Radar Update

Alan Watson

- Analogue radar
- Digital radar
- Broadband radar
- Pulse compressed radar

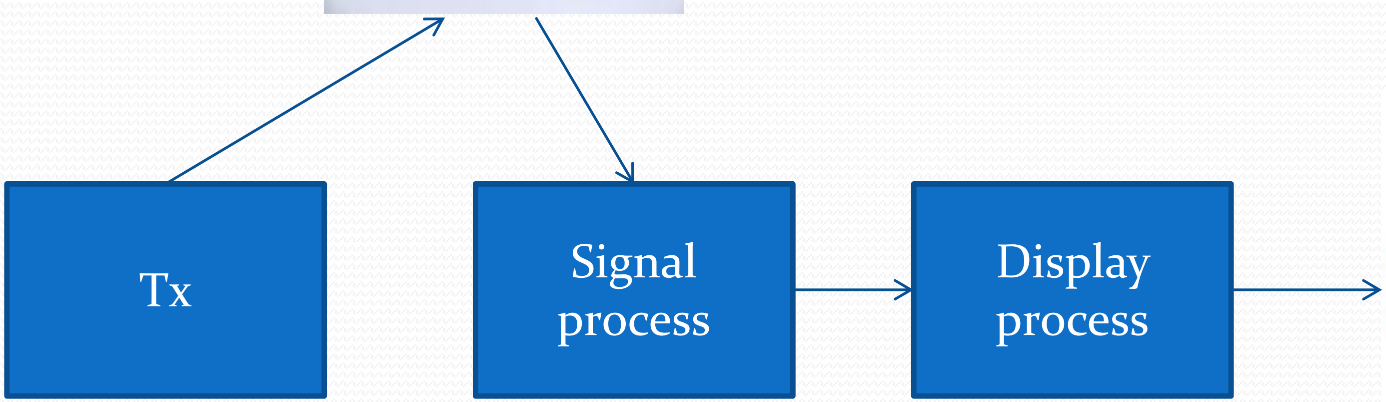
Traditional pulse radar

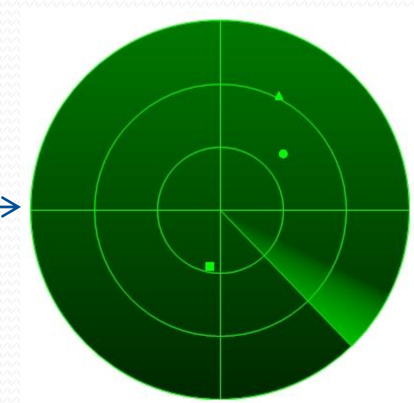
Pulsed Radar works by firing a short pulse of radio energy and then listening for reflections coming back

