OVERVIEW OF RADOME AND OPEN ARRAY RADAR TECHNOLOGIES FOR WATERBORNE APPLICATIONS

INFORMATION DOCUMENT

SITUATIONAL INTELLIGENCE, THE WORLD OVER

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1. Introduction

Providing a basis of comparison

This overview aims to clarify the subjective nature of radar technologies, design and selection.

Various manufacturers produce many different products all of which exhibit certain individual attributes or qualities that other competing products do not. This is why it is practically impossible to compare quantitatively the broad range of radars available today.

This document is intended to focus on applicable competing technologies to the Kelvin Hughes SharpEye™ SCV radar radome product and in doing so put the range of technologies available in this market into a relative context.

The intention is to not directly compare specific competing products hence the reference to ‘radar technologies’ or ‘technology types’. Whilst the author refers to SharpEye™ SCV by product name in this instance the product is also a technology type significantly different to other radar technology types to allow it to be compared based on an attributes and benefits basis.

This is not an attempt to compare every radar Kelvin Hughes makes with every radar available on the market.

The primary focus is the radar transceiver and not radar processor and display technologies.

Unfortunately, it is not possible to provide measures that compare all the radars directly however, sufficient understanding of the radar technologies enables a perceptive analysis to be made of the radar types and make comparisons accordingly.

2. Compromise

A decision on a surveillance solution may rely more upon the compromises that need to be made, rather than the theoretical achievable performance.

3. Radar versus Camera

Understanding the camera or radar as a target detection and tracking technology

RADAR	CAMERA
WIDE AREA SURVEILLANCE	SINGLE TARGET TRACKING
MULTIPLE TARGET DETECTION AND TRACKING	OPTIMAL AS A DAY TIME SENSOR (INFRARED AND NIGHT VISION OPTIONS)
FIELD OF VIEW OR 360 DEGREE	CAN BE CUED BY A RADAR
DAY OR NIGHT	LIMITED AUTONOMY
INCLEMENT WEATHER (DETECTS IN HEAVY RAIN AND HIGH SEA STATES)	SOME SOFTWARE PACKAGES PROVIDE A MEANS OF MANAGING TRACKS, PRIORITIES AND THREATS
AUTOMATIC CAMERA CUEING	NOT USEFUL IN INCLEMENT WEATHER
SOFTWARE CAN MANAGE TRACKS, PRIORITIES AND THREATS	CERTAIN CAMERA SYSTEMS CAN PROVIDE 360 DEGREEE COVERAGE
PROVIDES AUTOMATIC HANDOVER TO CAMERA	

Table 1

Radar provides navigation, situational awareness and security and surveillance capabilities. Synergy is achieved when combining the two systems (the radar and the camera). Integrating them provides an added identification and interrogation surveillance capability.

4. Quick Reference Capability Table

The following table provides a quick reference comparison on the key criteria reviewed during a radar selection process. As discussed above, the decision on a radar solution may rely more on the compromises that have to be made rather than the theoretical performance, however understanding what performance is required and which technologies best make a balanced trade-off will help navigate a way through the process.

