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Advances in the Realtime Simulation of Synthetic Clutter for Radar Testing and Evaluation

J STRYDOM, E PIENAAR, J CILLIERS AND K OLIVIER

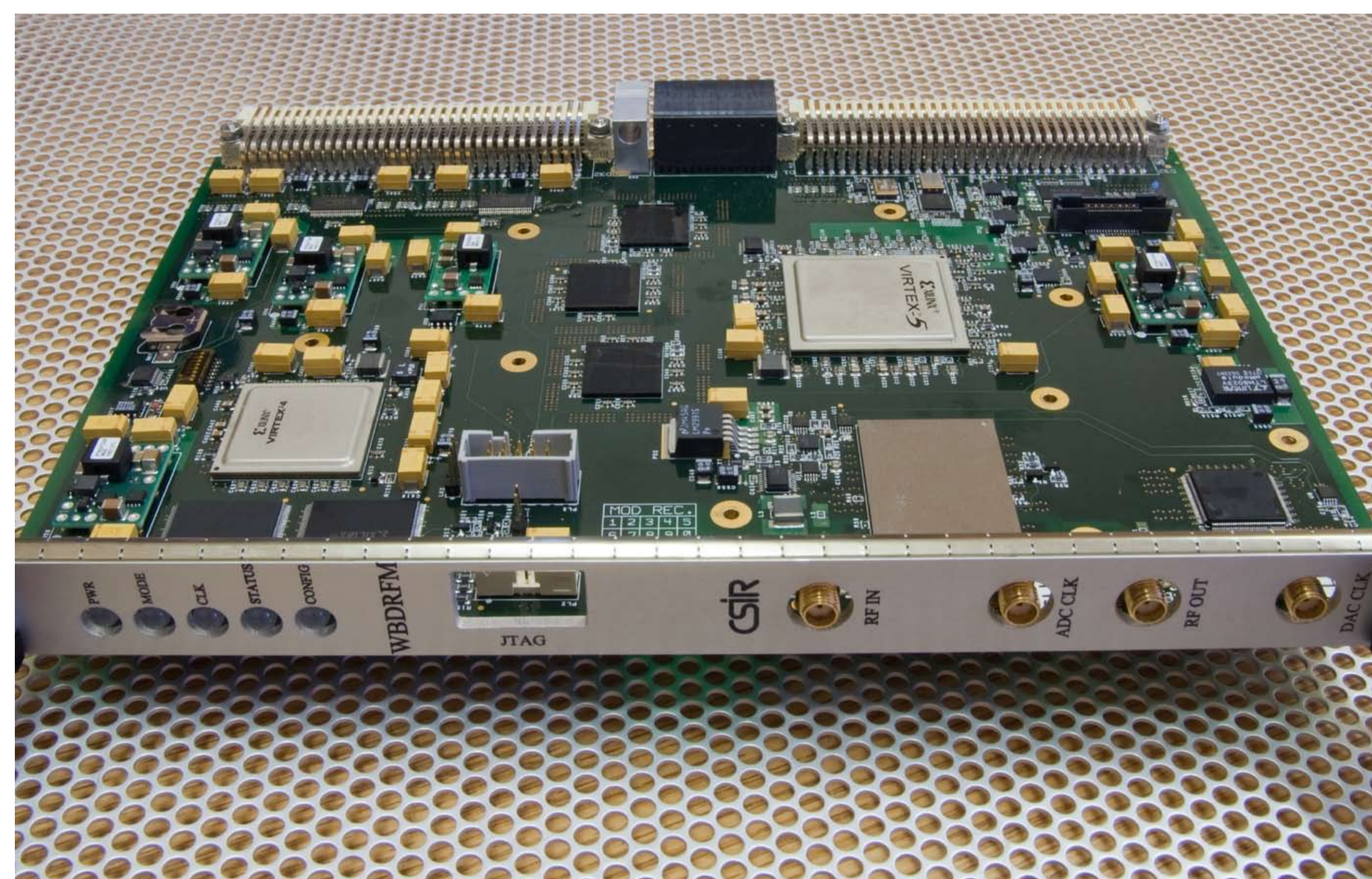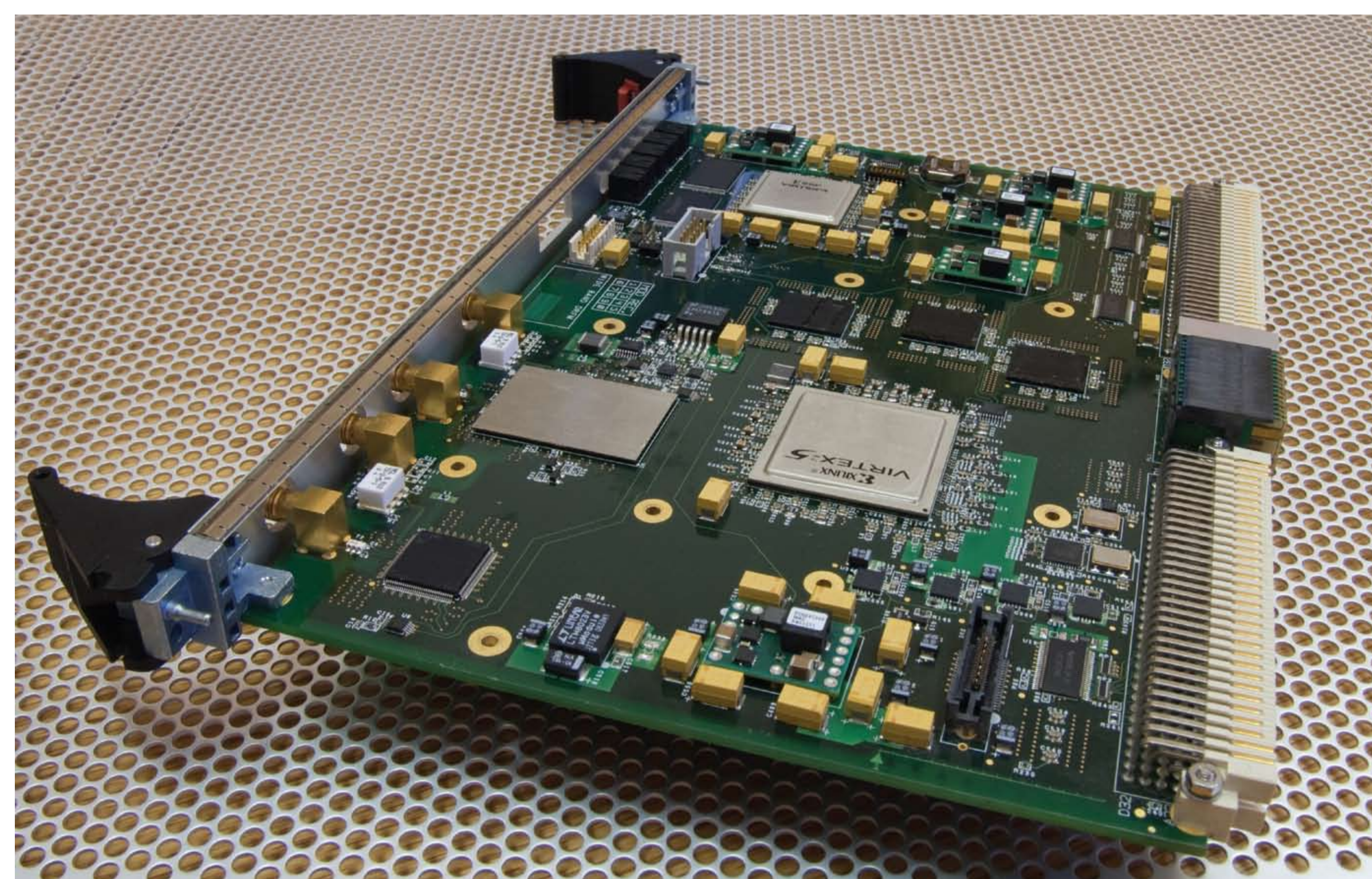