated with such trading that can impact on the financing deal. A carbon buyer in Europe could, for instance, be a counter-party risk. Fluctuating markets create price and exchange rate risks. Combined, these could lead to non-registration, placing the whole project at risk of not being financed. To a large extent, the project developer can manage project risk only.

Carbon credits

The carbon development mechanism (CDM) is widely regarded as the most significant outcome of the Kyoto Protocol. However, it is intrinsically linked to carbon credit and finance. CDM depends on the regulatory and legal framework that is generated by the protocol.

Companies in the European Union (EU) Emissions Trading System (ETS) will continue to demand carbon credits generated by CDM projects after 2012. However, all indications are that the ETS rules will change to restrict eligibility for new projects to only those in the least developed countries from 2013.

Projects that are not submitted for registration to the United Nations Framework Convention on Climate Change (UNFCCC) by 31 December 2012 cannot sell their emission reductions to the EU ETS.

However, there are some proposed alternative mechanisms to CDM beyond 2012, such as bilateral agreements, sectoral crediting, national appropriate mitigation actions (governed by national government) and verified emission reductions, among others. Such alternatives will require significantly greater involvement from national government, capacity-building within governments and sectors, and the development and approval of new systems and procedures to establish baselines, rules and guidelines.

All the new proposed mechanisms that could be applied by South Africa will take a number of years to develop and implement. What about projects that will be developed in the next two to four years, though? Instead of developing a single project, a Programme of Activities (PoA) could be developed, which can include multiple projects, and any number of projects can be added at any time for the duration of the PoA. The projects have a lifetime of 28 years. Therefore, once registered, projects can be slotted into the PoA for a period of 18 years. A coordinating entity will take on the responsibility for all the CDM activities on behalf of the underlying projects. This entity will then manage the verification activities, monitoring, reporting and contracts.

There are a number of carbon schemes that can be used to provide finance for energy-efficiency initiatives, as well as opportunities to benefit from carbon trading mechanisms. However, organisations that miss the 2012 deadline will miss this opportunity. ⊖

Many organisations experience problems with the way carbon financing is currently being implemented.

Key carbon finance concepts

- Carbon finance is a finance deal that incorporates the income generated from the sale of carbon reductions from a specific project, usually sold forward.

- A certified emission reduction (CER) unit is traded as a carbon credit, which is equal to 1 ton of CO_2.

- The carbon development mechanism (CDM) is the relevant mechanism for developing countries, allowing carbon reductions generated under the CDM to trade within the European Union (EU) Emissions Trading System (ETS).

- The baseline is the most likely scenario in the absence of an energy-efficiency project. When talking about CDM and carbon trading, one has to determine a baseline against which one trades it.

Prof Ciska Terblanche is a lecturer in Environmental Engineering at the University of Pretoria. She is also the managing director of CDM Africa Climate Solutions and a member of the UNFCCC Clean Development Mechanism Methodology Panel. She holds an MSc degree in Environmental Management and an MBA from the University of London, a BEng in Chemical Engineering and a BSc in Forestry from the University of Stellenbosch.

RIM opens BlackBerry Apps Lab at the University of Pretoria

Research In Motion (RIM) (NASDAQ: RIMM; TSX: RIM), the maker of the BlackBerry® smartphone and BlackBerry® PlayBook™ tablet, has announced that it has formed a partnership with the University of Pretoria and the South African Department of Communications (DoC) to open the BlackBerry Apps Lab at the University of Pretoria.

The lab will provide local developers, including University of Pretoria students, faculty and staff, local start-ups, social entrepreneurs and others, with access to industry-leading resources in development, marketing, sales and training to help them expand their ideas and business opportunities. RIM will work with developers to create locally and regionally relevant applications for BlackBerry® smartphones, the BlackBerry® PlayBook™ tablet and the upcoming BlackBerry® 10 platform.

Prof Stephanie Burton, Vice-Principal: Research and Postgraduate Studies of the University of Pretoria, said: "We are excited to be partnering with RIM to bring the BlackBerry Apps Lab to our campus. One of our key objectives at the University of Pretoria is to empower our students to develop industry-relevant skills that will accelerate mobile application development in South Africa and help create new economic opportunities and jobs in the mobile space. Our partnership with RIM and the DoC's e-Skills initiative will allow us to deliver on this promise."

Director-General of the DoC, Rosey Sekese said: "The e-Skills initiative aims to address the shortage of critical skills in the ICT sector. During this financial year, several initiatives are planned.
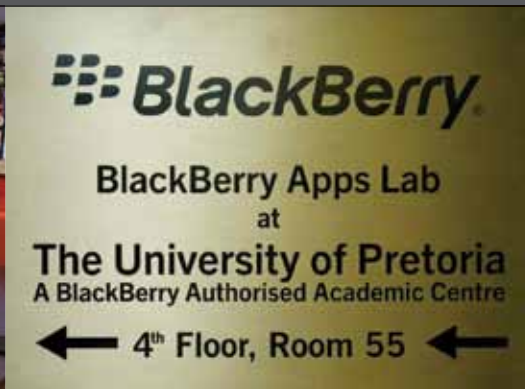
RIM will work with developers to create locally and regionally relevant applications for BlackBerry® smartphones, the BlackBerry® PlayBook™ tablet and the upcoming BlackBerry® 10 platform.

We are excited at the huge potential that this programme offers us in our quest to close the skills gap in the sector."

Bob Bose, Regional Managing Director for Africa, Benelux and Central and Eastern Europe said: "Through this lab, RIM aims to nurture mobile training and research that will benefit South African application developers and mobile development businesses. Our user community will benefit from an increase in locally relevant apps. This is yet another example of how we are supporting digital entrepreneurs in South Africa and Africa."

The BlackBerry Apps Lab will become part of RIM's developer programme that spans Africa and includes the following:

- **Egypt:** RIM has formed a partnership with the Technology Innovation and Entrepreneurship Centre of Egypt (TIEC) to open the BlackBerry innovation lab for application developers in Egypt, based in Cairo's Smart Village.
- **Kenya:** RIM provided Black-Berry devices to the Kenya iHub for use by local developers in a bid to increase accessibility to and encourage development for the BlackBerry platform.
- **Nigeria:** RIM supported the Mobile Web West Africa event on 2 April 2012; and hosted a mobile Developer Day at the Co-creation Hub in Lagos on 27 April 2012.

RIM also partners with groups like Mobile Mondays and Garage 48 across Africa to engage with African developers and mobile entrepreneurs; hosts BlackBerry developer days and the annual BlackBerry Innovation Forum, where developers are encouraged to share ideas with and hear from key business innovators, technology leaders and BlackBerry customers.

In addition, RIM has been working with over 39 universities, colleagues and schools across Africa through the BlackBerry Academic Programme, which successfully provides material and content to teach and educate students on mobile application development. ⊖

Broadband Wireless Multimedia Communications Research Group excels

Kahesh Dhuness and Prof Sunil Maharaj

The Federal Communications Commission (FCC) published a report in November 2002 that contained limited spectrum measurements from various urban locations. It suggested that there are spectrum resources currently available. However, traditional policies prevent the efficient utilisation of such spectrum resources. As the demand for bandwidth increases, a natural approach would be better utilisation of such a resource. It is this factor that has made cognitive radio (CR) a promising concept.

→ *Kahesh Dhuness and Prof Sunil Maharaj.*

The CR concept currently involves thinking of the frequency spectrum in terms of white spaces. A white space is a band of frequencies assigned to a primary user (PU), but at a particular time and geographic location. A secondary user (SU) is allowed to opportunistically use this white space, provided that it does not interfere with the PU's transmission. This process allows for more efficient utilisation of the frequency spectrum.

