RRS

35 years of innovation

1987–2022

PW van der Walt • Lia Labuschagne

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1987–2022

Reutech Radar Systems
a division of Reutech (Pty) Ltd

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The RRS building (2011)
Courtesy of SSFD / SCPS

FOREWORD

Reutech Radar Systems grew out of what was likely to be become a problematic project: A contract to build eight air traffic control radars under licence from Selenia, which ran into difficulties. Tasked to rescue that situation, 'Boel' Pretorius turned it into an opportunity to establish a radar industry in South Africa.

Reutech Radar Systems grew out of what was likely to be become a problematic project: A contract to build eight air traffic control radars under licence from Selenia, which ran into difficulties. Tasked to rescue that situation, 'Boel' Pretorius turned it into an opportunity to establish a radar industry in South Africa.

RRS has meanwhile completed three and a half decades of successful radar development, military and civilian, a salutary lesson in what South Africans can achieve when they put their mind to it. Not many countries manufacture, let alone develop radars, and all of those that do, have substantially larger industrial bases and much better defence and general research funding.

RRS blew past those challenges from a zero base to develop the radar for a self-propelled anti-aircraft system, an air defence battery radar and command post, a naval optronic/radar tracker for the SA Navy's Meko A200 frigates, a helicopter control radar for the Royal Norwegian Navy's Fridtjof Nansen class frigates, a series of low-probability-of-intercept radars, a staring array radar for armoured vehicle self-protection systems, and a dual-band 3D air defence radar for warning and missile mid-course guidance. Civilian products included a range of safety radars for open cast mines, and the development and manufacture of key elements of the Southern African Large Telescope.

Along the way RRS also developed and manufactured equipment for EADS, was the prime contractor for the replacement of the ATC radar at Subang in Malaysia, handing that over in 1996, and saw its Thutlwa battery command post radar deployed to Juba in South Sudan in 2011, to provide ATC services during the independence celebrations.

A busy quarter of a century, and the decade since then has seen further development and innovation: An upgrade of the Thutlwa, development of a frequency-modulated continuous wave radar/ optronic tracker, the RTS 3200 FORT adopted by the SA Navy for its new class of patrol vessels, development of the RSR 312 maritime surveillance radar for a country in Asia to monitor high-density small craft traffic, a vessel tracking system using interception of navigation radars together with AIS data to detect illegal activity, and a 2D hostile fire warning system for helicopters that can detect small-arms fire.

RRS has also expanded its civilian activities, further improving its mining radar, developing a ground-penetrating radar for crack detection and monitoring in underground mines, which is also being used by an Asian railway company to check for cavities under railway lines, a tilt-corrected digital compass for mining use and solar trackers for a large concentrated photo-voltaic array. RRS also joined forces in a Joint Venture company to develop a berm-monitoring system. Meanwhile its RSR 904 Ngada radar forms part of the Meerkat surveillance system that has helped reduce rhino poaching in the Kruger National Park, and a RSR 906 radar is monitoring small craft traffic off South Africa's diamond-rich north-western coast.

The story of RRS is a fascinating one in itself, but it also provides a model that South Africa can adapt to foster technology development and advanced manufacturing in other sectors, precisely what we need to do if we want to develop and grow our economy. So this history of the first thirty-five years is not just an interesting read, but also a primer for work yet to come.

At the quarter-century celebration I remarked that I looked forward to seeing what the next twenty-five years would bring, confidently expecting to be surprised. The first ten years of that next quarter of a century have confirmed my expectations!

Helmoed-Römer Heitman

INTRODUCTION: WHY THIS BOOK?

Within a period of 35 years Reutech Radar Systems (RRS) has grown from a fledgling enterprise into an innovative radar design and manufacturing centre at the southernmost part of Africa. RRS is a division of Reutech (Pty) Ltd, a company in the Reunert Ltd stable (listed on the JSE since 1948).

Over a period of 35 years RRS grew its research and development capability into one supplying a wide range of search and tracking radars and radar components for the South African National Defence Force and the international market. Subsequent successes in other areas followed and include those adapting RRS technologies for industrial applications.

The focus in this book is to outline the activities of RRS today as seen against its history. It records, in a relatively informal narrative, the history of the company from its founding in 1987 until 2022, and celebrates its achievements thus far. Woven into the story is a look at the organisational history and the development of some of the key products, while it also follows the vision of its leaders, the way RRS has been managed and the people who made it happen. Numerous informal anecdotes illustrate the challenges met over the years.

This is a tribute to all of those who make RRS what it is today. Therefore, it is shared with all the RRS customers, academic and business associates, technical advisors and other service providers.

RRS is proud of its current staff complement of around 220. Some have been part of the entire 35-year RRS history. Most are highly skilled and qualified specialists whose innovative solutions are keeping the enterprise at the forefront of our field – not only locally, but also internationally.

What may be expected in the future? We hope that, when the history of the next decades of RRS is written, it will show an equally interesting growth and development of a proudly South African company: one that illustrates that technology and innovation remains alive and well in our country.

Thank you to all of those who provided the information to make this book possible. In particular, we are grateful for the contributions of past CEOs of the company, project managers and others who provided technical information, as well as the communication department and the many individuals who shared historical recollections, reference documents and illustrations.

Message from

THE CEO

Mr Gerrit (Boel) Pretorius and Prof PW van der Walt's agreement many years ago, along with support from the South African DoD and Armscor, led to our creation, establishment and ongoing success. Moving into RRS in 2019 as COO and then shortly afterwards CEO, I was privileged to find myself at the helm of a team of professional, highly experienced and skilled people.

Radar is a multi-domain and multi-discipline development field, and we are fortunate to have world-renowned specialists to support our industry. It is through this expert resource base, backed by a wide diversity of support staff, that we have been able to establish ourselves, and retain, our strong position in the world radar market.

Today's complex global environment demands careful planning and execution of development and the resultant products, services and processes. The business environment requires a balance between product and technology development in order to sustain revenue and remain technologically relevant in the market-place. How a company anticipates and responds to this competitive landscape ultimately determines its survival and continuing success. We drive business on the principle of recurring long-term value-added customer engagements, a formula that has served us well over the past years and will continue to serve us well into the future.

Following on from our first 25 years, RRS has consolidated its position as a global radar company able to deliver maximum value to all our customers. We strive to uphold the highest standard of integrity in our actions and work together to meet the needs of our customers.

RRS has sustained business diversity through simultaneous domestic and foreign market business penetration. Sales volumes in these fields, both in the defence and mining radar markets, are steadily on the increase.

We would like to thank all our stakeholders for their support and contributions to Reutech Radar Systems' success and look forward to the next ten years!

Harald Bielfeld

RRS MANAGEMENT

MINING

Jan de Beer

HUMAN RESOURCES

Michelle Roos

PROGRAMMES

Jaco Roux

OPERATIONS

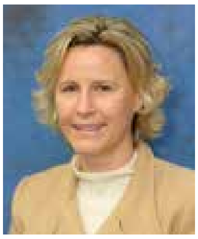
Kuben Thaver

FINANCES

Deryck Nel

INFORMATION TECHNOLOGY

Hildegard Schabort

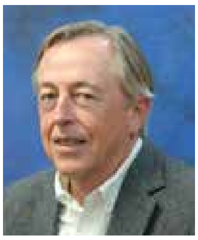


TECHNOLOGY

Pieter-Jan Wolfaardt

SYSTEMS & SOLUTIONS

Anthony Green



MARKETING & SALES: DOMESTIC

Sisa Tanda

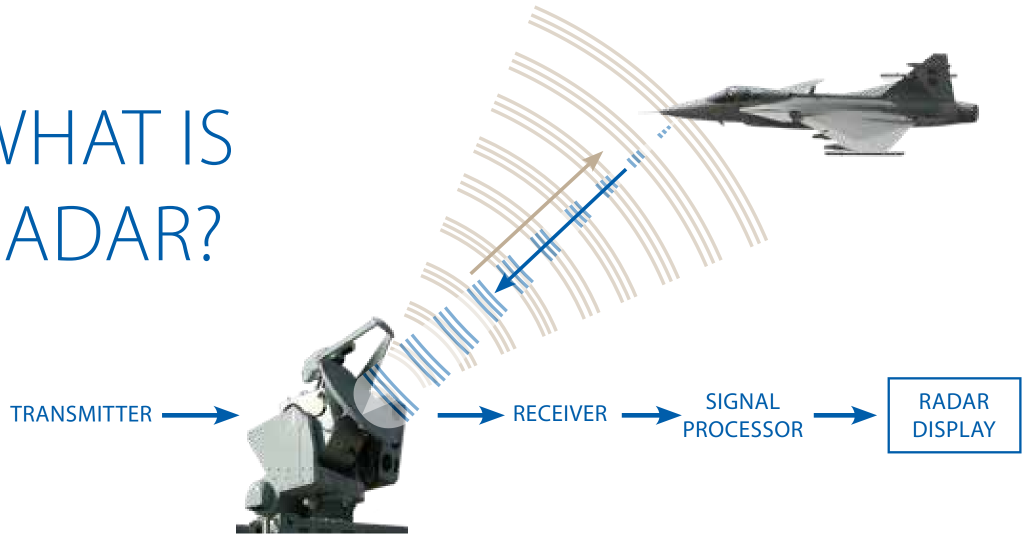
MARKETING & SALES: INTERNATIONAL

Sven Holfelder

PART 1

RADAR AND ITS HISTORY

WHAT IS RADAR?



1 The transmitter generates short pulsed signals that are radiated by the radar antenna as packets of radio waves in a narrow beam.

2 When encountering an object, such as an aircraft, the radio waves are scattered. A small fraction is scattered back in the direction of the radar system.

3 The radar antenna collects the reflected waves and routes the captured signal to the radar receivers.

4 The radar receiver amplifies and detects the miniscule echo signals and sends the information to the signal processor.

5 The signal processor extracts the desired target information and provides the information to the radar display.

6 The distance to the target is determined by the time taken by the wave to return to the radar. The pointing direction of the antenna gives us the direction to the target.

Radar (short for Radio Detection And Ranging) is a fascinating and complex technology. Modern surveillance radar provides the means to search through perhaps a 10 millions of cubic kilometres volume of air space in a few seconds and report the presence and location of any aircraft within that volume. Tracking radar can locate and track flying objects through fog to distances of tens of kilometres and accurately report their position in three dimensions. Slope stability monitoring radar can observe a mine slope from a distance of a kilometre, identify areas where the slope is moving and measure rates of movement of less than 5 mm per hour. No other systems or sensors can come even close to doing this.

A radar system detects targets by means of radio waves. In the case of a pulsed radar, the radar transmitter typically feeds a short pulse of a high-power, high-frequency electrical signal to the radar antenna, which emits a directed beam of radio waves. When these waves encounter an obstacle such as a flying aircraft or a ship, a small portion of the energy is reflected back in the direction of the radar. The reflected waves, called echo returns, are intercepted by the radar antenna and passed to the receiver, where they are amplified, processed and finally displayed. The range to the target is determined by the round trip time taken by the echoes and the direction towards the target by the pointing direction of the antenna.

Modern radars come in different guises, ranging from the small radar in a proximity fuse that may occupy a volume of less than 20 cubic centimetres, to the large thousand million dollar American sea-going X-band radar that can detect a missile at a range of 3 000 km. Some radars can locate targets in space in two dimensions, namely azimuth direction and range, while more sophisticated 3D surveillance and also tracking radars can locate targets in three dimensions in space, namely range, azimuth and elevation. With Doppler radars a fourth dimension, the relative velocity between the target and the radar, is also determined.

In this book the focus is mainly on 2D and 3D naval and ground-based surveillance radars, such as radars used at airports for air traffic control, naval tracking radars and specialised radars such as interferometric radars that monitor slope stabilities in open cast mines.

A SHORT EARLY HISTORY

The beginnings

Although it had been known since the late 19th century through the work of German physicist Heinrich Hertz that radio waves are reflected by metallic objects, the first patent relating to the detection of targets by means of electrical radio waves was taken out in 1904 by another German national inventor Christian Hülsmeyer, for his 'telemobiloscope', which he hoped could help to avoid collisions between ships. Hülsmeyer could detect the presence of moving ships with a continuous wave radar which relied on the Doppler effect* to produce a detectable signal. He demonstrated his device at various events in the same year, and it was received well by the press and the public. Unfortunately for Hülsmeyer, he was far ahead of his time and could not interest the naval authorities in his invention. Other similar devices were devised in the following two decades, but, like Hülsmeyer's system, could only determine the direction to the target: the lack of range information was a serious shortcoming.

Twenty years later the technological scene had changed completely. Radio broadcasting technology had produced electronic tubes capable of generating kilowatts of energy, as well as sensitive receivers. The enabling technology for radar existed, and it was only a matter of time before the idea of detecting targets by means of radio waves would resurface – and the time for radar as means of supplying critical and accurate information about objects in a specific air space would arrive.

Radar development prior to World War II in Britain

Following the introduction of the aircraft to a fighting role in World War I, concerns in Britain were increasing that bomber aircraft posed a threat that could not be countered. In 1932 the future Prime Minister Stanley Baldwin stated: 'I think it is well also for the man in the street to realise that there is no power on earth that can protect him from being bombed.' At that time the only technology available to detect approaching aircraft was through sound listening devices. Several large concrete sound reflectors concentrating sound onto a microphone were built in Britain, but they could at best give only a few minutes warning of approaching aircraft. A large-scale 1934 British air exercise clearly showed the shortcomings of the system: even though the routes the bombers would follow were known in advance, fewer than half of the bombers used in the exercise were detected before reaching their targets. Baldwin summed up the situation: 'The bomber will always get through.'

The Air Ministry set up a committee chaired by Sir Henry Tizard to examine and improve the air defence in the UK.

Even though there were several instances in the 1920s when engineers became aware of the presence of aircraft while testing communications systems, no one thought of using radio waves to detect approaching bombers until an article was published in the *New York Times* about a 'death ray' of focused radio waves proposed by Serbian-American scientist and inventor Nikola Tesla.

The Advisory Committee for Aeronautics, chaired by Sir Henry Tizard, commonly referred to as the Tizard Committee, asked engineer Robert Watson-Watt, superintendent of the radio department of the National Physics Laboratory in Teddington for his opinion on the death ray. In February 1935 Watson-Watt (who was later knighted for his work on the war effort) and his assistant Arnold Wilkins answered in a report, titled *The Detection of Aircraft*

*The Doppler effect or shift – named after the Austrian physicist Christian Doppler – is the shift in frequency of sound or electromagnetic waves for an observer moving relative to its source. For sound waves, it is most commonly heard when an ambulance or other vehicle sounding a siren approaches and passes the observer. The effect is also used in astronomy to determine whether and how fast stars and distant galaxies are moving away from (red shifted) or towards (blue shifted) us.

by Radio Methods, that the death ray was fiction, but added that radio waves could be used to detect approaching aircraft. Finally, the connection had been made!

After a demonstration later that same month with a continuous wave (CW) system using the BBC's short-wave radio transmitter at Daventry to detect a Heyford Bomber, a top secret development project was initiated in March 1935.

The designers decided that the system would be a pulsed system, so that the range to the target could be easily measured by measuring the time for the echo to complete the return trip from the transmitter to the target and back to the receiver.

The development team moved to Orfordness with a preliminary system built by the Radio Research Station. By May 1935, Watson-Watt's team had devised a 6 MHz pulsed transmitter that produced an output power of 100 kW and on June 17, 1935 the first echo returns were obtained from a flying aircraft. This date marks the first time an aircraft was located in azimuth and range and marks the birth of pulsed radar systems.

By the end of July the system detected and correctly interpreted echo returns from three aircraft at a range of 40 km and by the end of the year they could detect aircraft at ranges of about 100 km.

Watson-Watt became superintendent of the Air Ministry's Bawdsey research station in 1936 and work done there led to a chain of radar stations along the east and south coasts of England, widely known as the Chain Home (CH) system. The first of these became operational early in 1937, and the transmission frequency was gradually increased so that the stations operated between 20 and 50 MHz. Several companies, including Metropolitan-Vickers, GEC, Western Electric, Marconi, Ferranti, Pye and Cossor produced sub-systems for the radars. The CH system later played a crucial role in supporting the Royal Air Force during the Battle of Britain.

The Tizard committee realised that information obtained from a number of radar sensors would be useless without a proper Command and Control (C^2) system that could assemble an air picture and direct some counter action to threats. Initially reports from the different radars were telephoned through to the 'filter room' at Biggin Hill RAF Airfield, which was later moved to Fighter Command Headquarters. By the end of October 1937, twenty CH radars and the C^2 system were undergoing trials.

In the meantime, development projects were started by the Royal Navy and the British Army. The cruiser *HMS Sheffield* and battleship *HMS Rodney* were equipped with surveillance radars capable of detecting aircraft at a range of 80 km by the end of 1938.

The British developed their radar under the code name *R.D.F.* It stood for nothing, and was designed to confuse the enemy, who would be bound to link it to a radio direction finding system, abbreviated RDF.

Although they were first, the British were not the only ones to develop radar before World War II.

Developments in the USA before World War II

In the USA, Leo Young and Albert Taylor had been doing CW experiments on aircraft detection since the early 1920s and also came to the conclusion that pulsed systems would supply the required range information. Between 1933 and 1936 the Naval Research Laboratory (NRL) and the Signal Corps Laboratories (SCL) experimented with the detection of aircraft with radio waves, and by December 1934 they demonstrated the detection and location of aircraft at short ranges. Unfortunately, in the aftermath of the Depression the higher command showed little interest in funding their work.

A special appeal to the Senate Subcommittee for Naval Appropriations in early 1935 for funds to develop a 28.5 MHz pulsed system met with success, and $100 000 was made available for development work. Following a successful demonstration with a pulsed system in 1936, radar development was given the highest priority and hidden under a cloak of secrecy. After that, things progressed rapidly.

In April 1937, a demonstration 200 MHz system detecting flying aircraft at a range of 29 km was installed aboard an old destroyer, *USS Leary*.

The technology was disclosed to Bell Telephone Laboratories (BTL) and Radio Corporation of America (RCA), thus starting partnerships between industry and the military laboratories that paid handsome dividends.

In 1938 the NRL improved its system. It was designated the XAF and detected aircraft at ranges up to 160 km. During December 1938 the first RCA system operating at 385 MHz was installed on the battleship *USS Texas*, following which the XAF technology was disclosed to RCA and Western Electric and they were asked for competitive bids. RCA won the bid and in 1940 produced five CXAM systems for the battleship *USS California* and four aircraft carriers.

The SCL concurrently developed searchlight director radar for land-based air defence, designated SCR 268, which was first demonstrated in November 1938. Western Electric started production of the SCR 268 in 1939 and the first units entered service early in 1941. About 3 100 of these radars were eventually built during the war.

At the same time the SCL also developed long-range surveillance radar, designated SCR 270 for the mobile version and SCR 271 for the fixed version. Westinghouse received the production contract and delivered the first systems into service at the end of 1940. These systems could detect aircraft at ranges up to 230 km.

The Radiation Laboratory was founded at MIT by the National Defence Research Committee to do advanced research in radar in support of the Army and the Navy. The initial staff of twenty grew to 3 897 by the end of the World War II.

It appears that the Americans did not give the development of an accompanying Command and Control system the same priority as their British allies. This was clearly illustrated in 1941 during the attack on Pearl Harbour. An SCR 270 surveillance radar installed on the island of Oahu detected the Japanese raiders approaching Pearl Harbour at a range of 220 km. After checking the approaching blips for 18 minutes, and thinking perhaps something was wrong with the radar, the operators passed their observations to the newly-established aircraft warning system at Fort Shafter. The duty officer dismissed the alarm, ascribing it to a flight of US bombers known to be approaching from the mainland. The invaders were tracked until the planes were only 32 km away and Pearl Harbour was hit 16 minutes later. The radar did what it was supposed to do, but the C^2 system failed.

The Americans coined the acronym RADAR for Radio Detection And Ranging in 1941 to replace the British term RDF.

Developments in Germany

The development of radar in Germany followed a rather different route than in Britain and the USA, in that from the outset most of the development work was done in industry. Also, their initial work started at microwave frequencies and gradually moved down in frequency in search of higher transmitter power.

Rudolf Kühnhold of the Nachrichtenmittel Versuchsanstalt (NVA – Experimental Institute for Communication Systems), who is regarded as the inventor of radar in Germany, played a pivotal role by directing and coordinating activity in the GEMA and Telefunken companies. He started experimenting with a 2.22 GHz communications set that he had purchased from the firm of Julius Pintsch in 1933.

Kühnhold chose the high frequency in order to produce narrow beams with reasonably-sized antennas. His first attempts were unsuccessful because the transmitter could produce an output power of only 0.1 W. However, he got two young engineers, Paul-Gunther Erbslöh and Hans-Karl Freiherr von Willisen, interested in his experiments. They founded the company *Gesellschaft für Elektroakustische und Mechanische Apparate* (GEMA) in January 1934 and started experimenting with a CW system based on a Philips split-anode magnetron that generated 70 W at 600 MHz. Pintsch had in the meantime increased the output power of his set to 300 mW. Relying on the Doppler effect to produce a low-frequency beat signal, moving ships were detected by both systems at distances of 2 km and more.

Kühnhold worked with GEMA to improve their system to the point where strong reflections were observed from a flying aircraft in October 1934. This was good enough to obtain funding from the NVA which enabled them to turn their attention to a pulsed system. In May 1935 they detected echoes from woods across the bay at a range of 15 km, just a few months after the British and the Americans achieved similar ranges. However, this system had limited success in detecting a close-by ship and the receiver was rebuilt. In September 1935 they tracked a ship out to 8 km, measuring range accurate to 50 m and azimuth to 0.1°. The system was installed on the research ship *Welle* and marks the first time pulsed radar was installed on a ship.

Funding became available and GEMA was awarded contracts to develop the *Seetakt* naval radar and an Air Force contract resulted in the 125 MHz *Freya* surveillance radar. Several versions of this radar were developed with ranges up to 300 km and 150 sets were built during the course of the war.

A golden thread runs through the narrative of successful early radar development: the strong partnerships formed between government laboratories and private industry.

Telefunken also started experimenting with radar using pulsed techniques. In late 1938 the company was awarded a contract to develop a gun laying radar, which resulted in the *Würzburg* tracking radar. The pulsed radar radiated 10 kW pulses of 2 microseconds (µs) duration at 600 MHz. *Würzburg Riese*, a version with a larger antenna and higher power transmitter, had a range of about 70 km. About 4 000 *Würzburg* and 1 500 *Würzburg Riese* radars were produced during the war.

Developments elsewhere in Europe and the East

France and the Netherlands had radar systems before the outbreak of World War II, but development came to a halt with the German occupation.

The Soviet Union also had an active programme showing promising results. But the programme suffered a severe setback from the Stalin purge which eliminated many of the scientists working on the problem and the USSR entered World War II without a fully functional radar system.

There were early experiments in Japan, but with no cooperation between the armed services and with industry, the experiments did not lead to radars in the field. The first Japanese radars were based on German designs and only appeared late in World War II.

The Golden Thread

A golden thread runs through the narrative of successful early radar development: the strong partnerships formed between government laboratories and private industry. Government laboratories undertook the initial development of new systems and then turned their designs over to industry for industrialisation and production. As industry gained expertise, it later also initiated and undertook the development of new systems.

In Britain, many engineers and scientists were seconded from industry to government laboratories to assist with the development of radar. British industries were contracted to provide sub-systems, but system integration was handled by the government laboratories. After the war the engineers and scientists returned to industry, taking with them the expertise that enabled British industries to develop and produce radar systems after the war.

In America the government-funded Radiation Laboratory at MIT was a focal point for radar development. They had a hand in the development of the large majority of the 150 radar sets that were developed during the war. It is estimated that the industry in the USA produced a million radar sets during World War II.

In Germany a government laboratory coordinated and directed the activities in GEMA and Telefunken.

Early radar development in South Africa

Radar development in South Africa started when the British government decided in February 1939 to let members of the Commonwealth in on the secrets of radar so that they could help with the development and deployment of what was then still called RDF systems. The High Commissioners of Canada, Australia, New Zealand and South Africa were called to a meeting in London with Secretary of State for Air, Sir Kingsley Wood, and they invited member countries to send their senior scientists to Britain for a briefing.

The South African Department of Defence approached Sir Basil Schonland, head of the Bernard Price Institute of Geophysical Research at the University of the Witwatersrand, who placed himself and his institute at their disposal. Although Sir Basil could not attend the briefing in the UK, he met in September with the New Zealand delegate, Dr Ernest Marsden, on the latter's return journey by ship from the UK. Schonland joined the leg of the journey from Cape Town to Durban, where he used the facilities at the University of Natal to make copies of the few outline documents in Marsden's possession. Armed with these and the notes he had taken during the discussions with Marsden, Schonland set out to develop a South African radar system.

He assembled a team consisting initially of himself, geophysicist Dr Christopher Gane, and instrument-maker Mr J Keiller. They were joined shortly afterwards by three engineers, Dr Guerino Bozzoli (Wits), Prof Eric Phillips (Natal) and Prof Noel Roberts (UCT). They started development of a system that would operate at about 100 MHz with a pulse width of 20 µs and a peak output power of 5 kW. The pulse repetition frequency was synchronised to the 50 Hz mains frequency. They had a system – referred to as type *JB0* – up and running two months later. On 16 December 1939 the first echoes were detected from what they then believed was the Northcliff water tower. Dr Frank Hewitt, who joined the team in January 1940, thought the reflection was probably from the whole of Aasvogelskop, on which the tower stood, rather than from only the tower itself.

Steady improvements followed; by February they detected a flying aircraft at ranges up to 16 km, and by April at ranges of as far as 80 km. Around this time the Special Signals Service was established and all the members of the radar development team were inducted into the then Union armed forces.

Thus, early radar development in South Africa was limited to a military enterprise with no industry involvement. It was expected that British-manufactured sets would be deployed in South Africa. When it became clear that the delivery of those sets was going to be delayed, the Director of Signals instructed Schonland to develop a radar system for field use in the defence of Mombasa.

Work started immediately on type *JB1*. Several major design improvements by Dr Bozzoli were incorporated into the new set, but the system retained the two antennas of the *JB0*. These were synchronised by means of a hand-operated drive built from bicycle chains.

The set was taken to Durban in May 1940 for trials and erected near Umhlanga Rocks where they detected an approaching convoy while it was still far beyond the horizon under super-refractive atmospheric conditions. The set had been developed to a workable state within only six months.

The set was then taken to East Africa where it was erected at Mambrui, 160 km north of Mombasa. It was operational by July 1940. Schonland, who accompanied the set to East Africa, returned to South Africa in September and arranged for the construction of more radars. A set with a modified transmitter, type *JB2*, was installed at Thika near Nairobi, followed soon by two more of the same type.

Because of the need for a gun laying radar, the *JB* was modified to type *JB5* for this purpose. Riddled with problems, it never went into service and was scrapped. The *JB* sets were moved from East Africa to Egypt in 1941 where they were put to good use alongside British radars.

However, late in 1940 South Africa still had no radars to watch over its own ports. Since the *JB1* had performed very well against shipping in its Durban trials, a mobile radar based on the *JB1* – type *JB3* – was developed and was ready for testing by May 1941. Using two trucks and driving between Johannesburg and Vereeniging, they tracked aircraft at ranges up to 32 miles (51.5 km), at the same time proving conclusively that the radar was mobile.

This set was then driven to Signal Hill near Cape Town where it was deployed on 20 May 1941. The radar soon made its acquaintance with the Cape of Storms: the antennas were twice destroyed by storms in May and July. The problem was solved with a set of guys to anchor the antennas, while a second *JB3* system destined for Durban was completed by 22 July.

In June it was decided to construct another 25 *JB*s for deployment along the South African coast to replace the sets that had been shipped to Egypt. For type *JB4* the frequency was increased to 125 MHz, and the transmit-and-receive antennas were mounted on the same rotating mast. But since British radars once again became available, the order for *JB*s was reduced to 12.

Over the next two years a total of 25 coastal radar stations – a mix of British and South African systems – were erected, while filter rooms were established in the main centres and staffed mainly by women.

A common shortcoming of all these systems was that they could not differentiate between echoes from fishing vessels and submarines and could not be used to initiate air strikes against surfaced submarines. Nevertheless, suspicious radar tracks did lead to the identification of a submarine mother ship which entered Hout Bay. The radars were also quite effective to warn ships that were on collision courses with the coast.

The South African radar effort was an in-house military affair and did not involve South African industry until after the war, when expertise was channelled into the new National Institute for Telecommunication Research (NITR) as part of the Council for Scientific and Industrial Research (CSIR) of which Schonland was the first president.

The development of local radar systems came to a dead stop until 1951, when the NITR was asked to develop a modern surveillance radar, named the *JB51*. The second pre-production model, followed in 1959 by the first production model was deployed at Pienaars River north of Pretoria where it served as the principal training instrument for the early South African Air Force (SAAF) squadrons of interceptor aircraft.

When the SAAF started the development of an extensive air defence system for South Africa, radar technology was advancing rapidly in Europe and the USA, and the SAAF based its planning on the most modern systems. Once more South African radar development was placed on the back burner but the SAAF proved itself to be an expert user and architect of radars and radar networks. South African industry became involved in radar technology through various maintenance contracts for the defence force.

In the late 1960s a number of engineers (Dave Harrison, Lex Jackson, Olis Rubin, Jan du Plessis and others) from the CSIR's National Institute of Defence Research (NIDR) participated in the development at Thomson-CSF in France of the Cactus Surface-to-Air missile (SAM) system for the SAAF. The French Armed Forces were so impressed with the system, which had originally been called the *Crotale R440* that they too purchased the system for both their air force and navy.

The South African team returned to the NIDR in about 1970 with valuable experience in the principles and design of a modern S-band pulse Doppler radar for acquisition of low-flying aircraft and helicopters in heavy clutter, and a Ku-band monopulse tracking radar with good immunity against deception jammers and chaff.

Thus, by the mid-1970s South Africa had built up an impressive pool of radar expertise in the CSIR, the Defence Force and Armscor.

Their exposure to state of the art radar technology laid the foundation for the completely independent development at NIDR during the 1970s of a number of innovative experimental radars. These included an X-band monopulse tracking head and C-band electronically scanned altimeter for a sea-skimmer concept; a fully coherent X-band chirp pulse compression radar; the *Nimbus* pseudo-coherent Ka-band range tracking radar; and its successor, the coherent *Fynkyk* instrumentation radar with 4D tracking capability. For the X-band tracking radar receiver design, integrated stripline technology was used for the first time in South Africa by Koos Engelbrecht.

Thus, by the mid-1970s South Africa had built up an impressive pool of radar expertise in the CSIR, the Defence Force and Armscor. But the country fell short of the ability and capacity within the country's industry to design and produce its own radar systems. The closest we got was the local manufacture by ESD of air traffic control radars under licence from Selenia in Italy in the late 1970s and early 1980s.

