Special report for the ISWI Newsletter on two SANSA projects

By Catherine Webster, Jonathan Ward and Dr Ben Opperman,

all with SANSA (South African National Space Agency).

14 March 2014.

Space science and technology to stimulate socio-economic development

The establishment of the South African National Space Agency (SANSA) in 2010 gave rise to a giant leap for South Africa's undertakings in space science and technology and heralded a new era in the exploitation of space technology in service of humanity.

In its third year of operation, the Agency has been instrumental in moving South Africa into the global space arena as a serious space contender. SANSA offers state-of-the-art products, services and infrastructure that impact on the local and global economy, as well as the lives of all South African citizens and aims to grow the knowledge economy in Africa.

As an entity of the Department of Science and Technology, SANSA is tasked with coordinating the development of a national space programme for South Africa in collaboration with various local and international stakeholders.

Space is not as empty as you think!

While the name suggests that space is empty, that is far from true. Matter released by our sun and space weather events fills the area between our planet and surrounding bodies, and is known as space plasma. Plasma particles are the fourth state of matter (solids, liquids, gasses) and have an effect on how radio transmissions travel through space. It is important for scientists to understand what those effects are. Plasma is always confined by a magnetic field such as the sun's magnetic field, the interplanetary magnetic field or the Earth's magnetic field.

Three unique SANSA projects link to offer a deeper understanding of the world of space plasma. A digital upgrade to the South African SuperDARN radar in Antarctica, the construction of a High Frequency Direction Finding (HF/DF) interferometer array, and the tricky business of uncoiling a wire in space will all come together to give SANSA extended capabilities in space weather monitoring and space plasma studies.

Part 1: Icy challenges for SuperDARN project

The SA Agulhas II's December 2013 voyage to Antarctica saw the polar research and logistics vessel encounter tough conditions just before Christmas. Strong currents and thick sea ice prevented the ship from reaching the ice-shelf, which caused a two week delay.

When SANSA Engineers lead by Gert Lamprecht, Research Support Unit Manager, arrived at the South African Antarctic base, SANAE IV, they were informed that they would have three weeks less time than planned to install SANSA's new high frequency digital radar system.

The radar is part of an international network of 33 radars distributed over the northern and southern Polar Regions, called the Super Dual Auroral Radar Network (SuperDARN). This new digital system is going to replace the existing 17 year old analogue radar, which was due to be decommissioned in 2012, and will provide a more versatile, reliable and state-of-the-art research platform to study the ionosphere and other space weather related phenomena.

Understanding space weather, a term used to describe the effects the sun has on Earth and the planets of our solar system, is a global priority. SuperDARN data provides scientists with information regarding the Earth's interaction with the space environment. "Communication and navigation technology, town planning, resource and disaster management are highly dependent on satellites operating in our space environment. Understanding this environment has become vital in order to protect technology in space and on Earth from the devastating effects of space weather" said Dr Sandile Malinga, SANSA CEO.

Antarctica is an ideal location for space weather research instrumentation as the Earth's magnetic field lines converge at the poles and act like a funnel for space plasma to travel into the Earth's atmosphere. A single pair of SuperDARN radars can measure the position and movement of ionospheric plasma in an area of approximately 4 million square kilometres.

South Africa's SuperDARN radar project is a collaborative effort between SANSA, the University of KwaZulu-Natal (UKZN) and the University of La Trobe in Melbourne, Australia. All SuperDARN data collected at SANAE IV is sent to UKZN, where it is analysed to ensure it is of good quality. The data is then archived and distributed to the rest of the SuperDARN community. The system is largely based on the next-generation, T3 digital radar platform, which was the first fully digital SuperDARN radar platform in the network, developed by the TIGER Group at the University of La Trobe. The collaboration between SANSA and La Trobe has allowed for opportunities in international research partnerships and knowledge exchange to further enhance our understanding of radar in order to better develop local skills, training and capabilities in this field.

"The Agency's new radar not only marks a milestone for national and international space weather research but has also provided a unique platform for developing skills in space science and technology," said Dr Malinga.