In a paper presented at the Institute of Electrical and Electronics Engineers (IEEE) Africon '11 conference (for which PhD student Kahesh Dhuness and Prof Sunil Maharaj of the Department of Electrical, Electronic and Computer Engineering won the best paper award), an energy detection method was used to detect an orthogonal frequency division multiplexing (OFDM) DVB-T2 transmission. The drawback associated with such a transmission is highly inefficient transmitters. In order to improve the efficiency of the transmitters, a method called offset modulation (OM-OFDM) was developed for DVB-T2 transmissions. This offers a significant power performance improvement when compared to a traditional OFDM transmission.

The principle contribution of the paper was the derivation of a closed form equation, which can be used by an SU to determine the detection characteristics of any signal. To validate the derived equation, simulated and theoretical expected detection characteristics of OFDM and OM-OFDM transmissions were examined. Both the theoretically predicted and simulated results correlated reasonably well.

The OM-OFDM method has been shown to offer far superior detection characteristics than OFDM, which suggests that an SU should be able to easily detect an OM-OFDM transmission. Employing OM-OFDM will assist the SU from not interfering with the PU, thus making OM-OFDM a good candidate for CR applications. In addition to its good CR properties, OM-OFDM also offers good power efficiency characteristics when com-pared to an OFDM transmission.

University of Pretoria students support the MeerKAT/SKA initiative

The Carl and Emily Fuchs Institute for Microelectronics (CEFIM) in the University of Pretoria's Department of Electrical, Electronic and Computer (EEC) Engineering has pioneered microelectronics research (both at electron device level and at circuits/systems level) in South Africa over the past 30 years. It is the home of the Electronics and Microelectronics Research Group, where radio frequency (RF) and mm-Wave integrated circuit (IC) design has emerged prominently as a research focus area over the past 10 years.

→ *Students in electrical, electronic and computer engineering, supported through SKA scholarships, pay a visit to the site of the MeerKAT telescope.*

SKA scholarships

A project team from the University's Department of EEC Engineering is involved in research relating to technologies and systems for the MeerKAT telescope, which forms part of the Square Kilometre Array (SKA) Project. Seven undergraduate and postgraduate students are supported through SKA scholarships. A PhD project seeks to integrate a differential low-noise amplifier, using an SiGe technology node, which is aimed at delivering for sensitive SKA receivers. These projects of the Electronics and Microelectronics Research Group are under the leadership of Prof Saurabh Sinha, Director of CEFIM.

Because the telescope that is being developed as part of this project will be a radio telescope, making pictures from radio waves instead of light waves, the research conducted will be able to make an important contribution to this world-class project.

Providing a cost-effective solution

Due to the number of front-end receiver arrays anticipated for the SKA Project, the research team aims to develop an IC-based solution, which will be cost-effective. It is envisaged that the SKA Project will require tens of thousands of focal-plane arrays, where the total number of front-end receiver chipsets could range from hundreds to thousands. This calls for an integrated solution, which will reduce the cost of each receiver array. To validate the research findings, CEFIM is also equipped with on-wafer measurement capabilities, supported by vector network analysis capabilities up to 110 GHz.

The research team therefore aims to address a number of innovative concepts relating to IC receivers in the nominal mid-band SKA RF range, such as ultra low-noise amplifier development, variable gain control, improved I/Q phase and amplitude mismatch, instrumentation or mixed-signal IC design and the identification of model parameters that influence circuit performance. ⊙

UP Architecture students are reaping in rewards

Students of the University of Pretoria's Department of Architecture in the School for the Built Environment have been dominating some of the largest local and international architecture competitions in recent years. In the past two years, UP students won the Archiprix International Hunter Douglas Award, the Saint Gobain DesignHub Respond/Renew/Revitalise Student Architecture Award, the International Holcim Sustainable Construction Award, the Corobrick National Architecture Student of the Year Award, as well as the Fuchs Design Award. Winning students, as well as judges in these competitions, generally attribute this success to the Department's holistic approach in their teaching. *Innovate* features the two latest winners, Cliff Gouws and Calayde Davey.

Holcim Next Generation Gold Award

Calayde Davey, who until recently worked for a Malaysian architectural firm, Veritas, in Kuala Lumpur, was announced the gold winner of the prestigious biannual Regional Holcim Next Generation Awards in the Africa Middle East category late in 2011 for her 2010 MArch(Prof) thesis entitled *Proximity, vertical agriculture at the Old Pretoria-West Power Station.*

She was also one of about 20 South African students to win the prestigious annual Fullbright Scholarship, an American award for applicants engaged in postgraduate studies in all academic fields. This afforded her the opportunity to enrol for a PhD in Architecture and Environmental Design at Kansas State University, where she will soon commence with her studies.

Davey designed an architectural model to facilitate a programme of vertical hydroponic agriculture, or a 'vertical farm', on the existing industrial heritage site of the Old Pretoria-West Power Station. The adjudicators of the Holcim Awards commended her project for its visionary idea and impact that appears both feasible and constructible.

She designed a seven-storey, indoor food-growing building that is constructed entirely from contemporary and experimental building materials in the form of structural bamboo, structural steel and bamboo-reinforced concrete. The design provides for a vertical hydroponic food factory, an urban market and an agriculture park as part of the entire urban agriculture concept. The project aims to be sustainable and resource-efficient and aspires to become a model for urban reform through urban agriculture across the city of Pretoria.

Her design is totally ecological in terms of energy use, material and by-products, recycling and the local sourcing of building materials. The vertical farm caters for resource-efficient energy renewal by means of biogas production and rainwater harvesting, and produces a variety of products beyond food, such as composting, clean water and gas.

Furthermore, her vertical farm employs over 300 people and aims not only to be a prototypical development for new local economic incentives through vertical and urban agriculture, but also aims to prove the value of urban and vertical agriculture to reform urban environments in Africa.

"By creating an architectural model for vertical urban agriculture, my design aims to replace the redundancy and alienating impact of outdated 20th century industrial technology with a new, productive urban building and productive urban landscape. My project essentially aims to address the pressing issues of de-industrialisation, the adaptive re-use of industrial heritage, localised food production strategies through urban agriculture, and also promotes true resource-efficient architectural design by exploring the use of new building materials."

Davey praised the UP Department of Architecture for the creative freedom it offered her as a student. "The Department allowed me to play with ideas that run beyond the physical built environment and connect concepts that are of interest to me. I was encouraged to run with these ideas and do the complete project development. This is a very stimulating approach and the methodology is solid for not only the project, but also for building a professional career."

Corobrik National Architecture Student of the Year

With his MArch(Prof) dissertation entitled *Magazine Hill: A weathered continuum*, Cliff Gouws won the Corobrik National Architecture Student of the Year award for studies completed in 2011, as well as an international electronic thesis and dissertation competition. The Corobrik Awards is an annual national competition that honours the top architecture student dissertation in the country.

His thesis was recently also shortlisted as a finalist (out of 500 entries from students and professional architects) for an international competition, [Un]restricted Access, which deals with the reclamation of abandoned military sites around the world. This competition is judged by famous international architects Renzo Piano and Tom Kundig.

In his thesis, Gouws proposed the recreation of Magazine Hill, situated close to the Pretoria Central Prison, in such a way that the history of the area is communicated without changing its character.

Structures were built on Magazine Hill in 1890 where ammunition was produced until years after the Second World War. Ammunition magazines, five bomb shelters and ammunition factories can be found on this mysterious, abandoned and isolated site. These are all structures that represent an era of unrest in South Africa. In 1945, a mysterious explosion of the central magazine scarred the face of Magazine Hill, putting an end to the activities on the site, and trapping architecture in time and abandonment.

Gouws proposed building a brass foundry on site to recycle the spent ammunition shells of the South African National Defence Force (SANDF), and getting brass artists to use this melted brass to create works of art that can be placed on Magazine Hill. "Where ammunition was once produced, ammunition is now reduced. This design could form mediation between the public and the military, exposing different layers of the past by reinstating a connection between architecture and time," says Gouws.

Through this use of commemorative architecture, Gouws designed a space that celebrates history and heritage in a way that is far removed from the traditional way in the form of static museums and monuments.