One man was determined to rectify this situation. ESD CEO Gerrit Pretorius (commonly known as Boel) saw an opportunity and started planning to establish just such an industry – and he found able allies in Thinus Potgieter and Chris Steyn at Armscor.

By the middle 1980s, the Western world was steadily increasing the pressure on the South African government to abandon its apartheid policies through the arms embargo and cultural boycott that was gradually applied more strictly. At the same time, a strong Cuban force with USSR advisers was being built up in Angola with the liberation of Southern Africa as their ultimate goal.

South Africa had built up a formidable arms industry during the previous two decades under the guidance of the Armaments Corporation of South Africa (Armscor). The country had become self-sufficient in many fields of weaponry, including rifles, ultra long-range howitzers, ammunition, armoured personnel carriers and Infantry Fighting Vehicles. A high-tech industry had been spawned, capable of developing and producing air-to-air missiles, advanced projectiles, proximity fuses, shaped charge warheads, bombs, radar warning receivers, electronic intelligence gathering systems, direction finders and more. But there was one exception: there was no industry with the expertise and facilities to develop and produce surveillance and tracking radar systems to meet the special requirements of the South African Defence Force.

One man was determined to rectify this situation. ESD CEO Gerrit Pretorius (commonly known as Boel) saw an opportunity and started planning to establish just such an industry – and he found able allies in Thinus Potgieter and Chris Steyn at Armscor.

And thus started the RRS Story.

Background sources

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PART 2

THE COMPANY

REUTECH RADAR SYSTEMS

Reutech Radar Systems (RRS) is part of the Reunert group, a major player in the South African economy. Reunert Ltd traces its roots back to 1888 and was first listed on the Johannesburg Stock Exchange in 1948. Today, Reunert manages a diversified portfolio of businesses in the fields of electrical engineering, information and communication technologies and applied electronics. The company is listed on the JSE in the industrial goods and services (electronic and electrical equipment) sector.

The group operates mainly in South Africa with minor operations situated in Australia, Lesotho, USA, Mauritius and Zimbabwe. It has some 6000 employees including highly qualified engineers, technicians, research and development professionals and field support staff.

Companies within the Reutech Group are Reutech Radar Systems, Reutech Communications, Reutech Solutions, Omnigo, Nanoteq, Dynateq International and Fuchs Electronics.

What is known today as Reutech Radar Systems, was founded in 1987 as ESD South, a division of the Reunert company ESD. ESD was formed in the early 1980s through the amalgamation of Barlows Electronic Systems and Marconi South Africa, and was based at Halfway-House/Midrand. ESD's experience goes back to the manufacture of the Selenia (now Alenia) ATCR33 systems, which are still in use by the SAAF.

Reutech Radar Systems' product range has since expanded significantly and today includes applications both for military use, as well as for industrial, scientific and consumer applications.

Reutech Radar Systems is a living and learning company constantly adapting to a changing environment. As described in Arie de Geus's definition of a learning organisation from his book *The Living Company: Habits for Survival in a Turbulent Business*: 'It has two main hypotheses, namely that a company is a living being, and the decisions for action made by this living being result from a learning process.'

'A healthy, living company will have members… who subscribe to a set of common values and who believe that the goals of the company allow them and help them to achieve their own individual goals. Both the company and its constituent members have basic driving forces: they want to survive, and once the conditions for survival exist, they want to reach and expand their potential. It is understood that this, at the same time, is in the company's self-interest. The self-interest of the company stems from its understanding that the members' potential helps create the corporate potential.'

As with all high-technology companies, Reutech Radar Systems' key asset is talented and knowledgeable staff that thrives in an environment that encourages and rewards innovation.

REUNERT

REUNERT LIMITED

RENEWABLE ENERGY	ELECTRICAL ENGINEERING	INFORMATION COMMUNICATION TECHNOLOGIES	APPLIED ELECTRONICS	
Solar Energy	Power Cables	Business Communication	Reutech Communications	Fuchs Electronics
Storage	Telecom Cables	Total Workplace Provider	Omnigo	Dynateq International
	Circuit Breakers	Rental-based Finance	Nanoteq	Reutech Mining
		Solutions and Systems Integration	Reutech Radar Systems	Reutech Solutions

RRS PRODUCTS

Reutech Radar Systems' products are the result of intensive research & development (R&D) and systems integration.

RRS has established an extensive technology base to support the development, manufacture and maintenance of a wide range of radar sub-systems, including rotators/positioners, shock absorbers, antennas, microwave passive components, solid-state radio frequency (RF) power amplifiers, radar transceivers, frequency synthesisers, signal processors and display systems, and software/firmware. Our R&D capability allows RRS also to solve a variety of design problems that lie outside the traditional radar domain.

RRS is a supplier of search and tracking systems for application in the military and paramilitary environments. In 1999 RRS started exploring avenues beyond typical defence applications. The company now supplies movement and surveying radar systems for application in open-pit mines as well as control systems for other civil applications. It also entered the renewable energy systems market, and provides industrial solar control and generation systems.

A modern radar system uses an extraordinary wide range of technologies. The antenna itself and the microwave and RF electronics that form the heart of a radar system all require sophisticated design techniques. The robust mechanical structures needed to house and protect the system require sophisticated management of shock, vibration and other environmental factors.

Since a radar system is typically part of a larger system, electromagnetic compatibility is critically important. The antenna is pointed and stabilised by high precision electromechanical systems requiring a marriage of mechanical, electrical and power electronic sub-systems. The signal processors that extract information from the received signals rely on the latest digital technologies to reach the high processing speeds required.

In the highly competitive world of electronics, innovation is the key to success. State of the art solutions on a systems level require the continued mastery of new technologies even before they are required in final products. Often the components that result from this drive are also products in their own right and can be used as building blocks in systems developed by others.

RRS' facilities at Stellenbosch provide the backbone for its R&D and innovation efforts, which are augmented by intensive interaction with local universities, especially the universities of Stellenbosch and Cape Town. For instance, RRS and the Department of Electrical and Electronic Engineering at the University of Stellenbosch have joined forces to establish a microwave laboratory with state of the art equipment for precise microwave measurements.

THE PEOPLE

Reutech Radar Systems' team of around 220 well-qualified and experienced staff members covers all the disciplines required for complex engineering.

Mastering new technologies are risky business. By the very nature of its business, RRS needs not to be too risk averse. This implies that its operations present numerous exciting challenges and opportunities to specialist staff. These opportunities allow the company to attract and retain top people with positive, can-do attitudes.

The RRS staff component represents a diversity of culture, gender, skills, talent and qualifications contributing to the company's success. RRS offers its specialists a well-maintained and safe environment, sound IT and financial support systems, well-run stores, administrative and quality control systems, and human resources support. All of these services are provided by appropriately trained and appreciated staff members.

In line with its operations and overall approach, the RRS organisational structure is flat, and the culture is such that expertise rather than rank has the final say. Creativity is encouraged, with a strong emphasis on learning from experience, mentoring and internal knowledge sharing.

Luyanda Luwaca is adjusting Reutech Mining's MSR for optimum performance

Brent Nicol installing electronic components in the RSR 210 positioner

Carin Henn assisting a user at the IT Call Centre

You need stable hands to work on a modern PCB board

Modesty Gentle is the first person to welcome you at RRS

AWARDS AND RECOGNITION

Two Lifetime Achievement Awards have been made to two individuals for exceptional service to the company. In addition RRS also makes annual internal Technical Excellence and Service Excellence Awards since 2002.

Lifetime Achievement Awards

This award has been made twice thus far – to Pieter-Jan Wolfaardt and Prof PW van der Walt.

2010: Pieter-Jan Wolfaardt

Pieter-Jan Wolfaardt was made the recipient of the first Lifetime Achievement Award in recognition of his outstanding contribution to the success of RRS. The *Kameelperd*, *Leaf*, 360 L, *Eekhoring* Human Machine Interface (HMI), Software Signal Processor, Estonia, ModKits, Movement and Surveying Radar (*MSR*), Optronics Radar Tracker (*ORT*), RSR 210 *Nansen*, Active Protection Radar Tracker and *StealthRad* projects have all benefited from his inputs.

His most revolutionary contribution was to throw off the shackles of conventional radar dogma that preaches: *thou shalt not have grating lobes*! Pieter-Jan argued that if you can tolerate and solve range and Doppler ambiguities, why not spatial ambiguities?

With impeccable logic he convinced the doubting Thomases of the merit of his idea and the X and L-band Dual Band Radar (*DBRXL*) was born. He not only conceived the idea and sold it, but also made it work by recreating the signal processing for the first demonstration in a marathon session stretching over days.

Pieter-Jan's break with convention soon caught on. The TATS 150 Threat Acquisition and Tracking System bravely carried his idea one step further, this time resolving ambiguities in three dimensions, namely azimuth, elevation and Doppler. Pieter-Jan made a major input to make the system work, including solving the new problem of tracking targets with a dual-frequency radar. He is also admired for his ability to share information and his teaching skills.

2012: Prof PW van der Walt

Professor PW van der Walt's contribution to RRS has been legendary: from the very idea of the company until today. Since the first developments resulting in the *Hexagon* radar, PW has been a pillar of the technology innovation success that sets RRS apart from the rest. His status in the engineering and educational environment outside of RRS has also been exemplary, from his appointment to the position of Dean of the Engineering Faculty for two terms, to the awarding of the MT Steyn medal from the South African Academy of Arts and Science to his current position as Deputy Chair of the Council of Stellenbosch University.

During his distinguished career in education and engineering he has achieved a great deal in a selfless manner, with humility and respect for his fellow man. He inspired many undergraduate students to progress to postgraduate studies, which has provided enormous benefit to not only RRS, but South African industry in general.

Memories from the staff

PW remembers the beginning

'In 1985 I was sitting at the old Spier restaurant after a good lunch with Chris Steyn, Thinus Potgieter and Boel Pretorius. Thinus asked me what they should do to establish a radar industry in South Africa. My answer was to concentrate their efforts in one company. They had probably already come to the same conclusion, but I like to think that I planted a seed that day.'

'During 1986 I received a telephone call from Boel: *Would I help him to establish a radar company in Stellenbosch?* I answered by giving him a list of power transistors from the Philips catalogue that we would need for the transmitter. He ordered them – and that is how the power transistors used in all our L-band transmitters were selected.'

In 1987 PW was granted special leave by the University to help the new start-up and later spent two sabbaticals at RRS during 1988 and 1996.

'For the rest I followed the ups and downs from a safe distance, but I 'came home' in 2002 after retiring from the University. I now reported to my students! After flying a desk for 10 years at the University, RRS threw me in at the deep end and gave me design responsibility for the ModKits synthesiser. I found that in those ten years there had been a revolutionary change in the data books – but that not a single principle had changed! My conclusion is that a good education lasts a lifetime.'

PW concludes that he is 'mighty proud to still be associated with the company that we started in 1987 that has now grown to a competitor on the world stage.

'Thanks, Boel, for organising me such an exciting trip through my career! It is a great privilege to work with so many talented young people.'

PW van der Walt

RRS Excellence Awards

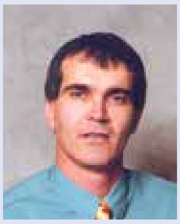
The RRS Excellence Awards have been awarded since 2002 in two categories: the RRS Technical Excellence Award and the RRS Service Excellence Award. All staff members (contract or full-time) in full-time employment by RRS are eligible, with the exception of executive management. The awards cannot be made to someone two years in a row.

The winners of the Technical Excellence category should, among others, have reached a major achievement on a tough and demanding project, exemplify learning and continuous improvement, deliver innovative work based on sound scientific and technical principles and be a team player aligned to RRS ethics and values.

The Service Excellence Awards are made to someone in a support or service roles, who provide a high standard of service, while being a team player and aligned to RRS ethics and values.

In 2020, the Selection Panel Members, appointed by the CEO, introduced the Technical Service Excellence Award. The award was to compensate for the gap that existed between the Technical and Service awards. It was also the first time an individual received a Special Award.

2002


Thierry Feret
TECHNICAL

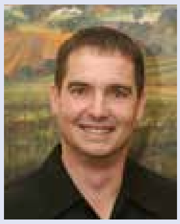

Michelle Roos
SERVICE

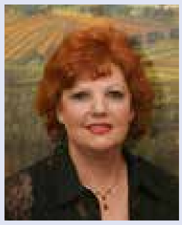
2003


Werner Steyn
TECHNICAL


Lucy Koopman
SERVICE

2004


Mike Martin
TECHNICAL


Manda Sanger
SERVICE

2005


Pierre van der Merwe
TECHNICAL


Nico Herbst
SERVICE

2006


Cornell Leibbrandt
TECHNICAL


Jan de Beer
SERVICE

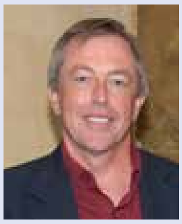
2007


Werner Steyn & Stephan Nortje
TECHNICAL


Hettie Wauben
SERVICE

2008


Bryn Jones
TECHNICAL

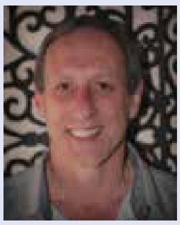

Anthony Green
SERVICE

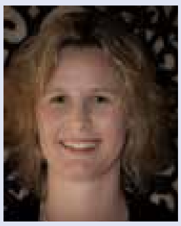
2009


Anton Joubert
TECHNICAL

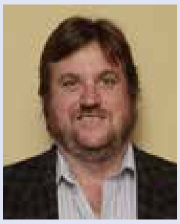

Peter Kirkpatrick
SERVICE

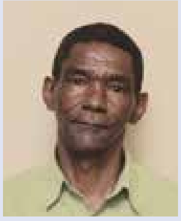
2010


Carel Kriek
TECHNICAL

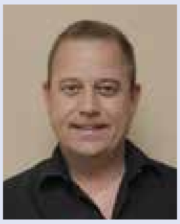

Hildegard Schabort
SERVICE

2011


Mike Movius
TECHNICAL


Jaco Mathian
SERVICE

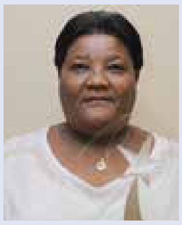
2012


Sean Hedenskog
TECHNICAL


Bertus Bresler
SERVICE

2013


Paul van der Merwe
TECHNICAL


Lucy Koopman
SERVICE

2014


Nico Bester
TECHNICAL

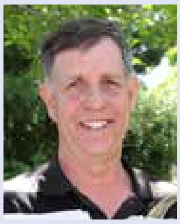

Marlinda Boonzaaier
SERVICE

2015


Paul van der Merwe
TECHNICAL

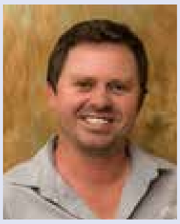

Xandri Farr
SERVICE

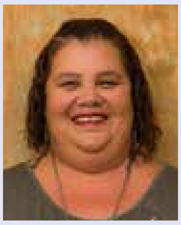
2016


Leon Nel
TECHNICAL


Marlene Robinson
SERVICE

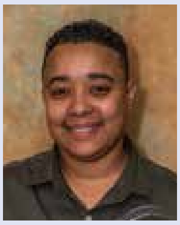
2017


Deon Steenkamp
TECHNICAL

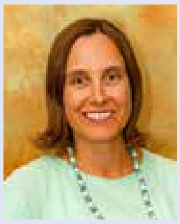

Samantha Fillies
SERVICE

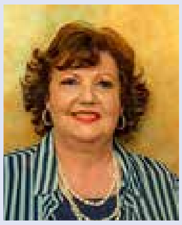
2018


Riyaadh Adams
TECHNICAL

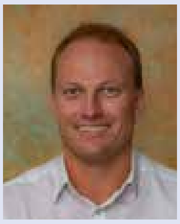

Nicole Moses
SERVICE

2019

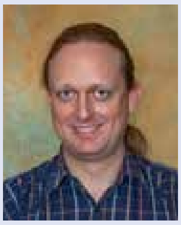

Martinette
van der Merwe
TECHNICAL


Manda Sanger
SERVICE

2020


Jurgens de Jager
TECHNICAL


Mfanelo Hadebe
TECHNICAL SERVICE


John-Philip Taylor
SPECIAL AWARD


IT Team (Hildegard Schabort, Olaf de Wet, Clint Reid,
Jose Robbertse and Onke Ruda) SERVICE

2021


Eon Burnett
TECHNICAL


Umesh Dulabh
SERVICE


Brent Nicol
TECHNICAL SERVICE

GIVING BACK:

Investing in people and our communities

As a responsible corporate citizen, RRS believes in participating in relevant programmes and ploughing back into those sectors and areas of the community with which it is closely associated.

RRS supporting the Pieter Langeveldt Primary School in Stellenbosch

THRIP

RRS has participated since 1999 in the Technology and Human Resources for Industry Programme (THRIP), a partnership programme funded by the **dti** and managed by the National Research Foundation (NRF). This programme aims at creating knowledge-based, internationally competitive South African Industries. It supports science, engineering and technology research collaboration on a cost-sharing basis with industry, promotes partnerships in pre-commercial research between business and the public-funded research base including universities and research institutions. The Technology Innovation Promotion through the Transfer of People (TIPTOP) is a part of the THRIP programme. It is an incentive mechanism to encourage industry employees to further their studies while continuing their employment and also encourages academics to obtain industry experience while remaining involved in research activities.

Up to 2012 RRS has funded 46 student-years and two TIPTOP students through THRIP. Four students were assisted to obtain PhDs while 14 completed their Masters' degrees.

Sunstep

South Africa still has a critical shortage of young engineers and scientists, especially from historically disadvantaged communities. Since 2002 RRS supported the SUNSTEP (Stellenbosch University Science and Technology Electronics Programme). This joint venture between industry sponsors and the University of Stellenbosch reaches out to learners to increase their awareness of science, electronics and technology.

SUNSTEP has trained 20 science educators and 700 learners, and to date RRS has sponsored 26% of the learners reached by SUNSTEP in the Western Cape and 20% of the learners impacted nationally.

Joint Microwave Laboratory

RRS has contributed R4.9 million towards equipment bought under the joint laboratory agreement with the Department of Electrical and Electronic Engineering at Stellenbosch. The equipment is housed either at the Department or at RRS and is available to students and academics in the High Frequency Group as well as to RRS staff.

Learnerships and study bursaries

Reutech Radar Systems focuses much of its community investment on education. The RRS Learnership programme established in 2004, has trained and employed many of the company's current staff or have supplied these trained engineering technicians into industry.

The focus on education also extends to a limited number of bursaries for university students and through support to primary schools in the region by purchasing much-needed educational equipment.

Air Defence Artillery Formation Old Boys Function

Reutech Radar Systems has been sponsoring the Old Boys Function in the Western Cape for the past 12 years. This provides a platform for retired gunners of the Air Defence Artillery Formation (ADAF) of the South African Army to get together on an annual basis and to socialise with fellow and retired gunners. The history of ADAF, previously known as the Directorate Anti Aircraft of the South African Army, dates back to World War II and was originally established at Youngsfield in the Western Cape.

Reutech Health Relay

The Reutech Health Relay is a prime event on the calendar of the South African Army, Navy and Air Force and is accessible to all members of the South

South African National Defence Force (SANDF). To cater for professional and non-professional athletes, prizes are awarded for teams based on handicapped performances and for the fastest teams. RRS currently partners with the SANDF Athletics Club to present this event.

Simon's Town Naval Base; one of the RRS Health Relay winning teams

Secondary and post-secondary support

The Reunert College was established in 1993 and forms part of the Reunert group's proud tradition of investing in education, technological innovation and industrial entrepreneurship. The College's two campuses are in Boksburg and Alberton. The year-long programme at the College aims to augment the mathematics, science and accounting capacity of a group of school leavers. Participating learners rewrite the subjects through the IEB (an independent assessment body) matric exam, and those who are successful can secure bursaries to study further and potentially gain employment at Reunert or elsewhere. Through guidance and tutoring, essential life and social skills are entrenched and build towards productive careers.

RRS also invested in the Legacy Centre, a community centre situated in Kayamandi, Western Cape. This after-school centre for more than 180 learners between Grades 1 and 12 has a programme based on the premise that the best way to bring real change and hope to the community is to build an accountable generation that will take responsibility for their own future.

Growing our own timber

South Africa faces a serious shortage of qualified young people, and the competition for talent will become ever tighter. It is a matter of strategic priority for high-tech industries to contribute to growing a qualified work force.

RRS is contributing to the pool by supporting youngsters to qualify themselves better and then offer them employment in the company.

Lerato Mogashwa is a case in point. After attending Reunert College, she enrolled for a degree in electrical and electronic engineering at the University of Johannesburg. She was awarded the B Eng (Electrical & Electronic Engineering) in 2021.


Lerato Mogashwa and Reunert CEO Alan Dickson with her awards for Reunert College Best Student in 2016

She is currently supported by RRS to study full time towards her Masters degree in electronic engineering at Stellenbosch University. Her specific area of interest is leaky wave antenna technology.

Another case study: RRS sponsored Anneke Stofberg's post-graduate studies at Stellenbosch University. Working on topics proposed by RRS, she obtained her Masters in Electronic Engineering at the end of 2014 with the thesis *IQ Reflected Power Canceller for an FMCW radar.*

She then enrolled for doctoral studies and was awarded the PhD (Engineering) degree in 2018 (dissertation: *Developing a Family of Optimal Phase Tracking Electronically Variable Attenuators with Limiter Protection).*

Afterwards, Anneke joined RRS full time. Her first assignment was to design a receiver protector: a direct application of her doctoral work.


Senior Design Engineer Dr Anneke Stofberg at work in RRS' Alpha Laboratory

RRS branding evolution

1987	ESD (Pty) Limited Edms Beperk
1993	REUTECH RADAR SYSTEMS
1995	REUTECH SYSTEMS
1998	RELNERT DEFENCE
1999	RRS
2008	REUTECH RADAR SYSTEMS

PART 3

THE RRS STORY

PREPARING THE GROUND FOR RRS

In the late 1970s, Barlow Rand subsidiary ESD had landed a contract to build eight Air Traffic Control (ATC) radars under licence from the Italian radar firm Selenia.

Gerrit (Boel) Pretorius

In July 1983 Jack Mayhew, CEO of Barlow Rand, summoned Boel Pretorius to his office. The project was running into trouble and Boel was to get things back on track. He consequently took up his duty as CEO of ESD on 1 August 1983, just a few weeks before the first systems were to be delivered. Boel found that the first system had not been fully integrated and that the project was in crisis.

This was the first attempt by South African industry to build a complete, advanced, surveillance radar, but clearly they had simply taken on too much. Having had no part in the development of the radar, the engineers were thrown in at the deep end and had to figure out the technology from Italian documents. They also produced many components in-house that would normally have been sourced elsewhere. To exacerbate the problem, at that time there was no supporting infrastructure in the country for testing radars. The Paardefontein far field antenna test facility did not yet exist and testing the large antennas became a major undertaking.

It was at this time (1983..85) that significant pioneering work was done in radar at ESD Midrand, with the production of a very high-tech "Instrumentation Radar" for use at the Overberg Test Range.

Flight tests were difficult to arrange. There were a fair number of South African engineers with academic knowledge of radar but they lacked practical experience in integrating radar systems.

Losses had run up to R17 million, an enormous amount for that time, and ESD's two shareholders, Barlow Rand and Marconi were not happy. Barlow Rand decided to take the loss for its own account, saving the relationship with Marconi.

Boel did the unheard of: he went to the Italians and asked them for help! An Italian team was sent over to South Africa and with their assistance the systems were eventually delivered to the client and are still in use at the time of writing.

Nevertheless, ESD was under pressure from Barlow Rand to recover the money that had been lost. And to add insult to injury, South Africa still did not have an industry capable of developing radars. But valuable lessons had been learnt and Boel recognised an opportunity in the country's need for a radar industry.

It was at this time (1983..85) that significant pioneering work was done in radar at ESD Midrand, with the production of a very high-tech "Instrumentation Radar" for use at the Overberg Test Range. The associated project was called SCALP and involved the integration of components sourced from abroad, together with major sub-systems which were designed and developed from scratch at ESD.

The SCALP team

We had gone head to head with the Israelis to get this contract and won! The seven ESD Midrand staff members who later joined the Stellenbosch branch in 1989 were drawn from this SCALP team (including Malcolm Sole, Ryszard Bil, Bryn Jones, John Ritchie, Chris May, Mike Movius and Eric Maxwell). They formed the core of the development team (Project *Catchy*) for the 35 GHz fire control radar.

Boel decided to have a second go at establishing a radar industry, and devised a strategy to reduce the risks. He had an excellent relationship with Keith Chittendon and Arthur Walsh of Marconi Radar in Britain, who were willing to help him. Early in 1985 and after reaching an understanding with Keith, Boel wrote an unsolicited proposal to Chris Steyn, then head of the Radar Division of Armscor. He proposed the development of a small surveillance radar for use on the *Rooikat* combat vehicle which was then under development. The risk of the undertaking would be kept at manageable levels by the technical aid and guidance from Marconi. He sent two young engineers, Steve Rich and Brian Goemans, to Marconi to gain practical experience in radar systems and to write a specification for the radar under guidance of Marconi engineers.

The search also started for a location to establish their operations. At that time there was a huge demand for engineers in the then Transvaal province (part of which is now Gauteng, the industrial heartland of the country), and job-hopping among professionals was commonplace. But Boel Pretorius had his eyes on the Western Cape, where he hoped the workforce would be more stable.

They zeroed in on Stellenbosch. The Department of Electrical and Electronic Engineering at the University of Stellenbosch had strong research groups in the fields of computer and control systems, high frequency electronics and antenna engineering. What is more, faculty policy strongly encouraged ties with industry.

'We had a requirement to do radar development and really, RRS was a solution to that problem,' says Bill Reeler, who was to become the first CEO of the company. 'It was not some grandiose idea. We would have started the company in the Transvaal at the time, where we had the necessary facilities within Reutech, but the truth of the matter was that there were not enough engineers available there. I could not understand why people would want to stay in the Cape if everything was happening up north, but it was only when I realised that people would do anything to stay in the Cape that Boel's thinking made sense to me. So when we came along and we had an incredibly technically challenging job, decent salaries and were situated in Stellenbosch, we just about had to close the doors not to have the place flooded with great engineers – which was just the opposite from what was happening in the Transvaal.'

'We hit the nail on the head by doing it that way. A lot of the original people are still involved – which is unheard of in Gauteng because people job hop and get poached by other companies. I think that you would probably find that in terms of the work being done in the country, the guys at RRS today still have some of the top jobs available,' he adds.

Boel, who had studied at Stellenbosch, contacted Prof PW van der Walt, generally known as 'PW' and co-author of this book. Boel asked PW if he was interested to become involved in his plans.

PW flew up to visit Boel in Midrand the next week, and offered his support for the project – also taking with him a list of microwave power transistors that he asked Boel to order for a power amplifier for the radar.

Boel then arranged for PW to visit Marconi Radar in Chelmsford to have a first-hand look at the microwave components developed for the Martello radar, which had a solid-state power amplifier. Boel had to go to London at the same time to finalise arrangements with Marconi.

One evening, PW found a dejected Boel at his hotel. He bore the bad news that Arthur Walsh had resigned from Marconi Space and Defence and that his successor, Rees Williams, who had previously worked in South Africa, had different thoughts about the project. Keith Chittendon had called Boel to tell him they could not go forward with the deal. Hoping to salvage matters, Boel spoke to Rees, but the latter was quite firm: the deal was off.

Boel developed serious doubts about going ahead with the project, but PW assured him of his personal support for the project. He undertook to arrange to take leave from the university the next year to assist with the project, and he would also introduce Boel to his post-graduate students. He was confident they would be able to handle the challenge: all Boel needed to do was to interest them in the project. They shook hands on the deal before their return to South Africa.

Boel asked his best technical manager, Bill Reeler, to lead the project. Bill had several meetings with Thinus Potgieter of Armscor, Prof Christo Viljoen, the Dean of the Engineering Faculty at Stellenbosch, and Prof Jan du Plessis, who led the computer and control systems group at Stellenbosch. Both of them expressed strong support for the endeavour.

The original idea was to rent office and laboratory space in the engineering faculty of the university for a small development team, but as the scope of the project started to materialise, the planned team soon outgrew the available university accommodation. Bill

Memories from the staff

Bruce Knobbs remembers

Bruce Knobbs tells how Boel Pretorius had an effect on his earlier career within Reunert: 'At ESD in Midrand in early 1989 I was standing outside Danie van Vuuren's office (Boel and Danie were both ESD executives at that time) when I overheard a conversation between Boel and Danie about allocation of people to the *Cheetah* aircraft project. It went as follows "....Knobbs will work on the VOR and then on the fire control radar (FCR) …". My career was mapped out for me! I thus worked on the VOR/ILS receiver (an aircraft navigation receiver) for about 18 months and then on the FCR and its derivative until about 1997. In 2000 he had a further effect on my career by closing down Reunert Control Systems and transferring a few of us to Stellenbosch.'

then found and rented a newly-built warehouse in the Plankenbrug industrial area of Stellenbosch.

In the meantime PW, supported by Prof Viljoen, had persuaded the university to grant him special leave for 1987 on condition that the university be reimbursed with his cost to the university. This money was used to pay teaching assistants to help carry PW's teaching load.

As agreed already in London, Boel invited PW's post-graduate students to join them in the enterprise, assuring them that the company would allow them to use their project work for their master's theses.

As agreed already in London, Boel invited PW's post-graduate students to join them in the enterprise, assuring them that the company would allow them to use their project work for their master's theses.

Piet Smit, Anton van Heerden, Don van Zyl and Pieter-Jan Wolfaardt bought into the deal. They were joined by Derek Morgan, another master's student who was being taught the intricacies of antennas by Prof Johannes Cloete.

Meanwhile Bill rushed to get things ready to start work on 2 January 1987. The warehouse was converted into offices and furniture was sent to the Cape from ESD in Midrand, with the support of Keith Wyatt, ESD's contract manager.

By the time of the annual closedown for the December holidays, just about everything was in place - except the sign with the company's name, ESD South. It would be unthinkable for Bill to welcome his team to a nameless building, so he purchased a ladder and affixed the sign himself.

Bill and his wife Marie moved to a new home in Somerset West in time to invite all to a New Year's Eve Party. Everything was set for the adventure to begin!

IN MEMORIAM

Gerrit (Boel) Pretorius passed away on 15 September 2021.

I met Boel in 1971. He was a student in the first class I taught as a then newly-appointed lecturer. We got better acquainted the next year, when I was his study leader for his thesis project – and also on those occasions when we could enjoy the occasional glass of 'Tassies' (red wine) together.