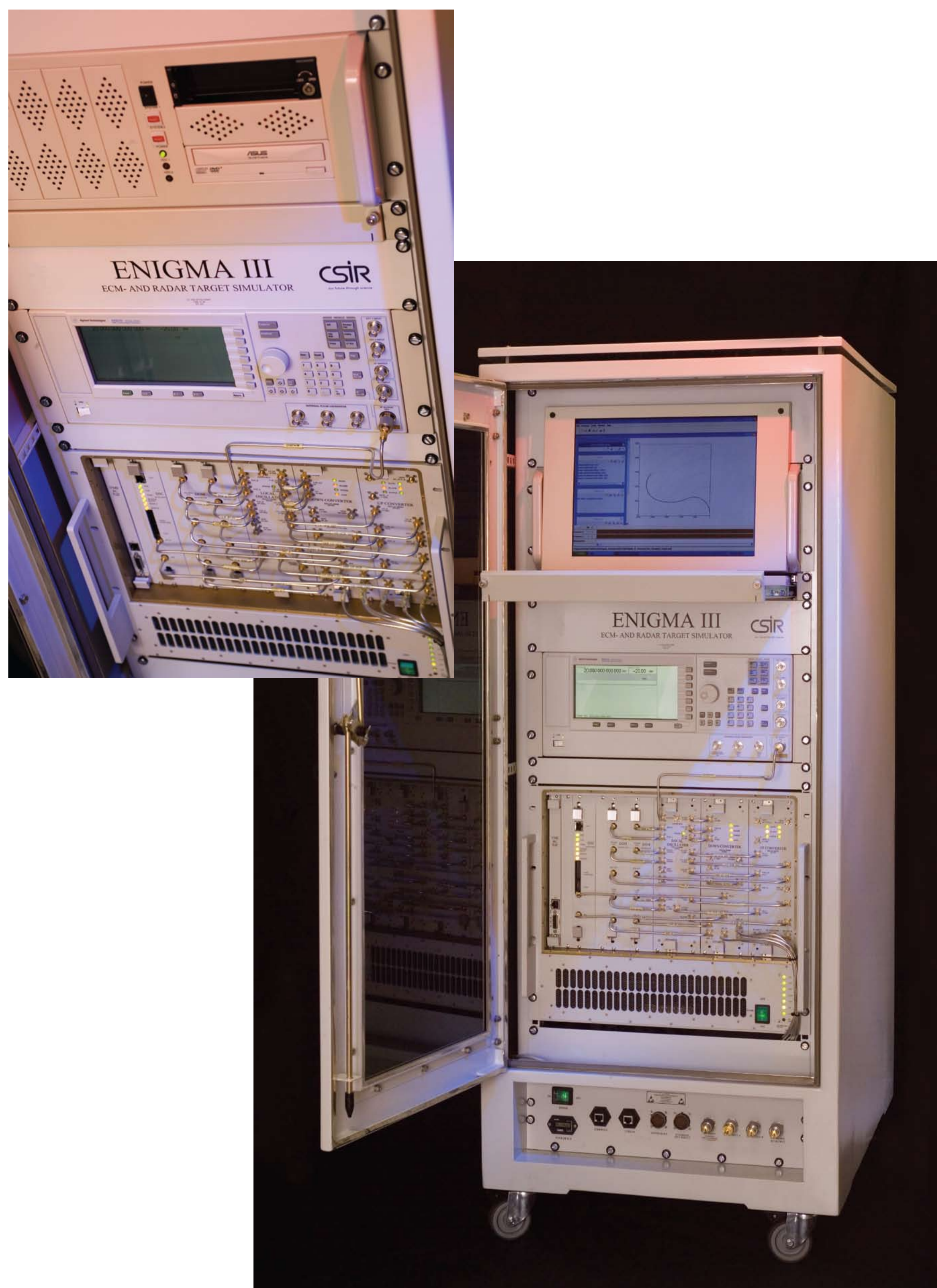CSIR Defence, Peace, Safety and Security, PO Box 395, Pretoria, South Africa, 0002