Gouws says his interest in heritage architecture was the inspiration behind his design. "I've always had an interest in heritage architecture and I feel that there is still a lot of room for improvement in this type of architecture. A large part of our heritage is being lost, therefore it is of critical importance that we find ways to protect it."

The adjudicators in the Corobrik competition praised Gouws for the way in which he managed to reconcile different phases of time and how he re-established a connection between the continuum of time and architecture. They noted how his project highlights imagination and intelligent, yet subtle design, while also being economically, socially and environmentally sustainable.

Gouws, who now works at Holm Jordaan Architects in Pretoria, attributes his success to the quality of the Architecture programme at the University, and the excellent lecturers who guided him through his studies. ❸

→ *Cliff Gouws (left): Corobrik National Architecture Student of the Year.*

Wooden light design earns a trip to Sweden

The prototype luminaire design of third-year BSc (Interior Architecture) student Mandi Botha was not just the overall winner of the national Haute Lumière Award for 2012, but also earned her a five-day trip to Alingsås, Sweden, to attend the Professional Lighting Designers Association Workshop, which is led by leading European lighting designers. The final prototype, entitled *Joint Exposure,* was also showcased at the South African Fashion Week in Johannesburg and the European Light and Design Centre in Cape Town.

The Haute Lumière Award is presented in association with *VISI* magazine, and reflects the need to explore and stimulate debate on light as a design medium. According to the organisers, fashioned and designed environments require imaginative light solutions, which convey meaning, mood, atmosphere and visual appeal.

The purpose of the award is to rethink the application of artificial light as a crucial, primary aspect of design and as an inventive medium that extends beyond the functional requirements of illumination. A different theme or subject is explored each year, and for the 2012 competition, entrants were invited to enter designs for wooden lights.

Entrants had to use only timber to create a self-supporting light fitting of any description. They had to manipulate light using any source and colour, and in designing the object, they were advised to think primarily of how light interacts with the light fitting and also with its surroundings. The adjudicating panel was looking for a design that was highly innovative, imaginative and original.

The competition was open to both student and professional designers and architects. The only requirement was that the designs should be original and created specifically for this competition.

Entries were evaluated on the basis of the exploration of light as a medium, not the refinement of a complete design. In stage one, five designs were taken forward and constructed as prototypes, and a winner was selected in stage two.

The adjudication panel was a veritable 'who's who' in the design world, and comprised Annemarie Meintjies (*VISI* magazine), Lucilla Booyzen (South African Fashion Week), Marc Machtelinckx (European Light and Design Centre), Atsushi Hirata (DSGN Interior Design), Paul Pamboukian (Pamboukian Associates), Randal Wahl (Regent Lighting), Robert Alexander (Regent Designs) and Silvio Rech (Silvio Rech Lesley Carstens Architects).

In evaluating Botha's design, the judges found that it met their criteria by going beyond the mere fact that light exists. She experimented with the unknown, pushed the edge and sought essence, worked with perception and deception, showed an understanding of light as a medium and how light occupies space, and celebrated and promoted excellence in the understanding and application of artificial light. Her design was not about a light fitting alone, but about light as a medium.

As winner, Botha had the opportunity to attend the Professional Lighting Designers Association Workshop in Alingsås, Sweden, in September 2012. The workshop was educational and she had the opportunity to work with the qualities of light and to realise an urban lighting project with state-of-the-art equipment. The workshop was led by leading European lighting designers.

In addition to delivering the winner of this competition, the University of Pretoria can also boast that four of the other six finalists in the competition were also graduates of the Department of Interior Architecture at UP. These are Esther Krugell, Sureen Gouws, Thomas Gouws and Tienie van Rooyen. ◉

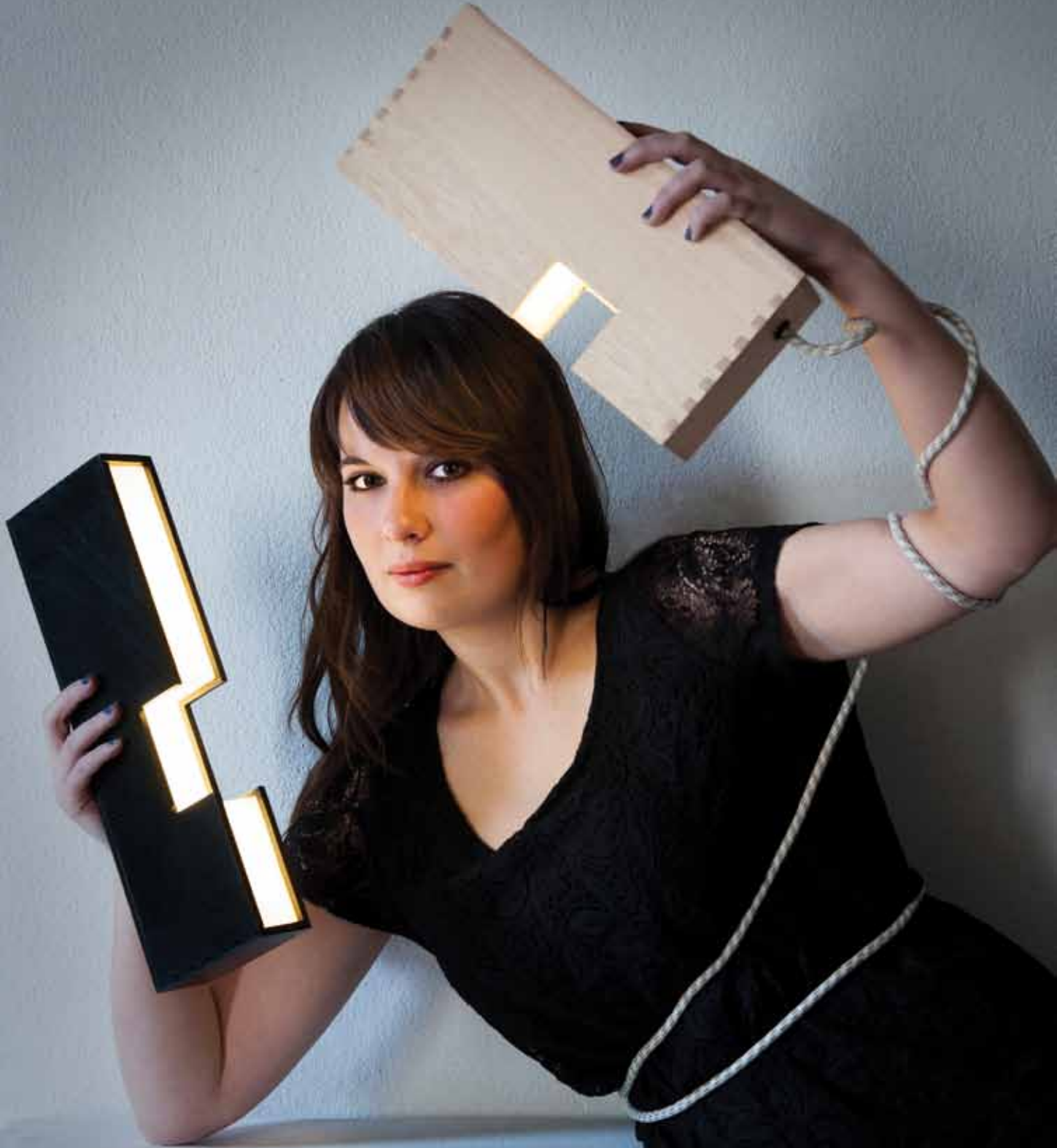Mandi Botha's design was not about a light fitting alone, but about light as a medium.

Photo credit: Dook

Architect receives award for sustainable design

Architect Jhono Bennet, who graduated with distinction from the University of Pretoria with a professional master's degree in architecture in 2011, was the national winner of the fifth annual Cement and Concrete Institute Sustainable Design Competition. He received the award at AZA 2012, the biennial festival of the South African Institute of Architects, in partnership with the Cape Town Institute for Architecture and Architecture ZA.NOW.