Armed with his BSc BEng qualification from the University of Stellenbosch (SU) cum laude, Boel went on to become an exceptional engineer. He also obtained a legal qualification from Unisa, and became an exceptional businessman. Boel had the gift of listening to good advice, but also the wisdom to know when not to take advice and rather to follow his own mind!

RRS occupied a very special niche amongst Boel's many interests.

His dream was to start a South African radar company. In the early eighties he carefully laid plans to start a company with Armscor's support. Central to these plans was obtaining the support of a major British radar firm to help the fledgling company on its way. His dreams were nearly shattered in 1986, when the company withdrew its support.

We were both in London at the time. Boel wanted to cancel his plans for a radar company, but changed his mind when I assured him that we had the know-how to do it and promised to help him. We shook hands to seal an agreement that never needed to be put on paper.

When RRS started out in 1987, Boel had to delegate the management of the company to others, but kept a watchful eye as chairman of its board. He wisely steered the company on a successful path.

Thirty-five years later, RRS is proof of what happens when someone works hard to make his vision come true.

Boel's friends are deeply saddened by his passing. South Africa has lost an outstanding entrepreneur – and all who knew him lost a friend and mentor. The one thing we all have in common is an enormous respect and admiration for the memory of Boel Pretorius.

PW van der Walt

1987–1989: STARTING OUT

First CEO: Bill Reeler

As BSc Honours Engineering graduate in Electronic Engineering (Digital and Control Systems) from the University of Pretoria, William (Bill) Reeler had won the HJ van der Bijl Medal for best engineering student. His subsequent career had already taken him via the CSIR and Kentron, before he joined the systems engineering group ESD in Midrand, where he became technical director of the company in 1984.

Having agreed to start ESD South, this brand new head of a new company was a newcomer to the Cape. He called up his newly-assembled team for duty on January 2, 1987, not realising that the Cape population was still celebrating *'Tweede Nuwejaar'* (Second New Year). Yet they complied and lined up for a historic photograph that marked the start of what was to become Reutech Radar Systems of today.

The group was full of smiles and eager to get started on Project *Hexagon*. Initial operations were under the banner of ESD South, a division of ESD.

Two more people came with Bill from the Transvaal: Steve Rich and Brian Goemans, the two engineers who had previously spent a year at Marconi. Bill, Steve Rich and PW van der Walt formed an executive

The 14 people who started at ESD South in January 1987. From left to right: Steve Rich, Piet Smit, Ken Smith, Brian Goemans, Bill Reeler, Anton van Heerden, Boel Pretorius, Rikus Erasmus, PW van der Walt, Derek Morgan, Don van Zyl, Pieter-Jan Wolfaardt, Riaan Louw, Pieter Kriel, Casper du Plessis committee for the day- to- day running of the project, while the rest of the technical team were Ken Smith ('Little Ken'), Piet Smit, Derek Morgan, Don van Zyl, Pieter-Jan Wolfaardt, Brian Goemans, Pieter Kriel, Rikus Erasmus, Riaan Louw, Anton van Heerden and Casper du Plessis.

The first-day photo includes Boel Pretorius, but does not show the initial office staff: Nelmarie Ackerman (secretary), Martin Smith (handyman) and his step-daughter Mauretta Philander (cleaner, who soon became the receptionist).

Ken Smith ('Big Ken'), an experienced radar designer at Marconi, decided to move to South Africa and joined the team later in the year.

Project *Hexagon*

Project *Hexagon* was a contract under project *Strelitzia* to develop a compact L-band aircraft warning radar for use on the *Rooikat* Combat Vehicle.

The system specification for the radar had been written by Steve Rich, system engineer during his stay at Marconi. The antenna, a dipole array similar in design to that of the Marconi Martello radar antenna, had to produce beam widths of approximately 15° in azimuth and 20 in elevation. The specification called for the transmission of an expanded pulse train with 1 kW peak power and repetition frequency 4 kHz on any one of 16 software-selectable transmit frequencies to provide frequency agility over the full L-band. The frequency plan for the triple conversion superheterodyne receiver was similar to that of the Martello receiver. Pulse expansion and compression was performed with Surface Acoustic Wave (SAW) delay lines.

Reutech Radar's first radar, the EDR 110 developed under project *Hexagon*

Memories from the staff

Surprise!

The first duplexer prototype had been manufactured and was ready for testing. It was a rather complex design with two large diameter low impedance coaxial lines protruding from the cavity housing the stripline circuit. The lines were terminating impedances for the PIN diodes and were important for wide-band operation. They also provided a cooling path for the diodes through a thin Teflon dielectric, hence the large diameters. The circuit had been thoroughly analysed with our Touchstone state-of-the-art circuit simulator and PW was confident that he had a winner.

Surprise! When the receiver path was switched to the OFF state, the signal happily passed through except for a single, very narrow frequency band where the specified attenuation was reached. After removing the PIN diode mounts, the stripline circuit was visible from the outside. Trying to figure out what was wrong, PW shorted the stripline to earth with a small screwdriver inserted into the hole.

Surprise! With the line shorted to earth, nothing happened. The signal passed through as if there was no obstruction! However, we figured out what had gone wrong. The signal power was transferred to higher order waveguide modes which simply propagated past the short and then reconverted to a stripline mode.

The lesson was learnt and the next attempt at the duplexer design resulted in an elegant component with excellent performance. Our dearly gained know-how was something you don't find in textbooks and was successfully applied many times in later designs.

PW van der Walt

Steve, who was responsible for the system block diagram and system integration, had to ensure that the different designers were all working towards the same end goal and that the sub-systems in combination would meet the radar specification.

Design responsibilities for the different sub-systems were delegated to Brian Goemans (signal and data processor), Derek Morgan (antenna), Piet Smit (power amplifier), PW van der Walt (RF front end), Anton van Heerden (low frequency synthesiser and up-converter), Don van Zyl (high frequency synthesiser) and Pieter-Jan Wolfaardt (receiver). Pieter Kriel was responsible for mechanical design.

Our basic approach had the long-term goal to master radar technology at a fundamental level. We designed circuitry from scratch, rather than using bought-in modules as building blocks. While this approach may have been more expensive in the short term, it paid dividends in the long run. Not only did we master the technology, we also ended up with sub-systems that we could very easily adapt for different requirements. It also lowered risk by reducing our exposure to UN sanctions that restricted the import of components for military applications.

The different sub-systems for project *Hexagon* served as the vehicles to develop and master a number of core technologies which provided the foundations for future development. Therefore we also describe the development of these systems in some depth.

Piet Smit was off to a running start with the power amplifier with the transistors Boel had bought the previous year. We designed and built two stripline tuners for load pulling and Piet, starting with the transistor manufacturer's recommended circuit layouts, steadily refined the matching circuits. The power amplifier had three stages: a pre-amplifier, driver amplifier and output stage in which the output signals of four bipolar transistors were combined to reach the 1 kW level.

The high-frequency synthesiser produced the local oscillator signal that was used to translate very high frequency (VHF) signals of the order of 100 MHz to the microwave band and vice-versa. The synthesiser consisted of a bank of 16 low noise oscillators and a 16 pole radio frequency switch and a frequency multiplier to provide the first local oscillator signal. Don van Zyl started by developing an oscillator using an SC cut crystal in a modified Leeson circuit that produced a very pure sine wave. The oscillators were individually housed in cavities machined from an aluminium block and connected to the output line with PIN diode switches.

The low frequency synthesiser had to produce the local oscillator signals for the receiver and up-converter. A low-noise crystal oscillator derived from Don's VHF oscillator was used as master oscillator and first local oscillator. The second local oscillator signal was obtained by multiplying the frequency of the master oscillator signal by four with two frequency doublers. The up-converter modulated the master oscillator signal with a short pulse. This pulse was expanded to a chirped pulse with a glass surface acoustic-wave delay line and up-converted to the second intermediate frequency (IF) and from

Memories from the staff

'You will understand'

One of the first things that PW asked after he started with ESD South was what the terms of engagement were. He was happy to fill in time sheets like the rest of the staff, but was appalled at the fact that he would get only 20 working days leave per year. When he also learnt that this leave had to be booked at least two weeks in advance, he made it clear that certain leave days in winter could not be booked in advance. When Bill questioned this he simply said: 'Just wait, you will understand.'
It took until late June that year when, after eleven dismal days of rain over the Cape Peninsula, the sun rose to a glorious 'diamond day' and Bill decided to take a day off and spend it at the beach. When he arrived in the Strand, he found most of the company already there. PW's prophecy had come true!

Bill Reeler

there to the final transmit frequency, called the radio frequency (RF), in the L-band – the frequency band between 1200 and 1400 MHz. The signal loss in the delay line was about 45 decibels (dB), so that the signal amplitude had to be recovered with a few stages of amplification. Easier said than done, because in the days before high frequency Integrated circuits, RF and IF amplifiers were built with discrete transistors and it took a few stages to recover the loss. Anton van Heerden threw himself at the task with great energy.

The first element in the radio frequency front end (RFFE) was a PIN-diode duplexer. A radar duplexer is an electronic switch that connects the antenna to the transmitter for the duration of the transmit pulse and then rapidly switches over to connect the antenna to the receiver. The duplexer must also protect the receiver at all times by blocking large signals. The duplexer was followed by a low-loss band-pass filter, a low noise amplifier and an image recovery mixer. PW van der Walt took design responsibility for the duplexer, band pass filter and mixer, while the low noise amplifier was developed by Werner Klein, one of his post-graduate students.

Pieter-Jan Wolfaardt was responsible for the receiver. He had to develop the low noise amplifier at the second intermediate frequency, the second mixer stage to mix the signal down to the first intermediate frequency and also the main IF amplifier with gain control and pulse compressor, followed by the last mixer stage down to baseband. The development task included all the filters, amplifier stages and broad-band matching networks.

The antenna and its feeds were developed by Derek Morgan. The dipole array consisted of nine identical horizontally polarised linear dipole arrays, or 'planks', stacked on top of each other to form a rectangular array. Stripline circuits were used to implement the power dividers and radiators in each plank as well as the vertical feed.

Brian Goemans took on initial responsibility for the signal processor. The processor implemented a three pulse MTI process, a Constant False Alarm (CFAR) detector and binary integrator and also provided a helicopter channel to identify helicopters via their blade flashes. Since this was before the days of wonderful devices like PALs and GALs and FPGAs, the processor had to be implemented with hard wired low power Schottky TTL integrated circuits. The processing load was kept manageable by performing pulse expansion and compression in the analogue domain with surface acoustic wave delay lines.

Data processing was performed using a Multibus II architecture using 80386 Single Board Computers (SBC). A custom-designed interface card enabled the signal processor detections to be passed on to the data processor. Within the data processor, three SBCs were used to perform plot extraction, tracking, radar manager and display functions. The display, called the Human Machine Interface (HMI) in radar parlance was based on gas plasma discharge technology.

Developing the signal and data processing hardware was a serious undertaking and help soon arrived in the persons of Johan Bras (hardware design, signal processing and plot extractor), John Stone (radar manager and control) and Theunis Bester (track-while-scan and HMI) who joined the company in April. When Brian left in 1989 Johan took over design responsibility for the signal and data processor and the display.

Mechanical engineer Pieter Kriel was responsible for the antenna rotator and the mechanical design of the antenna, antenna stowing mechanism as well as all the structural components for the radar.

By the end of 1987 most of the sub-systems had reached first prototype status. There were quite a few surprises along the way and many lessons were learnt. Meanwhile, PW qualified for sabbatical leave from the University in 1988 and decided to spend his sabbatical at ESD South.

Work continued through 1988 with the different sub-systems evolving to second prototypes. System integration started towards the end of 1988.

A memorable day was the first detection of a target in May 1989. The receiver and transmitter had been tested and integrated, but mechanical work on the antenna mount was still in progress. The excited engineers could not wait. The system was taken outside with two team members holding the antenna serving as a manual antenna positioning system. An oscilloscope was connected to the video output. A helicopter happened to fly past, the positioners swung into action and the fluttering butterfly (video trace representing the helicopter) was clearly visible!

Many hours were spent integrating and testing the radar in preparation for integration onto the *Rooikat* vehicle. Once the integrated system had passed its acceptance tests it was taken to Kentron in Pretoria for evaluation and integration onto the *Rooikat* vehicle. Johan Treurnicht was responsible for testing and recalls that the system worked quite well. However, with the changed political situation in Namibia and Angola, money for defence spending became tighter. The *Rooikat* vehicle programme was cancelled and the radar never went into production.

It did leave a tremendous legacy, though. Where we started off with nothing we now had several sub-systems that could be used as building blocks for future radars. Looking back, the spin-offs produced by this first radar project were quite remarkable.

New Projects

While all this work was in progress, Bill also had to look for future business. In March 1987, Bill met with Thinus Potgieter at Armscor to discuss the 3D radar needs and strategy. It was clear that competition was rife for research and development funding and he had quite a battle to secure funds for his young enterprise.

South Africa had acquired a few small short range *Eekhoring* battlefield surveillance radars from Israel. Plans were hatched under project *Contain I* to modify these for mounting on the *Buffel* infantry vehicle, but the radars did not meet the requirements of the soldiers who were to use them. There was a need for a longer range system on the Angolan border before the independence of South West Africa (Namibia), and they were looking for a new system. 'Armscor approached RRS and asked us if we could adapt the *Hexagon* and increase its range', explains Pieter-Jan Wolfaardt. 'There was a hectic time scale attached to it, because they wanted the system delivered within a year.

Some serious baseline creep took place and project *Contain I* migrated to project *Contain II*, with a requirement for a mobile medium range surveillance radar housed in an armoured cabin and carried by a 20 ton truck! The proposed system soon got the name *Kameelperd*.

The proposed radar system was based on the building blocks that were developed for the *Hexagon* radar. The *Hexagon* receiver, frequency synthesisers and exciter would be re-used for the new radar. Ten *Hexagon* power amplifiers would be combined by a 10 way power combiner to provide the required output power. The basic *Hexagon* antenna would be grown in size to increase the antenna gain. The antenna was to be mounted on a 10 m high foldable mast.

A second project was *Leaf*, a demonstrator for a 3D radar. *Leaf* was also based on *Hexagon* building blocks. In this case, the antenna had a vertical beam-former that could produce 8 beams on receive. Height information was extracted by comparing signal amplitudes in the different beams.

ESD at Midrand was also working on a Ka-band (35 GHz) tracking radar based on a prototype developed by the CSIR Institute for Defence Research. This project was sent to ESD South, along with engineers John Ritchie, Chris May, Malcolm Sole, Eric Maxwell, Ryszard Bil and Bryn Jones. Mike Movius followed the southward migration a year later and he and Bryn Jones drove down with a truck load of equipment and items to the new building in Technopark.

'It was really special to be the first managing director of Reutech Radar Systems, or ESD South as it was called at that time,' says Bill Reeler.

'We managed to develop, build and test the very first radar right at the start of the new company and also initiated projects to develop the *Kameelperd* medium range radar as well as 3D radar. Armscor and Reunert were both prepared to make large commitments to make sure things got off the ground,' he explains.

Bill Reeler recalls that the massive growth experienced in the beginning was not only very exciting, but also brought a number of challenges. Firstly, the need to get a radar development capability off the ground was great and there were not enough engineers in the then Transvaal to go around. 'We therefore had to go to Stellenbosch in order to find enough talent to do the job. Stellenbosch University also had two professors who were both willing and able to make a large contribution to the success of the whole endeavour: PW van der Walt and Jan du Plessis.'

Permanent building

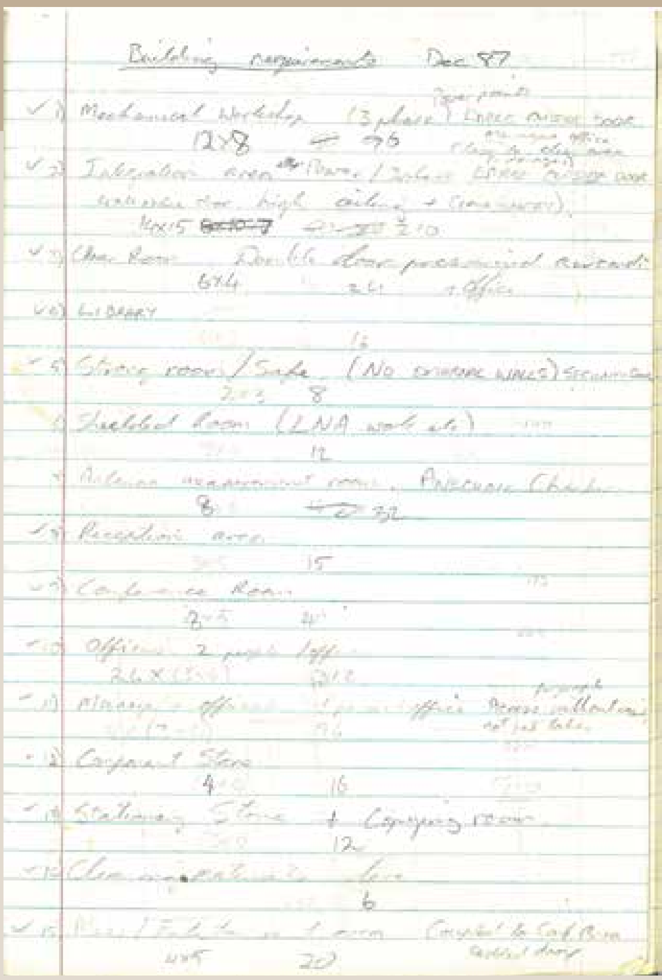
With all the wheels rolling, Bill now started to attend to the permanent housing of the enterprise. He and Boel convinced the Barlow Rand Board that an own building was the only way to meet the special requirements of a radar firm.

Christo Viljoen, the then Dean of Engineering at Stellenbosch University conceived the idea of a Technopark for Stellenbosch. With characteristic energy, he persuaded the local municipality to develop such a science park on the commonage. A hilltop site next to the Stellenbosch Golf Course just south of Stellenbosch was identified for the park. Development started in 1986, just in time for our new enterprise.

After much thought and argument because the properties came at a price, it was decided to erect the required building in the Technopark, a location within easy reach of the universities of Stellenbosch and Cape Town, the Cape Town International Airport and the industries around Cape Town that would become our sub-contractors. The chosen site was perfect for a radar company, with clear views towards the mountains surrounding the park and the valley towards Cape Town International Airport and False Bay.

Construction of the building in Technopark started towards the end of 1988, and it was ready for occupation towards the middle of 1989. Bill says one of the highlights of his period as CEO was that he

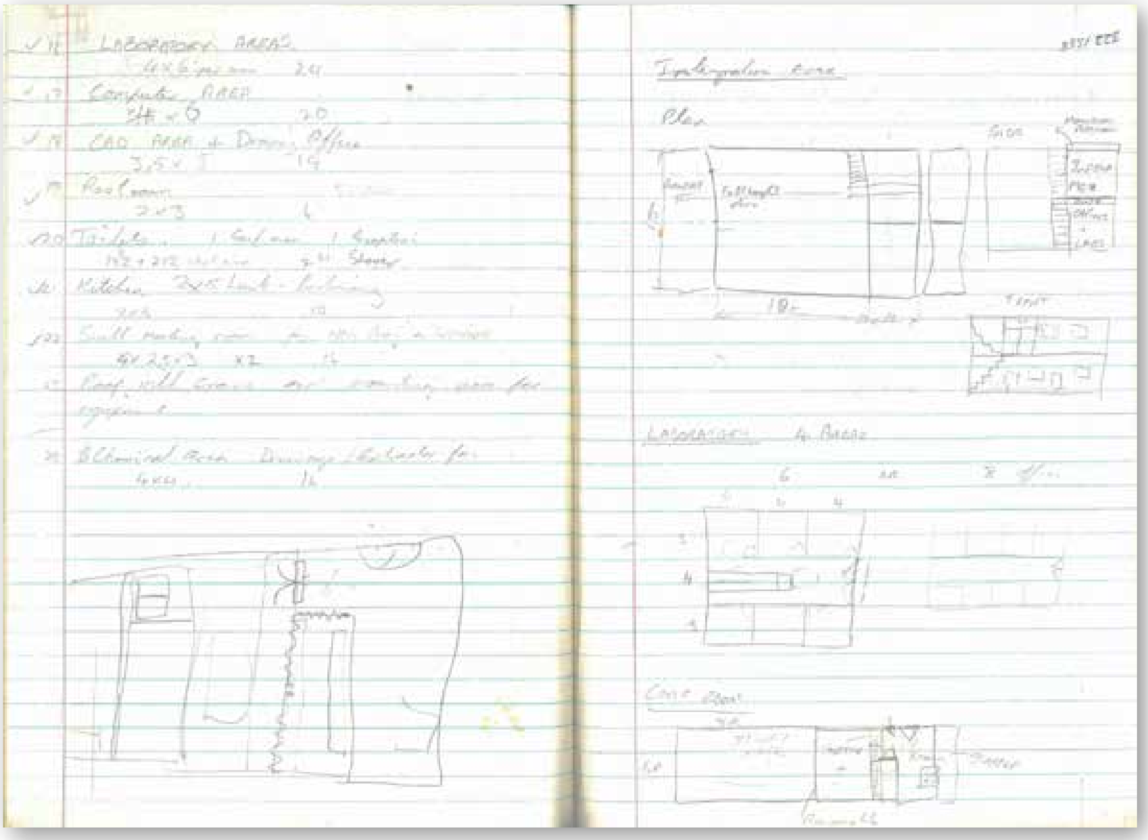
Bill and the Architect – Bill Reeler tells this story

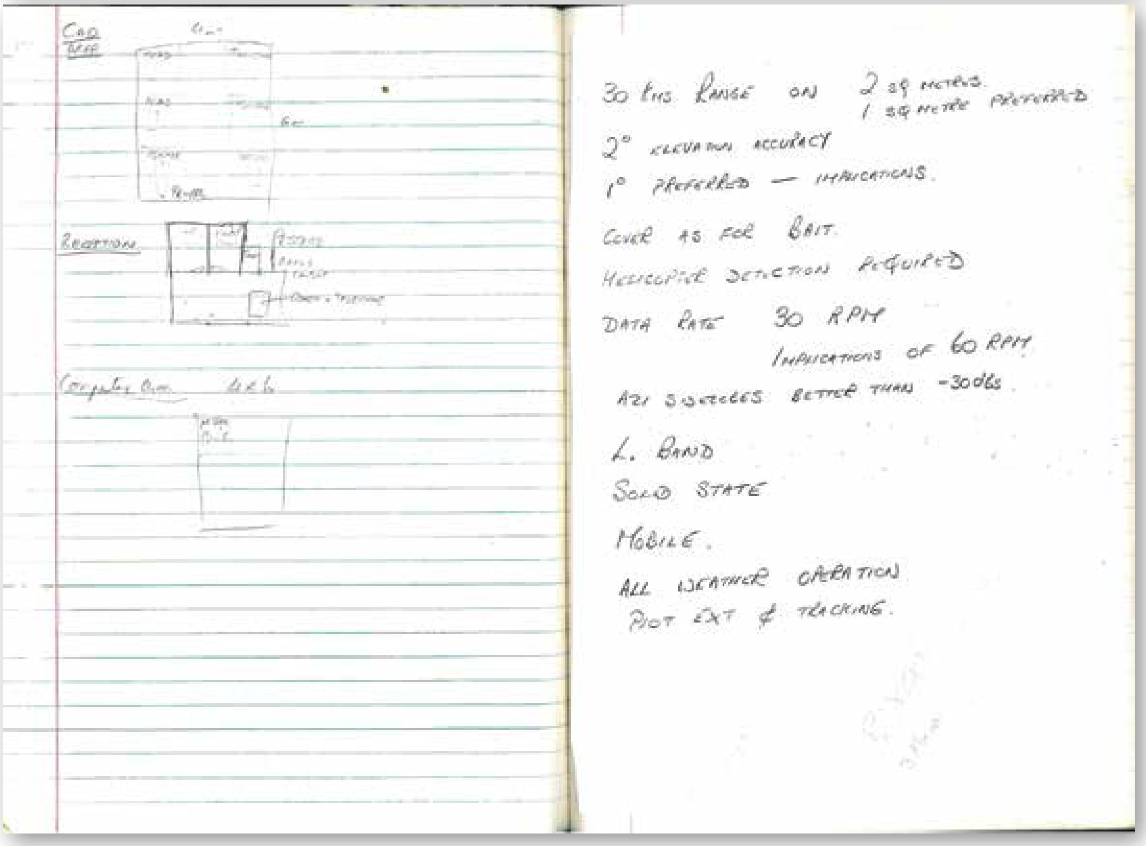


The architect of the new building was slightly-built, even by my standards, and when I saw the swing doors installed for the first time I called him and told him that the doors had been hung upside down as the 'push plate' was around my knees somewhere and I was afraid everyone would push on the glass panels. When he arrived, he briskly assured me that this was the way they had been designed, and that it was easy to walk through the door using the push plate. At this point I challenged him to walk through and push open the door walking at a normal pace and of course he had to prove it. When his hand hit the plate at that ungainly low angle, even for a tiny guy like him, his arm buckled and he walked slap bang into the door, nearly breaking his nose.

After this I could not resist taking him into the bar area where the glass racks he had designed were so high that he battled to reach the glasses, even when standing on a chair! *continued ...*

3 THE RRS STORY





Planning the new building where RRS is still housed today, Bill Reeler went to the Boards of ESD and Reunert in December 1987 to obtain approval for the building. The pictures of notes and sketches come from Bill's own black exercise book and show the early ideas. With inputs coming from PW van der Walt and Steve Rich, the architects received a very comprehensive planning brief.

had the opportunity to oversee the planning and construction of the building. It was the second major development in the newly formed Technopark.

'I have often said that being CEO of RRS is the best job in the country,' says Bill. 'The wonderful position with its views of the vineyards and the mountains and the technical challenge of the most enthralling development work, what more could a man ask for? It truly is as Christo Viljoen put it "the place where heaven and earth meet" (*die raakpunt tussen hemel en aarde*).'

Satisfied that Bill Reeler had got the enterprise started and housed in the new building, Boel Pretorius wanted Bill back in Gauteng.

Boel retained an active interest in the company. Lew Swan became CEO of Reutech Systems, which included RRS, and Boel went on to become the Managing Director of Reutech from 1989 to 1994. The contact was less frequent, although he still flew down regularly for meetings. From there Boel became the CEO of Telephone Manufacturers of South Africa (1994 – 1997) and before being appointed in 1997 as CEO of Reunert Ltd.

The small enterprise was ready for a second start, in a new building with a new CEO, Gavin Tatlow.

In discussion with BILL REELER CEO, 2 Jan 1987 – May 1989

What were the most important technological developments at the time?

Two technologies were crucial to the success of the radar industry. The first is the power amplifier for the transmitter. Here we used commercial L-band transistors to make a pulsed solid-state power amplifier.

The second very important technology was the building of the antenna using stripline techniques. This last task was accomplished with the assistance of a young expert from Britain. He came to help us in SA and developed some software that did not exist anywhere else in the world – it was brand new technology. When that was finished, we were right on the forefront of what could be done and was available at the time. It was also a great contributor to the success of the antenna that we then built.

What were the biggest challenges facing you as CEO?

There was nobody else with the right credentials and willingness to start the new company. I therefore had to uproot myself and my family and move to the Cape with an absolute minimum of infrastructure and support. Everything, including the furniture had to be put in place.

However, not only did the changes I had to make have a very positive outcome, they also made changes to my life and made me fall in love with the fairest Cape and Stellenbosch.

What were the biggest lessons that you learnt during that time?

A keen team of willing and dedicated staff can achieve much more than anyone could ever dream. Many people did not believe that the inexperienced group we had put together would be able to achieve the goals we had set but they came through with flying colours. We delivered the first working radar within two years.

Some further thoughts on the company then and now?

We were incredibly lucky that we were able to pull some of the top brains in the country into that facility and it is still the case. There is mutual respect between these people and as you chat to them you realise that just about everyone is an exceptional person.

In those days you knew everybody and the company today is still small enough for it to be a close-knit 'family type' community. James Verster, who managed the company for 6 years and I worked for another company until a few months ago. Carl Kies, the current CEO was one of the young engineers who were appointed in the early days.

1989–1994: THE EARLY YEARS

New CEO: Gavin Tatlow

Gavin Tatlow took over from Bill Reeler as CEO at ESD South and was the CEO from June 1989 until September 1994. He had been Technical Director at ESD in Midrand and before that a design engineer on Army vehicles. He had obtained his BSc (Eng) in Electrical Engineering at the University of the Witwatersrand, an MSc (Eng) in Electrical Engineering at the University of Cape Town and an MBL from Unisa.

At that time ESD Midrand was working on the ETS 2400 optronics radar tracker project *Catchy*, a contract awarded to them in 1986. Although Gavin was not involved in the project, the *Catchy* project and project team accompanied Gavin when he moved from Midrand to Stellenbosch. ESD sub-contracted the contract to ESD South.

The name ESD South was changed to Reutech Radar Systems, usually referred to as RRS during Gavin's term as CEO. The organisational structure of Reutech Systems, of which Radar formed part at that time, had Gavin Tatlow reporting to Divisional head Bill Reeler, who in turn reported to Derrill Burchell.

The early years of RRS were characterised by completing work on the *Hexagon* project which was then tailing off and the work on the *Kameelperd* medium range mobile search radar. Another highlight was the successful demonstration of the ETS 2400 *Catchy* system.

When the RRS building was completed at Technopark, Stellenbosch, it stood alone. Today it is surrounded by other buildings

The *Kameelperd* mobile surveillance radar

Kameelperd ESR 220

Negotiations to develop the *Kameelperd* had started a year earlier but the requirement was put down more or less the same time as the war in Angola drew to an end in 1988. Whereas it had originally been intended for use with air defence artillery, the South African Defence Force (SADF) also had a general requirement for such a radar.

The *Kameelperd* with Project Manager Keith Kriel and system engineer Pieter-Jan Wolfaardt became the second largest project of the fledgling company. It is a highly mobile, solid-state L-band 2D surveillance radar designed to provide early warning to air defence artillery troops in the field. From a radar point of view it is an upscaled version of the *Hexagon* radar. From a system point of view it is a mobile armour-protected surveillance radar and communications hub, capable of road speeds well in excess of 80 km/h. As a fully-autonomous armoured system with self-contained power plant packaged on a single truck, it is capable of being fully operational within 10 minutes of arrival at a deployment site.

There has been a programme of continuous improvement and upgrading on *Kameelperd.* It has been available to the SADF and SANDF ever since the first prototype system was delivered in 1992. It is now formally known as the ESR 220 *Thutlwa*. Thutlwa is the Xhosa word for a giraffe.

Even today, *Kameelperd* together with the RTS 6400 Optronic Radar Tracker (*ORT*), stand out as the two major development projects for military application throughout the history of the company. The development, testing and application of the *ORT* is discussed in more detail later.