It will only be aware of things that reflect radio waves

Under the lid:Analogue pulse

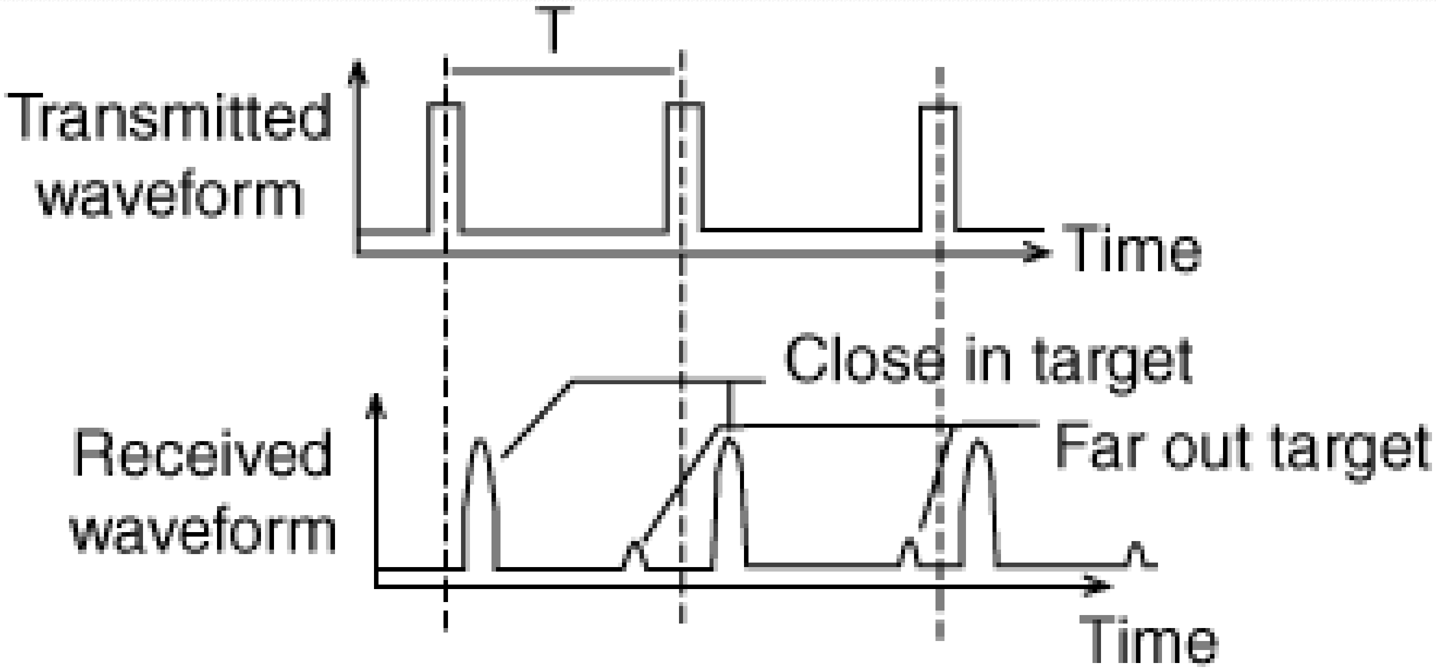
Single antenna used for tx/rx





What determines performance?

- Beamwidth
- Pulse duration
- Power
- Receive signal to noise
- External: target characteristics, clutter etc.