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RADAR ENVIRONMENT SIMULATION

Modern radars are complex systems, with many different aspects that have to be tested. Testing these complex radars in the field is often difficult, and the exercise becomes larger and more expensive, the more complex the radar. It is especially difficult to test the performance of a radar in clutter. Nature follows its own course and can delay performance tests for clutter scenarios that are rare. This creates a need for a radar environment simulator (RES), for the purpose of radar testing and evaluation of radar systems in a repeatable manner [1].

RADAR TESTING AND EVALUATION

There are two approaches to radar testing and evaluation. In the first approach the testing system is designed in parallel with the radar system. This approach allows the radar designers to design tests that are optimised for their radar design. As the complexity of the radar increases, the complexity of the radar test system also increases. This causes the radar to become the testing system for the testing system. This approach runs the risk of introducing incorrect implementations in both. A more generic and independent approach is thus required.

The second approach uses an independently designed and built generic radar testing system which can serve as a benchmark for radar testing and evaluation. The system can also be re-used between different radar designs, and allows the evaluator to quantify the performance of radars relative to each other. Because the system is generic it operates independently of radar parameters and algorithms.

Radar environment simulators have, in the past, been able to simulate single targets, complex targets, jammers and electronic counter measures. Recent developments in processing power have allowed for a ground clutter simulation capability to be added to this list.

RADAR CLUTTER SIMULATION

Radar clutter simulation is computationally expensive as a single range line can contain thousands of independent clutter samples. Clutter is a random process which exhibits temporal correlation and is thus characterised by a probability density function (PDF) in conjunction with a power spectral density function. More complex probability and correlation functions require more processing power to simulate.

REFERENCES

[1]   B. Manz, "DRFMs Grow to Meet New Threats," *The Journal of Electronic Defense*, August 2010, pp. 43-48.

