Innovation at UCT

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From the lab to the market: cutting-edge innovation

As a research-led university with a global reputation, innovation is at UCT's core. The university seeks to stimulate the creation of knowledge and ultimately the growth of the South African economy by fostering business development and job creation through the commercialisation and implementation of intellectual property (IP); thus transforming society for the benefit of all.

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Putting a freeze on the problem of waste

A case in point is water management. This is a field that has become a very important, if not the most important, sustainability issue within the global energy and mining resources industries. In South Africa, for example, more than R200 million will be needed just to halt acid mine drainage, which is affecting the western, central and eastern basins of the Witwatersrand goldfields area, as well as water quality in the Vaal and Crocodile river systems. The level of underground acidic water in the Johannesburg region has also risen to within 500m of the surface and more brine is produced than companies can recycle, mainly through evaporation processes. Besides the fact that these processes are highly energy intensive, they generate non-recyclable waste materials, and this makes it a non-sustainable solution from an ecological perspective.

The answer in the long run may lie in eutectic freeze crystallisation (EFC) and the research conducted by the Crystallization and Precipitation Research Unit under the leadership of Professor Alison Lewis. "After five years of intensive research on EFC, the unit is able to convert polluted water into 99 percent re-usable material, that is, water and chemical salts," says Professor Lewis. These results have been positively received by industry and in March 2011 the Coaltech Resources Association – one of the major funders of this research – announced its plans to build a R10 million pilot plant, which would be able to purify 1 000kL/day of brine.

Eutectic freeze crystallisation works on the principle that, when a waste stream is cooled to a specific temperature, ice as well as salt will crystallise out of the solution. The ice, being less dense than the salt, floats to the top of the crystalliser, while the denser salt sinks to the bottom, along with waste materials, and thus the process of ice crystallisation excludes most impurities, resulting in pure water when melted.

A typical brine treatment scheme is shown in the flowsheet below.

"A treatment process needs to focus on both the solid waste component (salts) as well as the liquid component (water) of the wastewater stream, and so we treat wastewater as a resource. This is the only way a truly sustainable and

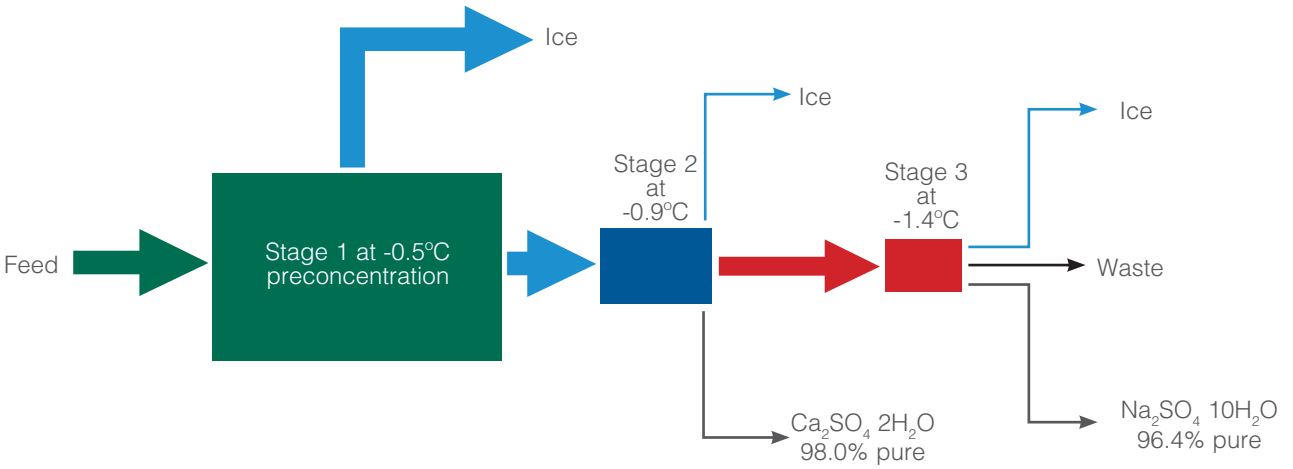


Figure 6 Typical eutectic freeze crystalisation brine treatment scheme




Researchers in the Crystallization and Precipitation Research Unit Laboratory.

environmentally friendly water treatment process will be achieved – EFC does exactly this," says Professor Lewis.