Wave form in pulse radar

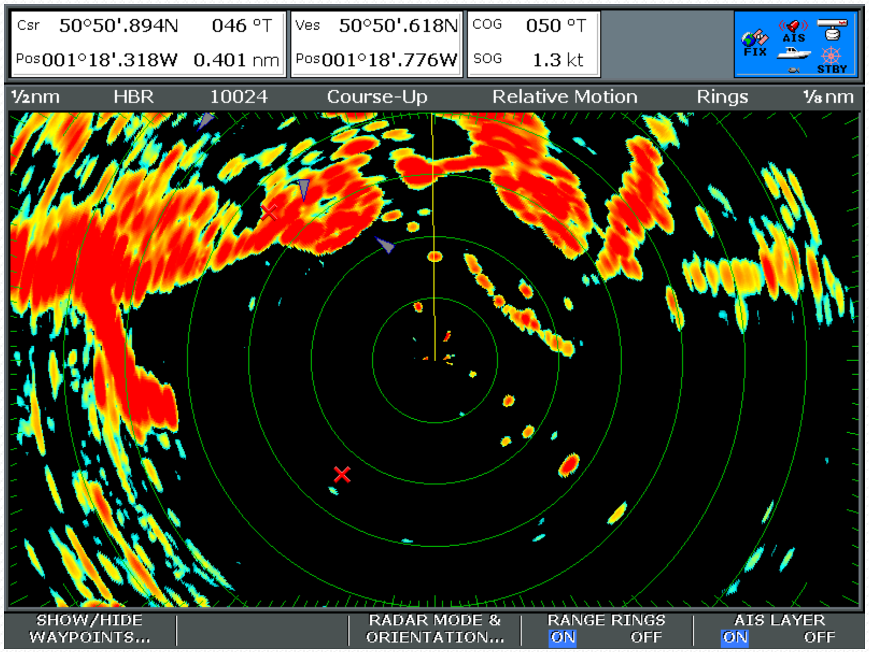
PRF = 1/T

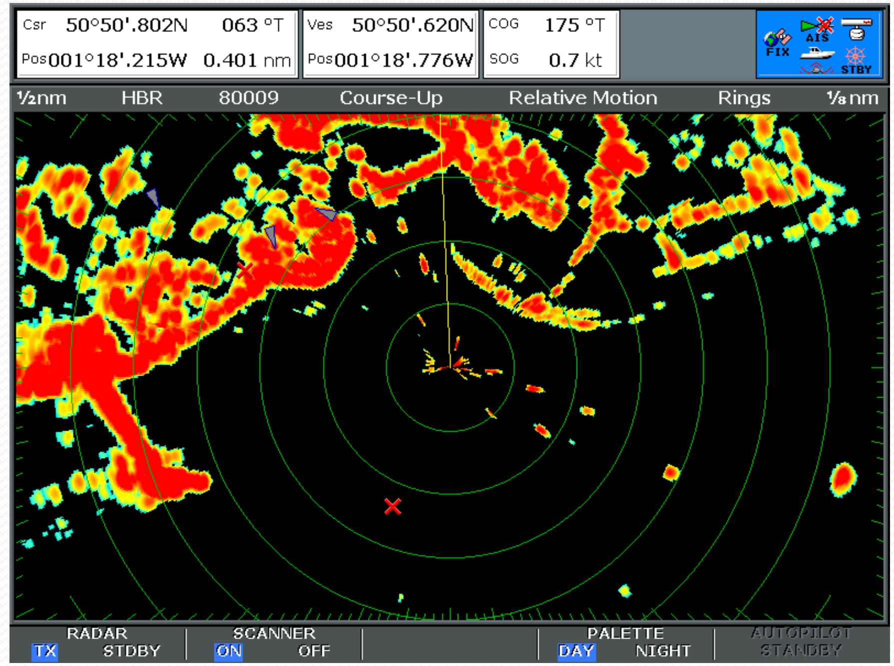
Radar range equation

$$P_{RX} = \frac{P_{TX} \times G^2 \times \lambda^2 \times \sigma}{(4\pi)^3 \times R^4}$$

P_{RX} = Receive power which has to be above a threshold to show on the screen
P_{TX}= transmitter power
G = antenna gain
λ= wavelength (3cm or 10 cm for commercial radars)
R = range
σ = radar cross section of target