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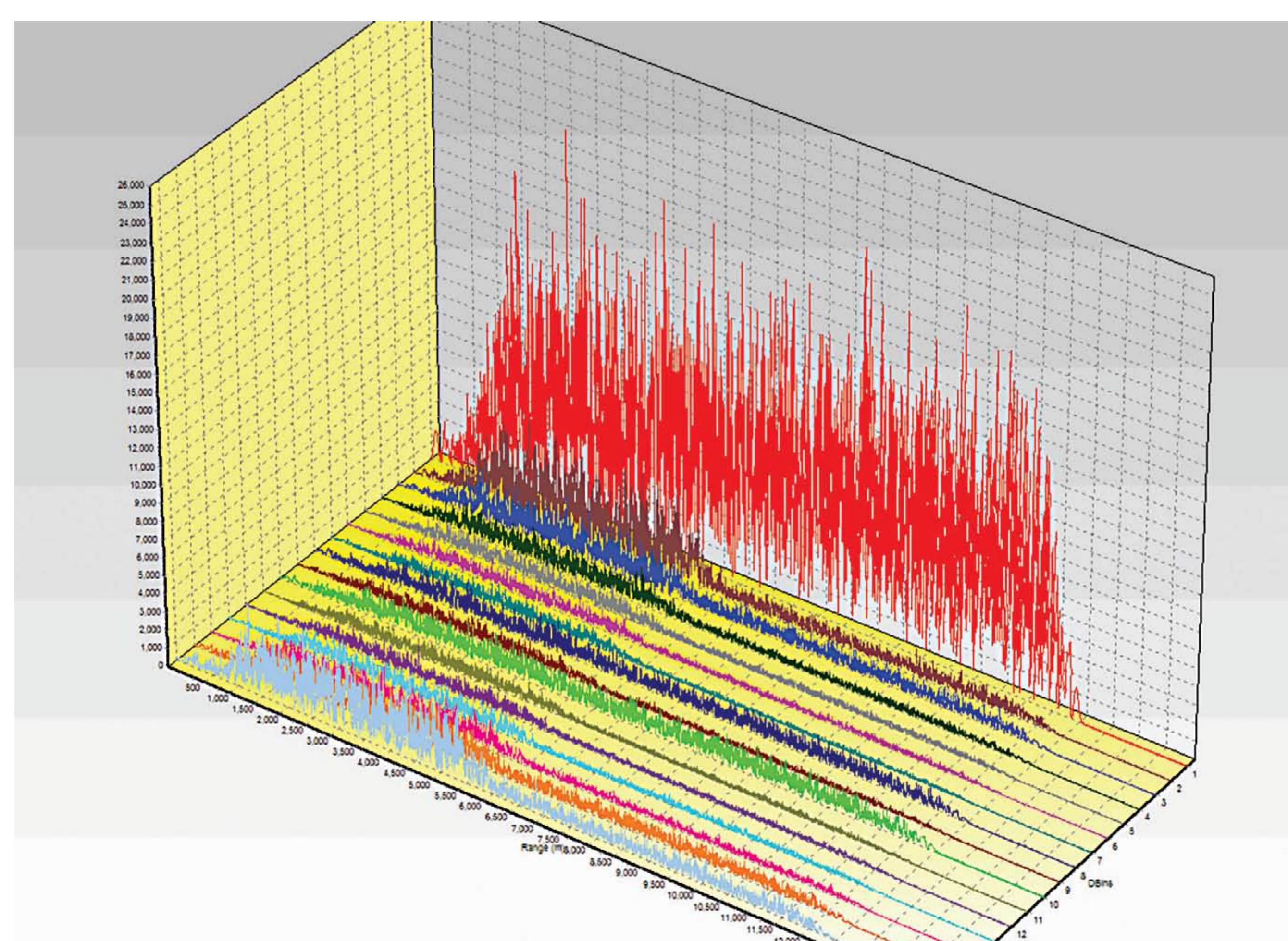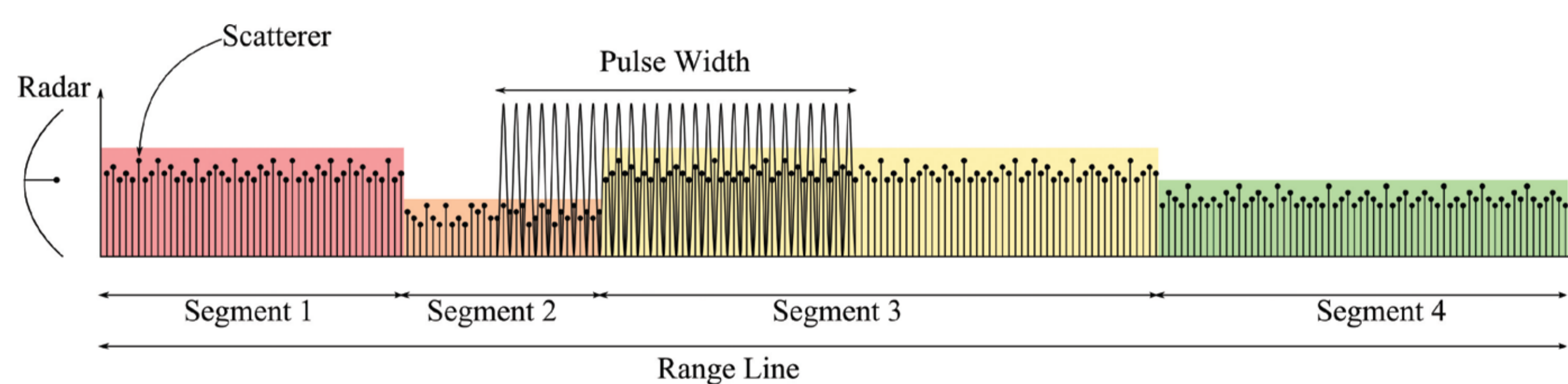CSIR Defence, Peace, Safety and Security, PO Box 395, Pretoria, South Africa, 0002
Email: jjstrydom@csir.co.za