RRS had demonstrated the company's capabilities through the successful delivery of the *Kameelperd* system to the Air Defence Artillery Formation. At the time, Brig Gen Jooste, Director of Army Acquisition said 'while the South African Defence Force budget is under pressure and the Army is adjusting accordingly, the *Kameelperd* system proves that the South African solder can still get first class equipment.'

The successful demonstration of an entirely locally-developed 2D radar in the form of *Kameelperd* also resulted in a contract from the SAAF to develop a prototype 3D radar system. At that stage the SADF and Armscor had already identified that the SAAF's surveillance radars and mission control radars would have to be replaced at some point, and the idea was to produce an indigenous replacement for the foreign-procured systems that were in use at the time and were getting old.

Leaf 340

The *Leaf* 340 search radar prototype project, the first 3D radar project undertaken by RRS, also started off in 1989. It was mainly a research project, to gain a thorough understanding of 3D radar technology. The *Leaf* 340 3D radar was the precursor of Project *Eclosion* for the SAAF.

ESR 360

The original Project *Eclosion* requirement was for a radar with a detection range up to 400 km, designated the ESR 380. Due to budgetary restrictions, it was decided to reduce the range requirement. This adaptation would still demonstrate the technology without incurring the high costs to meet the original requirement. The radar became the ESR 360, instrumented to 200 km and implemented with a partially populated antenna. The project started in 1991. It consisted of two elements: a radar sensor and a command and control centre that went

Memories from the staff

Confusion caused by an Afrikaans name

'The name '*Kameelperd*' meaning 'giraffe' caused some confusion in terms of where its technology originated from,' says Anthony Green.

At the time of its development, it was incorrectly reported in some foreign media, including *Janes,* that South Africa had obtained this technology from a Swedish company that happened also to have a radar system that looked similar to the *Kameelperd* and was called the Giraffe.

'In fact there was no technology commonality or origin between the two systems.'

Anthony Green

A model of the 3D radar ESR 360 antena

with it. RRS was contracted for the sensor part of it.

The ESR 360 was an impressive and complex machine. The antenna was 6 m in width with a height of 2.6 m. The antenna had 18 separate antenna 'planks', each with its own receiver front end and transmit power amplifier. A transmit beamformer fed the power amplifiers and the receiver outputs were split into six channels each and fed six 18-port receive beamformers to form six receive beams. Target elevation was determined by comparing the amplitudes of the signals out of the six beams. The mechanical work was beyond RRS' capacity and much of the design was contracted out to sub-contractors. The transmit and receive electronics was largely based on that of *Kameelperd*.

Albert Graham can attest to the scale of the antenna. The power amplifiers were mounted in the backbone of the antenna. The backbone was fitted with a special hoist for people working on the system. A belt failed while he was sitting on the hoist high up in the antenna backbone and he fell about 2 m to the bottom, causing some serious injuries to his back.

A further contract was later placed for an extended range system with a fully populated antenna, designated the ESR 360L. The project was managed by Lyndon Dunbar and system engineer Anthony Green.

EDR 120

Work on the EDR 120 project, a shorter-range version of the *Kameelperd*, started in 1991.

The EDR 120 system worked in conjunction with *Catchy*: the two radar systems formed the two complementary functions of air defence radar, namely general surveillance/search and tracking. Collectively, with the anti-aircraft guns the system was known as *DART*.

Hexagon had been started as part of project *Strelitzia* with the idea to have this as a designation system on the *Rooikat* vehicle - a highly mobile and fully integrated vehicle originally intended for use in the Bush War. The *DART* programme was started after the *Strelitzia* programme was shelved when the war ended. Armscor did not want to let the already-developed technology go to waste and *DART* was intended to capture this capability and became an important technology demonstrator.

Catchy

The *Catchy* Ka-band optronic radar tracker was a technology project which had started at ESD in Midrand in 1986 before the creation of ESD South by a team headed by Ryszard Bil and Malcolm Sole. It built on technology that had been developed earlier at the CSIR as the *Fynkyk* measurement system. The work done on the *Catchy* radar would later be the basis for the development of the RTS 6400 Optronics Radar Tracker (*ORT*).

Both *Catchy* and EDR 120 were development projects commissioned by Armscor that never went into production. The technology projects

In discussion with GAVIN TATLOW CEO, June 1989 – August 1994

What were the highlight projects during your period as CEO?

The *Leaf* 3D search radar prototype acquiring its first target; the optronic radar tracker (*Catchy*) being successfully demonstrated; the delivery of the first *Kameelperd* medium range mobile search radar and the start of development of the medium range 3D mobile radar.

Which internal and external influences were the most critically important in your decision-making?

Externally it was the effect of Defence Force budget cutbacks and also some reservations about whether local industry could deliver the goods. Internally it was the difficulty in recruiting good technical and project management staff. Overcoming the staff issue meant regular recruitment drives at the universities and technikons. Staff numbers grew to around 100 by the time I left.

What were some of the important technological developments at the time affecting RRS?

The advent of sophisticated signal processing microchips meant the opportunity to reduce the size of the electronics: instead of huge boxes that would need a lot of power and cooling, and because of the number of components would be less reliable and difficult to maintain, we could shrink it all down to a tenth of the size. This also made the electronics more reliable, easier and cheaper to build. Because they were programmable, errors could often be addressed with a software fix.

More powerful affordable computers enabling complex simulations to be done and these immensely more powerful computers also meant more could be achieved with less. In terms of reliability it was – and is – always a challenge to adopt some of the new signal processing components. There was always a trade-off between staying with something traditional that might become obsolete, and adopting something new but untested, that might not succeed and therefore disappear from the market.

Advent of solid-state high-power, high-frequency semiconductors: because devices that we used in the transmitters for the radar were new on the market and we sometimes had only limited support from the suppliers, it implied a learning curve to learn how to make them work reliably.

What were the biggest challenges facing RRS at the time?

Getting the Defence Force to commit to a long-range (3D) search radar project. It was a very exciting project and a technically challenging job with an excellent group of people working on it. But politically it was also quite tricky, because some members of the Defence Force were divided on whether they wanted to go that route, some being in favour of buying a complete system overseas. We had good support from Armscor who had given us a contract to develop such a system. We built a fair amount of equipment and it was successful as a technology demonstrator, and for the company to gain experience, but sadly in the end we were not successful in getting its manufacture for the SANDF approved.

Memories from the staff

Career impact

Bryn Jones has been with RRS since the company's first year and describes himself as 'SGM (Speciality Group Manager), project manager, systems engineer, designer and marketer'. He says the people who has had the greatest impact on him have probably been Malcolm Sole, Chris Reynolds and PW van der Walt.

'Malcolm was a no-nonsense person who demanded excellence, but at the same time gave you the freedom to grow technically and as a person. He was also instrumental in making us think like systems engineers and look outside the box. He never let us down.

'Chris Reynolds was one of those rare individuals, like PW, who took the time to explain technical issues and if you did not fully understand you could go back and ask more questions without feeling like a fool. They had patience and such a grasp of electronics that they could cover almost any topic.'

Bryn Jones

from Armscor played, and still play, a critical role in offering opportunities for local companies to expand their technology base.

Gavin Tatlow points out that the product developments during his period at the helm would not have been possible without the support from Reutech, Armscor and the Defence Force, as well as the enthusiastic co-operation from the various universities, especially the academic staff at Stellenbosch. The close association with Stellenbosch, particularly with Prof PW van der Walt, helped to provide a constant flow of talented engineers to the company and brought insight into new technological advances.

RRS Evolution

Tatlow explains this was also the period during which the company 'evolved into a systems design house which included mechanical engineering, software, power electronic, digital processing, RF and antennas.'

This also meant integrating in-house expertise with that of sub-contractors. For instance, for the *Kameelperd* there were large sub-contracts for the hydraulics and also for the carbon fibre antenna structure. Managing these sub-contracts and ensuring that they were delivered on time and within budget was also something new for the company's project managers.

'The original thought was that RRS would be a design house and when the design was complete, it would then be handed to someone else to manufacture. However, in the end we realised that it was not a workable solution because of the very low volumes of the high-technology systems we were designing. It would not have been practical to train a true manufacturing company to manufacture and test such systems. As we went along, we gradually realised that a project would have to be managed by RRS with portions of it sub-contracted out to specialist companies. We would then assemble, integrate and test the final system. A lot of the software development happened in-house, although portions of software have also been contracted out,' explains Tatlow.

Gavin's job was to manage a group of very bright but inexperienced engineering graduates who may not have fully realised what they had to accomplish in terms of developing products that could work reliably as planned. It was very challenging and exciting dealing with such a very intelligent group of people with their own ideas, but 'they were basically guys who had never worked in the "real world" before and although the individuals understood portions of radar, many of them had no experience of a complete radar system.'

He explains that one of the first objectives therefore was to ensure that we could build things that could work. Also, since the company had made certain commitments, there was a huge amount of work on hand. Another objective was to find more staff to work on those projects and get them trained where necessary. The company's location in Technopark, our good relations with the local universities and our reputation for doing interesting work helped provide a constant flow of talented engineers and insight in new technological advances. The company established a good workshop, while support staff and administrative appointments were also made, among others to ensure there were people to look after the documentation and archives.

The combination of R&D and getting actual products delivered was challenging 'because design engineers constantly want to make improvements but at some stage one has to say enough is enough and sometimes compromises are asked for to make it work.'

This meant that there was a huge learning curve for everybody to integrate academic knowledge with the practicalities of putting a complete system together. 'Designing something on paper is one thing, but making it work in the real world and also economical to build is a much more onerous task,' says Gavin. He adds that some of the people who had come down from Midrand had some practical experience, which was a great help.

Client relationships

'To some extent it was also necessary to educate our clients: the Defence Force and Armscor were in much the same boat as we were since this was also new to them and we were all learning together.'

Because of the nature of the business, working in the military field, it was a challenge sometimes to know exactly what the client – mainly the Defence Force at that time – needed. Quantities changed between the original brief and the final order. 'Sometimes we had to start a project before we had the contract to do it which meant we were risking the company's money, but if we did not proceed with the job, it would mean wasted human resources. Budgeting for such projects was not easy and sometimes made us and the people higher up in Reunert nervous. Most of the expenditure was on manpower, materials and sub-contracted work,' explains Gavin.

Gavin and his team managed this by maintaining close relationships with Armscor and the Defence Force to 'ensure that they knew what risk we were taking and what we were doing for them, and thus ensure that we got a viable contract out of them. It was quite a politically-charged environment as well.'

Two of the senior individuals who played an important role in successes achieved at the time was Ken Smith, who came from the UK with some experience and Malcolm Sole, who had worked in the radar industry for a number of years. 'From a technology point of view, their contributions were a huge asset in helping us to make the right technical decisions. The people who had come down from Midrand who had some radar experience in getting things built were also a big help to guide the younger and less experienced guys.'

As far as radar was concerned, Armscor saw air defence as a strategic capability and was investing in the young company RRS by giving it the challenge to develop relevant radar technology.

RRS becomes RRS

In 1993, the company's trading name was changed to Reutech Radar Systems and referred to in short as RRS, the same name by which it is known today, although there would be a few name changes between then and now.

Gavin Tatlow's objective had been to build a team of mainly inexperienced young engineers into a competent group of design, project management and systems engineers. By the time he left, RRS looked more like a company than a laboratory and there was an appreciation among the engineers that working in a laboratory is just a small part of making a company work – there was an appreciation for things such as good project management, working according to budgets and schedules. 'The mind-set change was a participative process with the senior engineers participating in the business decision-making rather than just technical decisions.'

He adds: 'My time as CEO of RRS were five of the most rewarding years of my career: challenging, doing engineering work with great people: it was fun and exciting.'

Upon leaving RRS, Gavin went on to become technical manager at another Reunert company, Telephone Manufacturers of South Africa (TEMSA), where Boel Pretorius had become the CEO.

Gavin was succeeded as CEO of RRS by Daan Botha.

1994–1999: ADAPTING TO A NEW ENVIRONMENT

Political change in South Africa was affecting every aspect of people's lives and economic activity, including the local military industry that had been supported heavily by the SADF and Armscor.

In 1991 Armscor had been divided into Denel, a new state-owned industrial company, which retained Armscor's production and research facilities, and Armscor, which retained responsibility for acquisition for the SADF. In 1994 the SADF was succeeded by the SANDF.

With the advent of a new democratic government in the country came the end of the sanctions era and the lifting of the United Nations mandatory arms embargo in May 1994. This meant major cuts in local defence spending almost immediately because the South African military products market opened up to international suppliers. 'This meant significant challenges to overcome for the local industry and we had to become much more commercially-minded,' says Daan Botha.

Companies working in the defence industry were forced to make changes to adapt and many had to downsize dramatically. Armscor funding started drying up and many technology development projects were cancelled. Although some of the companies did not survive, others – including the Reutech group as a whole and RRS in particular – did recover from this through the SANDF's Strategic Defence Packages (SDP).

Work continued on some development projects and there was a large contract – the *Kameelperd* – on the books.

New CEO: Daan Botha

After a short period of corporate orientation at Reunert Daan Botha was appointed in September 1994 as CEO of Reutech Radar Systems. The company would undergo a name change during his term and became Reutech Systems (Pty) Ltd from 1995 until 1998.

Daan held BSc, BEng (Electronics) and MBA degrees and had come from a military background. He had risen to the rank of General in the SAAF, where his management experience included positions as chief executive of logistics, engineering and technology management.

Since Daan had previously been involved in a project relating to the development and production of air-to-air infrared missiles for the Air Force, it was thought that his leadership could help RRS to move from development to production. 'We had experienced the same problem, namely that the missile development programme was located at the NIDR at the CSIR, and although the designs were good, they never progressed to become actual products. Creating the production house Kentron, had successfully transformed the project out of the R&D mode into production and delivered the missiles.'

International adventure

On 13 August 1994, a fire destroyed part of the Air Traffic Control radar at Subang International Airport in Kuala Lumpur. The Malaysian Government appealed to the world for the loan of a radar system, and in response, the SAAF made a Marconi S711 (*Sonic*) radar available to them. It was air freighted to Malaysia and made operational by the SAAF in a very short time.

At the same time the call went out from Malaysia to purchase a new transportable radar system, and RRS was given the contract against intense international competition. Because RRS' own systems could not meet the required ICAO requirements, the actual radar system was purchased from Marconi but the full spectrum of project management and systems engineering and integration was handled by RRS. The entire S-band Primary and Monopulse Secondary Surveillance Radar housing and operational centre was placed on the ground in December 1995. The system was formally handed over to the Malaysian Minister of Transport in September 1996 by Derril Burchell who was the Managing Director of Reutech Systems at the time.

Change management

When Daan took over as CEO none of the production baseline *Kameelperd* systems had left the factory floor. RRS had learnt how to progress from the laboratory on to the factory floor. It knew how to design working prototypes and had demonstrated project management and systems engineering skills through the Malaysian project. The time had come to move products from the factory floor out through the door to clients.

Although a great deal of work had been done on the prototype for the *Kameelperd*, there remained some technical issues and the South African Army was no longer prepared to invest additional funds on the project. Daan managed to convince Reunert to provide the capital to do so: it was critically important to get the job done in order to prevent the company's single, large client – the SANDF – from considering overseas sources for such systems.

For the *Kameelperd* project to succeed in as short a time as possible and for working systems to be produced for use and maintenance in the field, a new approach was needed…and found.

'We changed the prototypes into production versions by having several teams work in parallel on the systems, instead of having a large team work on a system from start to finish and completing the systems serially, one after the other. To get the systems out of the door, you would do some work on a radar, then do the same work for the next one, and so forth. The teams for the different stages differed, and so we managed to supply four *Kameelperd* systems within four years. The concurrent approach saved the client money and we made a better profit.'

'We had to try and maintain our umbilical cord to the Navy and Air Force,' remembers Daan, 'but we then started to consider and attempt to enter the industrial market.'

Becoming a product-oriented company also went hand in hand with a change in the corporate and management structure from a functional to matrix system. This had been one of the outcomes of a comprehensive strategic planning process.

'This meant we would use core competencies within the company to service all the projects. We were already working on more sophisticated radars for the Air Force as well as the optronics radar tracker for the Navy, and the same core skills could serve both,' says Daan Botha.

Logistical support

RRS also had to prove that it could not only successfully manufacture products but also maintain those in the field. At the time, in-house logistical support skills were lacking and Daan saw it as one of his challenges to ensure that the logistical support for systems was developed at the same time as the systems themselves. This included providing for all

ESR 360L at Roodewal EW camp

the necessary documentation, manuals, technicians and spare parts from the outset. It also meant that there had to be enough technicians and artisans to maintain systems. 'For some things you don't need a highly-qualified design engineer but a technician or artisan with the right skills at the right level.'

Culture change

The nature and volume of the work meant that the company also appointed a financial manager and additional administrative staff. The company had to keep an eye on its growing salary bill because the support staff's cost to the company had to be absorbed into the rates. Thus, while the looming challenges due to dwindling defence funding were clear, the company nevertheless grew in staff numbers on the back of the continued work on the *Kameelperd* systems. By the beginning of 1997, the company had 145 employees. In addition to the *Kameelperd* and *Eclosion* ESR 360 projects, a start was made with the development of the *ORT* (RTS 6400) in anticipation of the SDP.

It also became necessary to improve company processes that could lead to successful proposals and bids for contracts. Securing contracts for the supply of working products was something different from securing funds for pure technology development.

'At that time we were contracted on a cost plus basis by Armscor because of the difficulties of budgeting for development projects where it was difficult to predict the number of man-hours that would be needed, the cost of materials, sub-systems and so forth. There was a reason why the cost-plus contracting worked in the beginning but we had to become more competitive and change to a fixed cost contracting system,' explains Daan. Piet Smit developed an extensive standardised costing system for the company to prepare proposals.

'All of this meant a paradigm shift and major company culture change.'

Some smaller projects were still funded by technology development funds. Nevertheless, the company slowly shifted to survival mode while anticipating the SANDF package deals which were supposed to materialise around 1996-7, but for which contracts were only awarded in 1999.

ESR 360L trials and demonstration

In September 1996 the prototype ESR 360L 3D air surveillance radar became the first RRS radar to detect aircraft out to a range of 200 km. During these first trials, with the radar transmitting from the RRS factory in Stellenbosch, a scheduled flight up the Cape West Coast was tracked from take-off at Cape Town International airport until it disappeared off the screens near Clanwilliam. This was celebrated as a big achievement for the company.

A few months later, the system was railed to Waterkloof Air Force Base where it was exhibited as Reutech's flagship radar product at the Defence Exhibition Africa (DEXA). Its large size dominated the hangar in which it was deployed and presented the visitor with an imposing example of the company's technological capabilities. Since it was a static display within the hangar, there was no requirement to transmit and show the visitors an operational radar display. All that was required was that the system deploy correctly, for which little could go wrong. 'However,' recalls Anthony Green, 'RRS also learnt the dangers of short-notice demonstrations.'

'During the show the system was visited by a senior general from the armed forces of one of the Middle Eastern states. He announced that if we could demonstrate the successful detection and tracking of low-flying helicopters they would place an immediate order for a number of systems.

'As engineers, we were aware of the risks of demonstrating a newly-integrated prototype system that had only been on air for less than two months. Management instructed us to move the equipment to a site where we would be able to control chartered helicopters to prove to the general that the system was capable of the detection of low-flying helicopters. We were given less than a day to deploy and get the system operating properly,' Green remembers.

'The system was moved to Snake Valley Air Force base where we worked through the night to get the system operational for trials the following day. At 04:00 the morning before the trials, we went to bed less than satisfied that the system was stable enough to perform the demo.'

Memories from the staff

Daan looks back

Daan Botha singles out his successor, the late Piet Smit, as one of the most influential people in the whole history of the company:

'I had to lean very heavily on him as head of operations.

'Although there were many others, two particular stars in the terrific support team that I had were James Verster and Pieter-Jan Wolfaardt.

'I believe the strongest core competencies of RRS to be its systems and project engineering capabilities, underpinned by basic electronic and mechanical engineering skills. These competencies were the reason why the company survived through the toughest of times and also led to the successes that would follow.

'If you have systems and project engineering competencies, you can take any opportunity in that field. This was one of the reasons why RRS could successfully take on the high precision work required as of 2000 on the SALT project and why it could start moving into other industrial markets.

'I look back at the successful delivery of the first production *Kameelperd* as the major highlight of my time as CEO, followed by the landing of the ESR 360L contract and the subsequent development of the fully functional ESR 360L 3D technology demonstrator. There was also the development work done on the Optronics Radar Tracker (*ORT*) which would, in the years to follow after the tough times, become the company's largest single success story.

When the general arrived a few hours later, he says, 'we were already on station to execute the trial although we had nagging concerns over the system's sensitivity. The crackling voice over the air band radio informed us that the test helicopter had taken off from a helipad some distance away, and was on its way to the radar site at Snake Valley. Grave became our concern when the helicopter was heard chattering overhead with still no sign of it on the radar.'

The General wordlessly left the control container and was neither seen nor heard from again, says Green.

'During the post mortem, the fault was traced to prototype wiring incorrectly assembled during the demonstration deployment. The lesson learnt was never embark on a high stakes demonstration when the equipment is not mature enough to do so.'

In May 1997 RRS was given an order from Armscor for the integration of the ESR 360L 3D radar system into an airspace surveillance control system demonstrator and the detail design of the operations containers prior to manufacture by a sub-contractor were in progress. Furthermore, the integration of new components such as the new CFARs, master control and data processor interface and the digital pulse generator were far advanced. In addition, the antenna characterisation and optimisation task had been successfully completed.

DART trials

The *DART* system consisted of the L-band EDR 120 short range surveillance radar, the Ka-band *Catchy* gun fire control radar and two 35 mm Oerlikon anti-aircraft guns.

The ETS 2400 *Catchy* optronics tracker featured a sensor suite comprising a TV camera, a Forward Looking Infra-Red (FLIR) sensor and the 35 GHz Doppler tracker radar. The integrated optronics radar tracker system was a derivative of the *Fynkyk* radar prototype developed by the National Aeronautics and Systems Technology (NIAST) institute of the CSIR. In addition to the radar tracker, the system featured a fully automatic video tracking capability (by means of the M-TEK *Autotracker*) and was also capable of performing combined "sensor fusion"-based tracking.

The L-band EDR 120 short range surveillance radar directed the *Catchy* tracker to the vicinity of the target, from where the tracker with its narrow pencil beam performed a search to acquire the target. The tracker in turn controlled the guns.

The *DART* system proved its excellence during field trials and demonstrations in 1997 at the Overberg Test Range. The two radars formed the heart of the system and enabled quick detection, acquisition and precise position measurement of the target. During the field trials, the system twice engaged and shot down a towed target.

'The resounding success of the *DART* trials generated a high level of confidence in the ability of RRS to provide a modern solution to the SANDF,' said Daan Botha. Sadly, this very capable system never achieved product status.

In 1998 a corporate structure change in the Reunert group had the name of the company change to Reunert Defence ESD (Pty) Ltd. It reverted to Reutech Radar Systems (Pty) Ltd a year later.

Setback

The company experienced a significant setback that year as a result of cessation of funding for the *Eclosion* ESR 360 project. Consequently many of our staff went to work in other industries, notably the IT industry. Staff numbers dwindled to around 60 in 1999, and only started picking up three to four years later when the numbers doubled to 120 due to large contracts coming online. Two significant events resulted in a big positive change to the company's fortunes: the Strategic Defence Packages as a result of which RRS was awarded the *ORT* contract and a cash injection due to a major investment by EADS, a big European defence contractor later in 1999. In addition, there was the opportunity to work on the SALT (Southern African Large Telescope) project, which gave RRS and its engineers an important opportunity to demonstrate the company's flexibility.

Daan was succeeded by Piet Smit in 1999.

1999–2003: RECOVERY AND REGROWTH

New CEO: Piet Smit

When Piet Smit was appointed as CEO of RRS in 1999 to succeed Daan Botha, the company was at a low point and operating in survival mode with only 60 staff members. Piet had joined Reutech Radar Systems as a development engineer in 1987. Studying part-time, he obtained an MEng degree from the University of Stellenbosch and in 1994 an MBA from the University of Cape Town.

The top management then included Chris May as operations executive, Pieter-Jan Wolfaardt as technology executive, James Verster as business executive, Pieter van Antwerpen as financial executive and Frank Mueller from EADS as sales executive.

During his term as CEO, the two main focuses were on the *ORT* and later also on the Ground-Based Air Defence System (*GBADS*). *GBADS* used a building block approach to integrate current and future air defence assets into a single system. It is typically used to defend a key strategic point from aerial attack. The *Kameelperd* formed the primary surveillance sensor for this programme and this gave RRS a strong entry into the system managed by Denel.

'A lot of development work in collaboration with the CSIR had already been done prior to securing the *ORT* contract which was signed in 2000. The *ORT* took a huge amount of everybody's time. It alone drew the full-time efforts of about 40 engineers at RRS. Then there were of course the sub-contractors. I calculated at one stage we had more than 180 engineers working directly on that project, including those from sub-contractors like the CSIR, Intec and C^2I^2. The relationship with C^2I^2, who had designed the tracker radar console had soured and ended up in arbitration but it did mean that finally RRS redesigned the tracker radar console ourselves from scratch and technology remained inside the company,' says James.

RRS signed the *GBADS* contract in 2004 but the preparation for it had lasted for more than two years. At that time the South African defence industry didn't have an air defence contract management office, so James was asked to help set up such a capability. 'We did just that, but at the last moment, British Aerosystems bought a 25% stake in Denel, and it was announced they would become the prime contractor for that programme.' As part of the *GBADS* programme, RRS provided the signal processor for a radar system supplied by an overseas company.

During Piet's time as CEO the idea of a dual-band radar with an X-band add-on to the *Kameelperd* radar was also conceived. Piet had been the instigator of the idea that RRS should create such opportunities to take the *Kameelperd* into further technology development.

The signing of the *GBADS* contract in March 2003. Left to right;
Back row: Schalk Verwey, René Oosthuizen, Johnny Knoetze,
Steven Marumo, Sven Holfelder and Pieter Faure
Front: Frank Mueller, Paul Bester, Piet Smit and James Verster

New shareholders, new name

Piet Smit believed in creating strong partnerships and collaboration with other companies on specific projects and these consortiums were also aimed at securing additional contracts. One example is the company's involvement with the South African Air Defence Consortium, together with two Denel companies (Kentron and LIW) which aimed to cooperate in air force programmes locally and internationally.

The opportunity to benefit from the Defence Force's Strategic Packages and RRS being awarded the *ORT* contract has to be seen against changes in the company's shareholding and name in 1999, when DaimlerBenz Aerospace South Africa (DASA, which was later incorporated into the European Aeronautic Defence and Space Company – EADS) acquired a 33% shareholding in what was then known as Reunert Defence ESD (Pty) Ltd. The deal resulted in the company reverting to the name Reutech Radar Systems (Pty) Ltd.

The partnership deal also included the local black empowerment group Kgorong Investment Holdings (30%), while Reunert Ltd retained a 37% share. This partnership added clout to the company's abilities to pursue and capture major contracts.

The synergies for the joint venture partners were clear.

Reunert's then CEO, Boel Pretorius, pointed out that the deal would broaden distribution networks for both DASA and Reunert, while the inclusion of a black empowerment group illustrated the group's commitment to having black engineers involved in the development of 'some of the most advanced technologies in the defence of our country.'

Letepe Maisela, Chairman of Kgorong confirmed his company's core strategy to be an active investor and 'invest in commercially viable entities with above-average growth prospect. This is a small defence community and only through effective cooperation between interested parties can we really fulfil our customers' requirements.'

Speaking for DASA, Michael Woerfel said that they were proud to participate in the venture, explaining that 'the respective know-how of the partners will create a unique and outstanding centre in radar technology on the African continent. This underscores and demonstrates the commitment of the DaimlerChrysler group to the development of the South African economy and its electronic industry.'

At the time Piet Smit explained more about the background and the company's philosophies: 'We concluded three years ago that we have to develop export business to provide our local customers with the peace of mind of not being stranded on an island of technology. We have developed an excellent working relationship with DASA over the years and our products are very complementary. EADS also brings a lot of systems level experience and capability which allows RRS to expand its mission, with confidence, from radar products to ground and naval systems in the local and regional market.'

Peter Ibbeken (DASA), Letepe Maisela (Kgorong) and Gerrit (Boel) Pretorius (Reunert) at the time of the announcement of the partnership deal that had led to the formation of Reutech Radar Systems under that name

The South African Large Telescope (SALT) in Sutherland

South African Large Telescope (SALT)

RRS at that time also took its first step away from developing not only radar and radar-related systems, but also entered into its first project for a non-military client.

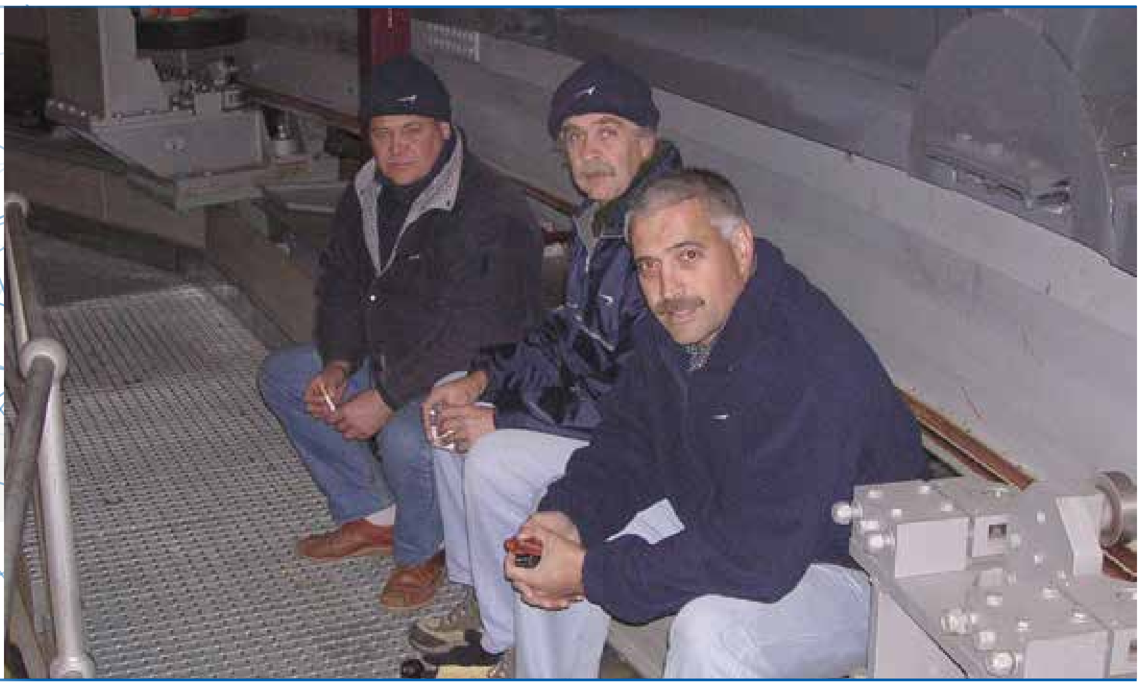
Reutech Radar Systems played a significant role in the construction of the 11-meter Southern African Large Telescope (SALT) in Sutherland by providing critical high-precision mechanical positioning and control systems for the telescope.

