New radar allows mariners to keep a SHARPEye™

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The techniques and technologies employed in Kelvin Hughes' new SHARPEye™ radar have their roots firmly embedded in the recent communications revolution and in over 60 years of military and civil aviation radar development.

Benefiting from Kelvin Hughes 60-year pedigree in radar design the new SHARPEye™ radar incorporates the very latest in solid state and signal processing technology to bring performance benefits, previously only possible in military or civil aviation surveillance radar systems, to commercial marine radar.

Technological development

Following the end of the Second World War the centimetric surveillance radar technology that had served the military well during the conflict was released from under a cloak of secrecy for a peacetime role as a navigational aid to commercial shipping.

In this period – the late 1940s – the non-coherent magnetron was the basic source of transmitted power and the cathode ray tube the mechanism for of radar image display. Although technology has become immensely more sophisticated, the basic requirement of military and commercial marine radar remains the same, to measure the range, bearing and other attributes of a target. However, despite this common heritage and purpose, the technologies employed in the two roles have diverged.

Now, 60 years later, we are perhaps seeing the beginnings of a reversal in this trend.

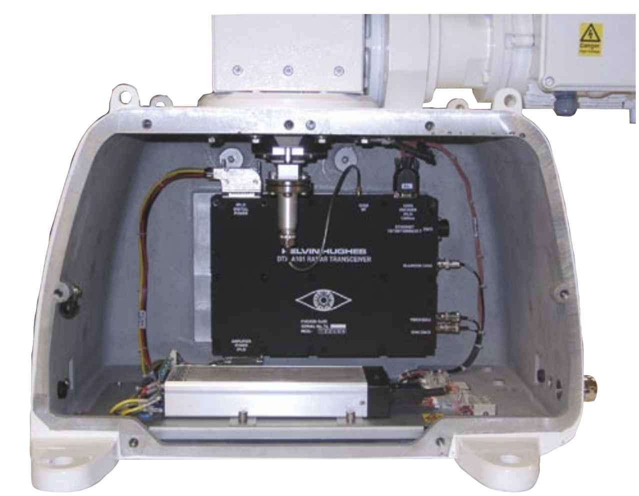
Fuelled by the cold war, the need to detect small, highly manoeuvrable and stealthy targets in all weathers, and the large defence budgets of western nations, military surveillance radar technology has evolved almost beyond recognition from its wartime origin.

Much of the development effort has been expanded on: improving the extraction of signals from a background of noise and clutter; extraction of more information from the received signal and its presentation to the operator and combat system; the improvement of displays; and increased automation.

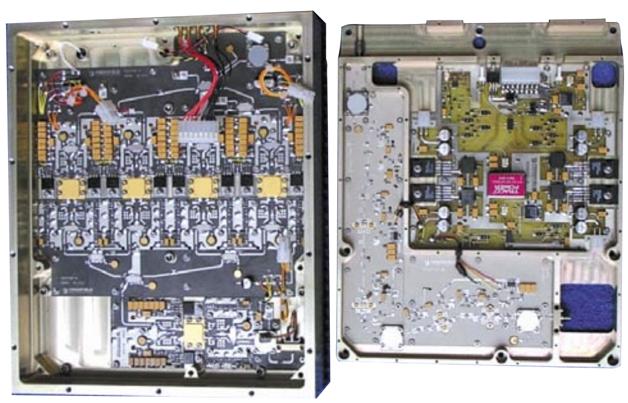
Also in the military arena it is no longer sufficient to provide only range and bearing information. To this must be added altitude information and the ability to automatically track a large number of moving targets (including airborne targets at both sub and supersonic speeds) while simultaneously providing normal surveillance cover.

Other developments have responded to the increasing operational requirements for radars to operate in a hostile electromagnetic environment, undoubtedly leading to a significant improvement in situational awareness and the warfighter's capability to engage threats. The disadvantage lies in the cost to develop the RF, analogue and digital signal processing technologies that underpin these improvements and in the escalation in procurement costs such technologies impose.

In contrast, the development of commercial marine radar has largely been in the hands of the equipment suppliers, latterly with some guidance on the minimum acceptable performance standards from international regulatory bodies. Thus, investment in commercial marine radar has been fuelled by market forces and hence its development has been at a much slower pace – and perhaps in a slightly different direction – than its military and civil aviation counterparts.