WATERBORNE SURVEILLANCE RADAR TECHNOLOGIES Table 2

		WATERBORNE APPLICATIONS				
		X Band Pulse Radar Magnetron Radome	X Band Solid State Pulse Radar Radome	Broadband X Band (FMCW) Radome	S & X Band Pulse Magnetron Open Array Radar	S & X Band Pulse Solid State Open Array Radar
Target Detection	Short Range	Poor	Good	Very good	Poor	Moderate
	Long Range	Good	Moderate	Poor	Good	Very good
	Detection	Optimised for long or short range	Concurrent long and short range	Concurrent long and short range	Optimised for long or short range	Concurrent long and short range
	Close In Targets	Poor visibility	Good visibility	Good visibility	Poor visibility	Poor visibility
	Radar Cross Section (RCS)	Not suited to man in water detection	Suited to man in water detection	Suited to man in water detection	Not suited to man in water detection	Can detect man in water
Resolution & Accuracy	Discrimination	Poor	Good	Good	Poor	Good
	Azimuth Accuracy	Moderate	Good	Moderate	Very Good / Good	Very Good / Good
	Range Accuracy	Poor	Good	Good	Poor	Good
	Clutter Suppression	Poor	Good	Moderate	Poor	Good
Transmit / Receive	Transmit / Receive	Requires stand by period	Requires stand by period	Stand by period not required	Requires stand by period	Stand by period not required
Energy on Target	Mean Power	Typically less energy on target	Maximum energy on target	Significant energy on target	Typically less energy on target	Maximum energy on target
Interference	Interference	Interoperability/Jamming can be an issue	Automatic Frequency Variation Frequency Diversity	Interoperability and or Jamming is an issue	Interoperability/Jamming can be an issue	Automatic Frequency Variation Frequency Diversity
Probability of Detection	Probability of Detection	High probability of intercept	Low to medium probability of intercept	Low probability of intercept	High probability of intercept	Low to medium probability of intercept
Platform Integration	Platform Integration	Nearby reflectors not a problem	Nearby reflectors not a problem	Nearby reflectors are a problem	Nearby reflectors not a problem	Nearby reflectors not a problem
Reliability	MTBF	Low	High	High	Low	High
Physical Properties	Physical Properties	Lightweight integrated radome enclosure	Lightweight integrated radome enclosure	Lightweight integrated radome enclosure	Bulky & Heavy	Bulky & heavy but transceiver can be mast mounted
Price Point	Price Point	Low to Medium	Medium	Low to Medium	Medium	Medium to High
Conclusions	Conclusions	High system noise limits resolution. Reliability of magnetron.	Provides affordable solution to middle ground surveillance coverage	Susceptible to interference from other radars and radar jammers. Not flexible/Short range applications.	High system noise limits resolution. Reliability of magnetron. Cannot be installed on very small boats and RHIBs.	Cannot be installed on very small boats and RHIBs.

5. Technology Types

X Band Pulse Radar Magnetron Radome

Historically, the most common radar radome technology referred to typically as 18 inch or 24 inch available in 2kW and 4 kW peak power output. Modern day versions incorporate a magnetron transmitter, which are driven by a solid state modulator.

The distinction to note here is the difference between a solid state modulator and a solid state transceiver. They are not the same thing. Fundamentally, the radar is a magnetron pulse transmitter.

The pulse refers to the method in which electromagnetic high frequency waves or energy is transmitted, with a pulse at a specific frequency being generated by the modulator and transmitted via the magnetron and then the transmitter switches off for a period to allow for the receiver to listen for the return pulse.

The optimal frequency band that radomes utilise is X Band usually around the 9.0 to 9.5GHz range.

The entire radar transceiver is self-contained in an IP rated plastic enclosure suitable for marine applications.

X Band Solid State Pulse Radar Radome

This technology previously reserved for multi-million pound military radar platforms has been made extremely affordable by applying the techniques developed during the military applications of the past decade and utilising power transistors and FPGA chips developed for the telecommunications industry.

Unlike a magnetron radar, solid state pulse radar transmits and receives simultaneously unique pulse sequences (a sequence that for example contains a short, medium and long pulse all transmitted together in each sequence) of typically 50W peak power. The mean power of a solid state pulse radar is significantly more than a magnetron, illuminating a target with more energy.

The significantly less peak energy makes solid state pulse radar much less susceptible to detection by counter surveillance techniques.

Additionally, solid state technology is inherently more reliable than a magnetron system and enables the application of Doppler processing providing a means of processing the received echoes into velocity bands giving a velocity measurement in addition to bearing and direction and also true clutter rejection by separating genuine targets based on their velocity. This capability significantly improves the CFAR (constant false alarm rate). The combination of simultaneous short, medium and long pulse transmission and Doppler processing improves the target detection and resolution of the radar at all range bands than any other radar type in the class.

In dense radar and radar jamming conditions, pulsed solid state radar is resistant to the jamming effects experienced by other radars.

At the time of writing, there is only one X band solid state pulse radar radome available on the market that is able to be mounted on a boat as small as a RHIB, which is the Kelvin Hughes SharpEye™ SCV radar radome.

Broadband X Band (FMCW) Radar Radome

FMCW (Frequency Modulated Continuous Wave) technology also referred to as broadband in some cases is also a solid state technology which is differentiated to pulse radar by the means in which it transmits and receives, this radar type continuously transmits a frequency wave or 'saw tooth' as opposed to a pulse.

This approach to radar provides a means of achieving high resolution especially at very short range but longer-range detection is limited. However, FMCW radars do not withstand dense radar environments or radar-jamming effects particularly well, as the frequency transmission is limited in the range it cannot easily be varied to compensate for any jamming effects that occur.

Another less obvious feature is that the receiver element of the radar requires a separate antenna due to the continuous wave energy transmission, which has a number effects on the performance characteristics of an FMCW radar over a pulse radar such as energy leakage at the transmit antenna face into the receive antenna face.