Comparative performance





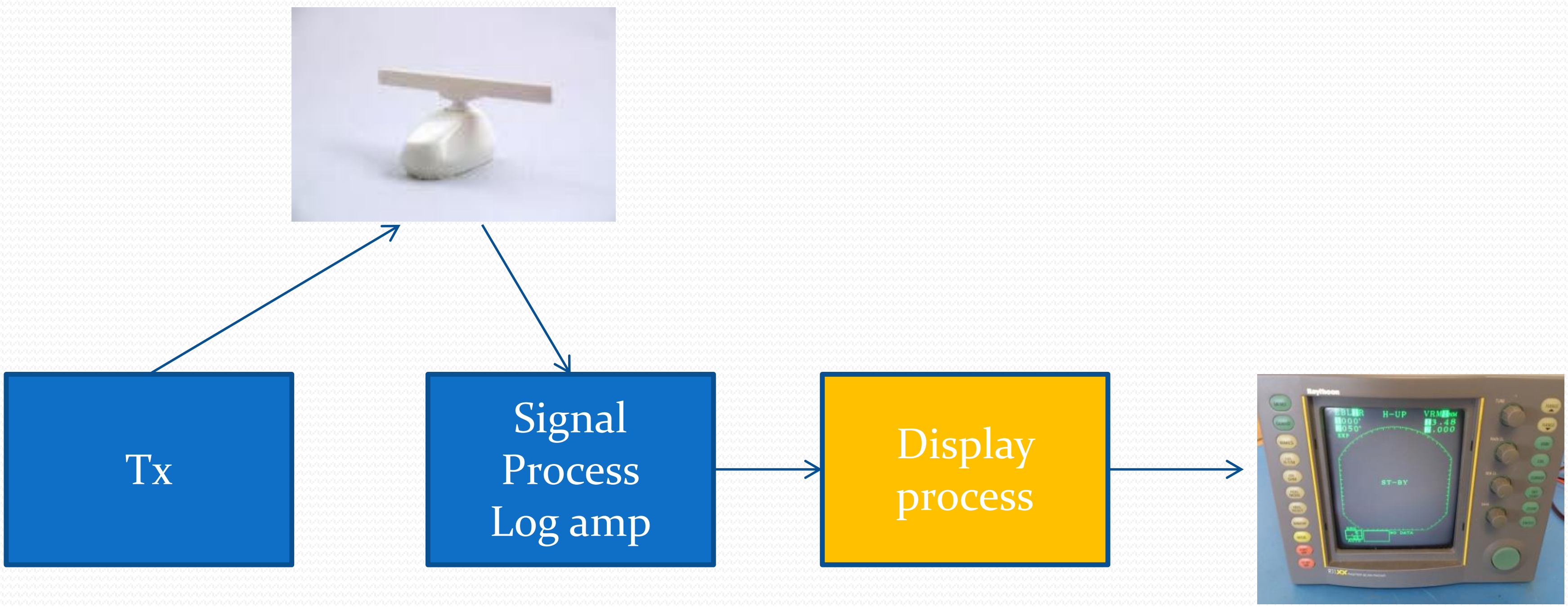
18 inch radome

4 foot open array

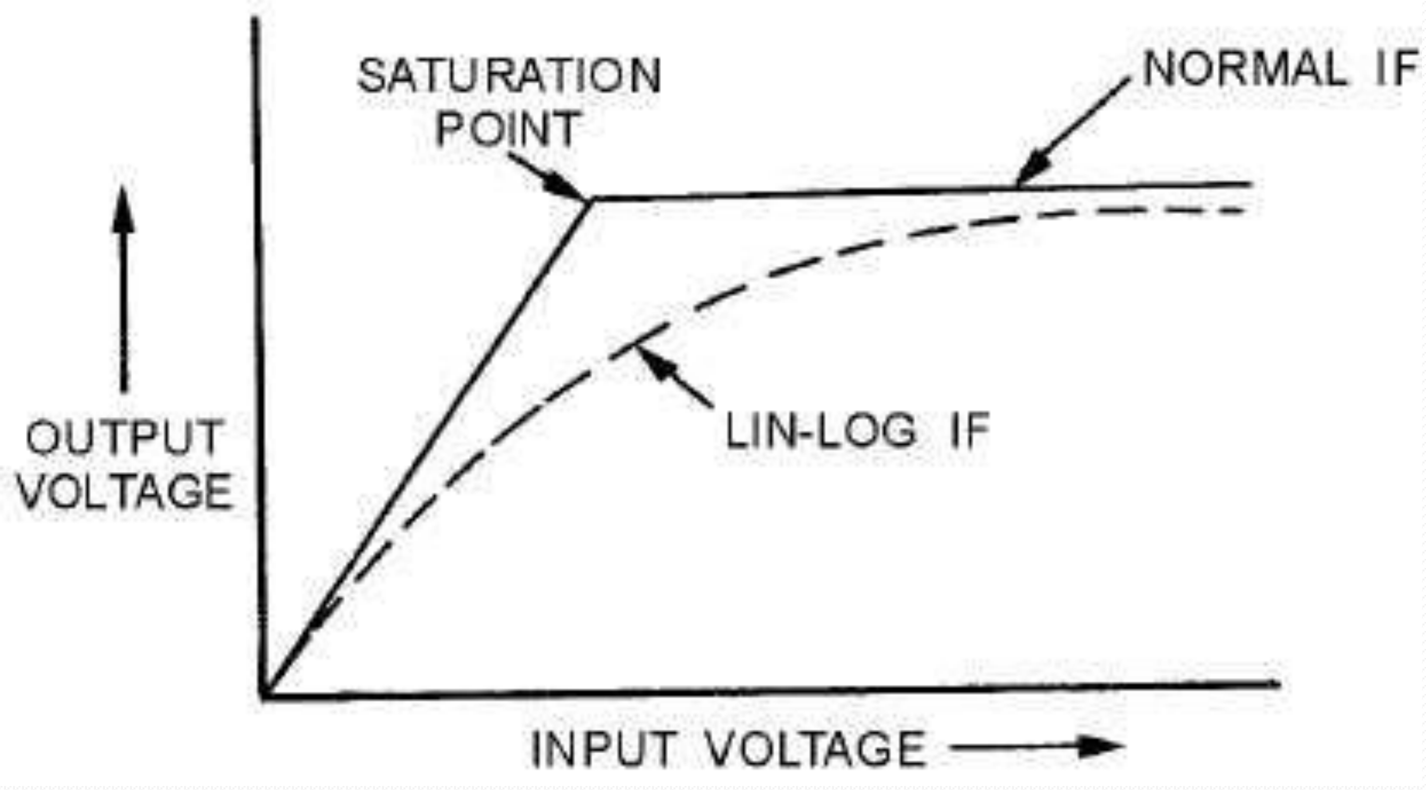
Total energy determines target detection