Since the world's population is increasingly moving towards urban environments, it is necessary for design to focus on imagining better African cities and urban systems. The theme of the Cement and Concrete Institute's competition for 2012 was therefore *Future African City*. The adjudicators were looking specifically for a design intervention using concrete or cementitious products that provide insight and solutions to real-world challenges.

Bennet's entry was based on the project that formed part of his postgraduate studies, *Platforms of engagement: A process of critical engagement with a developing context*. His point of departure was that the South African population has been experiencing an unprecedented rate of urbanisation that has left government bodies struggling to meet the qualitative and infrastructural demands of the emergent sector in undeveloped areas.

His entry focused on the intensive networks found in these developing areas of vulnerability, which display

→ *Jhono Bennet, winner of the Cement and Concrete Institute Sustainable Design Competition for 2012.*

strong cohesion due to activities surrounding the production process. He presented the premise that in order to intervene architecturally, designers should critically engage these networks through participative processes of research, design and ideally construction. ❷

The 21st century will not be dominated by America or China, Brazil or India, but by the city. In an age that appears increasingly unmanageable, cities, rather than states, are becoming the islands of governance on which the future world order will be built.

Joint first place for two UP teams

The annual Murray & Roberts Des Baker Architecture Student Design Competition is a highlight on the calendar of the Department of Architecture. This year, its students' hard work was rewarded when the judges awarded three joint first prizes, two of which went to teams from the University of Pretoria. The first team comprised Christopher MacClements and Johann Wiese, while the second team comprised Alex Becker, Justin Coetzee and Rikus de Kock. These students are all third-year BSc (Architecture) students at the University of Pretoria.

Preparing to meet new challenges

Bereket Demeke is an honours student in Computer Engineering. Formerly from Ethiopia, he immigrated to South Africa with his parents in 2008. He has excelled academically and is set to reach great heights as a computer engineer.

After matriculating from the Sol Plaatjie Secondary School in Mafikeng, North West, Demeke enrolled for a bachelor's degree in Electrical, Electronic and Computer Engineering at the University of Pretoria.

According to Prof Sunil Maharaj, who supervised his final-year design project, Demeke is an intelligent, disciplined and diligent scholar. "This has led to him being a top performing student," says Prof Maharaj. "He works hard and applies his mind to the challenge that he needs to address. He works well in a team, yet also excels when required to work independently."

Demeke's excellent performance in Mathematics, Physics and Computer Science in matric was rewarded with a bursary from the SENTECH Chair in Broadband Wireless Multimedia Communications (BWMC). This paved the way for a successful academic career. His hard work resulted in him obtaining his degree with distinction, and also receiving the Wilhelm Leuschner silver medal and prize for outstanding performance in the third and fourth year of study in computer engineering.

Demeke's choice of the University of Pretoria for his undergraduate studies was based on the excellent reputation of the University's School of Engineering, as well as the Department of Electrical, Electronic and Computer Engineering. He has been a residence student since his first year of study, and was able to take part in every aspect of student life.

During the course of his studies, Demeke put his excellence in Mathematics to good use by participating in the Dr Maths on MXit programme. This is an initiative of the Council for Scientific and Industrial Research (CSIR), and has been incorporated into the University of Pretoria's community engagement programme.

The highlight of his undergraduate studies was undoubtedly his final-year design project. This provided him with the opportunity of applying the theory he had learnt to a real-life situation. His project entailed developing a system of counting the number of passengers travelling in a particular taxi in a single day. It made use of video technology, as well as face recognition and tracking software. This would enable taxi drivers to monitor their earnings by keeping record of the number of passengers they transported daily.

Demeke is completing his honours degree in the SENTECH Chair in BWMC at the University of Pretoria, where he will have the opportunity to undertake research in the dynamic and innovative field of telecommunications. ❷

→ *Bereket Demeke.*

Multimedia students impress Hollywood actors and producers

Since the Department of Information Science at UP started to encourage its Multimedia students to take part in international competitions, four of them have already beaten contestants from across the globe to win their respective categories in these competitions. The latest winners from UP are Rudo Martin and Eleanor Harding, who won first and second place in the 30 Spot category of the Firefox Flicks video contest.

To win a large international competition like Firefox Flicks in North America, Latin America, Asia, Europe, Africa, New Zealand and Australia, takes exceptional filming, editing, production and creative skills. It takes large amounts of creativity, as well as a good understanding of the technical aspects needed to make a good production.

Providing students with an excellent combination of these and numerous other skills that the IT world requires from graduates, is exactly what the University's Department of Information Science aims to do through its relatively new Multimedia degree.

To have a student win an international competition is always a good reflection on the course and the University, but to have four students in a fairly young degree win such competitions within a timeframe of less than two years, is remarkable. In 2011, the Department started to encourage its students to enter some of the top competitions to put their skills to the test.

Joshua Goodman, a second-year Multimedia student, won first prize in the Best Live Action category at the fourth annual international Sparky Awards for his video depicting the possibilities of free access to information. Johann Botha (a final-year student) won first prize in Microsoft's Imagine Cup in the Game Design and Development category. He entered his final-year project, a computer game called *Purgatory*.

In 2012, second-year students Rudo Martin and Eleanor Harding surprised everyone, including themselves, by winning a category in Mozilla's Firefox Flicks international competition. Over 400 entries were received from across the globe. Contestants could enter videos for four different categories. Their work was judged on the quality of shooting and editing, and how closely they were aligned with the creative brief to "tell the Firefox story".

Martin won the 30 Spot category and Harding was the runner-up in the same category. Martin received $5 000 prize money and Harding $1 000.

What makes these two students' achievements so remarkable and special for them, is that big names in the entertainment industry judged their work.

"The realisation that Edward Norton and Shauna Robertson judged my video and actually liked it, is incredible! Winning this competition made me realise that all the hopes and dreams I have for the future are realistic."

The actor, director and producer Edward Norton, who starred in, among others, *Primal Fear*, *The Italian Job* and *Keeping the Faith*; Shauna Robertson, who has produced some of the best comedies, like *Meet the Parents*, *Elf*, *Anchorman*, and *Knocked Up*; and executive producer Ben Silverman, the man behind the shows *Ugly Betty*, *The Office* and *The Biggest Loser*, are just some of the celebrity judges of the Mozilla Firefox Flicks competition.

Martin made a video about "living in colour" and enjoying every moment in life. "No one wants to live in a grey society, so I showed that Firefox can open up a new colourful world that you haven't experienced.

It is a window into a brighter, more colourful future. My inspiration came from just being young and picturing those happy moments where everyone is just laughing and enjoying life. Those are colourful and memorable moments."

Harding's video portrayed Firefox as moving forward in a world that appears to be going backwards. "I was inspired by how often Firefox updates and how it is one of the few browsers that embrace and support new technologies where other browsers don't. The video further plays on how Firefox focuses on and empowers the user by putting the power into their hands. I personified the browser through my red hair and a blue dress and reversed the footage to give the effect of a backwards-moving world," she says.

UP Multimedia programme sets the trend

Modern information technology offers the design and creation of an almost endless possibility of different information products. We are creating more information products than ever before in human history. There is also no longer a single discipline that handles the combination of information products. These issues, the explosion of the web, as well as the exponential growth and power of information technology, require tertiary qualifications that train graduates in all aspects of IT and that follow international trends.

The UP Multimedia qualification addresses these shortcomings by exposing students to a wide range of skill sets that cover information science, visual design, computer science and digital media, which will make them employable in any field in IT – including the media, software development and industries. With South Africa's ICT infrastructure growing at a fast pace, so does the need for professionals in this field.