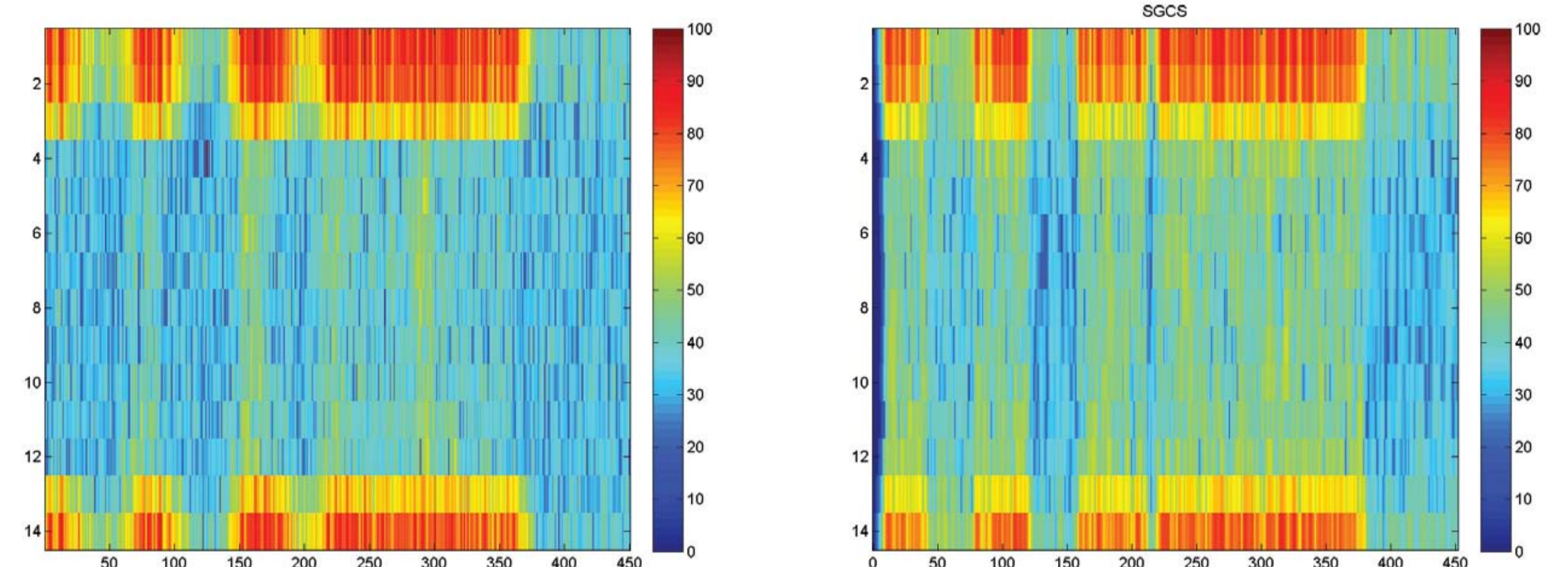## SYNTHETIC GROUND CLUTTER SIMULATION (SGCS)

An initial proof of concept version of an SGCS has been designed and implemented. The system can simulate clutter returned from ground surfaces and vegetation, for a stationary ground based radar platform with a constant look direction. The distribution of the ground clutter was assumed to be Gaussian [2].

The specifications of this design were as follows:
- Hundreds of clutter segments, each with a unique bandwidth and amplitude.
- Each clutter segment can have one or more independent clutter scatterers, each adhering to the statistics set by the segment.
- Clutter scatterers can be spaced as close as 1 ns apart in range.
- Each clutter scatterer is correlated from pulse to pulse.
- Clutter Doppler bandwidths from 1 to 20 Hz, Gaussian shaped.
- Radar bandwidth up to 400 MHz.
- Radar PRF from 500 Hz and higher.

Recorded radar clutter from the measurement radar at the CSIR

Simulated radar clutter from the SGCS system

SYSTEM TRADE-OFFS

Due to the fact that computational power is the limiting factor for a real-time clutter simulation system, certain trade-offs can be made to increase the fidelity of some aspects of the SGCS at the cost of other aspects. Because the pulse lengths that can be achieved for the maximum density of clutter points are relatively short, one might wish to increase this figure. This increase in pulse length can be achieved by reducing the bandwidth, or by lowering the fidelity of the clutter. More complex distributions might be required than those of the Gaussian distribution, and this can be achieved by reducing the clutter point density. There is no requirement for the clutter points to be spaced evenly in the range line for the case of decreased fidelity, but there will be a limit on the number of clutter samples per pulse length.

