

Paper Abstract - AOC

Hardware in the Loop Testing and Evaluation of Seaborne Search Radars

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Organisation: CSIR, DPSS (Council for Scientific and Industrial Research, Defence Peace Safety and Security)

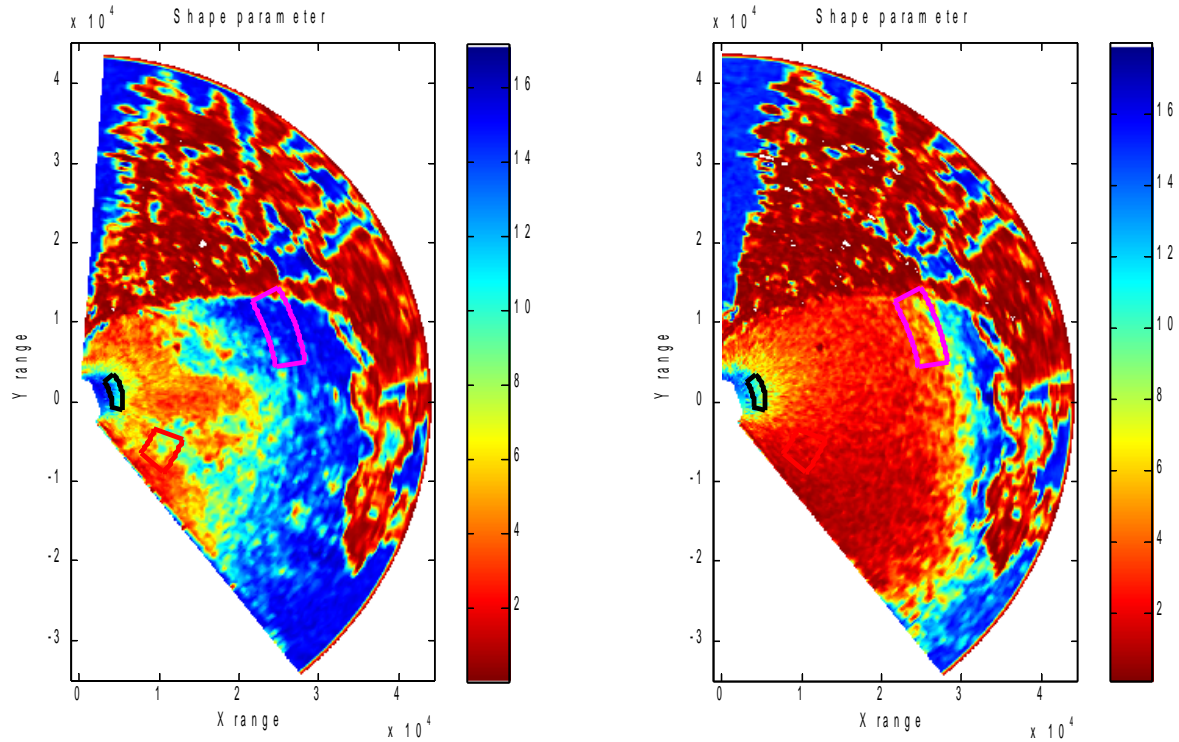
The testing and evaluation of a modern radar is becoming increasingly difficult owing to the adaptive nature of such radars. In general there are two approaches to this problem: Firstly the radar development house can design and build specialised test equipment for each radar. Secondly more generic test equipment can be designed which can be used to test a class of radars. This second approach is especially important to organizations, such as defence evaluation and research institutes (DERI) and other government agencies, which specialize in independent review, acceptance testing and optimisation of the operational utilisation of radar systems. The problem with the “in-house” test equipment in the first option is to prove that it is not biased towards the specific radar it was designed to be a test instrument for. The use of the more general, independently developed advanced electronic warfare (EW), electro magnetic spectrum (EMS) test systems is thus required for independent testing and evaluation of radar systems. The CSIR digital radio frequency memory (DRFM) hardware technology is used as the basis of these test systems. DRFM's are traditionally used for EW applications, but processing power of field programmable gate arrays (FPGA) have made the testing and evaluation of complex radar systems possible.

The clutter sensed by a radar which surveys a section of ocean probably encounters the most complex of all possible scenarios. Sea clutter is extremely complex to suppress because of its dynamic nature, and large dependence on weather conditions. The sea waves cause complex correlation patterns that are not observed in the presence of land clutter. The wind can pick up water droplets causing sea spray, or causes ripples on the surface of the waves which resonate electro-magnetically. The white-caps of broken waves and scattering from the crest of a wave also influences the electro-magnetic properties of the sea surface. These effects are detected by a radar as large spikes in the magnitude of the returned radar signal. The velocity component of these effects also cause a Doppler shift relative to the main body of the clutter. Since the battle is moving away from blue water scenarios toward to the littoral, these effects are even more profound. These effects trigger false detections, which causes the radar designer to increase the detection level to minimise the probability of false alarms. This approach inevitably increases the probability that small targets such as boats used in asymmetric warfare go undetected. This trade-off has to be optimised by the radar designer. Testing for all these conditions in real time in a lab environment is a game changer that aids the radar designer in building the best system in the shortest amount of time.

The K-Distribution has become the approximation of choice for sea clutter modelling. The ocean swell (long wavelength) is responsible for a modulation effect known as the texture component of sea clutter. The shorter wavelengths are responsible for the speckle component of sea clutter. The comparative figures below show the “spikiness” of the sea clutter measured during low and high sea state conditions using an X-band radar. In these figures the red areas indicate very “spiky” clutter, whereas the blue areas indicate Rayleigh (Gaussian) clutter. Table 1 shows the conditions relating to the light clutter and heavy clutter scenarios.

