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E L E C T R O N I C S

Intersoft Electronics'
ADVANCED PROCESSING
TECHNOLOGIES

WHITEPAPER

Executive Summary

Modern airport surveillance radar (ASR) must incorporate innovative algorithms to address the challenges of the changing airspace environment. Air traffic density increases, low radar cross section (RCS) targets fill the skies, windfarms create false detections and 4G/5G frequencies interfere with radar. Rest the more common issues of clutter suppression and weather phenomena like anomalous propagation. New technologies offer solutions and create other opportunities. Extracting accurate height information is such a novel feature of modern ASRs.

In this Whitepaper, a handful of innovative algorithms that are key to next generation signal processing are explained

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What is VCC ?

The short answer:

VCC or Vertical Clutter Cancellation is a patented algorithm for radar signal processing that allows to remove stable and unstable clutter from a radar image (such as from windfarms).

The longer answer:

— VCC improves radar signal processing in many ways. However, it's the emerging issue of windfarm interference with Primary Surveillance Radar (PSR) that motivated the development of this algorithm. Since 2013, VCC has been used operationally on an increasing number of ASR and En-Route systems, civil and military, all over the world, integrated in both service life extension programs (SLEPs) and brand-new systems.

— VCC relies on the typical dual beam operation of ASRs and is also applicable to multibeam systems. With VCC it is possible, for each range/azimuth processing cell, to virtually combine these two beams and create a vertical suppression notch in elevation in the receive antenna diagram.

— When it comes to windfarm mitigation, the notch can reduce the received signal strength by 20-30 dB for stationary clutter, caused by the wind turbine's tower and the nacelle, and it reduces dynamic clutter, caused by the turbine blades, by up to 20 dB.

— Because the VCC algorithm suppresses the ground clutter significantly, it lowers the clutter map and allows for sub-clutter visibility. That eases post-VCC processing and improves a PSR's detection performance without the need to increase the input power.
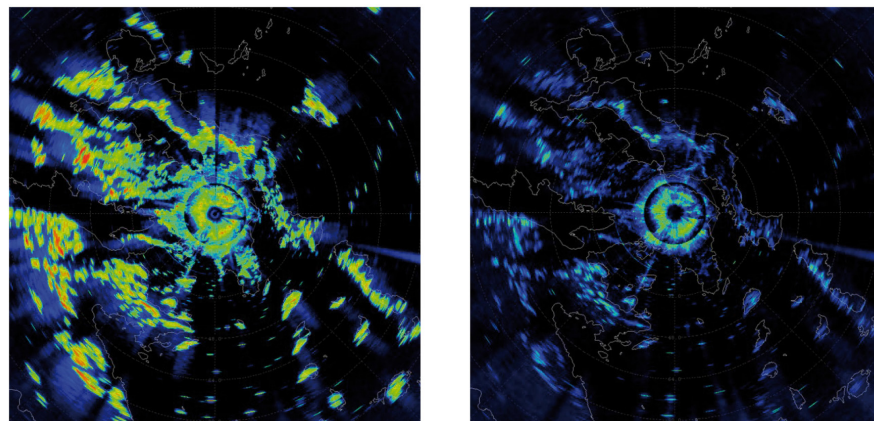

Figure 1 / Ground clutter cancellation by VCC

What is VCC² ?

The short answer:

VCC² is a radar signal processing algorithm that further improves the performance of VCC (Vertical Clutter Cancellation), particularly on windfarms close to the radar.

The longer answer:

— Where VCC processes a PSR's receive signal to reduce stable and unstable clutter levels, VCC² extents to the transmission part of the radar. VCC², is developed to further improve the stable and unstable clutter suppression capabilities of the Next Generation Signal Processing (NGSP®) platform.

— Using VCC², the system can control the elevation distribution of the emitted energy. This by introducing a full power and phase-controlled transmitter with multi-beam transmission.

— Elevation based power control is an innovative technique that reduces the required transmission power without compromising the detection performance. Well, on the contrary, it improves the system sensitivity by focusing the transmit power to the area of interest – and, as for windfarms, defocusing from areas of non-interest.

— Just like VCC, VCC² eases further signal processing and improves a PSR's detection performance as well..
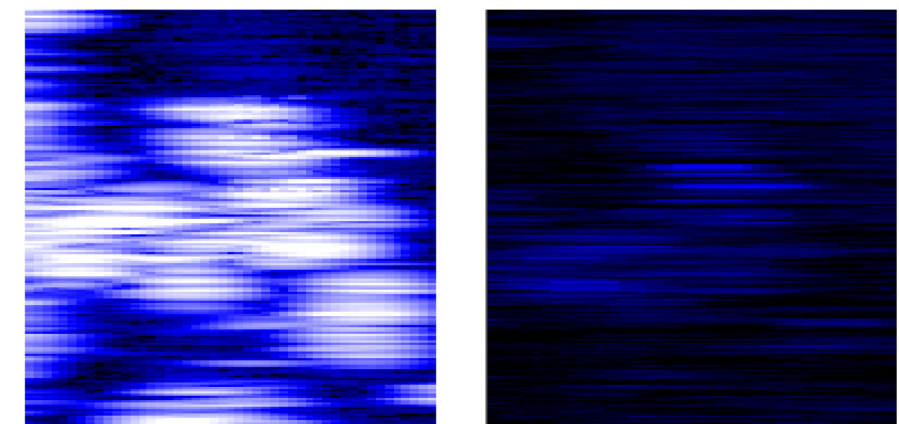

Figure 2 / Windfarm mitigation

How is Median Filtering used in radar signal processing?