Piet took the lead in getting RRS involved in the project. He saw in this not so much a profitable commercial venture (there is very little mass production on such a once-off project) but as an opportunity to present new challenges to the company's engineers. Ultimately this prestigious project gave the company valuable exposure and the chance to showcase its versatile engineering capabilities.

RRS was responsible for the design, manufacture, installation and commissioning of the 10 degrees-of-freedom robotic tracker, as well as the telescope, dome and shutter drives and the associated control systems.

This largest single optical astronomical telescope in the Southern Hemisphere was funded by an international consortium and its construction was a major multinational project. Although its design concept was based on that of the Hobby-Eberly Telescope (HET) in Texas (USA), SALT has a redesigned optical system resulting in a larger field of view and effective collecting area. Its spherical primary mirror array is comprised of 91 identical hexagonal segments. The complete telescope is tilted at a fixed angle of 37º from the zenith, so that it moves only in azimuth, rotating into position on air bearings and remaining stationary during each observation.

Precise pointing and tracking are handled by moving the optical corrector assembly and instrument payload at the top of the telescope tube. During an observation the tracker has to move the camera along a three dimensional curve in space 13 m above the mirror to an absolute positional accuracy of 5 micrometers relative to the mirror. To put this into perspective, the average diameter of a human hair is about 100 micrometers.



Darrel Liebenberg, Pierre van der Merwe and Piet Smit visiting the SALT site after installation of the components

This was done by means of a hexapod, a high precision robot with six precisely adjustable legs and a laser interferomer system to measure position. This design allowed SALT to be built at a much lower cost than telescopes of that size based on conventional designs.

The precision required for such a large science instrument is cutting edge and high demands were placed on contractors and sub-contractors.

Construction on SALT started in September 2000 and it was completed and inaugurated in 2005. The Department of Science and Technology contributed about a third of the total of $36 million to finance SALT for its first 10 years ($20 million for the telescope, $6 million for instruments, $10 million for operations). Approximately one third of the $20 million funding needed for SALT came from the South African government and roughly 60% of the construction and development budget was spent within the country.

From 2006 to 2009 SALT entered a period of commissioning and performance verification of its many different systems. During the period April 2009 to August 2010, SALT was out of action whilst undergoing major testing and repair work to fix a problem with the spherical aberration corrector (SAC) which is mounted on the top of the telescope and has four mirrors inside designed to correct for the defects of the primary mirror. The telescope has been fully operational since September 2011, and is delivering important scientific data. The systems provided and installed by RRS are performing as planned.

Before the SALT project the mechanical design department had lost many of its engineers. The project strengthened and revitalised the company's electro-mechanical design capability on control systems and brought it back in-house.

'The involvement with the SALT project added greatly to our credibility,' says current CEO, Carl Kies. 'It proved the capabilities of RRS to move into industrial applications beyond the military and clearly showcased the versatility of its team of design and project engineers.'

Systems for SALT

Robotic Tracker

One of the telescope's most complex sub-systems, the tracker carries the prime focus payload which houses the optical instruments. Together the tracker and the payload are the scientific nerve centre of the telescope. The tracker operates thirteen independent real-time servo systems, including a six degree of freedom hexapod. The total mass of the payload is just over 1 ton while the tracker itself weighs an additional 4,5 tons. The tracker can position the payload so that it can acquire and track celestial objects with an accuracy of 5 microns and 1 arc second over its entire range. This is equivalent to positioning a large truck 13 m above the mirror with an accuracy a small fraction of a hair's breadth.

David Birch at the installation of the tracker's hexapod

The lift of the hexapod after the installation of the tracker beam

Lifting the tracker beam

Dome and Shutter Drives and Control

RRS designed, manufactured and installed the suspension, drives and controls of the 30 ton, 25 m diameter hemispherical dome, as well as the drives and control of the dome shutter which opens the telescope at night. The suspension bogies were designed to support the rotating dome in sub-zero temperatures and secure it in winds of up to 220 km/h.

Structure Drives and Control

RRS also designed, manufactured and installed the drives and controls to move the 100 ton telescope structure in azimuth to within 0.02º. This included the control of 8 air-bearing pads to float the structure 15 mm above the pier wall while being rotated by 2 servo-driven drive wheels. Reutech Radar Systems also supplied the pintle-bearing system that constrains the structure radially while floating on the air cushion. The pintle-bearing system also measures the azimuth position within 3 arc seconds.

The technology for the solar trackers that currently form part of the company's renewable energy projects, can be traced back to the experience gained on SALT. The company gained a capability which has positioned it well for work on any other large project where there is a need for high precision mechanical design on large structures.

Sub-systems for EADS

The joint venture with DASA/EADS also meant new contracts for a number of radar sub-systems: ModKits (a radar upgrade kit which started in 2002), the TRS 3D Antenna (part of an EADS radar product which started in 2001), the TRS 3D stabilised platform (2002), an air channel signal and data processor for a Central European client (2003) and the naval TRS 3D MRR radar rotator (2000).

The antenna and rotator were for the same EADS TRS-3D radar and RRS manufactured these items under contract to EADS. The antenna was manufactured according to an EADS design, while the rotator was developed at RRS against a specification.

EADS were systems integrators for supplying a coastal surveillance radar with an air surveillance capability for a Central European country's coastline. Because EADS wanted to maintain ageing strike craft for the Client for longer periods, RRS had earlier (in 1994) proposed a digital semi-coherent radar system for the vessels. Although the proposal for the complete RRS system did not result in an order, it nevertheless led to a contract for RRS years later with the same client to develop a signal/data processor for the shore based surveillance systems.

ModKits was another EADS sub-contract. EADS had secured a contract to upgrade a radar system in a Mediterranean country and RRS was contracted to produce and deliver the new high spec receiver, exciter and frequency synthesiser sub-systems.

Installation against a snowy background of the stabilised platform developed for EADS in Germany

The involvement with these sub-systems also had the important outcome of revitalising the company's development capabilities. Very little technology development had been done after 1996, and with these projects, several core competencies were restored. ModKits stimulated new radio frequency design capabilities within RRS for receivers as well as frequency synthesisers.

Because of these projects, as well as the requirements relating to spares production for the *Kameelperd* and *ORT* systems, it was realised that RRS needed a production department. By the time that production for the Movement and Surveying Radar (*MSR*) for the mining industry started in 2007, it was also clear that RRS needed additional space for production, and a three story extension was added to the existing building. The origins of the *MSR* is discussed from page 75.

The RTS 6400 Optronics Radar Tracker (*ORT*)

Words from the staff

Grinning and bearing it…

In 1998 the social club mid-year function was held at the Stellenbosch Golf Course clubhouse when business was going badly and the staff complement was small. The theme was 'Titanic' in an attempt to thumb one's nose at the sinking business. Everyone dressed up in gear from the early 1900s, with Piet Smit, the CEO, dressed as a penguin.

What makes it a bitter sweet memory, was the fact that the turn-around came the very next year when the South African Navy's *ORT* contract came through, and the joint venture with EADS was sealed.

Individuals who had a major role in career:

- Piet Smit as CEO taught me not only business/professional skills, but by his actions, his value system and general outlook on life also imbued people management skills.
- Derek Morgan, now in a senior management role at Vodacom, was a systems engineer on ESR 360L, the first project I worked on at RRS 18 years ago. Derek is a highly capable engineer who eased my path into the radar world through the sharing of his extensive knowledge of radar.
- Prof PW van der Walt and Pieter-Jan Wolfaardt were (and still are) the greatest contributors to RRS' design and development capabilities. This company would not be a shadow of what it is at present had it not been for their immense contribution, engineering capability and knowledge of radar systems.
- Monique Lenhoff, who was appointed by Piet, brought for the first time a professional corporate image of RRS to the outside world. Up to that point, communications were those of individual engineers who were not necessarily the best at communicating RRS' abilities. The effect that Monique's contribution over the past 10 years has had on the marketing drive, and thus my career as a business developer, is thus considerable.

Anthony Green
Product strategy executive

Words from the staff

The person who had the greatest impact on my career at RRS was Piet Smit. He had the ability to see the best in people and played a big role in my career development. He was a man with integrity and high values.

'He was my role model – a people's person under whose leadership the company could flourish and grow. As leader he was fair, yet strict in his judgement. I will always think of him with affection and respect.'

Michelle Roos
Human resources manager

'When I started working at RRS in 2002, no communication function or strategy existed in the organisation. I was therefore given a carte blanche opportunity by my then CEO, Piet Smit, to establish and implement a communication strategy within the organisation. The trust placed in me was remarkable and something that I will cherish forever.

'For me, a highlight in RRS communication was the introduction of the RRS Excellence Awards. The awards not only highlighted excellence within our organisation, they also served as acknowledgement and appreciation of the input by our employees.

'Piet Smit was a remarkable leader and individual. The phase "lead by example" could have been coined by him. He was always first in the office and last to leave, but it was his work ethics and integrity that by far surpassed any expectation. I definitely also remember James Verster as a leader without scruples to take on any challenge and succeed.'

Monique Lenhoff
Communications manager

RTS 6400 Optronics Radar Tracking System (*ORT*)

RRS formed part of the South African Combat Suite group that was awarded the contract to supply combat systems for the new Valour-class frigates (then referred to as Patrol Corvettes) for the South African Navy. The project kicked off under the leadership of Peter Kirkpatrick (programme manager) and John Ritchie (system engineer).

The order placed on RRS was for eight RTS 6400 systems: 4 *ORT*s (the full RTS 6400 system with optronics and radar trackers) and 4 electro-optic trackers *EOT*s (RTS 6400 systems consisting only of the optronics tracker that could later be upgraded by adding a radar tracker). A ninth system would in due course also be supplied for back-up and maintenance purposes. It was the largest order the company had ever received and would herald a major growth phase for RRS.

The *ORT* system was produced using expertise gained in the development of the ETS 2400 short range Ka-band optronics radar tracker (the *Catchy* system). The *ORT* development relied on contributions from several South African entities including CSIR Aerotek, who supplied the signal processors and designed the antenna, and MTech, who were responsible for the mechanical positioners for the antennas.

Increased international focus

Piet Smit's vision extended beyond the borders of South Africa and he held the view that RRS could compete successfully on the international stage. He started a new focus on finding opportunities for export and supplying both sub-systems and complete systems to foreign customers. He was the first CEO of RRS actively to pursue the building of relationships with a new set of international contacts.

This new understanding of foreign markets was invaluable and led in due course to selling a naval radar to Norway and mining products to a number of countries.

In December 2003 Piet was appointed managing director of Reutech Ltd and on 1 August 2008, he assumed the responsibility of Chief Operating Officer of CBI-electric.

It was with deep regret that the people at RRS learnt that Piet Smit passed away on 27 August 2009 following a difficult period of illness. Piet will long be remembered for his warm personality, strength of character and great contribution to the success of RRS.

ORT stories

Cornell Leibbrandt remembers the first acquisition of a target at Overberg. The *ORT* project team was camped for weeks at the Overberg Test Range just outside Bredasdorp.

A young team with limited experience worked under pressure yet made progress, little by little. Initial successes involved getting all the sub-systems to boot successfully. This was followed by all sub-systems booting and being successfully configured by the central data processor and the ability to flow data through the system in an 'open loop' fashion. They also worked hard at developing tools that allowed the team to visualise and later capture the massive amounts of data being generated.

The team had to figure out how to align the system relative to the Earth, how to align the sensors with one another, how to think in deck relative (DR) or Locally Level Locally North (LLLN) reference frames, how to use an 'Optical Put-er On-er' (OPO, a South African term for an Optical Target Designator) to designate the tracker to a certain target and to show all of this information on the tracker radar console. 'Basically we were there to build a fire control radar system from scratch, starting with the numerous sub-systems fitted into the various racks,' says Cornell.

The team spent a long time trying to successfully close the loop, 'And then, suddenly, late one evening everything just came together and worked. Our

An optical 'Put-er On-er' (South African slang for an optical target designator) in use during the *ORT* trials

Peter Kirkpatrick, Mike Movius, Hennie Jordaan and Cornell Leibbrandt at the arrival of the *SAS Amatola* in South Africa on 4 June 2003

OPO designation resulted in a quick slew towards the target, followed by successful detections off it. The range gate was opened and from then on we were tracking. And we could do it repeatedly. The team was ecstatic.'

Amatola arrives and tests start

The new frigates for the South African Navy were built to the MEKO modular design concept, and are designated as the MEKO A-200 SAN class frigate. They were manufactured by the European South African Corvette Consortium (ESACC), consisting of the German Frigate Consortium (Blohm+Voss, Thyssen Rheinstahl and Howaldtswerke Deutsche Werf), African Defence Systems (ADS – part of the French Thales defence group), with a number of South African

The project group at a function celebrating the delivery of the first *ORT* and *EOT* to the *SAS Amatola* (23 September 2003) companies, including RRS, supplying systems and sub-systems.

The first of these, the *SAS Amatola*, was built at the Blohm+Voss shipyards in Hamburg, Germany, and she arrived in South Africa on 4 June 2003, much to the excitement of all concerned.

'There right before us was this massive, gleaming warship sitting, waiting to be fitted with our *ORT* and *EOT* systems,' remembers Cornell Leibbrandt. 'The contractors were allowed onto the *Amatola* for an inspection. We were able to quickly find our way to the operations 'room-to-be', as at this stage it was bare with bunches of cables sticking out of the raised floor and dangling from the ceiling, yet to be interfaced with equipment, including the *ORT* and *EOT* tracking consoles. We then made our way up to the weapons equipment room where the *ORT* below decks racks were to be installed. It brought home to the team the magnitude of the job ahead.'

The commissioning of the *ORT* and *EOT* trackers on the Navy's frigates required a range of stringent and formal tests. The *ORT* team members attended numerous tests and trials on the *Amatola,* including Surface-to-Air Missile (SAM) and Exocet Surface-to-Surface Missile (SSM) firing trials.

Of the whole testing and qualification regime, one of the *ORT* team's biggest highlights was the successful tracker stand-alone Sea Acceptance Trial (SAT1), which formally proved that the specified tracking

Surface-to-Air Missile firing trial on the *SAS Amatola*

accuracy and specified ranges where a certain probability of detection will be reached against a particular target could be achieved. Prior to that, 'many long days and nights were spent on-board the *Amatola*, both alongside and often out at sea, or spent shuttling between Stellenbosch and Simon's Town on numerous tests,' according to Cornell Leibbrandt.

'The Sea Acceptance Trial was a real turning point, since apart from being the stamp of approval of all the preceding effort, it also meant to the project team that the trackers could do what was specified.'

Another highlight was extending the *ORT* range. The specified instrumented range for the *ORT* radar was

Constant Force Shock Absorber

The ship-borne stabilised platform for the TRS3D antenna had to protect the antenna mounted on the platform against damage in the event of a mine exploding close to the ship and had to meet a very demanding shock specification.

Ferdie Kluever devised an innovative mechanism that was rigid until the load on the device exceeded a certain threshold, in which event the device would 'collapse', thus limiting the force that could be transmitted to the antenna through the platform to a safe level. Once the load returned to normal levels, the device would snap back to its original rigid configuration.

The solution proved to be controversial. While our tests showed that the device did what it was supposed to do, the client was sceptical that the radically different approach to protection against severe shocks could work.

The argument was finally settled when the ultimate test was performed: a real mine was exploded close to the ship. After the smoke had cleared, the stabilised platform and its precious antenna load emerged from the test unscathed!

25 km. 'Armed with the confidence of an approved Sea Acceptance Trial, we later came up with waveforms allowing us to more than double our instrumented range. It was really phenomenal to track target so far outbound and it was even more impressive to be able to acquire and establish track on inbound targets. More often than not, with pre-knowledge of the approximate bearing of an approaching aircraft, the *ORT* was able to achieve automatic self-lock-on before the ship's surveillance radar had established track on the target,' says Leibbrandt.

Among the important system functionality that was tested comprehensively, was the Gun Bias Calibration and Correction (GBCC), which involves a process of intricate interaction between the allocated gun and the *ORT*.

The RRS team working on the *ORT* and its commissioning faced many challenges to deliver on time and within budget.

'I think I speak for everyone that was part of the tracker programme in saying that an extremely strong tracker team spirit developed during the course of the programme. Members shared a sense of belonging to a "family" and each of us knew he (or she) could count on the other to do what needed to be done,' says Cornell Leibbrandt.

SAM firing trail

In support of the main combat suite integrator, some members of the project team found themselves on board the *Amatola*, and part of a Surface-to-Air Missile (SAM) firing trail. The target was a drone towed far behind a fast Lear Jet.

In the Ops room one could just hear a whooshing sound as the missile took off on its way to the target.

During the dry-runs great care was taken to ensure that the *ORT* was tracking the drone and not the Lear Jet and that the process could be reliably repeated.

One could cut the tension in the ops room with a knife…and then the 'red' run started. The surveillance radar did a great job of designating the target to the *ORT*. The *ORT* flawlessly acquired the drone during the first attempt and established a solid track on it. The drone was running in quite fast and at the right instant the SAM was launched.

In the Ops room one could just hear a whooshing sound as the missile took off on its way to the target. A few seconds quietly ticked by and then, in a flash, the target exploded as the SAM struck it from above. On the *ORT* range trace one could still see a return signal for a few seconds and then the *ORT* lost track on the drone as it had disappeared into the sea. It was a direct hit!

2004–2008: GROWING TECHNOLOGY AND INNOVATION

Brimming with confidence after the successful development of the SALT, *ORT* and ModKits systems, RRS was ready for more challenges. Several unique new radars were conceived and developed over the next few years, firmly establishing RRS as a boutique radar house that had the flexibility to tackle novel problems for its clients.

New CEO: James Verster

On 1 January 2004 James Verster became CEO of RRS – a post that he would hold until 31 January 2010.

James obtained his BEng from Stellenbosch University and enrolled for an MEng at Pretoria University while working as a development engineer for ESD. He moved to RRS as a development engineer in March 1993. He later became responsible for business development at RRS and while studying part-time for his MBA at UCT was put in charge of the development section prior to being appointed CEO.

James's time as CEO was marked by the commissioning of the *ORT* systems, the largest project in the company's history. James was willing to take some risk by co-funding development, and this made possible the initiation of several new development projects including the Mining and Surveying Radar (*MSR*), the Dual Band X-and L-band technology demonstrator *DBRXL*, the RSR 210 naval surveillance radar and the *StealthRad* series of FMCW surveillance radars.

ORT commissioned

The development of the RTS 6400 Optronics Radar Tracker (*ORT*) culminated in a major milestone when the system was accepted and qualified for the four MEKO A200 Patrol Corvettes of the South African Navy. The official handing-over ceremony and commissioning parade of the First-of-Class vessel *SAS Amatola* took place in Simon's Town, South Africa on 16 February 2006.

These ships are amongst the most advanced warships in the world today. Featuring a stealth

The RTS 6400 *ORT* system is the first South African radar tracking system to have been fully commissioned into the South African Navy. The official handing-over ceremony and commissioning parade of the *SAS Amatola* took place in Simon's Town on 16 February 2006

The RSR 210N

design, *SAS Amatola* combines a number of world-first propulsion technologies with an innovative and largely South African combat system including locally designed combat management, communications, electronic warfare, tracking radar, electro-optic, missile and gun systems from more than 20 South African high-tech companies, making the ship a show-case of SA engineering ingenuity and skill.

RSR 210N introduced

The naval and para-military small vessel market had a need for a light-weight air/sea surveillance radar that could provide fire support as a stand-alone sensor or as part of a combat suite. A market survey further identified the need for a radar that could provide a close-in surveillance capability on larger vessels, specifically for guiding helicopters.

RRS saw an opportunity to offer a low-cost and low-risk solution for such a radar by adapting the technology developed for the RTS 6400 *ORT* tracking radar which by then had entered service with the South African Navy to provide a search radar function.

On helicopter-equipped vessels, they also offered support for helicopter guidance during landing in high seas and adverse weather conditions.

The increased focus on border surveillance and protection at sea, including protection against smuggling and piracy, further intensified the demand for improved surveillance tools for smaller vessels.

The RSR 210N radar concept was introduced to the South African Navy and others at functions in Pretoria and Simon's Town in October 2005.

The development of the RSR 210N concept is a perfect example of how, over the years, RRS has used the experience gained in the development of one new radar to lay the ground for further advancement and other products. This approach made it possible to set up a demonstration model in a very short time using sub-systems from the *ORT* radar.

Because of the different requirements of surveillance radars and component obsolescence, the eventual ship-borne product was a newly developed system that drew on existing core competencies in the fields of radar signal processing such as the RRP 500 software signal processor, frequency synthesisers, antennas and precision electro-mechanical positioner systems.

The RSR 210N offers performance at the high end of the 2D combat radar spectrum at a competitive price.

Proving that it works

At the demonstration in Simon's Town of the RSR 210N

Prior to being given the Norwegian contract for the RSR 210N which at that time existed only on paper, the development team built a helicopter control radar concept demonstrator into the *ORT* integration container.

'In the weeks preceding demonstration date, the sea was generally calm and we were able to configure the system as surveillance radar during this period and got it to perform pretty well,' remembers Cornell Leibbrandt.

'However, on the morning of the demonstration we knew that we were in trouble. The wind was howling and the normally calm sea had turned into a bit of a monster, reaching sea state 3 and possibly higher.

'We were swamped by hundreds of plots over the sea with these in turn causing many false tracks to establish. Essentially the radar picture was useless, at least based on the system configuration set-up at that time which we had worked so hard on during the preceding days.

'Then the high-level delegates from the South African Navy, Reutech, Reunert, IMT and most importantly, the potential Norwegian clients started to arrive. The technical team was becoming quite anxious and hoping for the sea to calm. Instead, conditions got worse.'

Cornell adds that the delegates were gathered in a tent arranged for the demo, complete with big-screen TV to remotely show the Human Machine Interface (HMI). 'The radar picture looked like total chaos – many plots were declared over the sea and many false tracks were being generated. One could hear mutterings coming from the audience…

'The demo was started by Mike indicating to the audience "Now watch this!" On cue, we enabled Doppler filtering, notching out the effect of the wind-blown sea clutter.

'The effect was immediate; the audience fell silent, and the radar picture cleared up dramatically as sea clutter induced plots were no longer being generated. The last remaining false tracks soon died away and within a matter of a minute or so the radar picture was as good as one could hope for. It was clean with a few plots appearing randomly here and there as expected and we had beautifully clean and solid tracks of a number of airliners taking off from Cape Town International Airport. We had tracks of the remaining big vessels still out in False Bay and to top it all, we had an excellent track on our small test helicopter, flying towards us hugging the coastline.'

The Norwegian contract was signed about ten months after this demonstration.

NATO MILESTONE:

First major export order on a product level

Very good news relating to the RSR 210 was to follow in 2007. Anthony Green had spent three years building a relationship with the Norwegian Navy to understand their needs.

Anthony Green and James Verster celebrating RRS' first major export order

The RSR 210N was a perfect solution for their requirement but existed only on paper. A technology demonstration was arranged at Simon's Town with an adapted *ORT* system fitted with an antenna supplied by the Norwegians. The successful demonstration on a windy day with a very rough sea convinced the client of the merits of the radar. In December 2007 RRS won a contract as major sub-supplier of Norwegian company Electronicon, to supply the Royal Norwegian Navy with the RSR 210N for its five Fridtjof Nansen-class frigates, with primary role as helicopter control radar and additional supplementary surveillance capabilities. The deal also included ship integration services and a logistics package that included spares, training and documentation.

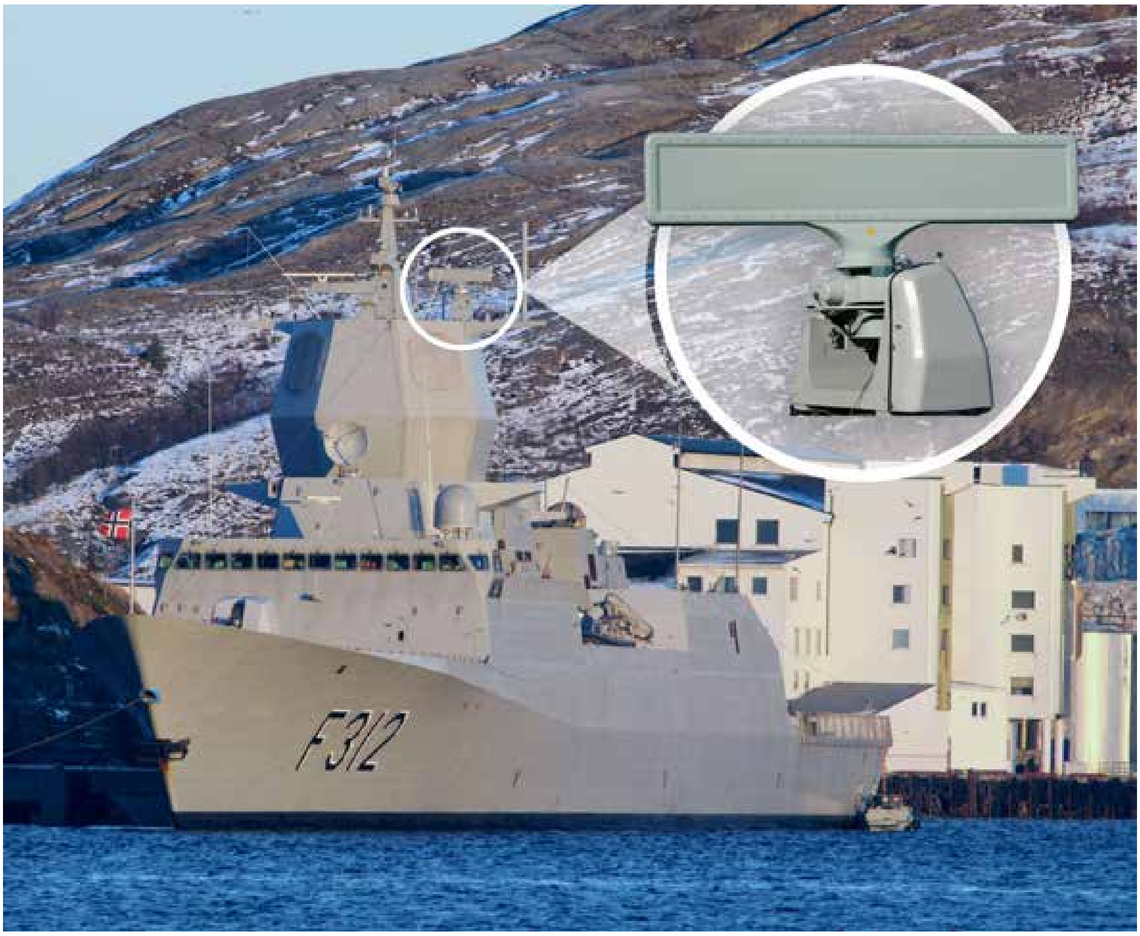
This was the company's first major export sale on a complete product level, therefore a particularly important international contract to strengthen the company's image as reliable supplier among international defence contractors.

The RSR 210N project team is extremely proud of the fact that, apart from the Waveguide Pressurisation Unit, all major installable units of the radar were designed at RRS. This included the antenna, the stabilised positioner, the whole of the transmitter unit, the complete radar front end, the complete 3 channel exciter, the 3 channel receiver including digital front end, the complete 3 channel Doppler-based signal processor, the complete data processor including radar manager, plot extractor and tracker processor and also the Human Machine Interfaces.

The development of the radar ran in parallel with that of the *DBRXL* X-band technology demonstrator, so that a high degree of commonality was achieved between the two systems.

This was the company's first major export sale on a complete product level and therefore a particularly important international contract to strengthen the company's image as reliable supplier among international defence contractors.

Some members of the project team had to spend some time on the Norwegian vessels at sea while integrating and testing the system. Whilst doing so, some 'once in a lifetime' type of experiences were



The RSR 210N occupies a prime position on the Nansen frigate

to be had, such as witnessing the Aurora Borealis or Northern Lights and experiencing the hammering that men and machines take when sailing on the open sea in sea state seven with waves up to 9 m high.

They were also on board during a simulated submarine attack, during which a real torpedo filled with instrumentation rather than explosives was used. On that occasion the RSR 210N system already proved its worth with a solid track of the launching submarine's periscope.

A significant milestone was reached less than four years later with the successful completion of the first (i.e. one per vessel) Final Qualification Review (FQR1) after Sea Acceptance Trials in Norwegian waters at the end of June 2011. As part of the run-up to these trials, several engineering trials often under adverse weather and sea state conditions, proved the system's ability to provide the ship with a high performance supplementary air/sea surveillance capability, as well as to provide high accuracy helicopter position reporting even under the complex clutter conditions encountered in the Norwegian landward, littoral and open sea environments.

Sustained performance during trials in the presence of electronic counter-measures has confirmed the status of RSR 210N as a true naval radar and the successful completion of the subsequent Final Qualification Reviews completed to date has established RSR 210N's operational standing aboard principal combatants of a leading NATO navy.

One of the most significant differences experienced between South Africa and Norway from a ship-borne radar perspective is the radically different littoral environments. In Norway hundreds of little

Memories from the staff

'James Verster played a major role in my career – as operations executive and later as CEO. I regarded him, and still do, as a highly versatile, intelligent, charismatic leader willing to take risks for the benefit of the greater company and fiercely loyal to his colleagues, once one has won his trust. As such I regard him as a role model.'

Cornell Leibbrandt
Chief system engineer

islands protrude above the waterline close to its coastal waters. For a radar system required to track stationary surface vessels, this environment induces 'false' surface tracks. This presented RRS with a challenging problem. The challenge lay in distinguishing between a real stationary surface vessel, i.e. a potential track, and stationary clutter.

'We had to incorporate the use of map-based track legitimacy checking whereby every single potential surface track is first checked against whether it is declared over land or over sea. If over land (including a little island), then that surface track is discarded.'

Added to this complex littoral environment were the many bridges carrying traffic that cross the fjords. Initially the maps supplied did not show all this detail. When the frigate would sail underneath such a vehicle bridge, there were plots of vehicles moving across the bridge sometimes causing tracks to be established. Another challenge was getting the radar to cope with the fact that the vessel would sail down any of the Norwegian Fjords with the radar finding itself within 100 m or so from many meters-high, nearly vertical, fjord cliff faces whilst radiating.

All of the above called for significant unanticipated effort; firstly to understand a particular phenomenon and secondly to design a technically sound manner to deal with it.