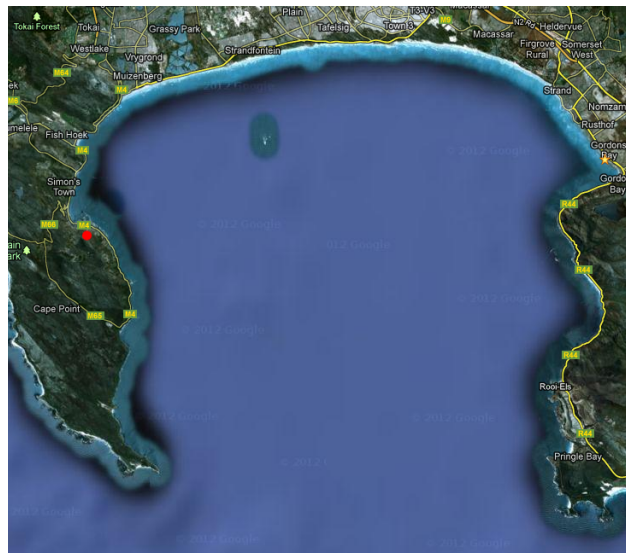
Table 1: Measurement parameters

Dataset	Light clutter	Heavy clutter
Wave height	1.52 m	2.89 m
Wave direction	North-North-East	North-North-West
Wind speed	12.12 m/s	16.45 m/s
Wind direction	South-West	North-North-East



(a) Low sea state clutter measurement.

(b) High sea state clutter measurement.



(c) Google Earth image of the radar environment, radar located at the red dot.

Figure 1: Comparison of the “spikiness” of littoral sea clutter for (a) low and (b) high sea states, for the area shown in (c).

Hardware in the loop (HIL) radar environment simulation (RES) on digital radio frequency memory (DRFM) platforms can be utilised to test the performance of a search radar in a sea clutter

environment for a myriad of conditions. Because most search radars scan in azimuth, time multiplexing of the DRFM system can be utilised to generate a highly complex scene, for the radar under test. A single range line can be divided into different segments with varying size and scattering properties. Additionally the environment can be divided into sectors along the azimuth direction. Each of these sectors can have a unique range line, with scatterers unique from all the other segments in all of the other sectors. This allows for the simulation of complex littoral clutter scenarios.

Although no simulation can replace real-world testing, it can greatly reduce the costs associated with such trials. Preliminary testing can be performed before a deployment reducing the cost of the radar system verifications process by reducing the amount of tests required. This preliminary testing can be used to conduct an initial level of testing, as a basic compliance test, before the more thorough and costly tests commence. A simulated test environment is also more repeatable, thus allowing several radars to be evaluated under very similar conditions. DRFM based test environments enable the characterisation of a radar system's target detection, target tracking and electronic protection capabilities in the presence of high fidelity simulated clutter conditions.

Summary of Authors

Jurgen Strydom

Jurgen Strydom graduated from the University of Pretoria in 2009 with a Bachelor in Electronic Engineering where he completed his final year project on synthetic ground clutter simulation on DRFM systems. He has been employed by the CSIR from the start of 2010 and is currently working in the experimental electronic warfare team as a systems engineer and signal analyst. His field of speciality is the generation of clutter on hardware platforms for radar testing and evaluation. He is currently studying for his masters degree on a part-time basis on the topic of clutter at the University of Cape Town.

Jacques Cilliers

Jacques Cilliers graduated from the university of Pretoria (South Africa) in 1994, was awarded a B.Eng (Hons) in 1997 and an M.Eng in 2001. He was appointed as a fellow of the Laboratory for Advanced Engineering (LGI) at the University of Pretoria during his post-graduate studies in digital communications. In 1997 he was employed by Kentron, a Division of Denel where he worked on small target detection for infra-red missiles. From 1998 to 1999 he moved back to LGI as part of a research team working on highly spectrally efficient communication systems. Currently he is employed by the Council for Scientific and Industrial Research's (CSIR) unit for Defence, Peace, Safety and Security (DPSS) where he is a system engineer and principal researcher in the fields of radar and electronic warfare. His interests span multidimensional adaptive signal processing, MIMO radar, Non-cooperative target recognition, radar cross section modelling, high performance pulse compression, array antennas, sea forward- and backscatter modelling and general clutter modelling. He is currently a member of the IEEE.

Andre McDonald

Andre McDonald graduated from the University of Pretoria (South Africa) in 2004, and obtained the degrees B.Eng (Hons) and M.Eng in 2005 and 2010. He was employed by the University of Pretoria as a junior lecturer in 2005. He is currently employed by the Council for Scientific and Industrial Research's (CSIR) unit for Defence, Peace, Safety and Security (DPSS) as a researcher in the areas of maritime clutter and detection. His interests include information theory, detection and estimation, statistical signal processing, optics and pattern recognition.

Klasie Olivier

Klasie Olivier is a principal systems engineer at the Council for Scientific and Industrial Research (CSIR) in South Africa. He specializes in the aspects involved in the design of wideband, high fidelity mixed-signal hardware platforms which includes the DRFM hardware platform and has been involved with integration aspects of DRFM technology as part of EW HIL simulator systems for more than 10 years. Klasie is a member of the international AOC and holds a masters degree in electronics from the University of Pretoria.