One of the potential disadvantages of conventional EFC is that it can require very low temperatures, depending on the salts present in the brine. This can make EFC uneconomical compared to other technologies. Professor Lewis and her group have resolved this problem through a process in which the natural eutectic temperature (the point at which crystallisation occurs) is elevated. This means that it becomes feasible to remove a range of salts at higher temperatures than their natural eutectic freezing points, thus reducing energy requirements. This process has been patented and has received a very favourable Written Opinion from the patent examiner at Patent Co-operation Treaty (PCT) stage, indicating that, based on the International Search Report, all claims are novel, inventive, and useful. UCT has subsequently pursued various international patent filings (Australia, Europe, and Canada) in addition to South Africa.

The unit is currently seeking funding in conjunction with commercial partner Proxa (Pty) Ltd, to build an EFC pilot plant that will operate at various client mines to treat wastewater, testing the amenability of this innovative solution for management of the waste and to generate the design parameters used as the basis for full-scale plant design. Proxa is involved in engineering, construction, and operation of mobile and fixed water treatment systems that cover the entire water cycle. Through the partnership, know-how built up within Professor Lewis's group at UCT has been transferred to Proxa, who have combined this with their own knowledge of full-scale plant design principles and the requirements for integration of EFC into a typical process flowsheet. The relationship is symbiotic, with UCT remaining involved to develop the detailed understanding of the specific requirements for the effective separation of a client's brine and any troubleshooting.

UCT is actively developing other intellectual property around crystalliser design, which will further augment Proxa's offering to clients and end users.

Drug and vaccine discovery given a booster

A number of essential ingredients necessary for drug and vaccine discovery and development have now been assembled at UCT, creating the ideal environment for innovation.

Vaccine research groups led by professors Anna-Lise Williamson and Carolyn Williamson have developed two HIV subtype C vaccines: SAAVI DNA-C2 and SAAVI MVA-C, in conjunction with the Medical Research Council (MRC) and the South African AIDS Vaccine Initiative (SAAVI), in response to the prevalent HIV subtype C epidemic in Southern Africa. These vaccines are currently in Phase I clinical trials in South Africa and the USA, one of which has already been approved by the United States' Food and Drug Administration (FDA).

In getting these vaccines this far into development, members of the research group have gained invaluable local experience as well as insight into and practical knowledge of the process of taking a vaccine from initial research to animal studies and thereafter to human vaccine trials (see **Figure 7**).

A further by-product has been the creation of an Organisation for Economic Co-operation and Development (OECD)-compliant Good Laboratory Practice facility at UCT. This laboratory, which is the only OECD-accredited facility in South Africa for the physical testing of pharmaceuticals, was used for potency testing of the SAAVI DNA-C2 vaccine.

Another unique facility is the H3-D Drug Discovery Centre, which brings the research machinery traditionally housed within big pharmaceutical companies to UCT. The centre, the first of its kind in Africa, focuses on a critical zone where the potential of research output is realised and matured into a form where biotech companies and pharmaceuticals become interested in these 'optimised leads'.

This represents a real opportunity for UCT. Market conditions are right – there has been a 50 percent reduction in European in-house pharmaceutical research and development capacity over the last two years and 70 percent of new drugs are now accessed externally by pharmaceutical companies. An important aspect of the centre is that it provides a local platform to draw on the potential of traditional knowledge and indigenous flora as the basis for innovative pharmaceuticals and to focus on solutions for often neglected diseases of particular relevance to Africa. UCT has a number of pharmaceutical-related patents directed at anti-malarial, anti-TB, and anti-cancer compounds in its portfolio.

Researchers in the H-3D Drug Discovery laboratory.

Biomarkers have great potential to be used to provide insight into how individuals with specific genetic make-ups will respond to drugs, relevant both in terms of extending the scope of clinical trials, but also in the context of investigating responses of African populations to drugs developed on first-world populations.

Collaboration with the Centre for Proteomic and Genomic Research (CPGR), an independent research entity physically located on the UCT campus, is bringing rigour to moving biomarkers down the innovation chain and assessing the potential of new inventions. One microarray developed by DST/NRF SARChI Chairholder Professor Jonathan Blackburn of the Institute of Infectious Disease and Molecular Medicine has already been licensed to CPGR and is now included in their routine analytical service offering. This close interaction is expected to translate other UCT inventions into other future innovations.