Example of the output of a radar signal processor (RSP) showing two simulated clutter regions with varying statistics, and a region where the clutter power has been set to zero. (The x-axis represents range, the y-axis Doppler bin and the z-axis amplitude)
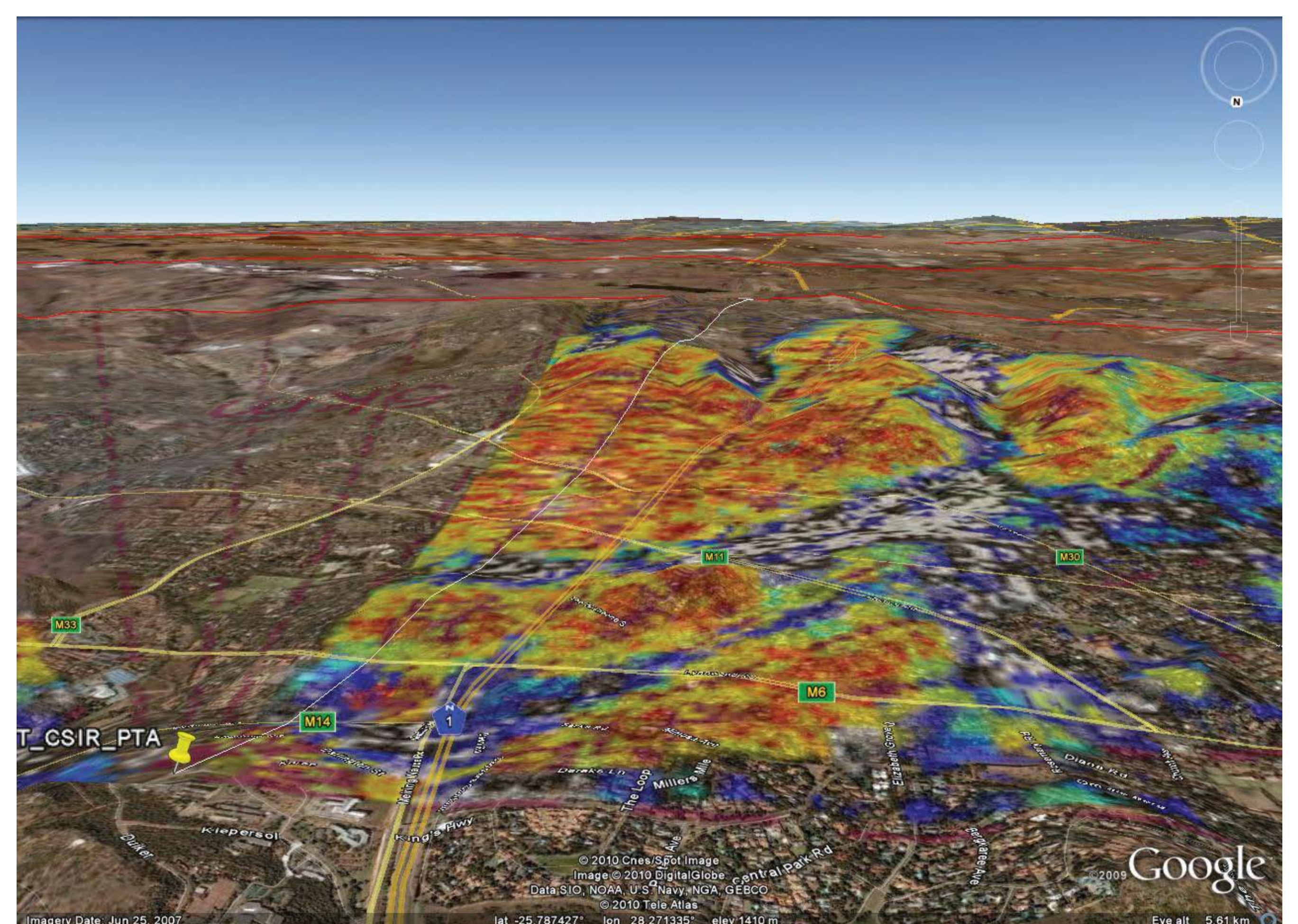

FUTURE

A new SGCS design is under way to allow for the increase of pulse lengths, at the cost of bandwidth, on a per experiment basis. New optimised hardware architectures will increase the processing power allowing for improved performance. Future development will focus on sea clutter, and clutter for moving radar platforms, such as airborne radar systems.

REFERENCES

[2]   J.B. Billingsley, *Low-angle Radar Land Clutter*, IET, 2002.