

Prof Johannes Cloete leaves career legacy for engineers

In 1964, when Stellenbosch University's (SU) Faculty of Engineering was 20 years old, the South African Navy enrolled Prof Johannes (John) Cloete in the five-year BSc, BEng degree course in electrical engineering.

Five years later, he was selected to be the engineering officer of the South African Navy's third Daphné-class submarine, which was being built in France. Consequently, he spent the year training, including doing a handy French language course, to prepare for joining the crew of the SAS Johanna van der Merwe (now the SAS Assegaai) in Toulon in 1970.

"At the last minute, as an afterthought, I was required to undergo a test in the diving school's hyperbaric chamber," Prof Cloete recalls. "The purpose was to check that my ears would 'equalise' while the pressure was varied to simulate the conditions when the submarine was snorkelling. They couldn't (possibly because I had a cold), and consequently, I left the chamber with ruptured eardrums. That was the end of my submarine career."

Defence research and microwave antennas

Prof Cloete resigned from the Navy in 1970, and with his wife, Susanne Langley, left the Cape and moved to Pretoria, where he joined the CSIR's National Institute for Defence Research (NIDR).

"In 1971, thanks to Dr Derrick Ashpole, the head of the Electromagnetic Systems Division, I was sent, by the NIDR, to the USA to do an MSc Eng degree in electrical and electronic engineering at the Department of Electrical Engineering and Computer Science of the University of California at Berkeley."

After Berkeley, he worked at Scientific Atlanta in Atlanta, Georgia. At the time, Scientific Atlanta was arguably the foremost company in the USA in designing and manufacturing precision instrumentation for measuring the characteristics of microwave antennas. They also designed and built antennas for satellite ground stations, point-to-point communications, etc. "I was fortunate to be given a challenging project to design, manufacture and test a shaped-beam 2-12 GHz reflector antenna, with log-periodic or Archimedes spiral feed antennas, for the United States Air Force. The resulting antenna was a commercial success."

"On looking back, I now appreciate how influential Prof John Whinnery at Berkeley and Searcy Hollis, the principal engineer of Scientific Atlanta, were in my subsequent career."

Back at the NIDR in 1973, Prof Cloete found that Ad Sparrius, who had attended UC Berkeley a year before, had realised a significant need for an indigenous research and development activity in electronic warfare.

“We therefore initiated a two-pronged programme. The first was the study of various adversarial weapon systems to identify appropriate electromagnetic countermeasures. The second was, among other things, the development of multi-octave bandwidth microwave antennas for radar-warning receivers (RWRs), jammers, and chaff and infrared flare dispensers. “As a result of one of these projects, I finally got my hands on a Daphné submarine. Working with Dr Dirk Baker and Bob van der Neut, we extended the frequency range of the 2-12 GHz RWR antennas of the newly arrived Daphnés to 18 GHz to deal with new threat radars.”.

“While at the NIDR, Bob van der Neut introduced me to the Marchand balun to feed multi-octave bandwidth Archimedes, logarithmic, and sinuous spiral antennas. I realised that the existing Marchand design methods were suboptimal, having been introduced to the exact synthesis of commensurate length transmission line networks by Prof Jan Malherbe.

“By applying this technique, I managed to invent an exact, optimal Chebyshev synthesis procedure for the design of the Marchand balun. I presented the results at the European Microwave Conference in 1979.” The paper is one of his most cited works and has been reprinted in *Classic Works in RF Engineering*, edited by JLB Walker et al., Artech House, 2006.

“My last project at the NIDR involved motivating, specifying, and procuring Scientific Atlanta instrumentation for a 500-meter outdoor antenna test range at Paardefontein outside Pretoria. The range was needed for the measurement of large radar antennas. Dr Dirk Baker took over the project when I left in 1981 for the University of Pretoria. He designed and supervised the building and calibration of the test range, turning it into a world-class antenna measurement facility.”

Education and research

From 1981 to 1983, Prof Cloete was an associate professor in the Department of Electronic Engineering at the University of Pretoria. “By then, Prof Malherbe had moved from SU to Pretoria, and I was able to collaborate with him on the design of slot arrays fed by non-radiating dielectric waveguides. I also presented postgraduate courses on radar systems for engineers working in industry. During this time, I was also involved in the development of the long-range Lunette tracking radars for the Houwteq Test Range near Bredasdorp.

In 1982, Prof Cloete was awarded a PhD from SU for a dissertation entitled *Design of Microwave Interdigital Linear Phase Filters*. Most of the research was done at SU in 1977 while he was on sabbatical from the NIDR. “My supervisor was Prof Malherbe. His colleague, Prof PW van der Walt, was appointed as one of the thesis’s internal examiners. He read the work critically and found a significant error which the other examiners had missed. Fortunately, the mistake did not impact the design procedure and was easily corrected!”

“In 1984, I was appointed a professor in the Department of Electrical and Electronic Engineering at SU. I introduced a new third and fourth-year course sequence on electromagnetic fields and waves. At that stage, the Department had no formal postgraduate programme in engineering electromagnetics. Prof PW van der Walt, and I set about remedying the situation. The structure

of the new two-year MSc Eng course consisted of lectures in the first year followed by individual research in the second.

“We obtained generous funding, notably from the National Research Foundation (now the Foundation for Research Development) under the directorship of Dr Rein Arndt, SU, Kentron, and others. These funds made it possible to design and build a microwave anechoic chamber for near-field antenna measurements—the first in South Africa—and procure a state-of-the-art HP8510 network analyser and various other measuring instruments. Most significantly, the funding enabled us to attract talented postgraduate students.”