SHARPEye™ Upmast Transmitter configuration showing its compact nature with the power supply in the foreground and the transceiver mounted on the casing.



Internal view of SHARPEye™ transceiver.

Despite this there have been notable improvements, helping to produce a clearer radar picture and adding valuable tools to help the navigator; such as ARPA, motion stabilisation, image orientation options, interference rejection, high-resolution daylight viewing colour displays, electronic chart overlays and scan-to-scan correlation. It is arguable that there has been little real improvement in the detection of targets in clutter as the techniques successfully employed in multi-million dollar military radar – such as coherency and MTI – have been considered unaffordable in a $40,000 commercial marine radar.

Today, and for some time past, most marine radars have probably been at the pinnacle of detection performance when using conventional non-coherent magnetrons. This level of performance is not considered adequate by many users who frequently experience heavy clutter conditions.

Tomorrow's technology today

The world's first new technology commercial marine radar, SHARPEye™, is a radical departure from current marine navigation radar practice in that it is a monostatic pulse doppler radar. This means that it utilises the doppler effect to determine the radial component of the relative radar – target velocity. Hence SHARPEye™ processes the echoes received from a train of pulses in a bank of narrowband coherently integrating filters, which resolve and enhance targets within particular velocity bands. By using a bank of filters, SHARPEye™ is able to separate the majority of wanted targets from clutter due to their differing radial velocity components. This 'extra' dimension gives SHARPEye™ a performance advantage in detecting small targets in clutter.

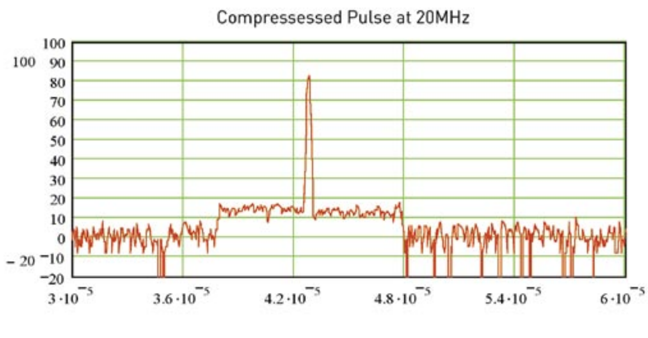
In addition to measuring the amplitude of the received signal, as in conventional radar, SHARPEye™ extracts the relative motion of targets by measuring the phase of the received echo relative to the phase of the transmission. Ensuring that a sequence of phase measurements solely represent the relative motion requires the transmitter and receiver elements of the radar to be extremely stable over the time taken to transmit the pulse train, precluding the use of a magnetron that is inherently unstable.

There are several alternatives to the magnetron that offer suitable stability, but the most attractive – primarily because of its high reliability – is the solid state power amplifier. Devices that are of comparable price to a magnetron unfortunately have a very low-peak power output. However, they can operate with a high-duty ratio.