The short answer:

Median Filtering is used to countermeasure RF interference and in combination with (micro-)stagger to cancel the second time around effect.

The longer answer:

- Median Filtering is a technique used in digital image processing to clean noise from a picture. Intersoft Electronics has adapted the mathematics to deal with radar complex I/Q signals.

- Essentially the median filter is a mathematical sorting operation effected in a sliding window. It sorts a number of samples and then chooses the value representing the statistical median value as the output result of the filter.

- Its most valuable application in radar signal processing is the suppression of interference from other electromagnetic sources such as 4G/5G base stations.

- If (micro-)stagger is used – i.e. slightly changing the pulse repetition interval –, then the second time around effect – i.e. false returns from very strong targets beyond instrumented range – can be cancelled through the use of the median filter.
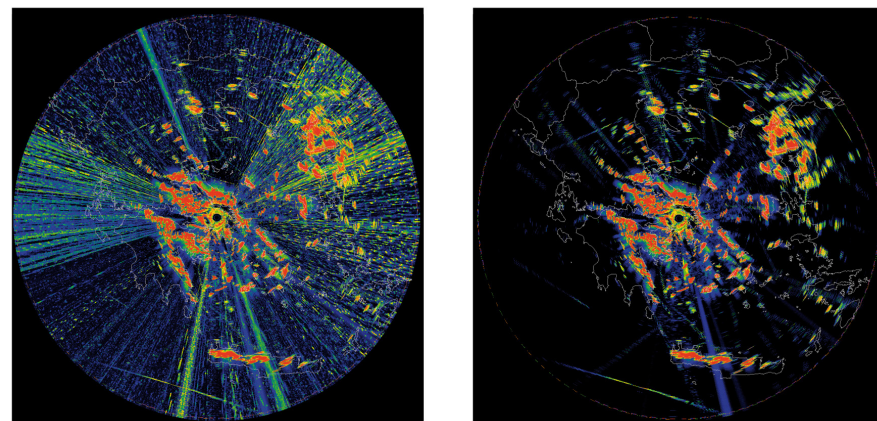

Figure 3 / Interference suppression by NGSP[2]

What is SCC?

The short answer:

SCC or the Slow Clutter Cancellation algorithm mitigates anomalous propagation through Doppler processing, improving weather and target detection.

The longer answer:

- Anomalous propagation occurs when the refractive index of the air is changed by pressure, temperature gradient, and humidity and can cause illumination of ground beyond the normal radar line of sight.

- During such occasions, additional ground clutter can slowly appear and disappear within a couple of minutes causing additional false target or false weather reports, as shown on the image.

- SCC uses information of previous antenna scans to calculate an amount of clutter that should be extracted from the new scan. The subtraction algorithm is only applied on processing cells where anomalous propagation is being detected.
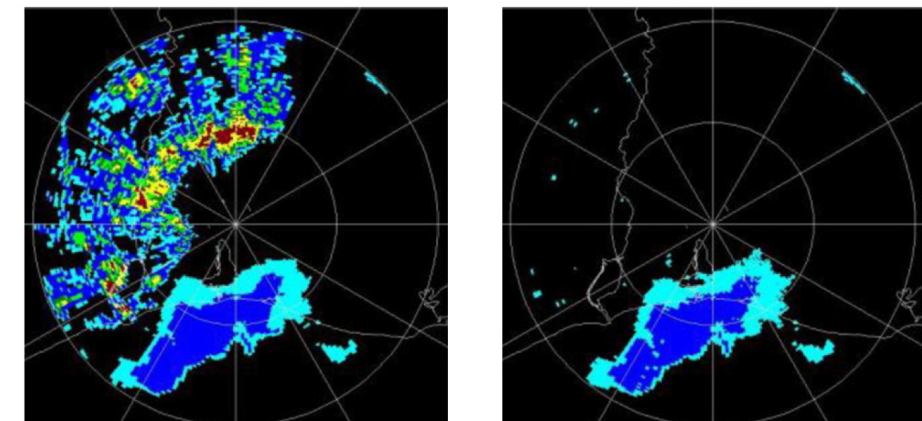

Figure 4 / Anaprop mitigation

What is True 3D Height?

The short answer:

True 3D Height is a PSR system's capability to extract target height information without a collocated SSR sensor.

The longer answer:

3D height on Primary Surveillance Radar (PSR) systems has long been the privilege of – often military – multibeam pencil beam systems. Amplitude differences in the stacked receive beams is then used to calculate a target's height.

Civil Air Traffic Control typically relies on Secondary Surveillance Radar (SSR) systems to output height information. That obviously requires a cooperative target, replying through its transponder, which is mandatory in civil aviation, but can cause tragedy in case of transponder failure or bad intensions. Remember 9/11.

Intersoft Electronics' True 3D Height algorithm can be applied to a traditional dual fan beam Airport Surveillance Radar (ASR) system. The relative difference in phase and amplitude between two COSEC2 fan beams provides a measure of the target's elevation angle.

True 3D Height allows the system to calculate the perceived Radar Cross Section (RCS). This information is key to separate aircraft from birds and drones while filtering angels and other unwanted clutter.

All these algorithms are incorporated in Intersoft Electronics' Next Generation Signal Processor (NGSP®), which is the modular processing solution for ASR-M® and Service Life Extension Programs (SLEPs).

The patented VCC algorithm is typically applied in combination with the other algorithms, improving their performance. VCC is the basis for proper signal processing. For ASRs operating in the proximity of windfarms, VCC² is activated on Intersoft Electronics Next Generation Transmitter (NGTX), the modular transmitter solution. SCC can be enabled when the typical atmospheric conditions for anomalous propagation occur.

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