These proteomic- (protein) and genomic (genes and chromosomes)-based assays can also play a key role in drug discovery, so there are strong synergies with the H3-D Drug Discovery Centre.

Clinical trials underpin new drug development. UCT has well-established expertise in this space and is extensively involved in phase one, two, and three trials for a large number of pharmaceutical companies, foundations, not-for-profit entities, governmental, and intergovernmental organisations. For example, UCT is currently the lead contractor in more than ten European and Developing Countries Clinical Trials Partnership (EDCTP) multi-site trials.

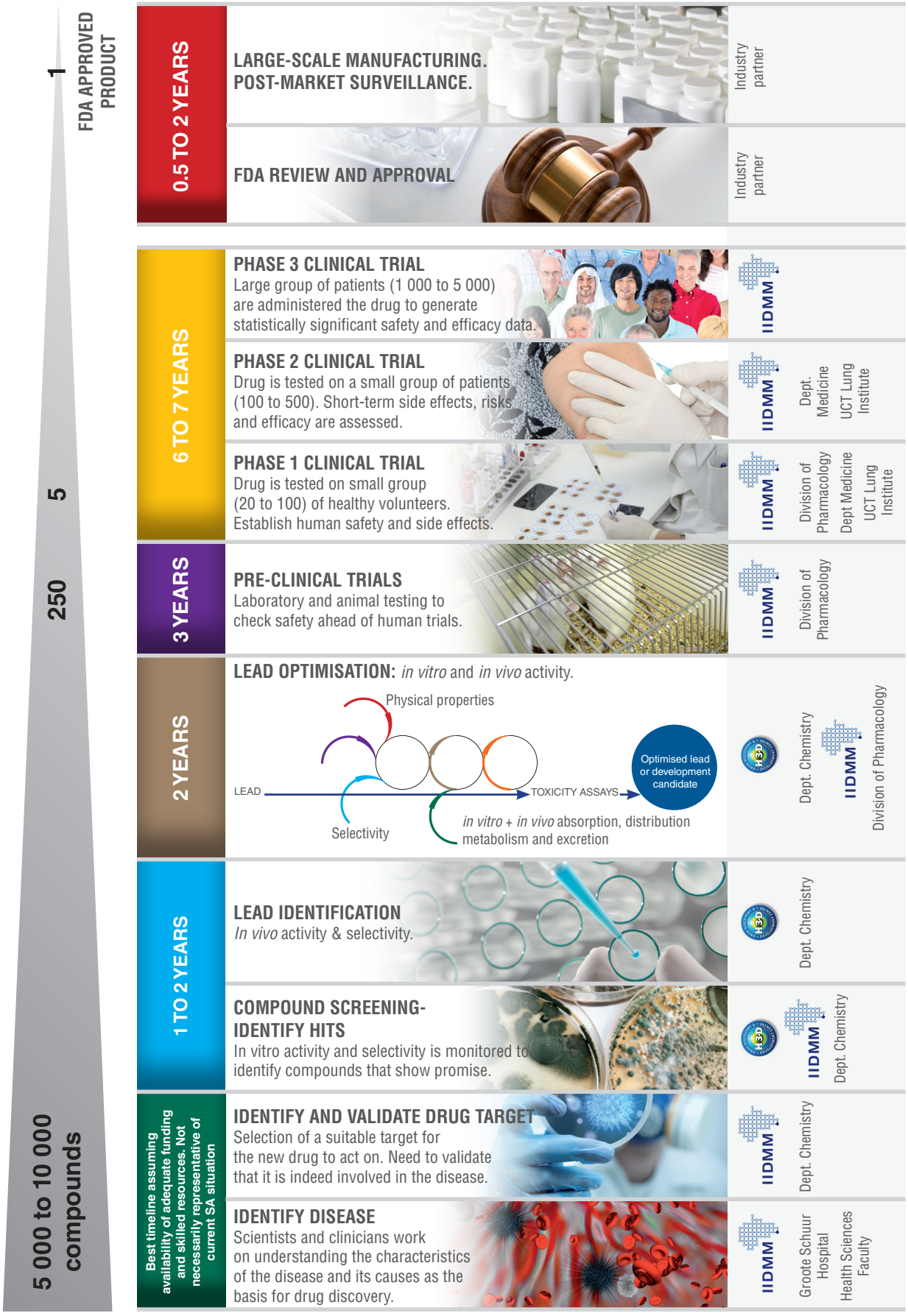


Figure 7 UCT players in the innovation stages from drug discovery through to commercialisation

Testing the waters

The Aquatest Research Programme was started in 2007 with the primary aim of developing a low-cost, rapid-response water test kit that could be used in rural or under-resourced areas. Led by the University of Bristol, the project team developed a device that would alleviate the need for complex and time-consuming laboratory tests.