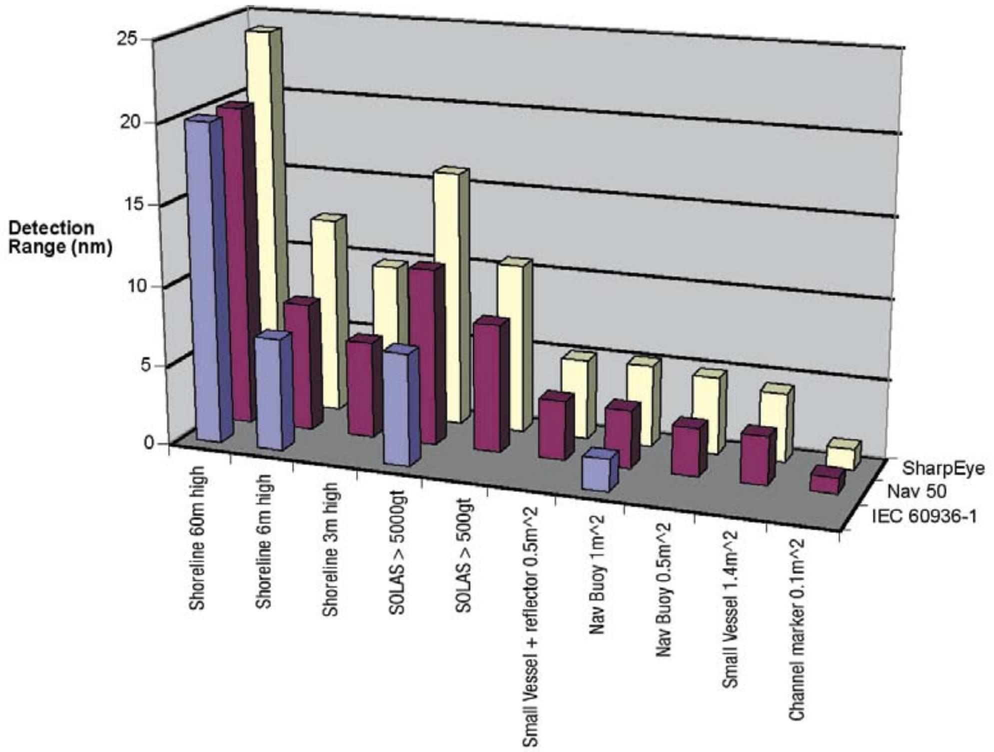
In the SHARPEye™ radar the power amplifier has a peak output power of just 170W and a duty of 10 per cent. This contrasts with current marine radar systems where the magnetron has a 30kW output and duty typically less than 0.05 per cent. To ensure detection performance is unimpaired SHARPEye™ transmits pulses of long duration, thereby equalling or surpassing the pulse energy obtained from a magnetron. Fine-range resolution is maintained by encoding the long-duration pulses in such a manner that they can be compressed into narrow pulses by digital signal processing techniques employed in the radar receiver.

Other areas where SHARPEye™ departs from conventional marine radar are in the transmission sequence and in the way that performance is monitored. SHARPEye™ transmits relatively long pulses in order to illuminate targets with sufficient energy for detection; the disadvantage this presents is that the minimum detection range can be considerably longer than that afforded by a high-power short pulse. To recover the situation and comply with IMO regulations, SHARPEye™ transmits a frame of different length pulses, each pulse within the frame optimised to cover a specified, but overlapping range bracket.

Overall the pulse sequence completely covers the instrumented range and ensures the IMO specified minimum-range requirement is met. Transmit frames are repeated continuously until a different instrumented range is selected by an operator. In the receiver, frames are grouped into blocks called a 'burst'.



SHARPEye™ Pulse Compression gives superb range sidelobe performance.



The SHARPEye™ performance advantage in a high-clutter environment is even more impressive. IEC60936-1 graph is the current performance requirement for navigation radars whilst Nav 50 represents the changes expected to be introduced in July 2008. Both show performance of magnetron based radars. SHARPeye™ performance greatly exceeds both these requirements providing a radar capable of offering superb navigation and tactical capabilities.

The duration of a burst is approximately equal to the time taken for the 3dB points of the antenna azimuth beam to sweep past a point target. Consequently the number of pulses in a burst is directly related to the instrumented range and antenna rotation rate. The echoes received during a burst are processed by the filter bank to extract the radial velocities of targets and clutter.

Within the digital signal processor, detection thresholds for each of the filters within the bank are calculated adaptively according to sophisticated algorithms. This provides optimum control of false alarms while maximising clutter suppression and target detection. Manual control of the thresholds is also provided for IMO compliance and for increased sensitivity where required by an operator.

Maintaining their reputation for innovation Kelvin Hughes has also incorporated Built-In Test Equipment (BITE) in the SHARPEye™ radar. The BITE continuously measures key performance parameters such as RF output power, VSWR, oscillator frequencies and receiver sensitivity at frame rate and informs the operator that the radar is operating within its performance envelope. This system alerts the operator within seconds of any degradation in radar performance and removes the need for operator-induced performance checks.

ABOUT THE AUTHOR

William Grant is a freelance maritime defence journalist with over 10 years experience in the industry. Publications he has written for include Jane's Navy International, EEZ International, International Ship Operator and Port Technology International, among others.

ENQUIRIES

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