- Energy= pulse length x pulse power
- Long pulse, lots of energy but poor range discrimination
- Short pulse, low energy but good range discrimination.
- Energy is important factor when considering to safety.

Under the lid: Digital step 1



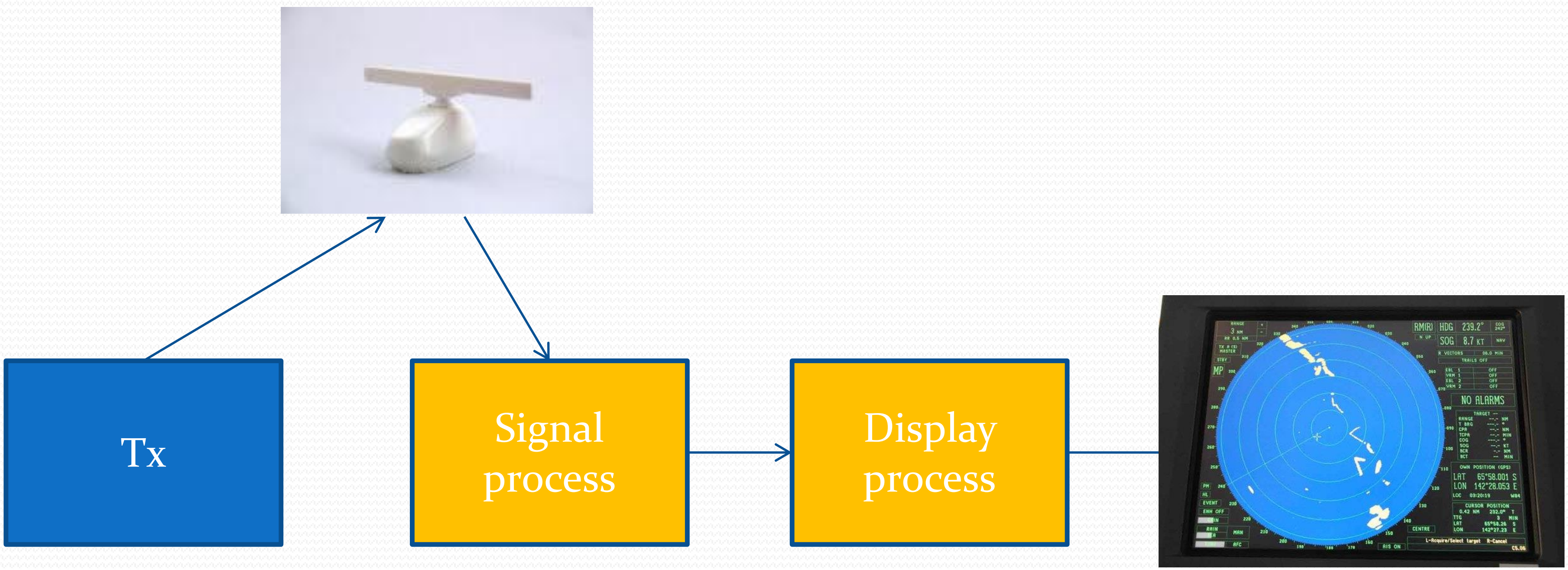
Logarithmic amplifier



