Clearing the clutter

Radar is without a doubt the backbone of any solid marine navigation system. Kathryn Bell, former editor of Jane's Navy International, argues that a new development has taken radar firmly into the 21st century.

Where would you be on today's crowded oceans without radar? Since the end of World War II, when the centimetric surveillance radar technology that had served the military so well during the conflict was allowed out into the light of day and given a peacetime role as a navigational aid to commercial shipping, it's been arguably the marine navigator's very best friend.

In the late 1940s, the non-coherent magnetron was the basic source of transmitted power and the cathode ray tube the mechanism for displaying radar images. Although the technology has become immensely more sophisticated over the last 60 years, 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 military and commercial roles have diverged significantly.

But that might be about to change.

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 money has been spent on a few key areas:

- improving the extraction of genuine signals from the background of noise and clutter
- extracting more information from the received signal and its presentation to the operator and combat system
- improving the effective display of information and
- increasing levels of automation in radar technology.

Also, any modern naval navigator knows that it is no longer sufficient to provide only range and bearing information. To this, you have to add 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.

Today's naval radar technology also needs to work in hostile electromagnetic environments, in an effort to improve situational awareness and the warfighter's capability to engage threats. The downside of the developments that have given naval radar this capability lies in the bottom line - developing the RF, analogue and digital signal processing technologies to underpin the improvements increases the procurement cost of the equipment.

In contrast, the evolution of commercial marine radar has largely been left in the hands of the equipment suppliers. This has meant that investment in commercial marine radar has been fuelled by market forces, so it is perhaps not entirely surprising that the development of commercial marine radar has progressed at a much slower pace - and in a slightly different direction - than

its urgently-evolving military and civil aviation counterparts.

Nevertheless, there have been notable improvements, which have helped to produce a clearer radar picture and add valuable new tools to help the navigator. ARPA, motion stabilisation, image orientation options, interference rejection, high-resolution daylight viewing colour displays, electronic chart overlays and scan-to-scan correlation have all had a significant impact on the way commercial marine navigation works.

There is one area in which commercial radar has been left firmly behind. Detection of targets in clutter has always been regarded as generally 'out of the league' of commercial operations: the techniques employed in multi-million dollar military radar systems - such as coherency and MTI - have been unaffordable in a typical $40,000 commercial marine radar.

Today, most commercial marine radars are probably at the pinnacle of their detection performance when using conventional non-coherent magnetrons – the modern-day equivalent of the original 1940s technology. But the truth is that for many users who frequently encounter heavy clutter conditions, this level of performance is simply not good enough.

New Kid on the Block

With this performance shortfall in mind, Kelvin Hughes has launched the SHARPEye commercial marine radar system, which represents a significant departure from current practice, and could help advance the developmental thinking in the field.

SHARPEye is a monostatic pulse doppler radar, which means that it utilises the doppler effect to determine the velocity of targets. By processing the echoes received from a train of pulses in a bank of narrowband coherently integrating filters, the system can resolve and enhance targets within particular velocity bands. The filters are then able to separate the majority of wanted targets from clutter by virtue of their differing radial velocity components. Kelvin Hughes claims this extra dimension gives SHARPEye a performance advantage in detecting small targets in clutter.

Conventional radar measures the amplitude of the signals it receives. In addition to this, SHARPEye extracts the relative motion of targets by measuring the phase of the received echo relative to the phase of the transmission. Ensuring that the sequence of phase measurements represents only the targets' relative motions means the transmitter and receiver elements of the radar need to be extremely stable over the time taken to transmit the pulse train. In other words, you can't use a magnetron, which is inherently unstable.

Thankfully, there are several alternatives to choose from. The most reliable option is the solid state power amplifier. Solid state devices priced equivalent to a magnetron have a very low-peak power output, but fortunately, they are able to operate with a high duty ratio.

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

The reason it transmits relatively long pulses is to illuminate targets with sufficient energy for detection; the downside of this is that the minimum detection range can be considerably longer than that afforded by a high-power short pulse. To address this 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'.
The duration of a burst is roughly equal to the time taken for the 3dB points of the antenna azimuth beam to sweep past a point target. This means that 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 limits 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.

Finally, SHARPEye has its own built-in test equipment. This continuously measures key performance parameters such as RF output power, VSWR, oscillator frequencies and receiver sensitivity at frame rate and alerts the operator within seconds of any degradation in radar performance.

Kelvin Hughes is by no means the only company developing 21st Century marine radar for the commercial user – and the variety is impressive and reassuring.
But for those who operate mainly or exclusively in hectic marine environments, SHARPEye brings naval quality clutter clearance within commercial budgets for the first time.