One of the challenges was to become acclimatised to high sea states off the coast of Norway

The team sometimes had to battle severe sea sickness during work on the Norwegian vessels as well as the wet, rainy, cold weather in and around Bergen, Haakonsvern Harbour and further south towards the Stavanger region. With Norway being so far north, an additional constraint placed on the project team was to fit in all the required work during the few daylight hours experienced during winter.

ENTERING NEW MARKETS

Movement and Surveying Radar takes off

In the years after James Verster became CEO in 2004, work on the *ORT* and *GBADS* was progressing smoothly. RRS had gained invaluable experience through the SALT project and was able to demonstrate its capabilities in terms of developing technology relating to a non-military industry. However, the Movement and Surveying Radar (*MSR*) became the first large project for RRS to establish a foothold in industrial applications with the potential for long-term and sustainable business. Growing the mining division into a viable business soon became a major focus.

Diversification into the non-military field with the development of the mining radar was not as a result of a pro-active business development drive on the company's part. In this case Anglo Coal approached RRS on the basis of its capability to develop new applications for radar technology.

The histories of many successful enterprises globally are rich with stories about how some of their most successful developments came about in unexpected ways. Here was an example of how new directions sometimes come about in serendipitous ways.

While James was studying for his MBA at UCT, he

Jan de Beer and James Verster at the first demonstration of the *MSR* at Anglo Coal on 21 February 2006

spoke to a fellow student who worked for Anglo Coal, who told him they were renting a radar rock face monitoring product. This first contact with the user led to the development of the first concept demonstrator model in collaboration with Anglo Coal South Africa by the middle of 2004. The first *MSR* 100 system was delivered to a mine in January 2006.

The team responsible for the delivery of the first batch of 3 *MSR*s to New Vaal Colliery on 6 Octber 2006

The *MSR* at an open-pit mine in Western Australia

Radar scanning equipment used in harsh mining environments continually monitor selected walls of open-pit mines to detect movement in the rock surface that could indicate the onset of a collapse of the rock face. The system generates slope-stability alarms once a predetermined threshold in movement and/or acceleration is detected. The advantage of such equipment is that the monitoring can be done without the need for people to be present in places where large mining equipment is being operated and they would be exposed to considerable danger.

New development work was needed, as the *MSR* was our first FMCW radar. While the electronics, signal and data processing differed radically from that of our previous radars, the know-how gained from previous developments was directly applicable. Like military systems, mining equipment has to operate reliably in harsh environments for long periods of time.

'Mining safety is extremely important, not only because of the human factor of avoiding fatalities, but also because it directly affects productivity. For instance, with the *MSR* you can identify a potential collapse, trigger it intentionally, clean up and then continue with normal operations. With forewarning of a collapse you can prevent damage to scarce, custom-made and expensive mining trucks and other equipment. There are many open-pit mines all over the world and there are mining companies that do not allow any open-pit mining without functional radar equipment.'

'The important thing was that the mining business held the promise of a growing revenue stream through recurring business because there is a constant demand resulting from a constant global need,' says James Verster.

The *MSR* was highly successful and resulted in industrial products overtaking military products in terms of revenue. It also brought with it a new understanding of how to work with, service and support industrial clients as well as a shift in mind-set relating to the marketing of such products.

Words from the staff

'If you consider radar, it basically consists of seven major sub-systems and the technological challenges lie within those sub-systems. I would say that at any point in time over the last 10 or 15 years, more than 50% of the company has been involved in development projects in any one or all of those seven sub-systems simultaneously.

'Our company has a culture where we do allow people – within reason of course - to make mistakes. This is a key aspect of a truly successful culture of learning and innovation.

'To keep up with the rapid evolution of electronics and electronic components, we're constantly busy with the development of new technology and modernisation of all the main sub-systems of radar.

'Over the last 10 years we have also grown a very acute awareness of the importance to explore new applications and adapt to changing market trends. For instance, I think there's a great opportunity for mining operations today to increase their productivity dramatically with new technology.

'When we entered the mining market we also immediately set a new benchmark for the operational availability (the percentage of time in a month that a system is fully functional) of mine monitoring radars.'

James Verster

The business decision to exploit the opportunity and sign the contract with Anglo Coal for the first ten *MSR* systems had many practical management implications, since it was one that was made when available human resources were already allocated to the *ORT* and *GBADS* programmes. There was also a need for additional space in which to develop and produce the systems. The additions that had previously been made to the north-eastern part of the RRS building were not enough to accommodate the production needs for the mining business and in 2010 James signed off plans for building additions on the southern side.

A new division and mining product upgrades

Because of the success achieved with its mining products, Reutech Mining was created as a division within RRS and headed up by Jan de Beer as mining executive. Supported by the wealth of experience gained at RRS through its R&D efforts over the past 25 years, Reutech Mining can solve a variety of design problems outside the traditional radar domain.

Field trials and interactive analysis of customer needs in the mining industry led to continual improvement in systems and in April 2007 RRS could announce the international launch of the *MSR* 200 – an upgraded version of the *MSR* 100 which had been the first unit delivered in January 2006. Jan de Beer explains that the shortcoming of using video equipment which is suitable for daylight operation only, was overcome by incorporating advanced 3D slope radar imaging that eliminates the need for a camera. 'The system now incorporates a fully integrated Total Station, a surveying instrument that allows the *MSR* 200 to be accurately geo-referenced. This capability enables the slope stability and surveying measurements to be accurately integrated with existing mining tools.' A high-resolution synthetic map allowing user defined pixel sizes as small as 3.9 m x 3.9 m at a standoff distance of 900 m also enables better slope movement analysis and alarm functionality.

The first RRS system to be installed in Australia was at Sunrise Dam mine, a deep open gold mine in Western Australia owned and operated by AngloGold Ashanti, where they opted for the *MSR* 200 system in 2007.

'The introduction of real-time radar slope monitoring to open-pit operations in recent years has been a major advantage in managing geotechnical risk,' said Sunrise Dam's operational manager, Peter Booth. 'The *MSR* 200 complements the existing slope stability risk management system by giving us the ability to focus on specific areas of the pit walls in much more detail than is possible using any other method of monitoring.'

The *MSR* 200 was followed by the *MSR* 300, which has the capability to detect submillimeter movement at an operating distance of 2 500 m. By the end of 2012 there were more than 90 *MSR* systems operating in 19 countries on 6 continents.

The *MSR* 300

2008–2012: A GLOBAL COMPETITOR

The period of 2008 until the present has seen RRS mature from an important local player to a notable global competitor.

The logos of Reutech Radar Systems, a division of Reutech (Pty) Ltd and Reutech Mining, a division of Reutech Radar Systems

In September 2008, the four defence companies within the Reutech group of companies joined forces to consolidate and streamline their defence businesses. The companies formerly known as RDI Communications, RDL Technologies, Fuchs Electronics and Reutech Radar Systems united under the single Reutech brand as divisions of Reutech (Pty) Ltd. Fuchs Electronics became Reutech Precision Products but soon changed to Reutech Fuchs Electronics to retain the strong international brand identity of Fuchs Electronics; RDL Technologies became Reutech Solutions; RDI Communications became Reutech Communications while the name of Reutech Radar Systems (RRS) remained unchanged.

At the same time the company increased its focus on developing new industrial applications in addition to the military radar products on which its origins were built.

Mining radar maturing

After being involved in the mining industry for four years, it became clear by 2008 that RRS had become established as a player locally, increasingly also internationally. The brand identity Reutech Mining was created and the *MSR* products were by then utilised with great success in South Africa, Namibia, Tanzania, Chile and Australia.

An *MSR* 200 radar system was deployed in the Sur Sur open-pit mine in Chile on 23 January 2008. The pit is located 80 km northeast of Santiago and situated at an altitude of 4 200 m above mean sea level. It forms part of Codelco's Andina Division, which operates the Río Blanco deposit and produces more than 240 000 metric tons of copper and 3 000 metric tons of molybdenum per year.

During the initial stages of monitoring, only minor movement was detected. On 7 February the system indicated significant increase in the rate of movement of a portion of the slope. The next day the acceleration increased and subsequent slope failure occurred about 30 minutes later. There were neither injuries nor damage as a result of the failure. At the time the *MSR* was deployed at a range of 576 m from the area of failure.

In June 2008 AngloGold Ashanti selected the *MSR* 200 radar system as their preferred solution to improve operational safety and risk reduction in their Navachab open-pit mine in Namibia. This mine lies 10 km southwest of the town of Karibib and produces over 102 000 ounces of gold per year. The *MSR* 200 scans the selected open-pit wall on a continuous basis to detect movement of the rock surface. The system will generate slope-instability alarms once a predetermined threshold in movement and/or acceleration is detected. The *MSR*

The marketing team celebrating the delivery of the 50th *MSR*. Left to right; back row: Jan de Beer, Nolene Kritzinger, Cala van der Westhuizen, Alex Pienaar, Peter Bradshaw, Garth Day. Front; Elisma Geldenhuys and Monique Lenhoff

thus provides real-time complete coverage without the need to install any reflectors on the mine surface. All measurements are fully geo-referenced.

By June 2008 RRS could also unveil the *MSR* 300. It offers continuous slope monitoring and surveying of rock surfaces up to a slant range of 2 500 m under all weather conditions. It is capable of detecting sub-millimetre movement of the rock face at this range, whilst employing the most modern propriety technology to eliminate the two major limitations experienced with radar-based displacement measurement systems until then. These limitations are caused by rapidly varying climatic conditions as well as slope movement that exceeds rates of more than 15 mm from scan to scan. Both can lead to inaccurate measurements that dramatically affect the performance of such systems.

The system also offered a significantly improved surveying capability, with a range accuracy of better than 50 mm on any specific point target, thereby allowing continuous real-time surveying of the area of interest under all weather conditions.

'When we decided to improve the *MSR* 200's range performance, we did not want to exclude existing users from the new benefits. We achieved this by ensuring that any *MSR* 200 can be upgraded at the user's site within a day,' said Jan de Beer, head of Reutech Mining. By fitting a slightly larger antenna and replacing some of the sub-systems, an *MSR* 200 system achieves full *MSR* 300 status within a few hours.

International collaboration

After much deliberation Reutech decided to make use of international distributors instead of opening its own office to distribute the *MSR* product range.

In 2006 Rock Australia was appointed as the official distributor for the Australasian region.

In 2007 Chilean E-Mining Technology was selected to distribute the product on the South American continent. This relationship was ended by mutual agreement and Clonsa Ingenieria took over the reins of the *MSR* in South America.

In February 2008 MALA GeoScience USA, Inc. was appointed as Reutech Mining's North American distributors of the *MSR* in North America (USA and Canada).

In March 2009 market-leading Elcome Technologies Pvt Ltd was appointed as the distributors of RRS' *MSR* range of products in India.

The signing of the distributor agreement between Reutech Mining and Mala Geoscience USA with Matt Wolf and James Verster (seated), and Jan de Beer and Cala van der Westhuizen behind them

The *MSR* at the open-pit copper mine at Batu Hijau, Sumbawa Island

The *MSR* production line at RRS' facilities in Stellenbosch

Another new international relationship was formed late in 2009 with Batu Hijau, a large open-pit copper and gold mine 1 530 km east of Jakarta on Sumbawa Island. The mine is operated by Newmont Mining Corporation's subsidiary PT Newmont Nusa Tenggara and it selected the *MSR* 300 as their primary monitoring system to provide early warning against potential slope failures. The size and shape of the Batu Hijau ore deposit makes it amenable to open-pit mining, using a conventional drill, blast, load and haul mining system. The mine, together with its mineral processing plant at Batu Hijau, operates around the clock, 365 days a year.

The market for this type of radar is growing, since mine safety is increasingly prioritised. Among others the use of these systems also facilitates the increase of the slope angles of certain mines. It results in major cost savings, since the amount of waste that has to be removed is reduced.

Future developments of the *MSR* systems will concentrate on increasing the operating range and reduce weight, thus improving their mobility.

Set-top Boxes and forming of Reutech Digital

Reutech Digital's Set-top Box project marketed under the DiViTech brand

A major initiative into a new field for RRS started in 2007 when the Department of Communication (DoC) approached South African companies to participate in the DVB-T digital terrestrial (DTT) migration process. RRS, through sister company RC&C Manufacturing, and other industry role players together with the DoC and the South African Bureau of Standards (SABS) began participating with the formalising of a specification for a DVB-T Set-top Box (STB) for DTT.

Viewers who currently view the analog terrestrial broadcasts through a normal roof grid antenna or 'bunny ears' will need a STB to continue watching television once the digital migration begins.

RRS started with its first DVB-T STB design, the QT100, early in 2008 and became the first South African company to design a DVB-T Set-top Box to the newly developed SANS STB standard for the South African broadcasters planned migration to DTT.

The RRS design was selected by the SABC and eTV in July 2008 as the preferred product for the DTT trial that officially began in October 2008.

The DTT trial was to have run for 6 to 9 months and if successful, the DoC would have issued tenders to South African companies for the supply of around 10 million DVB-T STBs. This would have been the single largest electronics project undertaken in South Africa to date. It was the intention of the DoC to use the 2010 FIFA World Cup South Africa™ soccer tournament as a catalyst for the uptake of the STBs. The trial was highly successful and information gathered by Nielsen (a global information and measurement company engaged by the broadcasters for the trial) reflected this.

During 2009 the DoC moved from DVB-T to ISDBT, a similar digital broadcasting technology developed in Japan and newly adopted by Brazil. ISDBT did not offer any significant improvement over DVB-T and was deployed in very few countries compared to DVB-T. This sudden shift in policy resulted in the DTT process stalling in South Africa until the beginning of 2011 when the DoC announced that ISDBT would not be selected. During this time the DVB-T technology had moved forward and a new improved format known as DVB-T2 had been developed which offered a 50% improvement on bandwidth use. In early 2011 the DoC officially announced that South Africa would adopt DVB-T2 and work began on updating the SANS STB specification for it. In

June 2012 the Minister of Communications, Dina Pule, announced the launch of the updated SANS specification for South Africa for the DTT STBs.

It was RRS' first attempt at designing a consumer product and also a STB so we did not have any legacy issues to influence us. The RRS approach to STB design was unique at the time. DVB-T was a new technology and there were not many international companies that had DVB-T products in the market. We decided to move from the traditional metal enclosure to an all plastic enclosure which we developed. In addition we also decided to implement a fully digital tuner on the single printed circuit board (PCB) inside the enclosure.

Our initial design was unique at the time in that we designed it to meet the SANS specification which only called for standard definition (SD) video reception and display. However, our STB could receive both standard and high definition signals but only provided an analog SD video output signal. As the delays in the programme crept in, RRS updated its design to stay current and eventually moved to a full high definition STB that could output video content in analog or HDMI digital format.

The STBs are manufactured by RC&C and supplied for both the terrestrial and satellite broadcast market. This combines the design capabilities of RRS as world class electronics design house with the manufacturing expertise of RC&C as electronics manufacturer. This also positions the Reunert group as a whole to expand their expertise into the African and international STB markets.

StealthRad™

In response to the increasing demand for light-weight, low cost and easy to operate Low Probability of Intercept (LPI), radar surveillance sensors, RRS developed and introduced the *StealthRad*™ family of radar products for para-military applications, such as for instance border surveillance.

The development of the *Spider* was an adaptation of technology that was being developed for the *MSR* and indeed represented a departure from the more common situation where industrial products are derived from military ones to the other way round.

A covert air and sea surface surveillance radar the RSR 940 *Spider* system was prominent during the *StealthRad*™ product development.

In addition, due to the SANDF's shift from defence to peacekeeping into the African continent, deployment in littoral waters and protection against asymmetric threats have become more important and the *Spider* is ideally suited for these needs. It can detect and track much smaller sea and air targets than current coastal and air surveillance radars in its class. The system is a fully coherent, low cost, light-weight, LPI frequency modulated continuous wave radar. Low transmitted power levels make it ideal for covert operations and the system is not easily detected by the conventional ESM systems. The *Spider* RSR 940 can be transported on a 1-ton pickup truck with the antenna stowed away to fit in the vehicle envelope.

The RSR 940 *Spider*

3 THE RRS STORY

In discussion with James Verster CEO, 1 Jan 2004 – 31 Jan 2010

James holds a BEng (Electrical Engineering) degree from the University of Stellenbosch, an MEng (Electronic Engineering) from the University of Pretoria, and an MBA from the University of Cape Town's Graduate School of Business. He joined the Reunert group as design engineer and by 1992 he was appointed as senior design engineer at ESD in Midrand. His MBA dissertation dealt with the management of complex engineering teams across multiple cultures – something that would be very useful during his time as CEO of RRS.

He was CEO of RRS until the end of January 2010 when he was appointed group business development manager as part of the executive management team at Reunert where he focused on the Nashua group of companies and led the strategic development team at Nashua Mobile.

Who played a major advisory role in your decision-making as CEO?

I have to credit Boel Pretorius, not only in the start of the RRS business, but also for instigating important paradigm shifts in terms of decision-making for people like Piet Smit and I. Boel encouraged us to look for and build on sustainable, long-term business opportunities to smooth the business fluctuations experienced in a company reliant on a small number of large projects.

The advice from Gerrit Oosthuizen, the Reunert commercial and legal executive, was also very important.

How did you deal with some of the biggest challenges facing you as CEO?

The effect of having to downsize a company and let people go is very traumatic for all concerned. We set about to prevent this from happening and develop a model that would ensure sustainable business through the development of applications in the industrial, safety and para-military areas.

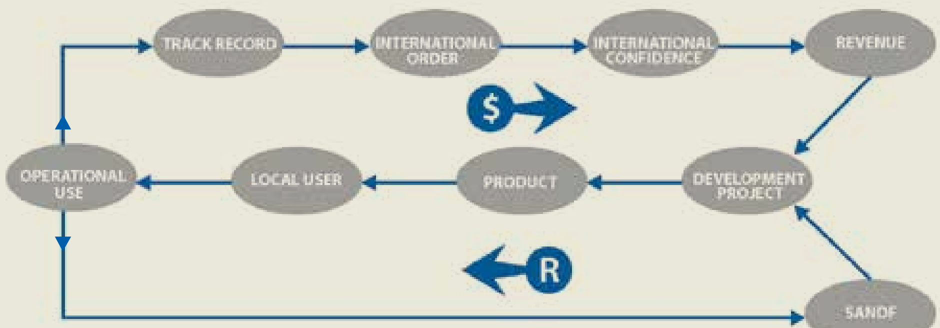
What were the most notable technological and business achievements during your time as CEO?

In terms of technology, the development of the very sophisticated yet affordable TATS 150 radar intended for self-protection purposes and which potentially has numerous applications in the safety and security markets, locally and internationally such as for key strategic points.

As far as business development was concerned, it was doubtlessly the development of a sustainable income stream through the mining division.

You worked closely with the late Piet Smit. What stands out as a major highlight for you during his time as CEO?

The rapid expansion of the engineering development capability of RRS to deliver operational high-tech systems for the first time at the level of the *ORT*. The company had never built production systems under a single contract before. Previously there were development contracts with no built-in production orders. The *ORT* was a single production order with the development element built into it. The two approaches differ fundamentally.



ADVANTAGE TO LOCAL USERS

The RSR 940 *Spider* at Simon's Town

By July 2009 a *Spider* system was installed in Simon's Town to undergo a product evaluation exercise.

A very different application for the *Spider* system was illustrated in November 2010 when Rural Maintenance (Pty) Ltd, the developer of the wind farm in the Vredenburg area, approached RRS to assist in the study of bird flight paths over the proposed wind farm site between the Langebaan Lagoon and Berg River estuary along the Cape West Coast. There were concerns that birds could collide with the 140 m high turbine blades of wind farms located along their line of flight. The study, led by consultant ornithologist Dr Tony Williams, involved combined radar and visual observations of flock movements between the two wetlands at night when they would be identified by their silhouettes as seen against the full moon, assisted by thermal imager observations.

Conventional navigation radar is generally unable to detect small targets such as birds against complex background reflections which dictates that advanced air surveillance radar was needed. The *Spider* supplied the range and bearing of birds observed, while a thermal imager was used to measure the birds' height. The types of birds – typically ducks, gulls and flamingos – were visually identified by Dr Williams and his team. According to Dr Williams this was the first time such a study was being conducted in Africa. Although there have been previous radar avian studies elsewhere, he was unaware of other combined radar and full moon watches anywhere in the world.

Various system configurations of the *StealthRad*™ were developed for different applications and products in this provide for a range of features that can be tailored to specific user needs. The shared technology – both hardware and software sub-systems – of these products ensures cost efficiency. The configurations range from a highly mobile (1-ton truck) setup to permanent installations (the RSR 970). The semi-permanent version is container-based and can be supplied with mast heights of 5 to 15 m above ground level.

Cornell Leibbrandt at the *Spider* demo in May 2012 at IMT, Simon's Town

TATS 150

TATS 150 concept experimental development model

SAAB Avitronics approached RRS early in 2007 and asked for proposals for a radar for integration into an Active Protection System (APS) intended primarily for vehicle protection. The problem called for a staring array radar that could continuously observe a volume covering an eighth of a hemisphere and detect and track up to 100 high speed simultaneous threats (typically missiles) anywhere within the hemisphere within milliseconds.

PW and Pieter-Jan, backed by Werner Steyn, devised a rather unconventional solution to the problem. After evaluating the concept the client placed a development project for a concept demonstrator. Paul van der Merwe got to work and towards the end of 2008 a concept demonstrator with nickname '*Robocop*' showed that the idea worked. A Concept Experimental Development Model (TATS 150 CXDM) followed in 2009 and was integrated into a full Active Protection System that was successfully tested in South Africa and also in the USA in December 2009.

New CEO: Carl Kies

James was succeeded as CEO by Carl Kies on 1 February 2010. Carl holds an MEng (Electronic Engineering) from Stellenbosch University and an Executive MBA from the University of Cape Town Business School. Carl's first job after graduating as engineer was at RRS, but after 1988 he left to gain additional experience in positions at various software and electronic engineering companies. In 2002 he started Acuo Technologies. After completing his MBA, he was ready to assume the role as CEO at RRS at the end of January 2010, when James was appointed group business development manager at Reunert.

Carl placed an emphasis on client relationships, maintaining and expanding networks with existing local and overseas clients and on building team spirit

Words from the staff

As current stores manager, Irvin has been with the company for 12 years and is responsible for ensuring that all operations within the store are accurate, effective, and streamlined.

He says 'the biggest milestone for me personally was when my team achieved 98.64% stock accuracy in the 2012 financial year-end and the tribal cohesion culture introduced by our current CEO.

'I regard Carl not only as CEO, but also as somebody who taught me a valuable lesson in business and in my life. He guided me in the right direction and gave me opportunities to empower myself.'

Irvin Vermeulen
Stores manager

The *DBRXL* technology demonstrator

amongst the RRS workforce. He is an enthusiastic proponent of renewable energy systems and strongly supported RRS' entry in the renewable energy market with the development of a prototype positioner for a concentrated photovoltaic (CPV) generation system that today feeds into the power grid at the RRS premises.

While the RSR 210 deliveries to the Royal Norwegian Navy proceeded at a steady rate, SAAB commissioned the development of RAD 150, the pre-production version of the TATS 150 sensor.

DBRXL technology demonstrator

In 2005 Pieter-Jan had a brilliant idea. Over the years radar engineers had learnt how to handle ambiguous echoes from far away targets outside the instrumented range of the radar and also ambiguous Doppler measurements resulting from a low sampling rate. Pieter-Jan wondered why, since we know what to do with these ambiguities, can't we also handle angular ambiguities? This led to a radically different low-cost architecture for a surveillance radar that would be accurate enough to do missile designation, a function that until now relied on a tracking radar.

By using a sparse antenna, an overall saving by a factor of between two and six in antenna and receiver hardware was accomplished. The idea was to combine an X-band radar with the *Thutlwa* (*Kameelperd*) L-band radar. The X-band system would provide the required precision while the L-band radar would provide for aircraft detection at long ranges.

He started to test the idea with other radar engineers, including engineers from CSIR DPSS and came to the conclusion that the idea would work. Armscor, as potential funder of a technology demonstrator, also needed convincing and this was accomplished in a first phase with the development of a very basic technology demonstrator which proved that the idea would work.

The *DBRXL* technology demonstrator development proceeded in two further phases, the first from 2007

Testing the *DBRXL* antenna

The first waveguide array was taken to the compact range at the University of Pretoria. After setting up the antenna, Werner Steyn started to measure the radiation pattern. Everything went according to plan until the boresight direction was reached where the received signal had to reach a maximum. Suddenly the received signal became smaller and exactly on boresight vanished completely!

After recovering from a severe panic attack, Werner realised that there was a phase reversal when one half of the symmetrical waveguide combiner was mirrored to form the other half and that this had caused a null in the boresight direction.

This was remedied with two strategically connected lengths of coaxial cable that produced the desired result. An elated Werner returned to Stellenbosch with the news that half a million Rand had been well spent on the development of the array!

The *DBRXL* technology demonstrator was taken through a next phase of development with the addition of a 3D L-band radar to the existing 3D X-band system. The system had 18 receive channels for each band and produced data at a rate of a full DVD disc every two seconds. With several software signal processors running in parallel, the demonstrator is the most complex radar system developed by RRS to date – a highlight to mark the end of RRS' 25th anniversary year.

to 2010 being the development of the X-band radar and the second from 2011 to 2012 to investigate the conversion of the *Thutlwa* to a 3D Doppler radar.

The whole South African radar establishment, including Armscor, the SANDF, DPSS, Denel, the universities of Cape Town and Stellenbosch and RRS, was involved in the project. This broad involvement was a first for South Africa and eventually led to the establishment of the South African Radar Interest Group (SARIG) that met regularly with Mr Lewis Mathieson as Chair with the mission to promote radar technology and application in South Africa.

Apart from the development of the *DBRXL* demonstrator, the technology project also focused on simulation studies of the radar system by DPSS and the associated missile system by Denel, and the development of tracking algorithms by Prof Norman Morrison of UCT. His work resulted in the publication of a textbook, Tracking Filter Engineering published by the Institute of Electrical Technology in London in 2013. The tracking filters developed by Prof Morrison are already in use in the South African missile industry.

The *DBRXL* development ran concurrently with the RSR 210 development and ample use was made of RSR 210 components for *DBRXL*. With transmission at three frequencies simultaneously and using an 18 channel receiver, the X-band radar was an ambitious project. The vertically polarised squint-free receive antenna was in itself a huge technical challenge. The final design was based on six 96 port linear waveguide combiners coupled to 576 small horn antennas in total. To save time and money, the signal processing was done on powerful personal computers running Matlab. This limited the radar to actively search in a small sector only.

D-day for the demonstration was set for Monday, 22 February 2010. By Friday, Pieter-Jan was still having problems with extracting target elevation angles. With a final marathon effort over the weekend however, Pieter-Jan managed to get the processor working and programmed a tracking filter to demonstrate a system on Monday that exceeded all the accuracy requirements.

RRS and the 2010 FIFA World Cup South Africa™

South Africa has been widely praised for its expert handling of the global showcase that the 2010 FIFA World Cup South Africa™ represented.

Many of the efforts to make this major global event enjoyable and safe for all were invisible to the general public yet depended on considerable technology and know-how.

The RRS ESR 220 *Thutlwa* played a strategic role with its use in a joint peace-keeping operation for the first time, providing early warning of possible threats to the security of the stadiums.

The SAAF and elements from other services and divisions of the SANDF were given the responsibility to secure the airspace around the World Cup stadiums over the 40-day period from 30 May until 11 July 2010.

The South African Army's Air Defence Artillery drew on the ESR 220 *Thutlwa*'s local warning radars for deployment around the Nelson Mandela Bay Stadium in Port Elizabeth and Durban's Moses Mabhida Stadium. The SAAF generated its air picture from their static and mobile radars and that of Air Traffic Navigation Services. The deployment of the ESR 220 *Thutlwa* completed the picture by providing coverage where low-flying objects such as micro-lights could be difficult to detect.

The Joint Operation Centre received a real-time ADC (Air Defence Control) picture from the ESR 220 *Thutlwa*, thereby supporting effective decision-making. RRS provided technical maintenance and support to ensure the full operational availability of the ESR 220 *Thutlwa* which drew the crowds in Port Elizabeth when it travelled to its designated deployment sites, escorted by both military and civil traffic services. In Durban, the deployment was much more low-key due to the *Thutlwa*'s more remote location.

Thutlwa goes to the Sudan

As part of the independence celebrations in South Sudan in 2011, the South African government deployed a military contingent to Juba, capital of Africa's newest state. This also heralded the first deployment of the ESR 220 *Thutlwa* beyond the borders of South Africa.

The purpose was to provide radar coverage for the airfield and the necessary airspace control for all the visiting heads of states and other VIPs at the airport. The ESR 220 *Thutlwa* was deployed at Juba airport to support the SAAF in providing radar coverage of the airfield for airspace management and air traffic control functionality.

The system was transported first on board an Ilyushin Il-76 cargo aircraft for the 5000 km journey to Juba. It was off-loaded and deployed and was declared operational the same day with an air picture via the Air Picture Display System to the air traffic controllers.

Some innovative thinking

Paul van der Merwe had to invent innovative methods to verify RAD 150 measuring accuracy. A first scheme was to erect a long run of PVC piping that he had accurately surveyed. He then fired a paint ball through the pipe and measured its trajectory with the radar.

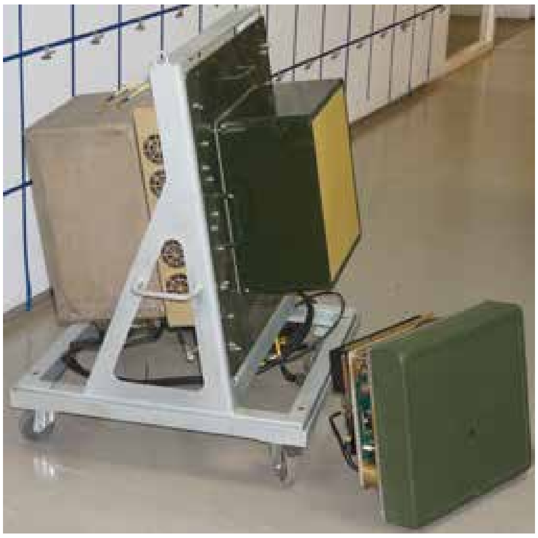
The Mark II scheme was to span a wire tightly out to about 50 m, with a block of expanded polystyrene attached to the wire at an accurately measured distance. The wire was also threaded through a golf ball with a hole in it and a 50 mm PVC plumbing bend. The bend was connected to a compressed air spud gun. The golf ball was pressed into the bend and fired along the wire. The sudden deceleration when it hit the foam block gave an accurate range marker while the wire defined a highly accurate trajectory.