The BIS (Multimedia) qualification at UP is a new field of study not offered at other local universities. It is aimed at students who are gifted both creatively and analytically, and who want to combine these skills with the use of technology. Students receive training in computer science, as well as visual design during their undergraduate studies. The practical knowledge is supported by a theoretical framework centred on the information society, with applications in online, entertainment and mobile computing areas.

Both winning students are in agreement that the diversity that the programme offers them played a big role in their winning these awards. "It doesn't matter whether you are interested in gaming, web design, application design, animation, films or even programming, the course creates opportunities for all platforms," says Martin.

"The Multimedia programme is so multifaceted and includes so many skills and opportunities to cultivate creativity. I find that all of the modules are engaging and relevant and all provide skills and knowledge that are applicable to other modules and also in real-world applications," says Harding.

Tina van der Vyver, Multimedia lecturer, says the Department will continue to encourage its students to participate in these competitions, as it enables them to stay up to date with technologies and lecturers can incorporate the newest technologies into their teaching, while it opens up doors for the winning students. ❸

The HexCore programming environment and simulator for CA experiments

Divan Burger, Megan Duncan, Apurva Kumar, Leon van Dyk and Karl Zöller

Team HexCore successfully completed a project in 2011 for the Department of Computer Science's final-year module in Software Engineering on the evolution and refinement of a cellular automata simulator and editor, designed by Team Core in 2009 (see article in *Innovate* 5, 2010).

Cellular automata (CA) have always been useful and valuable tools for the study of many phenomena, both practical and theoretical. Many researchers find cellular automata helpful in biology, artificial intelligence, geology and many other fields. The aim with this project was to implement a new cellular automaton simulator and editor that would provide enough generality to be adapted to many situations, as well as one with a large enough arsenal of features to describe a particular model in great detail. If used on a network, the system would make efficient use of the computational power at hand.

The goal was to develop a system that provided all the functionality of the 2009 system, as well as added support for heterogeneous worlds, rules that accept mathematical functions, CA cells that have multiple values per cell, and allow computation to be distributed across a network of computers.

Internal states of computational cells

The Core system of 2009 only supported one type of cell for the entire grid of the CA. The new system supports a nearly unlimited number of types coexisting on the same grid. This is known as a 'heterogeneous world'. Different cell types follow different transition rules. During the run of a CA, each cell value at any point in time anywhere in the CA world is a double precision floating point number that can change from time to time as the simulation goes on. In Conway's well-known *Game of life*, for example, there is one cell type and every cell on the grid belongs to this cell type. There is a single property representing whether the cell is dead or alive, which can be represented using a 1 and 0 value so that a simple type of cell only has two possible internal states.

A new programming language for cellular automata

Transitions between subsequent generations of a cellular automaton are normally specified by simple rules in which predecessor states, neighbour states and successor states are explicitly listed by value. This method is characterised by its inability to specify replacements with mathematical equations, as well as the large number of replacement rules needed even for simple simulations, such as Conway's *Game of life* (see Figure 1).

Thus, the need arose for a more explicit way of expressing the rules of a CA. Team HexCore chose to implement a new domain-specific language for this purpose. Furthermore, it was designed simply, so that a new user did not need to

```
[1,1,1,0,*,0,0,0,0] => [1,1,1,0,1,0,0,0,0]
[1,1,0,1,*,0,0,0,0] => [1,1,0,1,1,0,0,0,0]
[1,1,0,0,*,1,0,0,0] => [1,1,0,0,1,1,0,0,0]
[1,1,0,0,*,0,1,0,0] => [1,1,0,0,1,0,1,0,0]
[1,1,0,0,*,0,0,1,0] => [1,1,0,0,1,0,0,1,0]
[1,1,0,0,*,0,0,0,1] => [1,1,0,0,1,0,0,0,1]
[0,1,1,1,*,0,0,0,0] => [0,1,1,1,1,0,0,0,0]
[0,1,1,0,*,1,0,0,0] => [0,1,1,0,1,1,0,0,0]
[0,1,1,0,*,0,1,0,0] => [0,1,1,0,1,0,1,0,0]
...etc
```

→ *Figure 1: The rule that states a cell may become alive if exactly three neighbours are alive would have to be specified, in explicit fashion.*

spend much time to become familiar with this language. The language allows each CA world to be associated with a rule set. In order to support heterogeneous worlds, the number of cell types must be declared and rules specified for each type in a Java-like syntax. Each cell type may also have multiple floating-point properties, which need to be specified. That means that all the details of the world's behaviour are specified in one place. Lastly, the language makes standard variables available, such as 'self' and 'neighbours', giving the user explicit access to the values of the CA cells.

The new language supports various standard constructs such as 'for loops' and 'if statements' for the computation of cell values. The extensible standard function library includes functions such as sum, max, min, sin, cos, ln, log, random, round and count. The random function makes it possible to write non-deterministic CA simulations.

Multiprocessing

The 2009 version of the system only allowed a choice to divide one CA world into one, two, four or eight segments, which were then distributed to that number of processor cores through threading. For the reimple-mentation, Team HexCore went a few steps further. Now all simulations are multi-threaded so as to make full use of all processor cores on a single processor system. Moreover, the user also has a choice to distribute the workload over many computers across a network (see Figure 2).

Each of the initial segments sent to a computer also contains a read-only section of neighbour values. This allows a remote computer to know the values of neighbouring cells without requesting them across the network. The algorithm intrinsically balances the load across all the computers, since it sends out work as it gets results. Computers that work faster will automatically do more work than slower computers. Due to the timeout feature in the algorithm, the system has a built-in fail-safe for client machines that collapse during a simulation – their work will simply be sent to other clients resulting in only a momentary loss of speed in the simulation (see Figure 3).

Graphical user interface

The simulation screen is designed with usability and ease of use in mind. Many control possibilities were added for the user to allow for a more immersive simulation experience. Multiple viewports can be dynamically added and removed while a simulation is running. Furthermore, the user can choose to view the simulation in 2D, 3D, with or without wireframe and in full-screen mode. Users also have the possibility to control playbacks of a simulation. The user can pause, play, reset and step forward or back one frame at a time. An interesting feature in the new system is the ability to represent
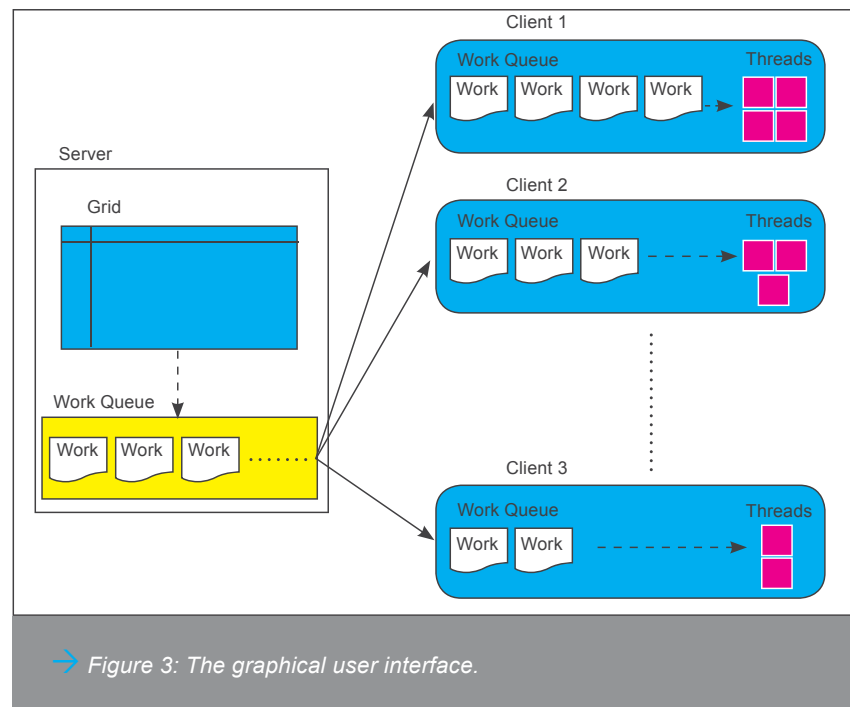
→ *Figure 3: The graphical user interface.*

```
Split world into segments related to the number of processing cores available on the network.
For each generation
    Send each computer an initial number of segments based on how many cores it has.
    Each client works on segments in parallel using its available cores.

    On results returned:
        Send more segments to that computer.
    On timeout:
        Resend segments to a different computer.
```

→ *Figure 2: Pseudo-code to illustrate the method of running a distributed CA simulation.*

cells using colour gradients instead of discrete colours. Two colours can be chosen for a bound on a property's range and the system will interpolate a gradient between those two colours.