Open Array Radars

Open array radars both magnetron and solid state exhibit the same qualities as their radome counterparts however, due to their increased antenna length, performance gains can be made however, the increased weight and size as a result of longer length antennas means their application is limited and generally not suitable for very small watercraft such as RHIBs and life boats.

6. Detection Range

Radar users understand the difference between instrumented range and actual detection in different conditions, a radar that performs in inclement conditions out to the radar horizon provides added capabilities and advantages to the user.

Traditional lightweight magnetron and continuous wave radar radome technologies forfeit detection range, a pulsed solid state radar fills the application and capability gap between a radome radar and an open array radar, gaining additional range whilst still providing the integration benefits of a lightweight radome.

The following is a perceptive diagram showing the unique technology types that are present on the market today and the detection range capability in comparison to the other available options. This information is prepared based on actual target detection as opposed to stated instrumented ranges. Unfortunately, it is not easily possible to provide measures that compare all the radars directly however, sufficient understanding of the radar technologies enables a perceptive analysis to be made of the radar types and make comparisons accordingly.

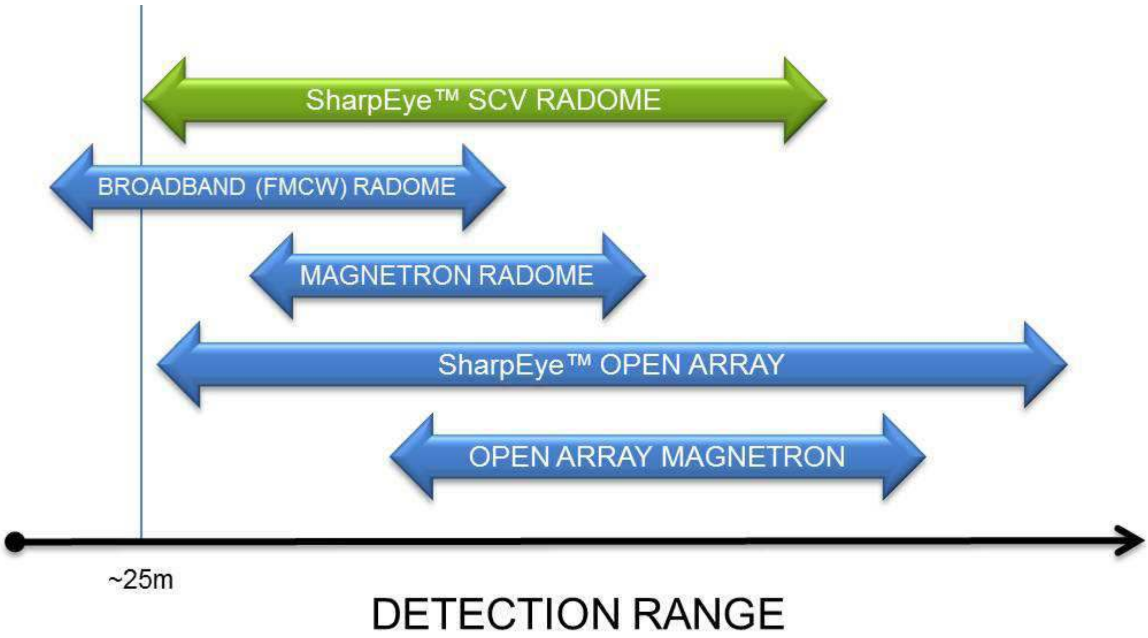

Diagram 1

7. Radiated Energy

Ultimately radar performance is achieved by the amount of energy that can be radiated at a target, and peak power is not a measure of radar effectiveness, mean power is.

The benefits of solid state technology win through here as significantly less electromagnetic emissions are radiated (kW versus watts) yet more energy is emitted illuminating a target.

The more energy on target the more energy returned to the radar receiver. The peak power of a solid state radar is significantly less than a magnetron, hence the probability of detection by counter surveillance devices is reduced.

The following diagram attempts to compare the relative amount of energy a given technology can typically radiate to illuminate a target.