As part of this project, UCT's Information for Community Oriented Municipal Services (iCOMMS) team, led by Associate Professor Ulrike Rivett, worked on a set of mobile phone applications. "This allowed for water quality test data to be collected remotely, using low-cost cellphones, and transmitted back to a central database where it could trigger real-time SMS warnings, and be aggregated into periodic reports for managers and the community," says Associate Professor Rivett.

The team produced three applications: two mobile phone tools, and a back-end web application, which provided an interface with the database. The data collection application, developed using Java technology, was targeted at low-end Nokia cellphones, which were distributed to water supply caretakers. An Android application was developed for local municipal managers to access daily information summaries while in the field, as the managers often did not have time to browse reports from their desks. The back-end application provided an administration console where SMS warnings, email reports, and staff lists could be managed. This application also contained an interface with Google Maps to provide an overview of data being collected in the field.

The mobile applications were piloted for two years, in seven sites located within South Africa, Vietnam, Cambodia and Mozambique. Caretaker incentivisation, work and information flows, manager decision processes, and municipal hierarchies were studied during this time. This pilot period ended in November 2011, although one testing site remains operational in the Eastern Cape.

The team's initial analysis of the pilot sites shows that the managers found benefits in having greater and more immediate access to the water quality test data. An area of research that Associate Professor Rivett's team is currently investigating is how to incentivise workers or community members to report problems with their drinking water supply, without resorting to monetary rewards. "Caretakers received increased social standing in the community through the programme, and we hope a greater community understanding of the importance of water testing through the caretakers' explanations," says Associate Professor Rivett.

Saul Maans, of Middelpos in the Northern Cape, using an H2S testkit to take a water sample. Saul tested water samples using the H2S kit as part of the Aquatest 2 Project, and then sent the results using the WQR (Water Quality Reporter) application, which was uploaded on his cellphone.

UCT pivotal in growth of medical device hub

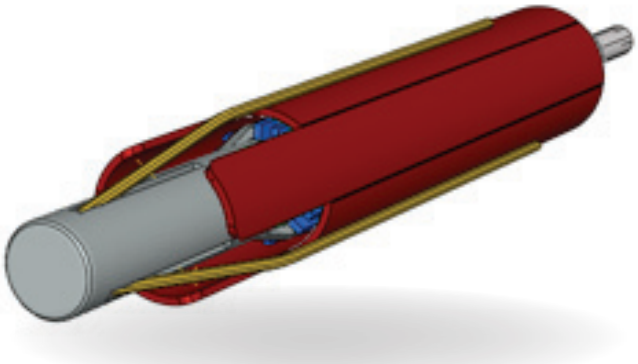
Since the Cape Town Steriotactic Pointer (enabling neurosurgeons to pinpoint brain tumours) was developed by Professor Laurie Adams in 1998, Cape Town has established itself as a hub for medical device innovation and UCT is a key player in the growth of this sector. UCT's IP portfolio currently contains a total of 22 medical device patent families and three UCT medical device spin-off companies were formed over the last few years, with another imminent in 2012.

UCT is also a signatory to the MRC Medical Device Innovation Platform (MDIP) initiative, which will further enhance medical device development. MDIP provides bursaries and funding to support innovation projects, and creates a network of collaborators within the field with linkages to rapid prototyping centres and domain experts.