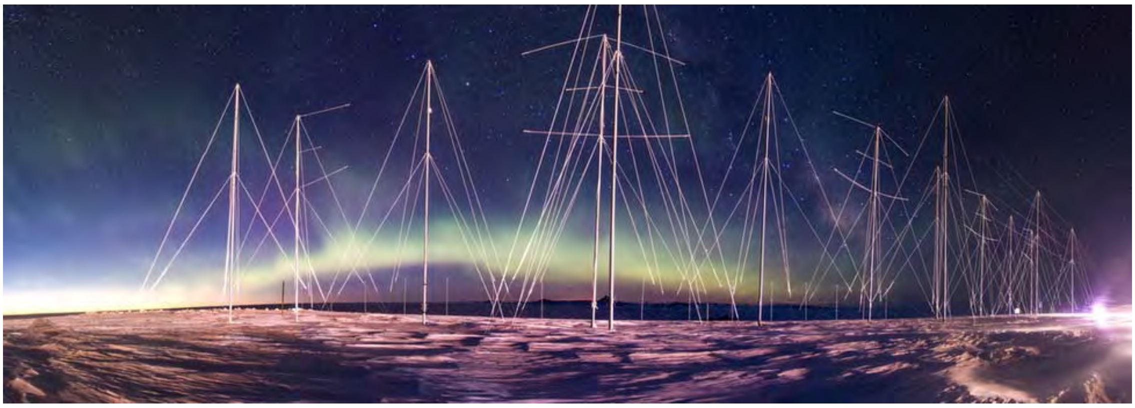
Despite a few challenges and the hostile Antarctic environment the radar has been installed successfully and is receiving data. Two engineers will spend the rest of the year at the Antarctic base to monitor and maintain the suite of space monitoring instruments operating from the ice, and ensure that meaningful data is transferred to the SANSA facilities.

The team who installed and helped develop the new SuperDARN Radar. They have each performed the role of SANAE IV Radar Engineer over the last 5 years.

Left to right: Francois Olivier (S53), Philip Mey (S52), Jonathan Ward (S51), Ruan Nel (S50) & Roger van Schie (S49). Image credit - Brett Anderson (Dartmouth College/NASA)

SANSA Engineer's with the new SuperDARN radar system after it was successfully installed at the Antarctic research base SANAE IV.

Left to right: Roger van Schie, Jonathan Ward, Philip Mey, Francois Olivier.



SANSA's SuperDARN Radar array located at the South African research base in Antarctica.

Image credit - Rob Coetzee (S52)

Part 2: Uncoiling an antenna in space

While the new SuperDARN radar has been installed in Antarctica, back on the home front SANSA is managing an experimental aspect of South Africa's first nano-satellite mission. The experiment aims to determine how to broadcast a long wave radio signal using an antenna on a satellite that can fit in the palm of a hand.

The satellite had to have an antenna of 10.5 m attached to it. That's a big feat for a small satellite. Dr Robert van Zyl from the Cape Peninsula University of Technology (CPUT) devised a rolled up antenna which is coiled like a fishing rod reel.

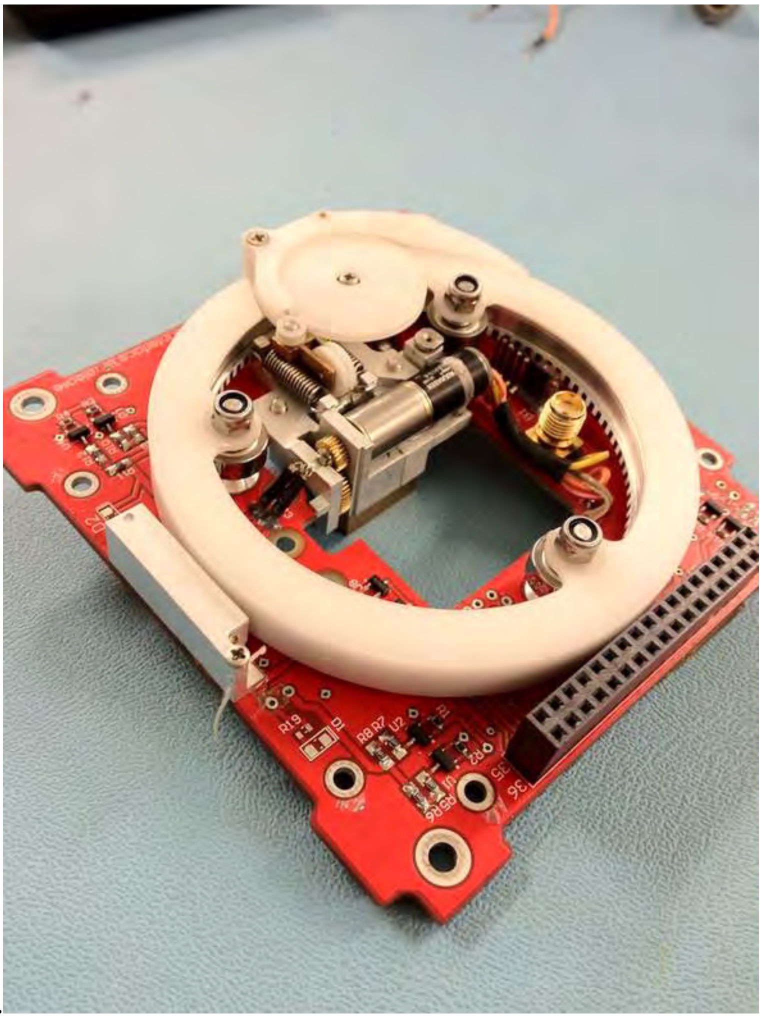
Now that TshepisoSAT has been launched, the 0.01 mm thick wire must be slowly uncoiled into a straight antenna. With a small tip mass placed at the wire's end, the satellite will be put into a spin, using the Earth's magnetic field and two small electromagnets fitted to the nano-satellite. This process should slowly uncoil the wire, which is similar to a piano wire in rigidity. If it bunches up or bends too much, it will fail. Between two and ten centimetres of antenna wire will be uncoiled each day. If all goes well, the antenna should be straightened out over a period of several weeks.