RAD 150

Following on the successful demonstration of the TATS 150 Concept Demonstrator (CXDM), the development was taken to an Advanced Development Model (ADM) named RAD 150. The technical challenge posed here demanded a skilled multi-disciplinary team, headed up by John Ritchie, Ettiene Smit (project managers), Gottlieb van der Merwe and Paul van der Merwe (project engineers).

The challenge on the mechanical/thermal side (headed up by Stephan Nortje) was to shrink the Concept Demonstrator with its mass of 120 kg and volume of 291 litres to a unit weighing 17.5 kg with a volume of 28.1 litres. That is a reduction in weight by a factor of about 7 and in volume by a factor more than 10! At the same time the performance had to be improved and the system had to be rendered proof against small arms fire and impact with odd obstacles such as 75 mm thick oak tree branches. To top it all the system had to be submersible to a depth of 2 m.

On the RF side (headed by Paul van der Merwe and Werner Steyn), the RAD 150 called for a hitherto unprecedented (for RRS) level of integration of microwave circuitry. A six channel X-band receiver



RAD 150 next to the TATS 150 concept experimental development model

including antenna couplings were implemented on a single printed circuit board (PCB).

The soft/firmware challenge was no less onerous -the functions performed in the CXDM prototype by three Field Programmable Gate Array (FPGA)-based single-board computers were squeezed into a single powerful FPGA on a PCB measuring less than 18 x 12 cm and the two channel frequency synthesiser was

Thutlwa in South Sudan in 2011

RRS' solar tracker at a CPV solar power plant near Touws River in the Western Cape with from left to right; Carl Kies, Pierre van der Merwe who led the tracker design, Sean Hedenskog, Dieter Matzner from Hatch and Peter van der Bijl (Reutech group CEO)

fitted onto a similar sized PCB. RAD 150 met all its performance specifications.

Sadly, the plug was pulled on RAD 150 development/production just prior to the final industrialisation phase. Changed market conditions forced the client to withdraw funding in mid-stride. The ADM unit remains an example of state of the art radar development, with enormous potential.

Renewable energy

Few things prove as clearly how far RRS has come in the past 25 years as the company's growing confidence to move into product development for new markets and to market those successfully to industrial clients.

Renewable energy applications are high on this list because with RRS' proven radar and mechanical control engineering skills and experience and the growing demands in terms of clean energy supply, there was a clear opportunity and good fit to get involved in systems relating to renewable energy.

According to the Department of Energy the goal is for 42% of all newly-installed capacity in the next 20 years to be based on renewable energy sources. Government guidelines for renewable energy include strict requirements regarding local content, and this opens important opportunities for local companies to get involved in the supply of relevant systems and sub-systems.

The move into product development for renewable energy projects bore fruit when a contract was signed late in 2012 with Soitec, a world leader in the energy industry, for the supply of solar trackers for its 50 MW concentrated photovoltaic (CPV) power plant near Touws River in the Western Cape. On completion in 2014 this facility near the Aquila private game reserve where Soitec already had installed a pilot facility, will be the largest CPV power plant in the Western world.

The plant forms part of Bid 1 of the Government's Renewable Energy Feed-In Tariff (REFIT) programme that will add 1400 MW of renewable energy to the national grid. Soitec had been selected by the Department of Energy as one of the preferred bidders through the country's Independent Power Producer (IPP) programme.

The RRS team developed, built and installed the first prototype at Touws River after only two months of extensive mechanical design engineering. This represents a very short timescale for high-tech projects and illustrates how flexible and efficient the project teams at RRS had become.

In cooperation with sister companies within Reutech it is possible to offer integrated solutions for renewable energy. RRS' capabilities also include wind loading analysis, stress and deformation analysis, field assembly and maintenance, fixed and single axis mountings for photovoltaic power plants and optimised mechanical structures for custom requirements.

Marketing development

'The current challenging defence market condition is forcing companies to revisit their approach towards maintaining a sustainable business model. This includes an ongoing critical review of product and marketing strategy, as well as focussing attention on key clientele. This necessitated the urgent need for the role of a sales and marketing executive', said CEO Carl Kies early in 2011.

In March 2011 Sven Holfelder was appointed as sales and marketing executive to lead the RRS business development team and to help create value with RRS' products and competencies in the defence, parastatal and civilian markets.

Sven had started his career at RRS in January 2002 with the role of finalising and managing the *GBADS* programme. Before joining RRS, he was a programme manager at ATE. Sven's qualifications include a BEng (Electronics) degree from the University of Stellenbosch and an MBL from UNISA.

Key meeting


Carl Kies, Min Lindiwe Sisulu and Peter van der Bijl (Reutech CEO)

In November 2011 RRS played host to the first-ever formal engagement between the Minister of Defence, Dr Lindiwe Sisulu and the Aerospace, Maritime and Defence Industries Association of South Africa (AMD) as representatives of the SA Defence Industry (SADI). The primary objectives of AMD are to represent the industry in matters of mutual interest and the promotion of a profitable, sustainable and responsible industry.

At the meeting, Minister Sisulu emphasised that industry and government are partners who are dependent on each other.

2013–2022: FINDING THE BALANCE

Road Map

The years 2013 to 2022 were interesting times. RRS is a high-technology business – and this presents management with unique challenges.

A high-tech business relies on the skills of an expert workforce and this expertise must be continuously maintained and expanded. This is especially true for enterprises in the field of radar, as radar systems comprise a very wide range of technologies, and also because some of the technologies evolve rapidly.

Expertise generally develops rapidly during a development project that, in the case of radar, has as its goal the development of a new system that meets specific – and usually new – user requirements. Development projects are expensive and have to be funded from either internal or external sources. Development is a risky business and not always very profitable. However, it is very important for maintaining the technology base.

During its earliest years, RRS relied strongly on the Department of Defence (DoD) for development funding, as DoD implemented a strong strategy to build a technology base in South Africa – one that would be on par with international capabilities. In time, overseas clients supplemented the DoD funding, as exemplified by the RSR 210N contract with the Norwegian Navy.

The development of the MSR mining radar marks the first time that non-military private enterprise co-funded a development project. The *Spider* radar was the first fully-internally funded project that established a technology base that had many spin-offs.

The return on investment (ROI) of development projects can be increased by tailoring systems to the requirements of a wider market and selling them in large numbers. This was achieved with the mining radars, and several hundred have been sold.

The mining radar success led to a decision by RRS management to focus its marketing on product sales instead of on the marketing of development capabilities. However, too strong a focus on saleable products comes at a price, as its demand on company resources may take the focus off maintaining the technology base.

The proceeds of sales must be reinvested in development projects. This leads to cross-subsidisation within the company and means that RRS must find and maintain a balance between marketing development projects and products. Resources must also be allocated to establish an inventory of marketable products by refining those systems developed into products with a wider market appeal.

With the strong support from the DoD, RRS had relatively secure funding prospects early on in its company history, so that the pressure to grow the international market was not very high. In the past decade however, DoD funding declined rapidly in line with the cuts made to the DoD budget, which is now down to 0.67% of GDP. This necessitated a much sharper focus on overseas marketing.

The approach was to market co-development projects where the client's staff is co-opted onto the development team. The RSR 312 radar development with an Asian partner is a good example of this approach. It provides a strong incentive for the client to acquire a deep understanding of its own system being developed, and radar in general.

Carl Kies

Early in 2019, Carl Kies, at that time RRS' longest-serving CEO, was called up for duty elsewhere in the Reunert Group. He is currently with sister company Blue Nova Energy, where he is helping James Verster to steer this very fast growing company in the renewable energy industry.

As Business Development Executive at Blue Nova, Carl says he is 'exactly where he wants to be, again having some time to dirty his hands at the technology workface', having returned to his original specialisation field of control systems.

Carl Kies looks back

Carl takes some time to single out some of the many highlights of his time at RRS.

The development of the ground-based dual-band radar technology demonstrator (*DBRXL*) and the short-range air defence (SHORADS) demonstration at the Overberg Test Range stand out. He was extremely disappointed when the development project was terminated, because the radar performance was outstanding, and it had very good potential for a breakthrough into international markets.

As a close second to *DBRXL* comes the Touws River CPV plant that captured his imagination and opened his eyes to the potential of renewable energy. Today Carl is an outspoken proponent of renewable energy systems and is doing his share to improve renewable technologies through his role at Blue Nova.

Other highlights include the development of the Sub-Surface Profiler and *Esprit*, and the deployment of CSIR's Postcode *Meerkat* surveillance system in the Kruger National Park.

And the biggest disappointment? Several opportunities that were lost due to international politics.

New CEO

Harald Bielfeld took over as RRS CEO in February 2019 after a period in the role of Chief Operating Officer at RRS. He was previously with Grinaker System Technologies, and brought with him a wealth of highly applicable experience.

Harald's first impression was that RRS had not developed its international business to the level that he would have expected. He found the mining business very well placed as a major global supplier, but the defence radar segment was lagging.

Under his guidance RRS will continue to place a much greater emphasis on refining its radars to achieve good product status, while intensifying its overseas marketing drive with a special focus on maintaining the technology creation loop through technology development projects.

COVID-19

The interesting times became even more interesting when the COVID-19 epidemic struck. International travel came to a halt with no advance notice. The overseas marketing drive became a big challenge overnight.

Looking back, RRS emerged from the pandemic with relatively minor damage. While the company had its first unprofitable year in its history, no staff were laid off because of the pandemic but sadly three members of our staff succumbed to the virus.

RRS wasted no time in registering as an essential business – which it could do as a supplier of mining safety systems, thus keeping its facilities open for key staff members. Innovation also came to the rescue! The box tells how the mining division commissioned new radars by remote control.

Remote assembly and commissioning

When the pandemic struck, the mining section had several new *MSR* radars delivered overseas – but those were not yet assembled and commissioned. The mines were clamouring for their radars and our technicians were not allowed to travel.

Jan de Beer and his people quickly hatched a plan. They asked one of the client's technicians to wear a webcam on his forehead. With this camera connected to the internet, they could watch what the technician saw on a monitor screen back in Stellenbosch. With a VOIP connection they were in business!

Given step by step instructions, the client's technician could assemble, test and commission the system. Several radars were commissioned this way.

Indeed, the practice worked so well that it is still used sometimes, even though travel is again possible.

PROJECTS

DBRXL

Having successfully demonstrated the X and L-band components of the integrated *DBRXL* system separately, the final phase in the development project was to evaluate the full system as a search radar, and also to test its capability as a missile designation system.

The L and X-band system was demonstrated in Stellenbosch at the end of February 2013 and then taken to the Overberg Test Range (OTR). There the radar was taken through its paces. It performed so well that it was decided to test it in its missile designation role with a real Umkhonto missile. The test was passed with flying colours.

This, however, also marked the end of the development programme.

The *DBRXL* idea originated with Pieter-Jan Wolfaardt around 2005. Breaking with radar tradition, he conceptualized an X-band system that used a sparse antenna. The antenna produced exceptionally narrow beams on receive at the cost of spatial ambiguities, making it possible to achieve exceptional angular accuracy at very low cost. To meet all the requirements for a missile guidance radar, the X-band radar – a relatively short-range radar – was supplemented with an L-band radar that could detect small targets at long ranges.

The horisontal radiating elements introduced several new technologies to RRS. Looking for an inexpensive alternative to laser welding of waveguides, we experimented with adhesive bonding to assemble the waveguide elements, shown in the figure below.

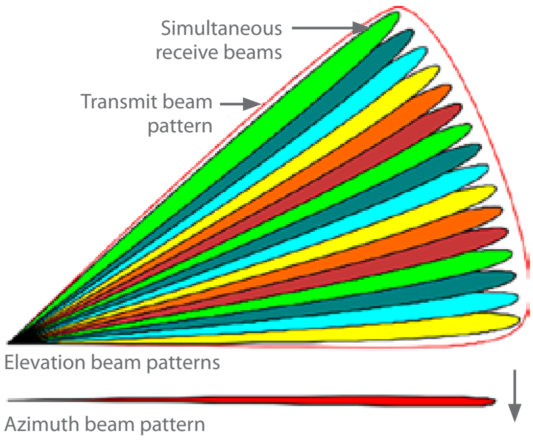
The *DBRXL* grating lobe concept

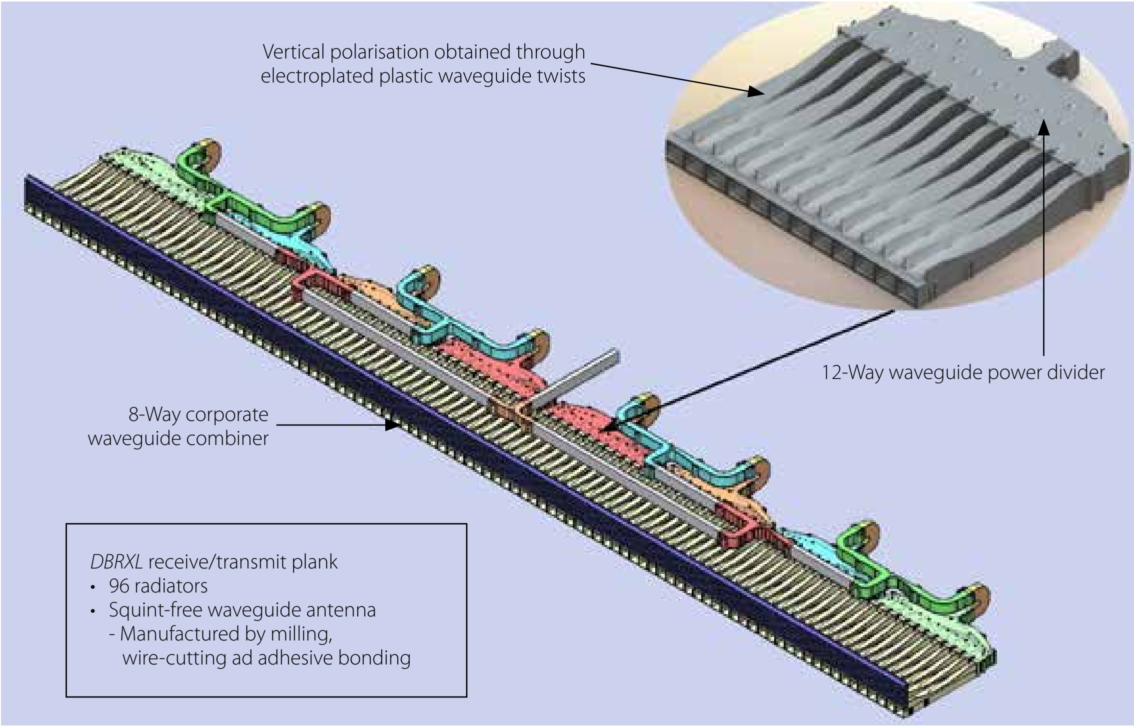
A multirole surveillance and missile guidance radar must very precisely locate a target in range, azimuth as well as elevation, and also produce a good estimate of its radial velocity. Location in azimuth and elevation requires a narrow antenna beamwidth. A narrow antenna beamwidth in turn requires a large antenna. In this case, a conventional X-band antenna would consist of a stack of 36 horizontal radiating elements, each with a length of about 2.4 m. To aid detectability and ambiguity a system using composite pulses where each of the sub-pulses has a different carrier frequency, together with digital beamforming on receive, would require a 108-channel receiver – a very complex and expensive machine.

Pieter-Jan Wolfaardt reasoned that in radar you regularly have to deal with ambiguities in range and Doppler, so why not in elevation as well? He devised a scheme with a sparse antenna, using only six horizontal radiating elements and 18 receiver channels. The sparse antenna would create ambiguities in elevation, but these could be resolved with multi-frequency pulses.

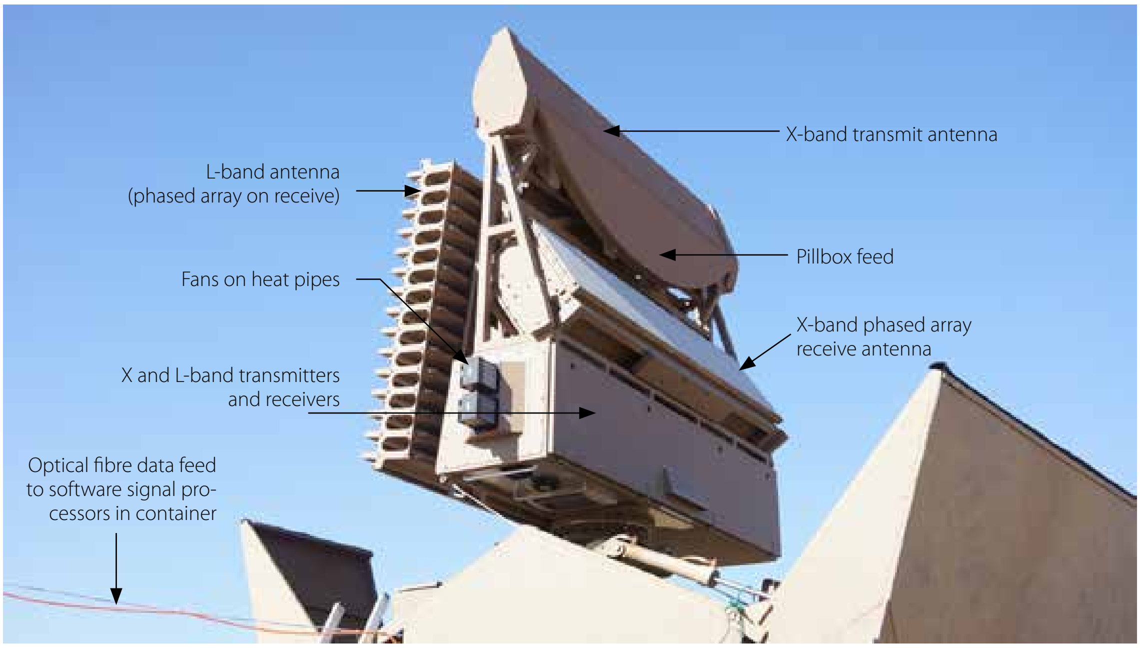
The elevation beam pattern is shown in the figure, with ambiguities illustrated in colour. A target in a yellow beam could be at any one of three elevations. However, the beam pattern is different at different frequencies and with observations at two or three frequencies the correct position can be found.

With the narrow beams the elevation of the target could be measured with an accuracy of better than 0.1°.

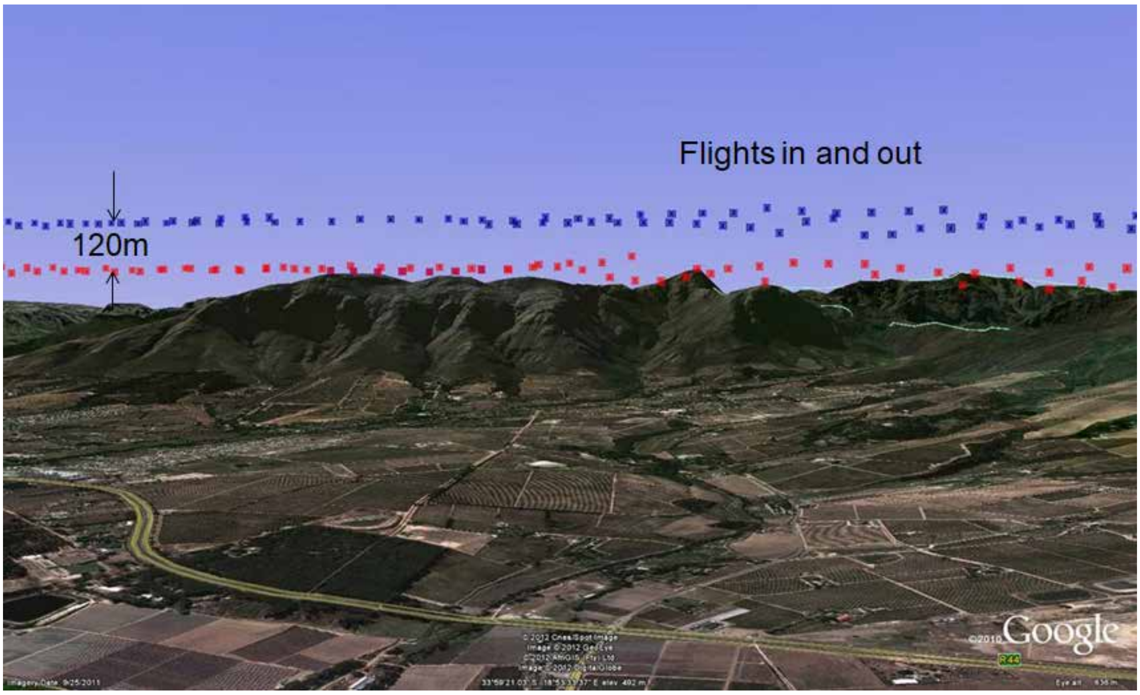




The figure below gives some idea of the complexity of the *DBRXL* system.



The *DBRXL* radar performed outstandingly well. The following figure shows a *DBRXL* track on a helicopter towing a calibrated radar reflector below the helicopter from a 100 m cable on an outbound and return flight. The track is projected on a Google terrain image.



The *DBRXL* had an extreme signal processing requirement. It had to process 1.5 GB/s worth of data in real time. Three high-speed processing units, each fitted with two graphical processing units (GPUs), provided the necessary computing power. Using standard computational platforms such as the Blade has enormous implications for obsolescence management.

The *DBRXL* development project had a significant legacy. Besides the grating lobe technology that had its first spin-off in the RAD 150 radar, several new technologies were established at RRS.

Prof. Norman Morrison, an emeritus professor of applied mathematics at the University of Cape Town (UCT), also joined the project. He investigated the tracking problem of estimating the position and velocity of a target when it is tracked by radar.

The ingenious Kalman tracking filter algorithm was developed in the years following World War II when computing resources were limited. It is the standard go-to solution to tracking problems up to this day. Prof. Morrison, knowing the weaknesses of Kalman filters, had other ideas. With modern computing resources at his disposal, he went back to the basis laid by Gauss two centuries ago for tracking planets and other heavenly bodies. Together with his young protégé Johan Kannemeyer he implemented a new approach to radar tracking filters. His solution performed very well and was also adopted by other members of the team for their own systems. Prof. Morrison published his ideas in a textbook on tracking filter design with title *Tracking Filter Engineering: The Gauss-Newton and Polynomial Filters.*

Processor Tales

The Blade system for *DBRXL* fitted with 3 Blade processing nodes (without GPUs) cost ZAR700 000. To process all the data required two high-end GPUs per Blade processing node. The Blade processing node was designed to accommodate Tesla GPUs, and only Tesla GPUs. At ZAR120 000 per GPU, these were outside the available budget. Thierry Feret, in his ever-ongoing quest to evaluate new processing hardware and not giving up, identified a commercial gamer's GPU that, at ZAR18 000, costs a small fraction the Tesla. It is also twice as powerful.

The only problem standing in the way of using the GTX Titan Black GPU was that it would not fit on the Blade processor. But Thierry found a way to make it fit with fairly minor modifications to the Blade processing node. After convincing the system engineer and project manager that the risk of damaging the Blade was low, the Blade processor was successfully modified and used with the gaming GPUs as processing platform for the *DBRXL* radar.

DBRXL Tales

RRS impacts epoxy supply chain!

Development projects regularly have to address the unforeseen: with new technology there are always surprises – sometimes from unexpected sources. These often lead to races against time to reach the finish line.

And so it was with the assembly of the DBRXL X-band receive antenna when the delivery of conductive epoxy used for bonding the waveguide components was late and the shipment could not be traced. In desperation, a new batch was ordered from the British suppliers, only to be told that they could not fulfil the order: "Some company in South Africa had brought the entire British stock!"

Fortunately, the missing shipment arrived in the nick of time.

Pieter-Jan talks about *DBRXL*:

When asked about the highlight of his career, Pieter-Jan Wolfaardt answers without hesitation: "DBRXL!". DBRXL bought together the most important role players in radar in South Africa to work together on one project. During this time there was the establishment of the South African Radar Interest Group (SARIG) that remains a forum for promoting radar technology in South Africa.

And, the cherry on top: "Everything in the radar just worked precisely according to plan!"

During the demonstration at Overberg Test Range (OTR) a helicopter towing a sphere was again tracked (see the photograph). "The range resolution was good enough to separate the two targets in range, so that both could be tracked in elevation, spectacular performance for a surveillance radar. Pieter-Jan remarks that "an invitation to a competitor to repeat the exercise with their system was declined."

Accidental Cell Phone Network Jammer

Albert Graham, who was responsible for the radio frequency hardware development, remembers:

'As part of the *DBRXL* project, we needed to implement and evaluate the performance of side-lobe cancelling. During one of the off-site exercises, side-lobe cancelling receive antennas were added to the *DBRXL* system and Pieter-Jan added the required code to the signal processor. At this point, Pieter-Jan decided "all we need now is a noise jammer to test". Albert sprang into action. A noise source and a connectorised gain block amplifier were crafted into a rudimentary noise jammer. The noise jammer was placed some distance away from the system and the team promptly forgot about it.

During the ongoing tests, they received a number of visitors. One visitor enquired whether there was any cell phone reception. The team told him that cell phone was generally poor at the deployment site – which indeed it was. However, later the team also noticed that the cell phone reception was particularly bad that day. In fact, there was none. That is when they realised that the noise jammer was still active.

They had a good laugh and Pieter-Jan remarked that maybe RRS should build jammers rather than radars, because we can do that without great effort!

High power pulsed amplifiers require special care in the DC power supply circuitry. A new approach to this problem was developed for the *DBRXL* L-band transmitter, resulting in excellent clutter-improvement performance. The technology has since been used in all our pulse radars.

To save cost and to meet space requirements for the X-band transmit antenna, a pillbox antenna was used to illuminate a specially-shaped reflector. The pillbox had a mind of its own when exposed to sunlight. Expansion due to uneven heating deformed the roof of the pillbox, which had to maintain a spacing of about 12 mm to the floor over a circular segment measuring more than 2 m on the chord. The illustration on page 96 clearly shows ample thermal isolation applied to the faces of the pillbox. Nonetheless, the lesson was learned that what looks like a simple antenna can turn out to be a beast.

Touws River Solar Trackers

As mentioned earlier, RRS won a bid against international competition to build the solar trackers for the Touws River Concentrated Photo Voltaic Plant (CPV). The platform was built according to an RRS design by Pierre van der Merwe and his team. It shaved 300 kg off the design initially proposed by our client, while at the same time achieving better stiffness.

Winning the bid was only the first step. The next challenge was to actually build 1560 trackers. This was a major undertaking for RRS. How do you build a system using more than 3000 tonnes of steel? RRS certainly did not have the facilities to do this. Two companies in Johannesburg were contracted, one for manufacturing the steel components, the other to galvanize the components before shipment to Touws River.

The end date for the project was fixed when contract negotiations began and remained fixed as contract negotiations for the ZAR140 million project dragged on and on. Work could only start once all the papers were signed. By that time, the project was already far behind schedule.

Quality management of the manufacturing and galvanizing processes proved to be challenging, as the manufacturing specifications were stringent. Pierre van der Merwe (responsible for the design of the trackers), Chris May (RRS Production Manager) and Marchel Pieters (RRS Quality Manager) maintained a virtually constant presence at the subcontractors' premises to keep an eye on every step of the different processes, while under intense pressure to catch up on deadlines.

Relief came in the form a *force majeure* declared by the supplier of the steel, after a fire broke out in a steel plant. This unfortunate event delayed the project long enough for RRS to catch up. Afterwards RRS was always ahead of schedule. (A second *force majeure* event was in fact declared later by the steel supplier after a countrywide strike by metalworkers, but had no impact on RRS.)

Tracker Tales

Transport problems

Disaster struck early – shortly after the first shipment left the galvanizing plant in Johannesburg in the evening. The load was not properly fastened and fell off the truck after a few kilometres. There was a rush to clear up the mess, and by early the next morning nothing was to be seen except for some damage to the road.

The truck was reloaded, with damaged parts replaced by finished parts. The load arrived safely at Touws River in the nick of time.

Concentrated Photo Voltaic vs Photo Voltaic

In a CPV plant the diodes that convert light energy to electric energy are illuminated at a level of several hundred suns. This is accomplished by placing each diode behind a magnifying glass. At this high illumination level, conversion efficiencies of more than 40% can be attained, compared to about 22% with standard PV panels. This, however, requires that the diode and its associated glass concentrator must be accurately pointed at the sun. This requires an expensive tracking system. Ultimately, considerations of cost favour the standard panel with its much lower efficiency.

Solar trackers during construction of the solar farm at Touws River

After manufacture of the pedestals and frames, the tracker components were transported by road to Touws River where the trackers were assembled on site. A total of 1560 trackers were supplied, of which only 1500 were erected due to environmental constraints. The project was completed on time.

The successful tracker design also found its way to overseas CPV installations, where several trackers were built under licence according to the RRS design.

Esprit

The initial *MSR* 200 series slope stability radars were designed to monitor slopes at ranges of up to 200 m – a short distance compared to the pit size of a typical mine. Mines would rather deploy slope stability monitoring on the banks of the mines than inside the pits, and there was a constant demand for systems that could monitor slopes at longer ranges. The range limitation is imposed by the atmosphere and the update rate of the radar.

The velocity of propagation of radar waves in air is strongly affected by the water vapour content of the atmosphere. When humidity and therefore water vapour content increases, radar waves slow down and the distance between the radar and slope increases in terms of wavelength. Since the radar measures small changes of slope movement by measuring the change in range as a fraction of a wavelength, the effect of increasing atmospheric water content on the radar is exactly the same as that of a slope movement away from the radar.

The radar measurement becomes ambiguous if the apparent movement of the slope is more than a quarter of a wavelength between measurements, and the longer the time between measurements, the more serious the problem. In a scanning radar the update rate may be several minutes if the scanned area is large. Much time and money has been invested in developing software to manage this problem and not cause false alarms and, more importantly, not to miss real movement. The range of the *MSR* 300 series of radars was extended to 2500 m, but even this was not enough.

The real solution is to dramatically shorten the update rate of the slope monitoring radar.

From the viewpoint of established radar architecture there is a well-known solution to the problem, called a phased array radar. In the case of slope monitoring the system would have a small low gain transmit antenna that illuminates the full slope, and a large receive antenna array with multiple elements each feeding a receive channel. Such a radar can form several hundred beams simultaneously, covering the complete slope in a single measurement.

However, this approach would not solve the mining radar problem, as the system would become unaffordable.

Enter Pieter-Jan with a solution to the problem in the form of a MIMO (multiple input, multiple output) 3D radar. The MIMO antenna has nearly 200 transmit and receive active elements, each of which has a bi-phase modulator in its signal path running a unique code from a family of lengthy orthogonal codes. The transmit elements are all excited from a single transmitter and the received signals are combined into a single channel in the receiver. The receiver output signal is digitised and fed to the signal processor. The composite signal is then unscrambled in the signal processor and processed into beams, producing the equivalent of about 9000 distinct receive beams. The individual beams have beam widths ranging from about 0.3 to 0.45º and cover the full slope. The unscrambling and beamforming process takes less than two seconds in 2D mode, and *Esprit* completes a full slope measurement in seconds – something that would typically take minutes to complete with a scanning radar.