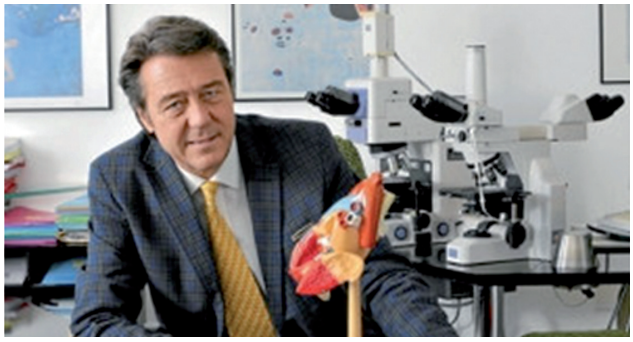
In 2011, the Technology Innovation Agency (TIA) approved funding for the development of a novel aortic replacement heart valve deployment device patented by a UCT start-up, Southern Access Technologies (Pty) Ltd (SAT). The funding was dependent on co-funding of the project and UCT's Professor Peter Zilla was instrumental in finding the necessary co-investment.

"The magnitude of the investment and the fact that it was made by a private-sector investor at this early stage of development is significant and signals the changing attitude towards the potential of early-stage inventions in this field," says Deputy Vice-Chancellor Professor Danie Visser.

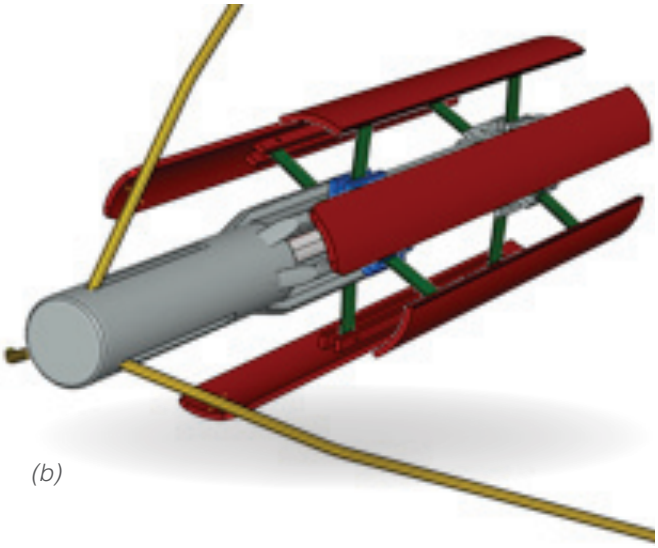
In Africa there are more than six million patients needing heart valve treatment and 320 000 in South Africa alone. Currently, valve replacement surgery can only be performed in South Africa and Egypt due to the sophisticated operating theatre requirements. With the SAT device, however, a general surgeon would be able to replace an aortic valve without open-heart surgery, thus bringing hope for treatment to patients in many more African countries.



(a) Mechanical expander in the collapsed and (b) in the expanded configuration.



Professor Peter Zilla.



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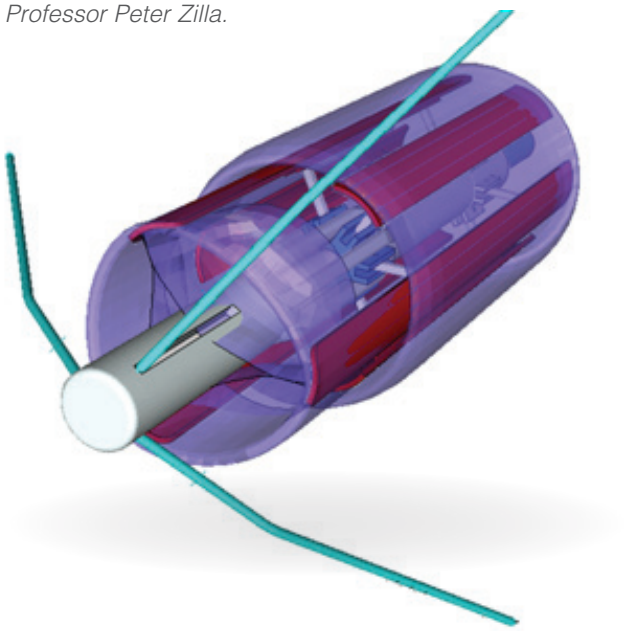

(c) Complete expander device showing locator arms (turquoise), annular balloon and temporary valve (purple), expander arms (red) and central rod (grey).

Dr George Vicatos (left) with Alan Duggan of Popular Mechanics *receiving the Inventor of the Year Award.*

The Vicatos-Hendricks distractor (above) being tested on a 3D cast ahead of installation on a patient.