TshepisoSAT is the first nano-satellite to be constructed in South Africa. Funded by the Department of Science and Technology, it was designed and built by postgraduate students at the French South African Institute of Technology (F'SATI) at CPUT, in collaboration with SANSA.

Prof. Robert van Zyl, said the strength of the satellite programme is its use of nano-satellites as technology platforms for practical, hands-on skills training and applied research. "This approach offers students a unique learning experience and prepares them very well to participate in the South African space industry."

The satellite is currently intact and with most tests completed it is ready to begin its experiment. When extended, the antenna will transmit a simple radio signal that can be received by the Hermanus HF/DF array and the SuperDARN radar in Antarctica, as well as the rest of the SuperDARN network.

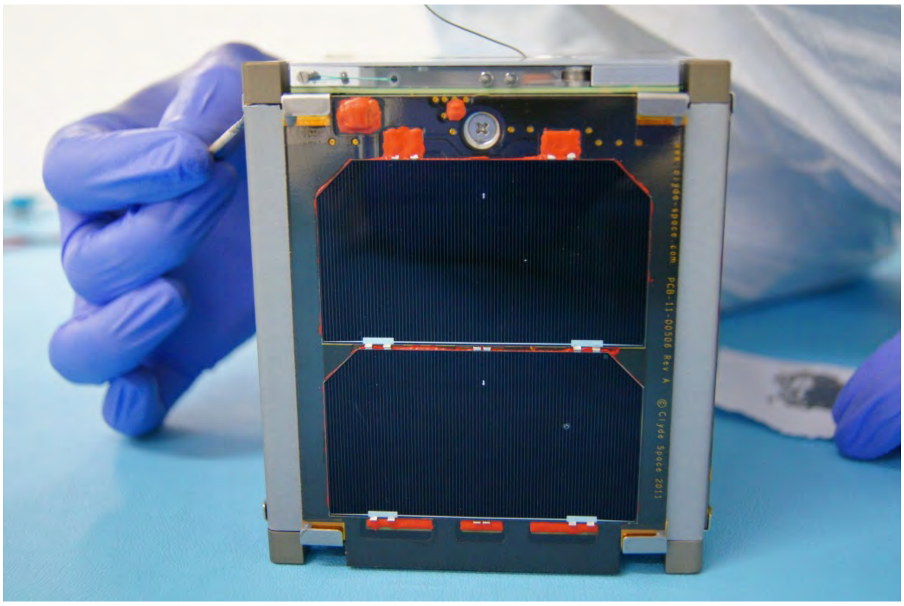
This will ensure there is comparable data and enable the team to determine what effect the plasma in space is having on the travelling radio wave as it propagates through it. Once the effects of the plasma are known TshepisoSAT can act as an HF beacon, and since its location in space is accurately known, it can be used to calibrate the SuperDARN radar.



.

The HF Beacon on-board TshepisoSAT. The 10.5 m antenna is coiled in the reel like casing.

Image credit – CPUT



The 10 centimetre cubic satellite known as TshepisoSAT, meaning “promise” in Sotho, is South Africa’s first nano-satellite to be launched into space.

Image credit - CPUT

Part 3: HF/DF interferometer array construction

Electric plasma in space has always affected radio frequencies transmitted to Earth from man-made satellites – in the same way glass diffracts rays of light through windows. SANSA scientists aim to better understand just how plasma diffracts radio waves. This experiment brings together the SuperDARN radar at SANAE IV, the special coiled-up antenna mounted to TshepisoSAT and a high frequency direction finding (HF/DF) interferometer array under construction at SANSA.

The project has started small – three separate antennas laid out in the shape of an 'L' are being constructed on an area of 10.5 m. Each antenna consists of two square loops one metre in diameter. The mini-array should take six weeks to complete and there will ultimately be seven antennas, the last four of which will be built when the test signals from TshepisoSAT's special antenna are confirmed as successful.

TshepisoSAT's transmissions will be received from a known position in space by either SANAE IV or the HF/DF array. The difference between the measured and the true incoming angles of the radio wave at either antenna locations should supply the team with comparable data. This data should be enough to determine just how the signal was refracted by the plasma in space. Experience from the project will be used to calibrate SANSA's SuperDARN radar and the resulting data will be invaluable to gain a better understanding of how radio signals propagate through space.

Published by SERC of Kyushu University

ISWI Newsletter

under the auspices of the United Nations

This pdf was circulated in Volume 6, No. 031, on 26 March 2014.