Sky’s the limit for satellite control system expert Prof Herman Steyn

***Caption**: Prof Herman Steyn*

The launch of SunSAT, the first microsatellite designed and manufactured in South Africa, propelled Emeritus Professor Willem Hermanus (Herman) Steyn into the orbit of space and eventually the small satellite market.

SunSAT was built in the 1990s by postgraduate engineering students in Stellenbosch University’s (SU) Department of Electrical and Electronic Engineering.

At the time, Prof Steyn was one of the academics working with Proff Jan Du Plessis, Arnold Schoonwinkel and Garth Milne on this low-earth-orbit microsatellite project in the Faculty of Engineering’s Electronic Systems Laboratory.

The idea behind embarking on the ambitious project was to offer postgraduate students the opportunity to increase their involvement in practical design activities by designing and building a fully functional microsatellite.

Africa’s first domestically developed satellite, featuring a high-performance earth observation camera, emerged from this initiative. This was a landmark achievement within the Faculty, with NASA even citing the programme as a model for other universities at the time.

The SunSAT project ran for almost a decade, and roughly 100 students earned their graduate (or postgraduate) degrees in some aspect of it.

Prof Steyn did his PhD on the control system of this 64 kg satellite (roughly the size of a washing machine) which heralded South Africa’s entry into the space age.

“I never expected to venture into this space,” Prof Steyn recalls. “At the start of SunSAT, I was offered the opportunity to do a Masters degree in satellite engineering at the University of Surrey, and it all gained momentum from there.”

Prof Steyn spent four years as principal engineer and team leader for satellite control systems at Surrey Satellite Technology Limited (SSTL) in the United Kingdom. There, he participated in many European space missions, including the European Space Agency’s Rosetta mission, where he led the development of a momentum wheel for the Philae comet lander. (The Rosetta mission was the first to rendezvous with a comet, follow it in its orbit around the sun, and deploy a lander to its surface.)

“At SSTL, I got involved in the control systems of satellites of different sizes. So, I got to work on the entire spectrum of satellites ranging from big to small (roughly 500 kg to 5 kg in mass). It was

a wonderful opportunity, offering me a foothold in both the commercial and the academic space."

When Prof Steyn returned to South Africa in 2002 as head of product development at South Africa's first satellite engineering company, SunSPACE, he helped develop, build, and commission earth observation satellites for international customers. SunSpace, a company born out of the SunSAT satellite programme, was formed to expand and commercialise SunSAT's technology.

Innovative pioneer

Prof Steyn is considered an expert in satellite systems, satellite orbit and attitude control, and process and adaptive control.

According to Prof Petrie Steyn, acting dean of the Faculty, his contribution to satellite systems technology has helped propel South Africa to the forefront of satellite innovation. "Prof Herman is an example of how SU experts are leading South Africa's charge in space technology, blending academic excellence with pioneering innovation. He has provided innovative contributions to satellite technology, thereby inspiring many students, paving the way for South Africa's booming technology and respected microsatellite industries, and bringing both SU and the country international acclaim."

Leading from the front

Over more than thirty years, Prof Steyn has conducted substantial research, particularly on satellite control systems.

In 2005, he joined SU full-time and established a satellite engineering research group inside the Electronic Research Laboratory to develop low-cost nanosatellites and their components.

Prof Steyn became a professor of aerospace and industrial control systems in the Department, delivering several firsts for the local satellite industry.

As head of product development at SunSpace, Prof Steyn helped to develop, build and commission earth observation satellites for international customers and SumbandilaSAT, the first earth observation satellite for the South African government.

In 2005, the then Department of Science and Technology commissioned SU and SunSpace to develop SumbandilaSat, a technology demonstrator in conjunction with the South African industry. The satellite was delivered fifteen months later and launched from Baikonur, Kazakhstan, in 2009 with monitoring and satellite support from the South African National Space Agency (SANSA) Space Operations facility in Hartebeesthoek.

"SU was a natural choice to spearhead the SumbandilaSAT project after its success in building and launching SunSAT in 1999," Prof Steyn says.

“The building of SumbandilaSat was a significant milestone in 2009,” he reflects. “This represented a huge step forward in South Africa’s space exploration objectives.

“Working on SumbandilaSAT was definitely one of my personal career highlights. I remember watching the satellite pass through the night sky through a telescope outside my mother's holiday home in Glentana. It was a great feeling thinking I had some part in its operational system.”

The satellite continued to provide valuable data during its more than 12 years in orbit. On the academic front, the SumbandilaSAT programme produced 18 Masters and two PhD students in engineering at SU.

Seeing that government funding for satellites stagnated after the SumbandilaSAT project, Prof Steyn returned full-time to SU, where he started focusing his research efforts on Cubesats. These satellites are much smaller than conventional satellites, resulting in lower costs.