Besides measurement facilities, their research required good computational resources. “The Olivetti M24 PC became available in 1983, and thanks to the initiative of my late colleague, Prof Jan du Plessis, all our students had access to one. “However, it soon became apparent that we also needed a lecturer whose research field was computational electromagnetics (CEM). Fortunately, I knew someone who perfectly fit the bill — David Davidson, whom I met as a student at the University of Pretoria.

“I obtained external funding to establish an associate professorship in CEM and persuaded David to apply for the position, which he did. He joined the Department in 1988 and, by 1991, had developed a new postgraduate course in CEM and completed his PhD on parallel computing algorithms for simulating wire antennas. By the time he left SU in 2018 for Curtin University, Perth, he had supervised numerous M and PhD students, written a highly regarded textbook on CEM, and established himself as an international authority in this field. Computational electromagnetics is now one of the Department’s strong research fields.”

Advancing science and technology

Many post-graduate students were taught the intricacies of electromagnetics, antennas and microwave circuits by Prof Cloete, who was not only their academic supervisor but also their mentor throughout their careers. In this regard, Prof Petrie Meyer, acting dean of the Faculty of Engineering, mentions: “Prof John’s academic contributions have influenced both theoretical and practical aspects in the field. His ongoing involvement in and support for his students underscores his commitment to advancing science and technology in South Africa and beyond.

During Prof Cloete’s two decades tenure as professor (1984-2006), he supervised or co-supervised 15 PhD and 36 MSc Eng graduates. “Between us, we published 49 papers in refereed journals and presented 122 papers in conference proceedings. Approximately half of the conferences were held in the USA and Europe. This exposure was especially valuable because it showed our students that their work was, at least, on a par with that of their international contemporaries.”

“Our research was influenced by a number of international colleagues. These included Prof Israel Navot, Technion, Israel; Prof Ed Miller, USA; Prof Martin Wedepohl, University of British Columbia; and Professor Iain Mason, Sydney University, Australia.”

Collaboration with industry

Throughout this period, Prof Cloete and his students and colleagues fostered and maintained good relations with South African antenna and microwave engineering companies. These included AMS, EMSS, EMSS Antennas, Eskom, Houwteq, Magus, Omnipless, Plessey and Reutech Radar Systems.

“EMSS is an exceptional success story. Based in Stellenbosch Technopark, it was founded in 1994 by Dr Gronum Smith and Dr Frans Meyer (one of Prof David Davidson’s PhD graduates) to provide consulting services for the South African and international industry. A CEM software product, FEKO, was developed to support these activities. FEKO, having become a world-leading product, was sold to Altair, an American company, in 2014. Dr Johann van Tonder and Dr Marianne Bingle, co-developers of FEKO at EMSS, are now employed by Altair and continue their work on FEKO.

“EMSS Antennas, a subsidiary of EMSS, was founded in 2002 by Dr LJ du Toit. He was joined in 2006 by Dr Isak Theron from EMSS as director and principal engineer. Since then, EMSS Antennas has gained an outstanding international reputation for designing and manufacturing radio telescope antennas, notably the KAT-7 and MeerKAT antenna arrays. EMSS Antennas is now deeply involved in building the South African component of the Square Kilometre Array Observatory.

“Omnipless was founded in 1993 by Johan Pretorius (also an SU Magister graduate) as a joint venture with Plessey Tellumat. Their first product was a flat panel microstrip antenna patch array used in a portable Inmarsat communications ground station. Since then, the company, in the guise of Thales Aerospace Communications, has grown into a major designer and manufacturer of avionics systems for the international aerospace market. Dr Pierre Steyn (promotor Prof Davidson), Dr Nelis du Toit, Ian George (unfortunately, he didn’t complete his PhD), and Dr Marius du Plessis played key roles in the Omnipless success story.

“Other of my PhD graduates are employed as follows: Dr Jaco van der Merwe, Philips, Eindhoven, Netherlands; Dr Marc Rutschlin, Simulia, Dassault, Germany; Dr Paul Herselman, Reutech Radar Systems, Stellenbosch; Dr Paul van der Merwe, Garmin, Stellenbosch; and Dr Wernich de Villiers, OMICRON, Klaus, Austria.

Strong connections remain

Prof Cloete retired in 2006, after which he was reappointed for two three-year terms to do research and lecture. “During this time, I presented a course on electrotechniques for SU’s first-year engineering students. I also developed and presented a course, Antennas for Radar and Electronic Defence, for the radar Master’s degree course at the University of Cape Town (UCT) for three years. This course was especially challenging because most of the students (from overseas) didn’t have an adequate background in Maxwell’s electrodynamics and computational electromagnetics.”

“At the same time, I was consulting for Magus, an EMSS company in Technopark. Under Sam Clarke and Brian Woods (both M graduates from SU), the company was developing a powerful, validated, high-level CEM software product, Antenna Magus, to design and analyse a wide range of microwave antennas. They kindly made the software available for my UCT students, allowing me to leapfrog the gap in their electromagnetic deficiency. Subsequently, Antenna Magus was purchased by Dassault and is now a part of their Simulia simulation software suite.”

Prof Cloete pays tribute to his former colleagues, “who created a wonderful collegial environment in which I could flourish”. “In particular, I want to single out Professors Jan Malherbe, PW van der Walt, David Davidson, Keith Palmer, Howard Reader, Petrie Meyer, Dirk de Villiers, Matthys Botha, and Willem Perold. I also thank Petrie, Dirk and Matthys for making the ‘ou manne’, PW and myself, feel welcome at events like the annual South African Institute of Electrical and Electronic Engineers AP, MTT and EMC symposium.

“In conclusion, I particularly enjoy meeting up from time to time with some of my former students and colleagues over coffee or a glass of good red wine to discuss applied electromagnetics and many other topics.”