Dr George Vicatos, a mechanical engineer, with co-inventors Dr Rushdi Hendricks and MSc student James Boonzaier have already made a remarkable and significant impact on the lives of two patients with their Maxillofacial Distractor. Dr Vicatos was named Inventor of the Year by *Popular Mechanics* in its inaugural recognition of South African inventors. The team also won an award in the Cutting Edge category. In further recognition of their invention, the team, represented by Dr Hendricks, was a finalist in the NSTF-BHP Billiton 2011/12 Awards.

The Maxillofacial Distractor device is particularly beneficial in cases where bone has had to be removed due to cancer in a patient. The process of Transport Distraction Osteogenesis (TDO) has developed as a novel way of reproducing new bone and soft tissue. This process involves moving two bone ends gradually apart (distraction), allowing new bone to form in the tiny gap and to grow together with the surrounding soft tissues. While devices have existed for the lower jaw (mandible) prior to this invention, none exists that is capable of dealing with the demands of the upper jaw in terms of the complex anatomical constraints.

Dr Lebogang Ramma (Health and Rehabilitation Sciences), and Samuel Ginsberg (Electrical Engineering) have developed a hearing aid that is suitable for use in the South African public health sector. The device is built using available components, but through smart design and innovative software it outperforms existing alternatives in terms of both function and cost. Software and a simple button selector on the hearing aid casing enable the user to switch between four options to optimally cope with different sound environments.

A fortuitous development emerged through collaboration with GeoAxon (Pty) Ltd whose Kuduwave Audiometer is used for remote hearing testing. The Kuduwave enables an audiologist based in a main centre to interact via the internet with trained technicians deployed in the field to diagnose hearing loss in patients living in remote rural areas. The challenge, however, was how to fit the appropriate hearing aid after diagnosis – a task normally performed by an audiologist. Almost at the point of GeoAxon (Pty) Ltd starting to develop a complementary hearing aid, serendipitous timing meant that the UCT device could be developed and adapted to interface with the GeoAxon Kuduwave, allowing the hearing aid to be programmed remotely over the internet to meet patients' needs.

The device is currently undergoing trials at both local and remote test centres, supported by UCT's pre-seed funding. "GeoAxon is already conducting remote audiometry in South Africa and in neighbouring African countries, with intentions of expanding its reach further, says Dr Andrew Bailey, UCT's Intellectual Property Manager. "If proven to be successful, this device will most probably become an integral part of GeoAxon's service package."

The UCT inventors have a host of other ideas around hearing aid development that they will pursue once this model has entered the market. While much of the IP protection to date has been reliant on copyright, it is anticipated that patenting opportunities will arise through the new developments. These ideas will have a significant impact on user experience and maintenance in a low-income environment.