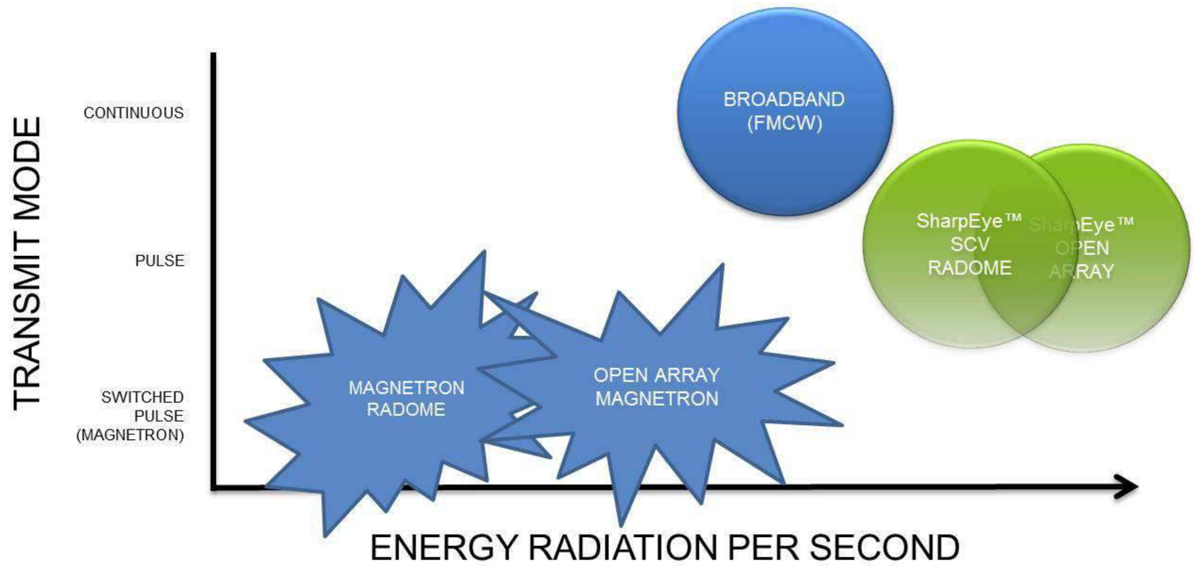

Diagram 2

8. Resolution

High-resolution radars are very useful bringing new elements of safety, situational awareness and threat detection to the operator of a ship or small watercraft. Arguably high resolution at very short range offers little tactical advantage but has safety benefits such as spotting targets low to the water's surface especially if moving at high speed, visually these could be missed, however high resolution radar at medium to long range offers significantly more tactical advantages and therefore options.

Open array radars with the option of much longer antennas enable higher resolution to be achieved. Many radar radome manufacturers counter this issue by inferring higher resolution by way of processing the radar picture.

Being able to produce higher resolution at the radar itself ensures more target information is provided to the processor enabling more tactical information to be acted upon as opposed to filtering out valuable information at the display in order to provide a clearer looking picture.

The combination of Doppler processing, X band, solid state transceiver and state of the art antenna technology provides a means of a radome to achieve optimal resolution.

Kelvin Hughes SharpEye™ SCV technology now fills that capability gap between short range resolution and medium to long range resolution, providing a high resolution radar that can perform almost as well as an open array radar but still be applied to small watercraft such as a RHIB as a lightweight radome.

Please note the shorter the resolution or distance between two targets the higher the resolution.