The rapid measurement rate has significant implications for the slope stability monitoring function because it completely eliminates the ambiguity problem and greatly simplifies the management of atmospheric changes.

Esprit Tale

Calibrating signal paths of the 192 active elements in the antenna is the first step in preparing an Esprit radar for field use. Errors of two degrees in the electrical phase of these signal paths can result in a doubling of the antenna beamwidth.

To calibrate the antenna, a radar beacon is placed about 100 m in front of the antenna. The beacon consists of a receive antenna, a long delay line and a transmit antenna. These emulate a target far away from the radar and the whole system is then calibrated to produce a point target return. By rotating the Esprit antenna, the radiation pattern can be calibrated in the azimuth plane.

That was the theory.

Nico Ehlers was assigned the task to perform the calibration. After spending hours in the hot sun doing repeated measurements, Nico found that the calibration simply did not work. He and Pieter-Jan Wolfaardt repeatedly checked their calculations and the software but could find nothing wrong.

Then the penny dropped! The transmit and receive antennas of the beacon were spaced about half a metre apart in the horizontal plane, a long-established practice with other radars. What was different this time was that, with the extremely narrow beamwidth of *Esprit*, the two antennas were placed in adjacent beams of the antenna while theory demanded that they be placed in the same beam.

Everything fell into place when the transponder antennas were place in the same vertical plane.

This is typical of the subtle surprises awaiting those who venture into new technology.

FORT (RTS 3200)

Conventional tracking radars such as the RTS 6400 Optronics Tracker Radar (*ORT*) due to their performance and associated complexity are relatively expensive. RRS identified a need for a low-cost tracking radar for use on smaller patrol vessels and set about developing a radar based on frequency-modulated continuous wave (FMCW) technology. The concept called for a planar antenna array rather than a parabolic reflector. Following our experience with RAD 150 and *DBRXL*, a phase comparison technique was the preferred technology for accurate directional sensing.

The first prototype used the electronics of the RSR 906 as is, so that the development effort entailed mainly the mechanical design and construction of the positioner and the antenna. This was overseen by Pierre van der Merwe.

Werner Steyn designed an antenna consisting of a transmit waveguide array and four interleaved waveguide receive arrays. The antenna has the rather peculiar property that the direction of the antenna beam patterns is frequency dependent – technically known as squint. It simply means that the antenna does not beam in the direction of the normal to the plane of the antenna and that the offset depends on frequency. The angle offset can, however, be calculated exactly. A camera on the tracker is used for target identification and verification. The camera had to point in the boresight direction of the antenna – and that depended on the radar transmit frequency, which required the camera pointing direction to be dynamically adjusted by the tracking computer. This part of the development work was delegated to Mike Movius, who also designed the signal processing and tracking system. Mike laughs when he relates how they ended up doing it rather differently from what they had envisaged at the start of the project.

In the end it worked well. The radar has an accuracy rather better than one milliradian. That means that a target at a range of one kilometre is located with an error of less than one metre in the crossbeam direction.

FORT features prominently on the Multi-Mission Inshore Patrol Vessel (MMIPV)
Picture: Damen Shipyards

FORT Tales

Range deficiency

The RTS 3200 *FORT* started as a technology project to replace the ageing laser range finders in use by the SA Navy. A frequency-modulated continuous wave (FMCW) ranging demonstrator was built using FMCW technology from existing RRS sensors. A Potter horn, an antenna with very low side-lobes, was quickly designed and built to use as a transmit antenna.

Successful trials were undertaken with various surface and air targets. However, there was one worrying detail. Mike Movius found that the target echo was weaker than expected, and this limited the maximum range of the system. From all other appearances the demonstrator was working as it should.

This remained a puzzle until after the trial Mike realised that the Potter horn was rotated around its axis by 90° from the correct mounting position. The cross-polarised echo was much smaller than the expected co-polarised return.

Therefore, despite the worrying oversight on the demonstrator, the RTS 3200 *FORT* had indeed worked as it should…

Black Magic

Once the first build of a new radar system is complete it must undergo several qualification tests. One set of tests is to certify the electromagnetic compatibility (EMC) of the system. The system must not unduly interfere with the proper operation of nearby electronic systems, while its own performance must not be unduly affected by other electronic systems in its vicinity.

These tests and the remedies for problems found often lead people to describe high frequency engineering as 'black magic'.

During the *FORT* EMC test, an unacceptable level of radiation came from the *FORT*. After struggling for a few days, Jurgens de Jager called in Prof. PW van der Walt, who soon diagnosed the problem and asked Jurgens to fasten two short-braided copper straps to the rotator. The radiation level went down to an acceptable level and the test was passed. A simple addition to the rotator – not complicated 'black magic' this time – fixed the problem for good.

FORT undergoing Electro-magnetic Compatibility (EMC) tests at Houwteq

Radar is a complex system that often needs to be fine-tuned to perform optimally when deployed in a different environment. Client training is an important part of radar logistics. The picture shows new SA Navy users after learning about the details of the *FORT* tracker. Instructor Jurgens de Jager is with his class on the steps of the RRS building.

NRIS (RIS 100X)

All non-military ocean-going vessels larger than 300 gross tons must carry an Automatic Identification System (AIS) transponder and an X-band radar. The radar is used for navigation and to avoid collisions, while the complementary AIS system broadcasts positional and other information such as vessel type, course and speed to each vessel in the vicinity.

Some satellites also carry AIS receivers and as a result, a world-wide picture of marine traffic is built up.

AIS systems are required to be permanently switched on unless the safety of the vessel may be compromised – as in waters where piracy is rife. Thus, a vessel would normally have its radar and AIS system on unless it is involved in some illicit activities such as illegal fishing, which would give it a reason not to broadcast its location.

Thinking along these lines, Anthony Green conceived an inexpensive system that could provide marine authorities with valuable information: an intercept receiver restricted to the 9 GHz marine radar band that could provide an accurate bearing on a radar transmission together with enough processing power to extract a waveform signature of the transmission, and a means to display intercepted signals together with AIS information about local shipping. With two intercept receivers spaced some distance apart, the exact location of a transmitter of interest can be determined.

Also taking a leaf out of *DBRXL* technology, Werner Steyn and PW van der Walt proposed an architecture for a low-cost system. With the unconventional waveguide antennas designed by Werner Steyn, a small receiver that can determine the bearing of a radar transmission with exceptional accuracy was developed. High accuracy aids in resolving targets in crowded waterways, and allows the association of bearing lines, or strobes, with a particular AIS report. Labelled transmitter positions are plotted together with AIS data on the *NRIS* display.

NRIS is currently being evaluated by several marine authorities.

An *NRIS* intercept receiver can be set up in locations with minimal infrastructure

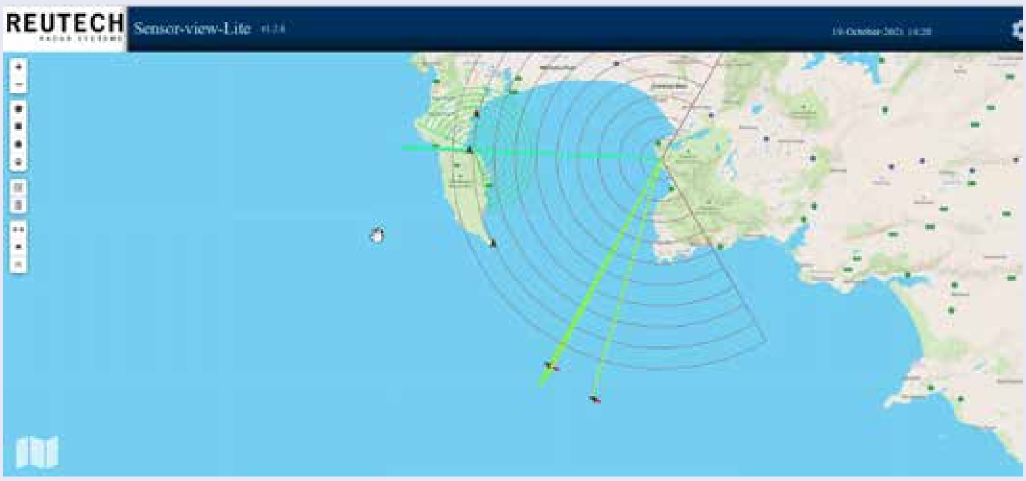
NRIS Tale

Anthony Green recalls: "During early evaluation of *NRIS*, multiple shore-based trials were conducted to confirm the system's ability both to detect the presence of navigation radar emissions and accurately establish the bearing to the source of the emissions. These land trials were largely successful using internet-based AIS vessel applications to report and confirm which vessel was emitting which signal. This success spurred us on to get the receiver onto a ship and head out to sea in pursuit of ships with navigation radars.

The SA Navy kindly made a mine-hunter vessel scheduled for routine patrol available to us and the *NRIS* was duly installed. Since we did not have an AIS display in the vicinity of the *NRIS* display, it was decided that binoculars would suffice in identifying the vessel producing the bearing indication on the *NRIS* display.

All went well until we left Simon's Town harbour. After this, a thick, pea-soup fog descended on us. *NRIS* reported many vessel detections, but we were left with a sense of not quite achieving our goal because we could not visually identify the vessel producing the emissions.

Ironically, by the time we docked in Simon's Town after completion of patrol, the fog lifted, and it was a sunny day…"



An *NRIS* display on the screen of a personal computer or tablet, showing strobes on detected radar transmissions from vessels with AIS receivers. A strobe without an AIS marker arouses suspicion

SSP

A rock burst is one of the major safety risks in platinum mines.

The Merensky reef was formed ages ago by lava flows, and flows at different times often have a weak seam or even a crack between them. During mining operations under a sloping crack, a wedge-shaped chunk may fall out of the roof, injuring people and destroying machinery. It is therefore important to detect sloping cracks in the roof where the reef is being mined. To date, this was mainly done by drilling inspection holes into the roof and examining the drilled-out cores.

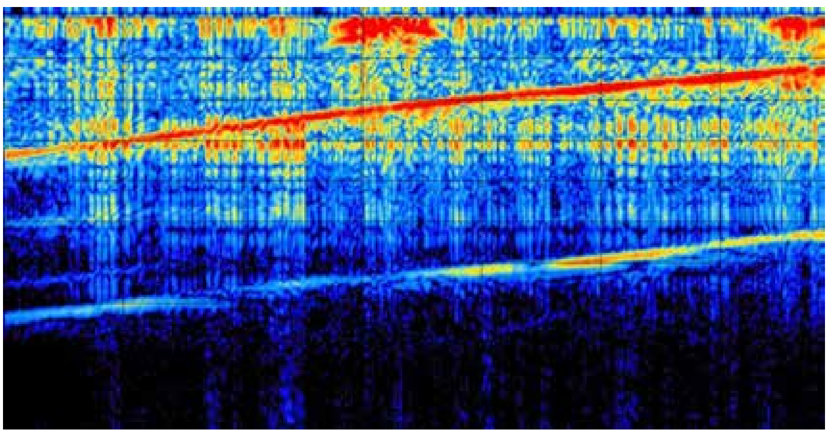
Ground-penetrating radars such as those used to detect pipes under roads in the civil industry were tried out in platinum mines with limited success. The radars were difficult to deploy in the mine environment. They had to be dragged across the roof of the mine by a miner walking on his knees while negotiating a way between supports with the umbilical cord connecting the antenna unit to the display unit. The radar displays were also difficult to interpret.

After a visit to a few platinum mines, PW van der Walt and Paul van der Merwe proposed a lightweight wide-band system that could traverse the roof on a roller while using a radio link to transmit information to a display in the form of a ruggedised tablet.

Paul van der Merwe was put in charge of the development of the system and came up with the very practical battery-operated system pictured below. A full charge of the lithium batteries allows up to four hours of operation. The radar is certified intrinsic safe for use in hazardous environments.

The *SSP* is a light-weight ground penetrating radar with excellent ergonomic design features. The picture at the right shows how the radar is held when scanning the mine roof

Paul found that the radar picture remained difficult to interpret – until he used information derived from the movement of the radar across the roof. This produced a marvellously sharpened picture of the structures inside the roof. The picture shows a scan of a crack inside a granite rock.



A scan produced by the *SSP* shows cracks inside a granite rock

The *SSP* has been found to have unexpected uses. A far-Eastern railway company scans railway tracks to locate underground cavities beneath the tracks. In Stellenbosch, an *SSP* supported a police operation to locate a body thought to be hidden in a garbage dump. The body was found within a few minutes at a depth of 4 m.

SSP Tale

Dummy mine

During the development of the *SSP* system, Paul van der Merwe had a problem. How do you do development tests in the Western Cape on a radar intended to inspect the roof of a platinum mine in Limpopo?

His team's solution? You turn the mine upside down!

They argued that granite rocks have electric properties that are similar to that of the norite rock of platinum mines – and there are several granite quarries in the Western Cape. One quarry in Paarl was particularly well suited to the team's requirements.

In the picture, Danie Brink pushes an early prototype *SSP* along a granite bench while Bernhard Meyer monitors the screen display on a tablet. At the same time, they could get a preview of what the radar should find because one face of the rock had already been laid bare by a previous cutting. The quarry tests provided valuable data for developing the optimal processing algorithms. Their solution was much less costly than tests in a mine – and equally reliable.

Danie Brink and Bernhard Meyer scanning a bench in a granite quarry.
The quarry proved to be a perfect development laboratory.

Thutlwa Upgrade

After a service life of 20 years, the *Thutlwa* radar that started life as *Kameelperd* underwent a major upgrade of its electronics.

This was the first application for RRS of Gallium Nitride (GaN) power amplifiers in a radar. The transmitter, receiver and frequency synthesiser were upgraded to the latest electronic components. A new duplexer (the transmit/receive switch) capable of handling the increased power of the transmitter was developed and duplexer cost was reduced by using printed circuit board technology instead of machined coaxial components.

While the appearance of the upgraded *Thutlwa* is not discernible from *Kameelperd* radar, the modernised version itself is a highly capable radar with an increased detection range. Capable of operating in low as well as medium Pulse Repetition Frequency (PRF) modes, the radar has outstanding Doppler performance. The upgrade process furthermore served to make available radar upgrade kits suitable for the modernisation of similar radars.

RSR 312

Radar architecture requires complex, multidisciplinary design activity.

The fundamental radar equation is not all that difficult: the ability to detect a target is governed by the energy content of an echo received from a target. That energy is inversely proportional to the fourth power of the range to the target. To increase the energy, you simply have to increase the transmitter power.

The modern trend, however, is towards solid state amplifiers, and these are characterised by low peak power. The energy in the returned echo can be increased by transmitting longer pulses more often to raise the average power and thereby the energy of the returned pulse. However, this saddles the radar with the problem of having to resolve ambiguities in range. Generally, a pulse radar cannot receive while it is transmitting, and this creates a dead zone where the radar cannot detect targets. If care is not taken, the long pulses could potentially blank the very targets the radar needs to detect.

A target such as an aircraft also has a 'mind of its own'. Because there are many reflections from the different nooks and crannies in an aircraft, these reflections sometimes interfere constructively, sometimes destructively – depending on the precise direction of the impending wave. The energy received in the echo fluctuates continuously. To combat this, a radar often transmits waves of different frequencies in quick succession or simultaneously.

The radar architect must balance these and other often conflicting requirements, while at the same time keeping costs in mind. A wrong decision can cost millions.

The RSR 312 radar is the result of innovative thinking by Pieter-Jan Wolfaardt, and the product of years of experience in devising radar architectures.

The X-band radar uses two solid state amplifiers transmitting simultaneously on different frequencies through two antennas that are also used as receive antennas, feeding two receive channels. A third lower gain receive antenna provides an input for a third receiver that provides for the detection of close-range targets through intra-pulse processing while the transmitters are active.

The antenna housing accommodates the power amplifiers as well as the receivers, while the signal processor, data processor, power supply and display units are housed in a separate container below the antenna.

The RSR 312 design grew out of a client's requirement for a maritime surveillance radar covering a stretch of ocean carrying thousands of small craft, with each of these to be managed by the data processor. The RSR 312 project is therefore a good example of a major co-development project. The client sent an engineering team to work closely with the RRS development team. At the end of the project, the client had a much better understanding of the capabilities of their system, were well equipped to make optimal use of the radar, and could maintain it in-house.

The antenna of the RSR 312 against a backdrop of Stellenbosch mountains.
The antenna also houses the transmit and receive electronics

RSR 312 Tale

Powerful surprise

The design of the receiver front end was just about completed when we received some information about the site where the radar would be deployed.

There, right next to where the RSR 312 would be located, stood an old X-band radar from a time when pulse compression was not yet commonplace, and radars transmitted short pulses with very high peak power.

RSR 312 would have to contend with a very large signal from an antenna a few metres away pointing straight at it, at a frequency right in the centre of our receive band! Without adequate protection, our front end would have been converted rapidly to smoke and ashes.

This came as a complete surprise to designers Martinette van der Merwe and Anneke Stofberg, as the user requirement made no mention of this threat.

The receiver protector was therefore upgraded to a waveguide model that would survive exposure to the high-power pulses.

Alexander Bay Deployment

The *Spider* radar mounted on a durable rotator was renamed to RSR 906. A first permanent deployment of this radar on the South African coast was completed recently at Alexander Bay where the radar continuously monitors coastal traffic.

The remote-controlled radar communicates via the cell phone network to various locations, including RRS, where its performance is monitored regularly. The radar picture is available to various users.

RSR 906 keeping watch from a hilltop overlooking the ocean at Alexander Bay

Alexander Bay Tales

Theuns Botha was put in charge of erecting the radar on high ground near Alexander Bay. The area is surrounded by desert. Theuns had to find a good location for the radar, lay on an electricity supply and get it working.

He says the two-week stay opened his eyes to the desert. He was astounded to find fountains with clear potable water surrounded by nothing but rocks and sand, and large Oryx roaming free.

The terrain was difficult. Theuns got sound instruction on how not to get bogged down in sand – with lots of practical experience thrown in, because concrete had to be mixed at the foot of the mountain and carted up the hill by the bucket-load via a sandy road.

They also erected a shaded area, and at one stage suspended a big fat salami from the awning where each person could slice off a piece to still their hunger.

Then, there was a sudden loud crack and the shade shook. The next thing they saw was a brown hyena hightailing it downhill at high speed with their salami in its jaws. A gourmet-loving hyena with a good nose and a soft spot for salami!

A Rhino's friend

Radar is a unique sensor with unique capabilities. It is capable of day and night operation, and to a certain extent can penetrate shrubs and forests. It is a very sensitive detector of movement and can provide information on a target location in two or three spatial dimensions.

These qualities made radar a critical sensor in the *Meerkat* system that was developed by the CSIR and deployed in the Kruger National Park to combat rhino poaching. Consisting of an RSR 904 'Ngada' (*meaning=meerkat*) radar sensor, an infrared camera and a command-and-control system, *Meerkat* performs a 24/7 patrol duty by first detecting moving objects or persons within a detection circle around the system. When an alarm is raised, the infrared camera is automatically directed to the relevant location. Optical inspection can confirm whether the target is a person up to no good. In the case of poachers, an armed patrol is directed to the position to apprehend the intruders.

The system is an unqualified success. Francois Anderson, who conceived the system, states that poaching incidents have decreased from one per day to one per year within the observational radius of the radar.

The *Meerkat* system keeps a 24/7 watch over the rhinos in the Kruger National Park. The RSR 904 radar initiates a response when it detects moving objects.

HOSFIN

The RSR 150 (also known as RAD 150) radar is a remarkable 3D sensor, yet the development project was terminated before it reached product status. Anthony Green analysed the problem and concluded that a stronger business case could be built for a less expensive sensor used to protect a higher value asset than the armoured vehicle for which RSR 150 was initially conceived.

A helicopter is typical of such an asset. Helicopter pilots often fly low, well within range of hostile rifle fire from the ground. Because of the noisy environment, pilots cannot hear when they are shot at from the ground and they are usually not aware of it when they have been hit. The result can be catastrophic – so a sensor that warns of incoming rifle fire would be a valuable aid for a helicopter pilot. The sensor in this case could also be simplified as a 3D sensor is not required for hostile fire detection.

Hostile fire warning sensors are currently available, but these are optical systems that tend to produce high false alarm rates because warnings are based on single, fleeting, observations. A radar sensor can produce more reliable warning with a lower false alarm rate because it can establish a track on incoming projectiles before giving warning.

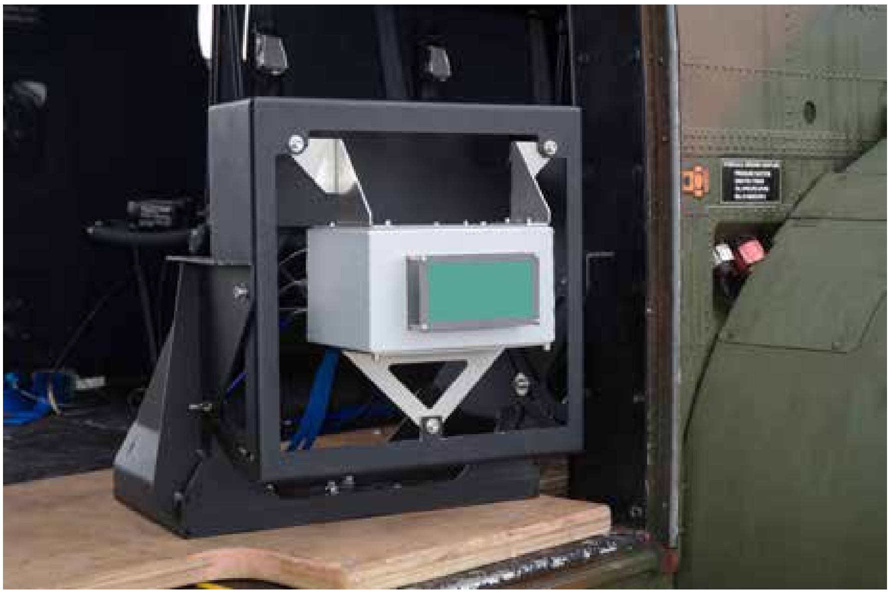
The RRS *HOSFIN* concept using 2D radars for warning against hostile fire is illustrated below.

A helicopter is equipped with four sensors covering the four quadrants towards the side and a fifth sensor to cover the ground directly below the helicopter

Anthony knew that the RSR 150 could detect rifle bullets at ranges of more than 100 m and started to market a RSR 150 derivative to the South African Air Force. His first move was to demonstrate that RSR 150 could detect rifle fire when mounted in a flying helicopter. This demonstration proved to be successful.

The next step was to build a demonstration model of a less expensive version of RSR 150 that was optimised for its new role. The outcome of this test was also positive.

A final model of the *HOSFIN* sensor is currently under development.



The *HOSFIN* demonstrator showed that rifle bullets could be reliably tracked from a flying helicopter

MINING

The Reutech Mining Division continuously improves the software environment of its mining radars – leading to additional tools for mines.


Berm Monitoring System

For instance, the Reutech Digital Compass (RDC) is a very useful mining tool. The tilt-corrected electronic compass helps miners to seamlessly map geological structures, measuring dip and direction of dip and strike at the press of a button. Measurements are transferred to other digital devices via a Bluetooth radio connection, from where the information gleaned is fed into the mine's database.

A Berm Monitoring System was developed jointly with German companies, where RRS manufactures the trailer and solar power supply that houses a laser provided by one of the partners on a rotatable mast. Another partner provided the software for the system. The system continuously monitors the berm heights where the mines trucks unload. If a berm is lower than specification, a message is automatically sent by WiFi link to a tractor operator, who then restores the berm.

Reutech also supplies the *MSR* Connect software suite. It provides a radio connection to computers, tablets and cell phones to communicate slope stability data, including images of areas of movement of the high wall – allowing managers to view slope information from wherever they are.

Reutech Slope Vision integrates a high-definition georeferenced camera into the monitoring system, allowing managers to visually inspect slopes in areas where warning of failure have been generated or anywhere else.

REUTECH MINING

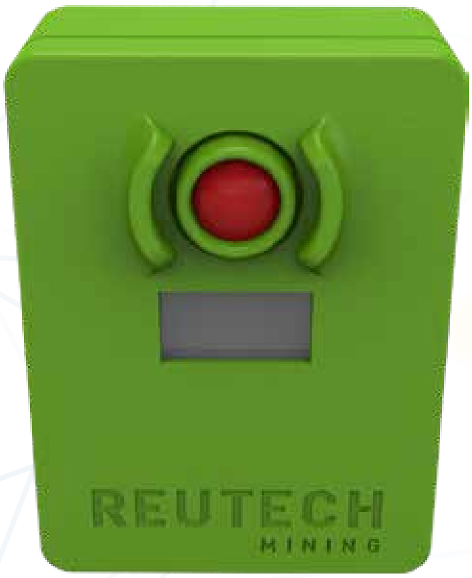
For the past several years the mining division has placed an increased focus on mitigating the environmental impact of its products.

Several products offer options to operate from renewable energy sources, waste is reduced by keeping systems up to date by upgrades rather than replacement and new products are introduced to improve mining productivity.

The division recently revised its branding to emphasise its commitment to the environment. In its new logo, the colour green symbolises environmental concern while the chevron emphasises an aggressive approach to reduce our environmental impact.

THE STORY BEHIND
THE REUTECH DIGITAL COMPASS (RDC)

Bryn Jones tells that, in the early days of the *SSP* industrialisation, he attended a progress meeting at RRS with a client.



During the meeting the discussion drifted to typical geotechnical uses for the *SSP*. At some point Dip and Dip Direction measurements with a compass were discussed, and included how the readings from an analogue compass could be used in conjunction with the results from the *SSP* to map out geological features.

The client's representative explained how the analogue compass (Brunton compass) was used to measure Dip and Dip Direction. The process was convoluted and cumbersome. It got Bryn thinking.

He had already had some experience with micro-electronic mechanical sensor (MEMS) accelerometer and magnetometer integrated circuits. Used together, these were ideal for the task because the 3-axis accelerometer could be used to tilt-correct the magnetometer.

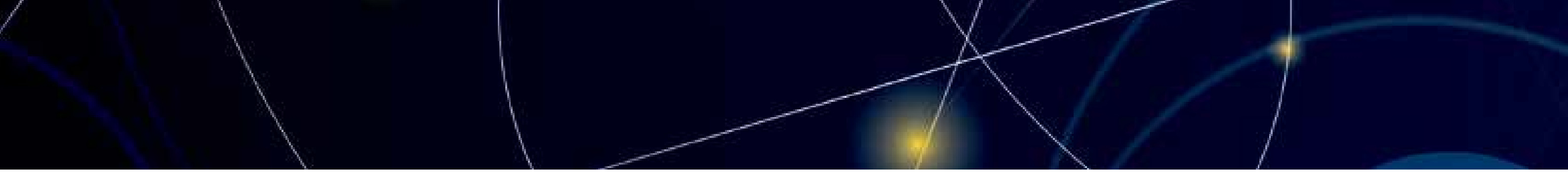
He then built a proof-of-concept demonstrator proving the applicability of the idea.

This prompted the development of the RDC.

A miner using the RDC to measure Dip and Dip Direction

PART 4

RRS: THE FUTURE



A BRIGHT OUTLOOK

Harald Bielfeld, the current RRS CEO, commented on the current state and future of the company. He noted that, thanks to the efforts of its dedicated people, RRS has successfully navigated the rough seas of rapid change of the past decade.

Apart from managing rapidly-shifting marketing opportunities, the company has had to adapt to new working conditions forced on the global economy by the COVID-19 pandemic. Now, with the worst of the pandemic behind us, things are returning to what we experience as 'normal'.

'RRS is very well positioned for the near future, perhaps better so than at any time in the past. With travel restrictions lifted, local and foreign marketing is again in high gear, and we are hard at work to turn opportunities into contracts. Indeed,

the company is already seeing rapid recovery in its overseas business, in both the defence and mining markets,' he says.

Bielfeld furthermore points out that the marketing drive is strongly supported by a growing inventory of innovative and marketable technologies and products. All of this is underwritten by highly qualified and motivated staff. RRS has succeeded in attracting and retaining experts—and in 'growing its own timber' through support and development programmes.

'I am indeed looking forward to an exciting and prosperous future for RRS,' says Harald.

ABOUT THE AUTHORS

PW van der Walt

Pieter W van der Walt obtained the BSc, BEng, MEng, and PhD degrees in electronic engineering from the University of Stellenbosch.

He joined the Department of Electrical and Electronic Engineering of the University of Stellenbosch in 1971, was appointed Professor in 1980 and Dean of the Stellenbosch Faculty of Engineering from 1993 to 2002.

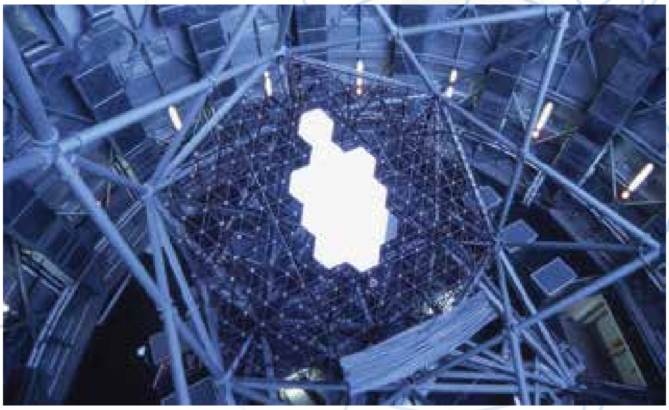
He served as a full time consultant for ESD (South) in 1987 and as a part-time consultant for ESD (South)/Reutech Radar Systems from 1988-1997.

After his retirement from the University in 2002, he joined Reutech Radar Systems as Technology Executive responsible for RF and Microwave Technology. He retired in 2012 but he is still involved as a part-time consultant. He was Vice Chairman of the Stellenbosch University Council until 2017.

Prof van der Walt is a registered Professional Engineer and Senior Member of the SAIEE and the IEEE. He received the SAIEE best paper awards in 1987 and 1990, The Chief of the Army's Commendation in 1989, The IEEE Third Millennium Medal in 2000, the ECSA Certificate of Merit in 2001 and the MT Steyn Medal in 2008.

Lia Labuschagne

Lia Labuschagne is an independent writer, editor, and communication consultant with qualifications in literature and marketing. She edits and/or writes for a wide range of publications on a variety of topics – including science, technology, engineering, architecture, sustainability, environmental issues, business and music. Her experience includes positions in senior management at major organisations nationally, and seven years' working experience in Europe.



REUTECH

RADAR SYSTEMS