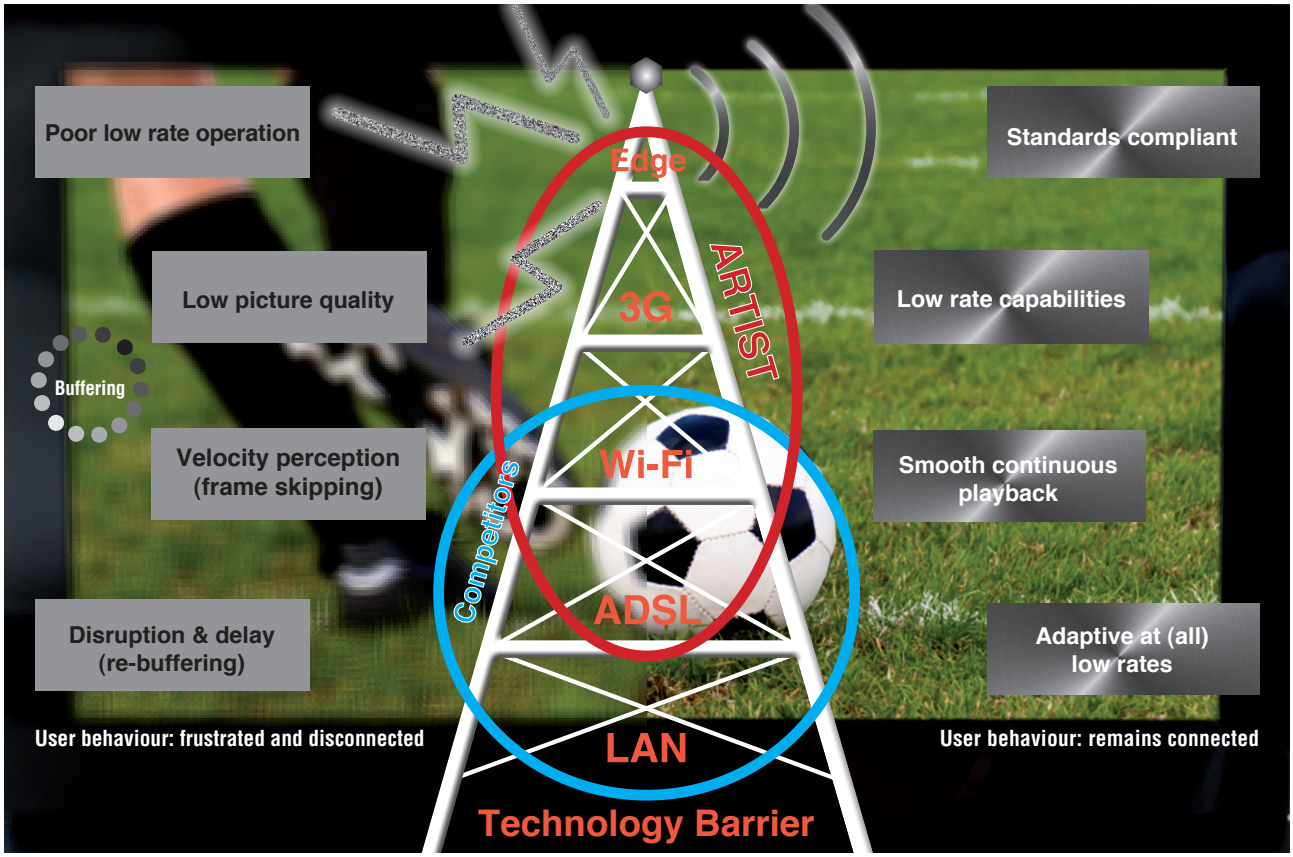

Figure 8 Technology Barrier Overcome by the ARTIST Technology to Provide Quality, Continuous, Live Video Transmission to Mobile Devices [based on a graphic of Dr Keith Ferguson, CSIR]

Giving buffering the boot

The internet is a 'best effort' transmission platform without quality or service guarantees. In a congested environment there are significant fluctuations. Most of us have experienced the finger-tapping frustration of waiting for 'buffering' to complete before the next gripping bite of a YouTube or other online video clip. The situation is exacerbated in constrained bandwidth environments such as South Africa and further deteriorates as one moves into the realm of wireless mobile devices such as cellphones and tablets.

The Adaptive Real-Time internet Streaming Technology or ARTIST project, a collaboration between the Council for Scientific and Industrial Research (CSIR), East Coast Access and UCT, and funded by the Technology Innovation Agency (TIA), has led to the development of a much-needed low bandwidth video broadcast platform that will overcome this problem. ARTIST exploits various algorithms to conduct video coding and compression that is not bandwidth hungry and does not degrade signal quality.

ARTIST fits into a very specific niche: one-to-many (users/viewers) live internet-based broadcasting. Potential applications are diverse, from entertainment, such as coverage of local sporting events and community 'TV' broadcasts, through to education (schooling or adult education – entrepreneurship, farming, health, and rural community healthcare worker training).

ARTIST has already been successfully piloted at radio station Y-FM, and is opening the way for a new mode of operation, application and business opportunities. "Blurring the lines between a TV and a radio station, during the pilot listeners were able to watch DJs spinning the decks and see studio interviews," says Dr Bailey.

The technology challenge that ARTIST addresses is represented graphically in **Figure 8**. The graphic also shows where existing competitors sit in relation to ARTIST – mainly in the LAN, ADSL and Wi-Fi space – whereas ARTIST addresses the ADSL, Wi-Fi, 3G and Edge space used by mobile devices. The UCT components of the licensed IP include a patent family, considerable know-how and software copyright that has been developed by the core UCT research team in the Department of Electrical Engineering: Associate Professor Mqhele Dlodlo, Emeritus Professor Gerhard de Jager, and Dr Guy-Alain Lusilao. Contributions were also made by postgraduate students: Veronica Sentongo, Josephine Kakande, Charles Lubobya, Rohini Koduri, and Norman Morrison.

The technology will be commercialised by a Gauteng-based spin-off company, Tuluntulu (Pty) Ltd.