Rendering the images

One of the team's goals was to improve the performance of the rendering system of the HexCore CA software. For the 3D representation, the rendering component uses vertex and index buffers, which resulted in a major performance boost compared to the 2009 system, so that now everything is much more aesthetically pleasing.

Due to the new system supporting multiple properties per cell, the team had to come up with a way to represent multiple properties in an intuitive and effective manner. The renderer can draw each property separately as a slice. A slice is a rectangular prism placed on top of each grid cell, the height and colour of which is determined by the property that it will represent. Many slices can be placed on top of each other so that multiple properties can be visualised.

In a flood simulation, for example, the first slice could be the land height property, which would result in a 3D height map terrain. The second slice could be the water depth property, which would be placed on top. This results in a realistic representation of the water level in each cell, as the land height and water depth would both contribute to the height of the cell (see Figure 4).

The resultant system is one that allows a scientist to design a CA and simulate it in an intuitive and efficient manner. Small additional features, such as the saving of world configurations, as well as the ability to export and import cellular automaton language (CAL) program code, make it easy for a scientist to collaborate with others regarding CA research. This is now made even easier, since the system is cross-platform compatible and fully tested on both Windows and Linux (with a Mac version in preparation).

The aim is to continually improve the HexCore system. It has been made available as open source software and is freely available at https://github.com/Hexcore/HxCAS. ✏
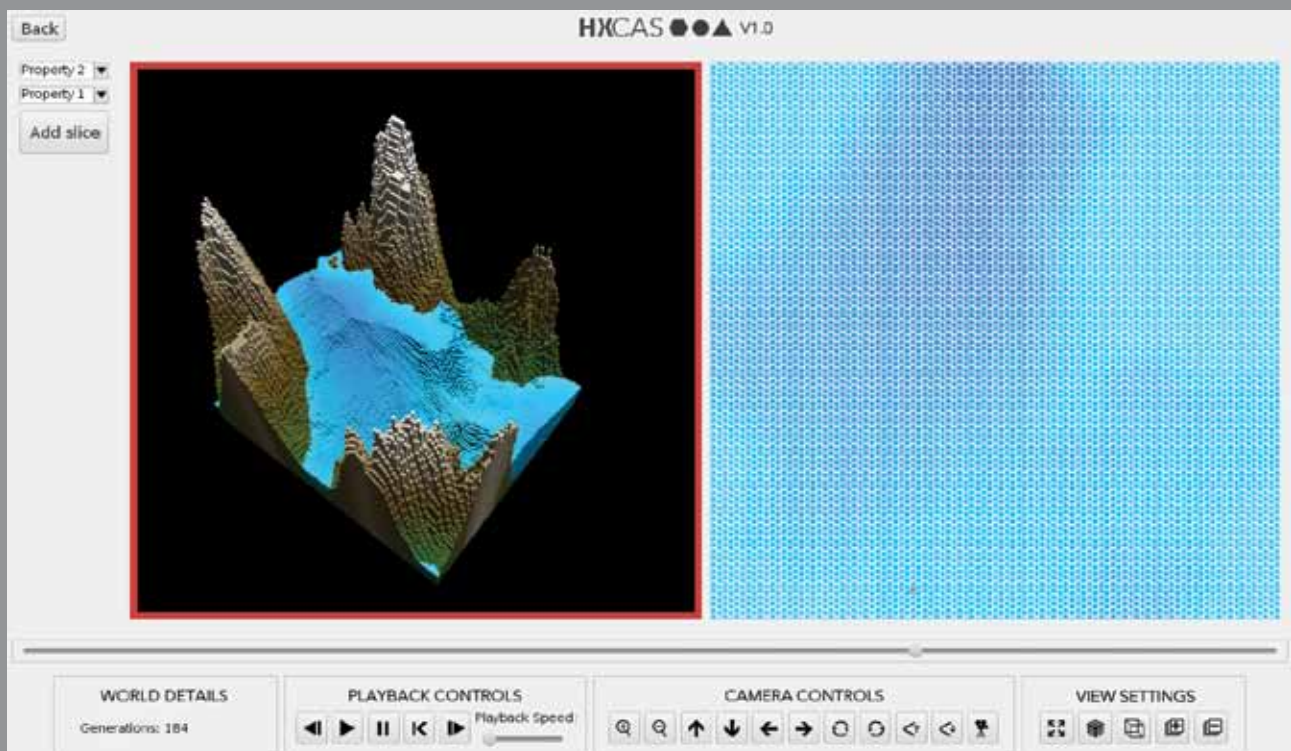
→ *Figure 4: An example of the 3D representation.*

Science transformed?
Debating claims of an epochal break

Prof Stefan Gruner

"The practical relevance of science, its great technological ambitions, its public appeal, and the heavy application pressure under which it operates today have prompted a flurry of analyses." This is because we have, over the past few decades, been experiencing (although not always fully consciously) an accelerating cultural shift due to that "we are expecting from contemporary research not primarily the discovery of truth, but the solution of pressing problems".

This magazine, *Innovate*, is itself a product, a witness, and an amplifier of the very same cultural and science-political tendencies that are addressed in the various chapters of *Science transformed? Debating claims of an epochal break*, edited by Alfred Nordmann, Hans Radder and Gregor Schiemann.

The question as to whether or not the most recent changes and evolutions in the sciences, in their applications, and in their sociopolitical contexts constitute a major 'epochal break' in this era of our civilisation is not only a question of history and philosophy of science, but also a question of philosophy of history. Our history-philosophical notion of what actually constitutes an 'epoch' will surely influence our judgement about whether or not we are currently witnessing an epochal break in the history of science and its related methodology. However, whether an epochal break or not, the empirically observed changes in our contemporary business of science are real and should not be ignored by any discerning scientist or academic.

The book is divided into two parts. In the first part, the authors of the various chapters discuss the epochal break thesis and reach different conclusions from a general perspective (without a particular focus on specific sciences). Such a more specific focus on particular sciences is then provided by the authors of the chapters in the second part of the book. The authors are especially aware of the irreversible effects of the digital computer – with all its enhanced possibilities of number crunching, data visualisation and complex process simulations – on the contemporary methods and methodology of a new kind of 'technoscience', in which the classical borderline between technics and science is becoming increasingly transparent and invisible.

This book can be strongly recommended not only to the older generation of academics (who have known science before the most recent cultural shift), but also to the new generation of young researchers who were born in the midst of that shift and who have never known science before and outside its contemporary paradigm.

The book is also recommended to all economists, politologists, law-makers and policy-makers in the state and the commercial industry, as well as in the parastatal research funding agencies, who have such a strong influence on the ways and manners in which our contemporary sciences are carried out.