As project leader, Prof Steyn and his research team partnered with the Surrey Space Centre at the University of Surrey and participated with other European companies on several FP7 projects since 2010. The FP7 was the European Union’s research and innovation funding programme from 2007 to 2013. The list of projects included DeorbitSail (a small satellite mission built to deploy a drag sail in a low earth orbit), QB50 (an international network of CubeSats to model the lower thermosphere) and RemoveDEBRIS (a satellite research project that demonstrated various space debris removal technologies).

In 2012, Prof Steyn chaired the Space Engineering Expert Group of the National Space Programme for SANSA to plan future government space activities in South Africa.

Small is beautiful

Prof Steyn subsequently worked on CubeSpace, a satellite components manufacturer born out of SU’s research labs. The company has produced more than 4 000 satellite components and more than 350 intricate control systems, positioning itself as a leader in satellite innovation.

“Although CubeSpace doesn’t conduct satellite launches, its team locally designs, manufactures, and assembles components, contributing to groundbreaking missions,” he says. “The company is leaving its mark on the satellite sector with a diverse clientele spanning Europe, the US, and beyond.”

“Control systems are the backbone of satellite operations,” Prof Steyn says. “They ensure precise manoeuvrability, which is crucial for many applications.

“CubeSpace allowed us to commercially exploit the small satellite market with turnkey attitude control systems and attitude determination and control system components. CubeSpace has, for instance, spearheaded the development of control systems for the United Arab Emirates’ lunar rover mission, a remarkable feat in space exploration.”

Under Prof Steyn's guidance, the team has commercialised its innovative work, bridging the gap between science and entrepreneurship.

A big future for compact orbiters

"In recent years, small satellites have opened up new possibilities for the space industry," Prof Steyn says. "Ranging from the size of a refrigerator to a shoebox, these nimble spacecraft are much smaller than traditional ones.

"With the current technology available today, satellites are getting smaller and smaller and can be built faster. You can say we are witnessing the democratisation of the satellite industry, with more players being able to join."

Since 2005, university nanosatellite programs have grown significantly. Small satellites are crucial to the future space market, with estimates of over 15,000 satellites to be launched from 2021 to 2030, around 90 per cent of which will weigh less than 500 kilograms.

Many small companies and universities are now involved in nanosatellite programmes. Nowadays, it is also possible to build a constellation of small satellites. "It's no longer just one satellite that you launch, but you now launch 10 satellites or 20 or 100 satellites to do a certain thing, say to deploy an internet communication system in space."

Small satellites are not a new concept; however, modern satellites differ from their predecessors in several significant ways. One of the most notable advancements is using widely accessible microelectronics combined with innovative management strategies. This advancement enables the creation of spacecraft that can operate independently or as part of satellite constellations, performing complex functions with high utility while consuming significantly less space, money, and time than earlier generations.

Prof Steyn says small satellites, which can be launched with small, modern launchers, play a central role in what is referred to as the 'new space' market. Small satellites are also very suitable for testing new technologies in space because they are standardised, available in different sizes, and can be provided quickly on demand.

"Everything you can do with a large satellite can now almost be done with a small satellite. The electronics are getting smaller and smaller. All the components are getting micro- and nanosized. We can now do what we did on picosatellites of 1 kg on a 100 kg satellite 20 years ago."

Nurturing the next generation

Prof Steyn is passionate about nurturing the next generation of engineers involved in satellite-related research and leveraging space technology.

Many of his former students now work at CubeSpace or are making significant contributions to satellite research within the Faculty. Notably, two of his former PhD students, Prof Willem Jordaan and Dr Arno Barnard, serve as senior lecturers in the Department.

Reflecting on the evolution of South Africa's space industry, Prof Steyn attributes its growth to developments that began in the early 2000s.

"The transition from military to commercial applications, coupled with a growing interest in space exploration, laid the foundation for our industry's expansion." He highlights that the Electronic Systems Laboratory has been at the forefront of satellite development in South Africa since the late 1990s. This postgraduate research laboratory within the Department focuses on autonomous vehicles and trains satellite engineers to excel internationally.

Since the days of SunSAT, the Department has played a crucial role in developing nanosatellites—small spacecraft often no larger than a shoebox yet equipped with significant scientific capabilities. These small satellites undertake a variety of missions, including earth observation and telecommunications.

These initiatives have also stimulated the growth of several new commercial space enterprises in the Western Cape, many of which were founded by former SunSpace personnel.

Prof Steyn notes the success of the province's commercial space component suppliers on an international scale, noting that numerous space missions currently incorporate South African-developed components. Many companies contribute essential components to global clients, further enriching the region's space value chain.

Prof Steyn highlights the interdisciplinary collaboration between academia and industry and between different engineering principles in driving technological advancement in this field.

"The possibilities are indeed endless," he concludes.