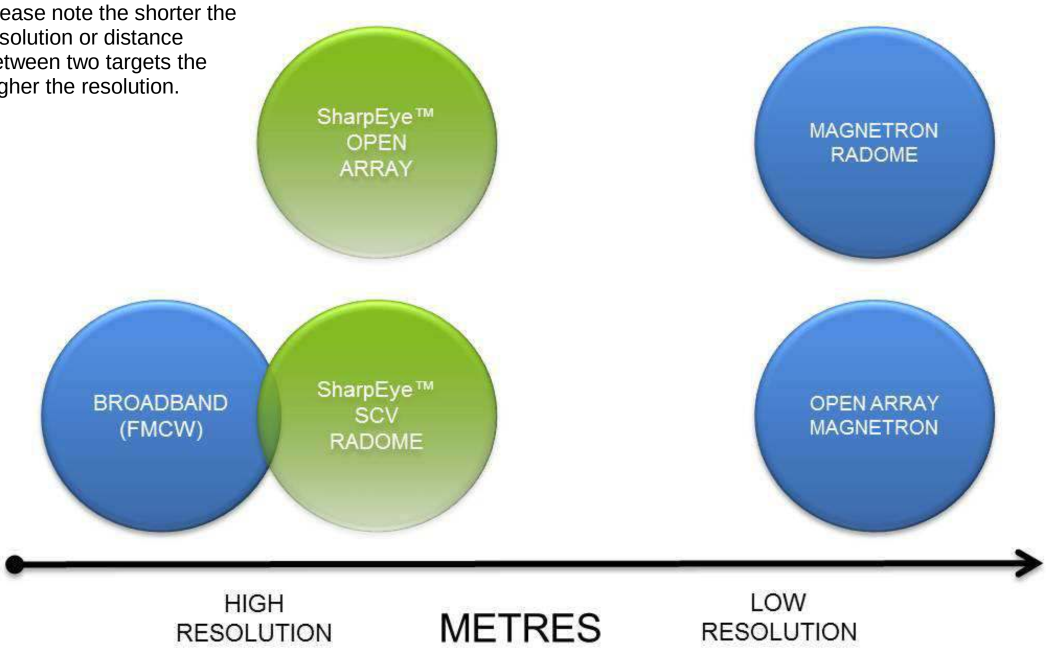

Diagram 3

9. Price position of radars for small watercraft

As with most decisions, often the price question starts to drive the thought process on what to trade off and compromise on. Radar selection is very much a process of compromises to be made in order to meet the application requirements at an affordable and value for money price. Theoretical performance is not the basis to make the decision.

It is understood that solutions that provide more capability, cover more of the middle ground and hence reduce the need to make compromises are better value for money.

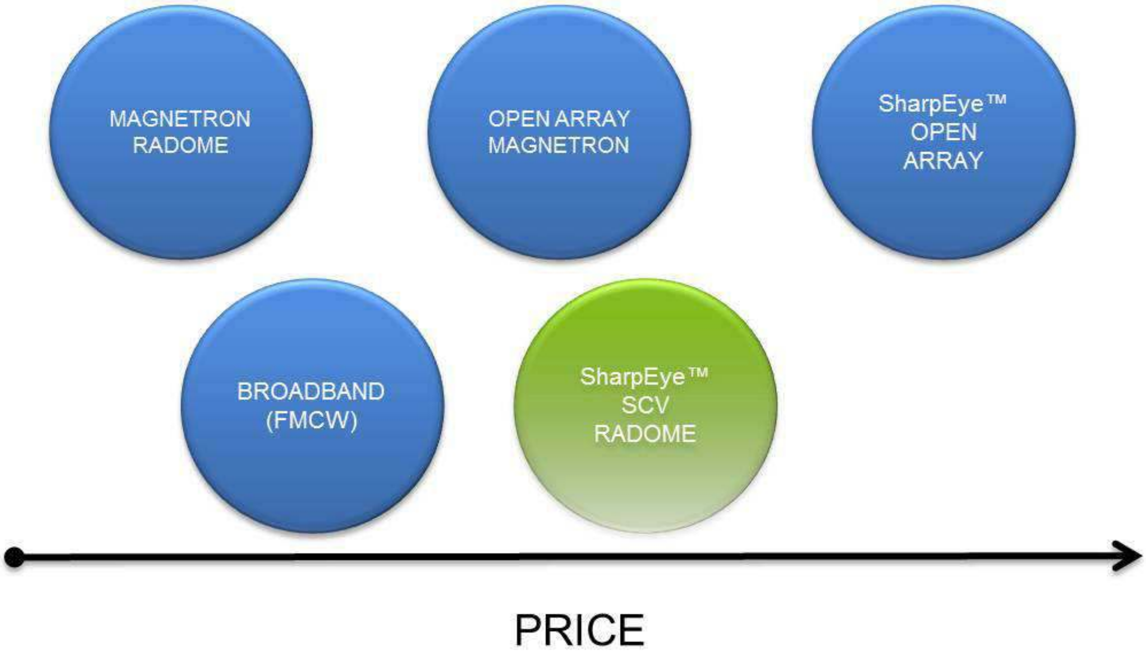

Diagram 4

10. Conclusion

Where high resolution and excellent target detection at extended ranges is required a pulsed solid state radar radome or open array solution is the only technology that can satisfy these requirements and also match the characteristics of the other technologies.

Radar jamming in heavy radar emission environments and also deliberate jamming from counter surveillance operations can easily render a magnetron or Broadband FMCW radar unusable.

Much cheaper technologies satisfy a smaller less demanding range of requirements and open array solutions limit themselves to larger vessel or ship applications.

A pulsed solid state radome solution with near matching performance characteristics of a pulse solid state open array solution for a capital ship, opens up a plethora of new applications affordably not least for the smaller work boats of the life boats organisations such as the RNLI but also the militaries, navies and paramilitary organisations.