This book is published by Pittsburgh University Press.
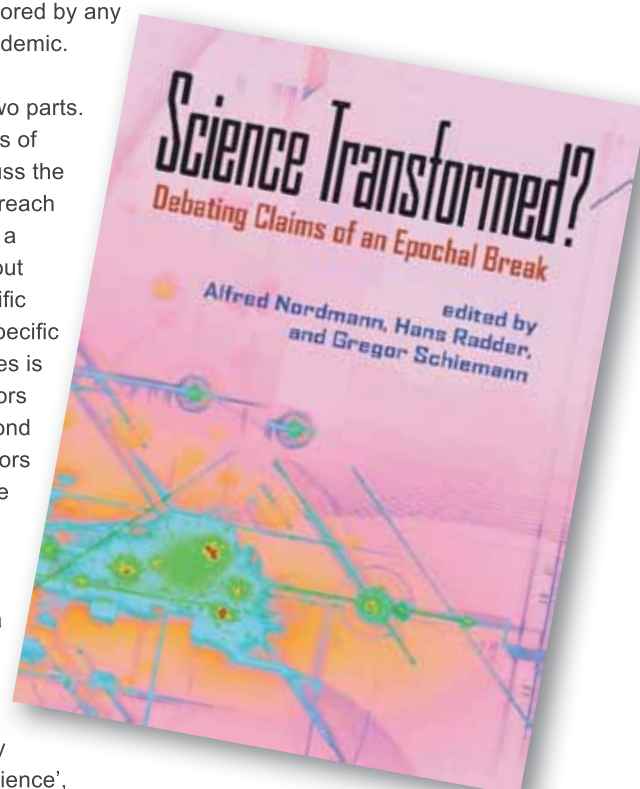
Landscape architecture in South Africa celebrated

Marlene de Witt

What are probably two of the most important books on South African landscape architecture to date were launched on 11 April 2012. *South African landscape architecture: A compendium and a reader* is a book set that celebrates and documents the achievements in South African landscape architecture over the past three decades. It also debates the theory and current thinking behind the profession today.

The book set was officially launched at the University of Pretoria, where it was conceptualised and produced with the support of the Institute for Landscape Architecture in South Africa (ILASA).

The editors, Dr Hennie Stoffberg, Clinton Hindes and Liana Müller were all associated with the University of Pretoria at the time that the books were conceptualised and compiled. Hindes and Müller are now both lecturers at the University of Cape Town.

A compendium

A compendium takes the reader through the evolution of the discipline of landscape architecture in South Africa since the 1980s by featuring the complete collection of projects that have won ILASA awards since the inception of the awards in 1985 until 2009 when this book was conceptualised.

Although there have been many international publications over the years that have featured a collection of important works in landscape

architecture, a book such as this one was lacking in South Africa, where the discipline commenced as early as 1946. Furthermore, only five publications on South African landscape architecture have been published in the last 30 years. *A compendium* was initiated with the support of ILASA, with the goal of documenting and conserving all these important projects in one compilation. This book is sure to become a key reference work to guide and inspire those in the profession.

A compendium starts with a section featuring some of the foundational landscape architecture projects of the 1980s, which illustrate the diversity of project types that were being undertaken in the profession, such as the Berg-en-Dal restcamp in the Kruger National Park, the Environmental Impact Control Plan of the Palmiet pump storage scheme in Grabouw, Church Square in Grahamstown and the Durban South Beach play park.

The second section features projects that were rewarded for excellence in design, for example, the Reserve Bank

→ *The Outeniqua Pass between George and Oudtshoorn.*

→ *The Berg-en-Dal restcamp in the Kruger National Park.*

→ *The Palmiet pump storage scheme in Grabouw.*

in Johannesburg and the rehabilitation of the Outeniqua Pass between George and Oudtshoorn. These are followed by projects undertaken between 1998 and 2003 that have won awards for their ecological consideration in design. These include the new visitor facility at Cape Point, the upgrading of the Table Mountain cableway and the development of the N3 toll road between Cedara and Heidelberg.

The last section features award-winning projects that can be seen as a celebration of the South African landscape. These include the Big Bay development at Bloubergstrand, Freedom Park in Pretoria, The Mitchells Plain Public Transport Interchange and Thesen Islands in Knysna.

Although not all important projects were necessarily entered for the ILASA awards, only the award-winning projects were selected for the scope of this book.

However, it is hoped that the other important projects omitted here will also be documented in the future.

A reader

A reader contains a collection of articles, written by academics actively involved in the field, who together reflect on the theory and thinking behind the discipline today. It features theoretical analyses, as well as examples of how theory is implemented in good project design across different sectoral projects. Such project descriptions add tremendous value to the discipline and integrate theory and academia with the profession.

A reader serves as a platform for current South African landscape architecture research and theory to be made widely accessible to peers involved with research, both nationally and internationally. The articles published in this book were all double-blind peer reviewed and fall in three

broad categories: culture and heritage, science and strategy, and design.

Papers in the first section cover topics relating to, among others, the role of landscape architecture in an urban environment, the role of history in development, and the role that community factors play in the planning and design of South African parks. The second section deals with visual impact assessment, the role that climate regions can and should play in design, and carbon storage and the sequestration of trees in an urban landscape. The last set of papers deals with examples of how design can and should be used in landscape architecture.

It is hoped that *A reader* will significantly add to the dialogue on the developing discourse of South African landscape architecture and that it will bring about a better understanding of the importance that landscape design plays, or has the potential to play, in our society today. ℹ

→ *The Berg-en-Dal restcamp in the Kruger National Park.*

→ *Grahamstown Church Square in the Eastern Cape.*

Reviewing engineering asset management

Engineering Asset Management Review (EAMR) Series **is a publication of the International Society for Engineering Asset Management (ISEAM) dedicated to the dissemination of research by academics, professionals and practitioners in the field. It complements other emerging publications and standards that embrace the wide-ranging issues that concern the management of engineered physical assets. Prof Joe Amadi-Echendu of the Graduate School of Technology Management is the editor-in-chief.**
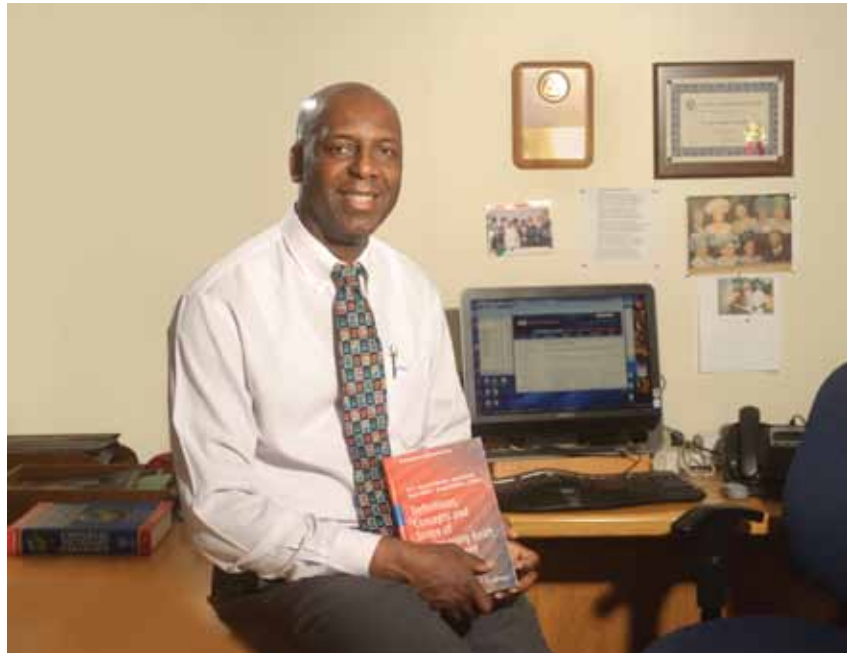
→ *Prof Joe Amadi-Echendu, editor-in-chief of the* EAMR Series.

The book series was launched in 2010 with an inaugural issue dedicated to the definitions, concepts and scope of engineering asset management. The subject matter is multidisciplinary and integrates traditional science, engineering and technology disciplines, logistics and operational research, as well as the disciplines of business management and psychology.

The second volume in this series will be launched early in 2013 and comprises selected papers from the first, second and third World Congress on Engineering Asset Management, convened under the auspices of the ISEAM in collaboration with organisations in Australia, the United Kingdom and China. It covers topics related to asset condition, information systems and decision models, and will be of particular interest to finance, maintenance and operations personnel whose roles directly affect the capability value of the engineering asset base, as well as asset managers in both industry and government.

It focuses on the conversion of raw data into information that should guide managers to making valid decisions, especially regarding the operational condition of assets. The articles highlight quality issues such as the appropriateness and integrity of data and information that describe the condition or 'health' of the asset.

The articles further illustrate how multidisciplinary views of the asset influence not only the acquisition and analysis of data and information, but also what models are used in making decisions regarding the asset.

The book series is published by Springer-Verlag London Limited and is available online and in a hard-cover format. ●

Researching the value of project management

Prof Giel Bekker

In 2004, the Project Management Institute (PMI) requested proposals for research designed to quantify the value of project management. The successful team was led by Janice Thomas of the Centre for Innovation Management, Anthabasca University, Canada, and Mark Mullaly of Interthink Consulting Inc. As a result, intensive fieldwork and cross-disciplinary analyses were done on the topic from May 2005 to June 2008.

The question of measuring the value of managerial actions has always been contentious. In order to contextualise their research, Thomas and Mullaly provided an in-depth review of the three main conceptual approaches to the value question: return on investment (ROI), the balanced scorecard and organisational competency.

The review concluded that the various attempts to quantify the value of any organisational function have not resulted in a satisfactorily and generally accepted model. The team then decided to follow a more fundamental approach by formulating the following research questions:

- What are the practices implemented in organisations that represent their approach to project management?
- To what extent are these practices appropriate in managing projects within the context of the organisation?
- What is the value that organisations have realised as a result of adopting these practices?

The research included 48 research team members who qualitatively and quantitatively analysed 440 interview transcripts and 60 case reports. The results failed to derive or define a formula for ROI that could be used to allocate a monetary value to the project management effort. Instead, the research acknowledged the fact that there does not seem to be a particular value component that is recognised from one project management implementation or context to another for the case organisations. Eventually it became clear that the fit between the context (internal and external) in which the organisation operates and the nature of the project management implementation can be combined to deliver value for investments in project management.

Researching the value of project management makes a very important contribution to the field of project management. The management discipline of project management has thus far suffered from definition and justification, except when projects go wrong. Organisations agree that there should be value when investing in project management, but how to leverage the investment often seems problematic. Even though abstract at first, the research succeeds in establishing the importance of 'fit' between the context, implementation and drivers of the value of project management.

It is a complex and at times difficult read for practitioners. However, academics and those interested in improving project management in organisations will gain much food for thought. ☻

→ *Prof Giel Bekker.*

The roots of industrial engineering: Girolamo Cardano – the gambling physician

Compiled by Prof Paul Kruger

Girolamo Cardano was a real rogue. He lived a somewhat less than charming (certainly not conservative), but nevertheless very colourful and interesting life. He had an unhappy childhood, but was gifted. He was a physician, a philosopher, an engineer, a theoretical and applied mathematician, an astrologer, an eccentric and a liar, but above all, he was a gambler. It was with this passion for gambling that Cardano converted experimentation into theory, making a lasting contribution to the early basis of modern probability theory.

The ancient Britons, Greeks, Romans and Egyptians, as well as the inhabitants of South America, the Middle East and the Far East, used *astragali* (knuckle bones, or 'dolosse' in a South African context) as a means of introducing unpredictability into games of chance (gambling) long before the birth of Christ. It was the Romans who imitated the *astragalus* by carving a rough cube from stone, wood or ivory and inscribing the sides with lewd figures and differing numbers of dots, thus creating the present-day dice.

These 'random generators' are still used widely in a variety of games of chance, but they were also used extensively in all kinds of religious ceremonies, specifically as a mechanism for soliciting the wishes of the gods (divination). The involvement of religion, and even magic, may be the restraining reason why no known attempt was made to mathematically analyse the stochastic process of throwing a die until the 16th century.

A mid-13th-century Latin poem, *De Vetula* (*On the old woman*), attempted to evaluate the number of ways of obtaining a given total from the throw of three dice, but it was left to the Italian from Pavia, Girolamo Cardano, to show the audacity of suggesting that there may be some kind of logical structure in the seemingly unpredictable magic of a die.

Girolamo Cardano (or Hieronymus Cardanus or Jerome Cardan, 1501–1576) was the illegitimate son of Fazio Cardano. Fazio was a lawyer in Milan, but his expertise in mathematics was so extraordinary that he was consulted by Leonardo da Vinci on questions of geometry.

He also lectured on geometry, both at the University of Pavia and at the Piatti Foundation in Milan. He eventually married the mother of Girolamo, but only when the boy was already seven years old.

Girolamo Cardano seemingly inherited this intellectual gift from his father, but he was a troubled man. Quite a lot is known about Cardano, as he wrote a lengthy autobiography, *De propria vita* (*The book of my life*). However, some historians are of the opinion that the content of *De propria vita* is a complete hoax, or at best a figment of Cardano's overactive imagination. Cardano was a skinny man, with a long neck, heavy lower lip, wart over one eye, and a voice so loud that even his friends complained about it.

He was appointed Professor of Medicine at Pavia in 1543 and at Bologna in 1562. In 1551, he treated the Archbishop of St Andrews in Scotland for an asthmatic complaint and in London cast the horoscope of King Edward VI.

Cardano wrote 131 printed works on many subjects, including mathematics, astronomy, physics, urine, teeth, the life of the Virgin Mary, morality and immortality.

He claimed to have burned 170 other manuscripts before publication and left behind another 111 manuscripts when he died. Some of his most popular and best-selling works include *De sibtilitate rerum* (*On the subtlety of things*), *Ars magna* (*The great art*) and *Liber de ludo aleae* (*Book on games of chance*).

However, it was probably his passion for gambling that motivated

Cardano to apply his considerable mathematical skills to the analysis of dice throwing. He converted experimentation into theory, defined 'an honest die', used the concept of mathematical combinations to calculate 'chance' (he never used the Latin word *probabilitas*; this honour belongs to Galileo Galilei), defined equally probable events and the concept of expressing probability as a fraction. The very early basis of modern probability theory should be seen as his lasting contribution to mathematical science. Once Cardano had broken the (d)ice, further development of the mathematics of chance followed relatively quickly, with significant contributions made by most of the great mathematical minds of the time, placing probability theory on a firm mathematical foundation.

Cardano unfortunately had a tragic and troubled personal and family life. His eldest son was executed for the murder of his wife, his other son was constantly jailed for various crimes and his daughter was a prostitute. The Inquisition arrested him for heresy at the age of 69, since he dared to cast a horoscope of Jesus Christ (contained in *De astrorum iudiciis*). He immediately recanted and was subsequently hired by Pope Pius V as an astrologer and later granted a pension by Pope Gregory XIII.

He did not escape the consequences of his lifestyle. In his own words: "I suffer from diarrhoea, ruptures, kidney trouble, palpitations and even an infection of a nipple." He was also fully aware of his own peculiar personality traits: "I am hot-tempered, single-minded, given to women, cunning, crafty, sarcastic, diligent, impertinent, sad, treacherous, a magician and a sorcerer, miserable, hateful, lascivious, obscene, lying, obsequious and fond of the prattle of old men."

Cardano was strongly disliked by some of his contemporaries and

despised by some of his successors, while his biographers alternately described him as a charlatan and a persecuted savant. He was a brilliant academic, physician and mathematician, widely respected, but rather outspoken.

For example: "The things which give most reputation to a physician nowadays are his manners, servants, carriage, clothes, smartness and caginess, all displayed in a sort of artificial and insipid way..." During his stay in

Bologna, he made many enemies. He humiliated a fellow medical professor in front of his students by pointing out errors in his lectures and his colleagues tried to get the Senate to dismiss him by spreading rumours that his lectures were practically unattended.

It has been claimed that Cardano predicted the date of his own death by casting his own horoscope. However, since he was healthy at the end of the specified day, he poisoned himself! ❸