Display progression

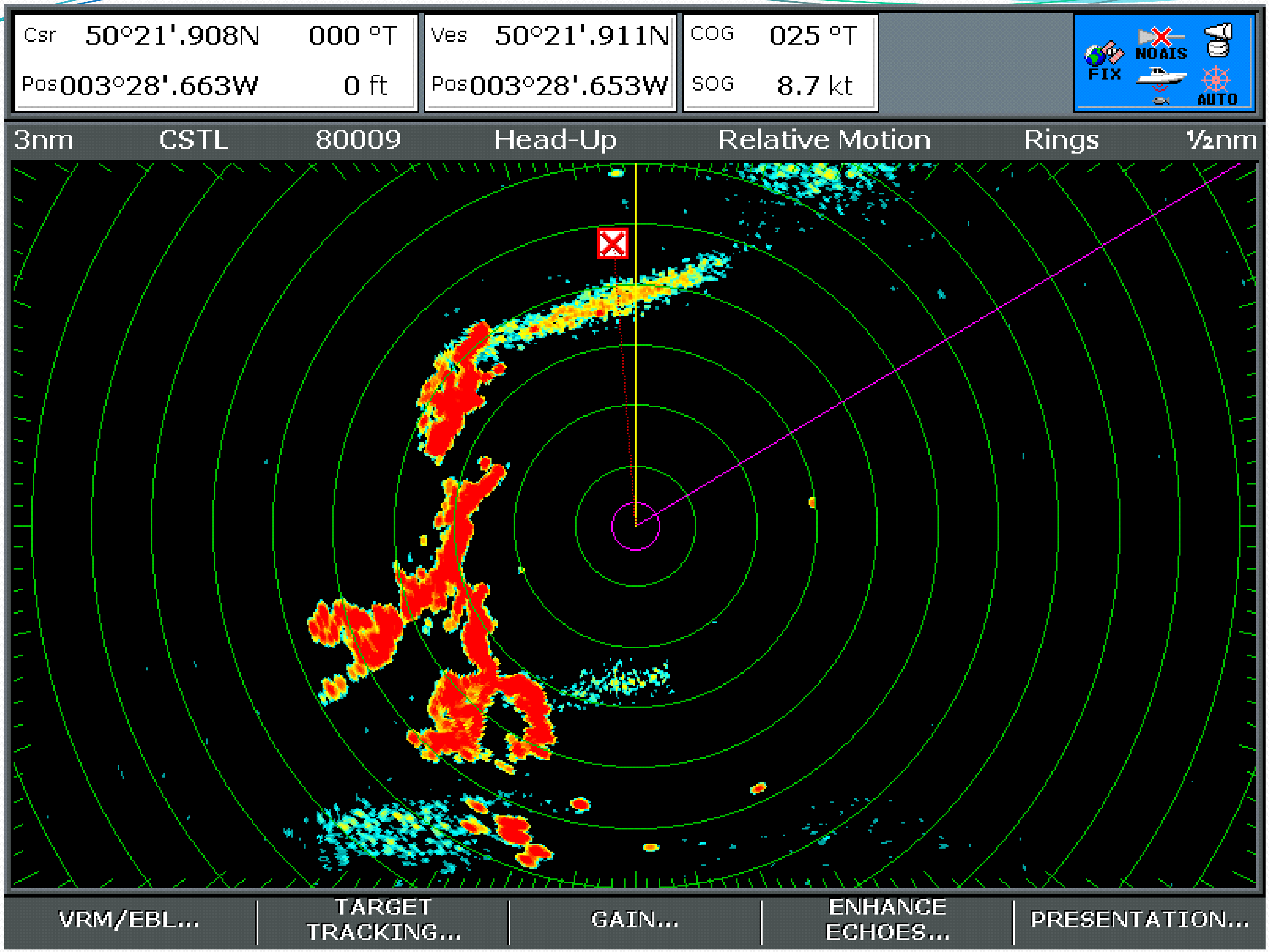
- Analogue, radial scan
- Raster scan, first use of "digital"
- Daylight viewing but limited by memory etc.
- More memory, more processing
  - Correlation
  - Wakes (target history)
  - MARPA
  - Overlay
- LCD screens, multicolour.

Under the lid: Digital step 2

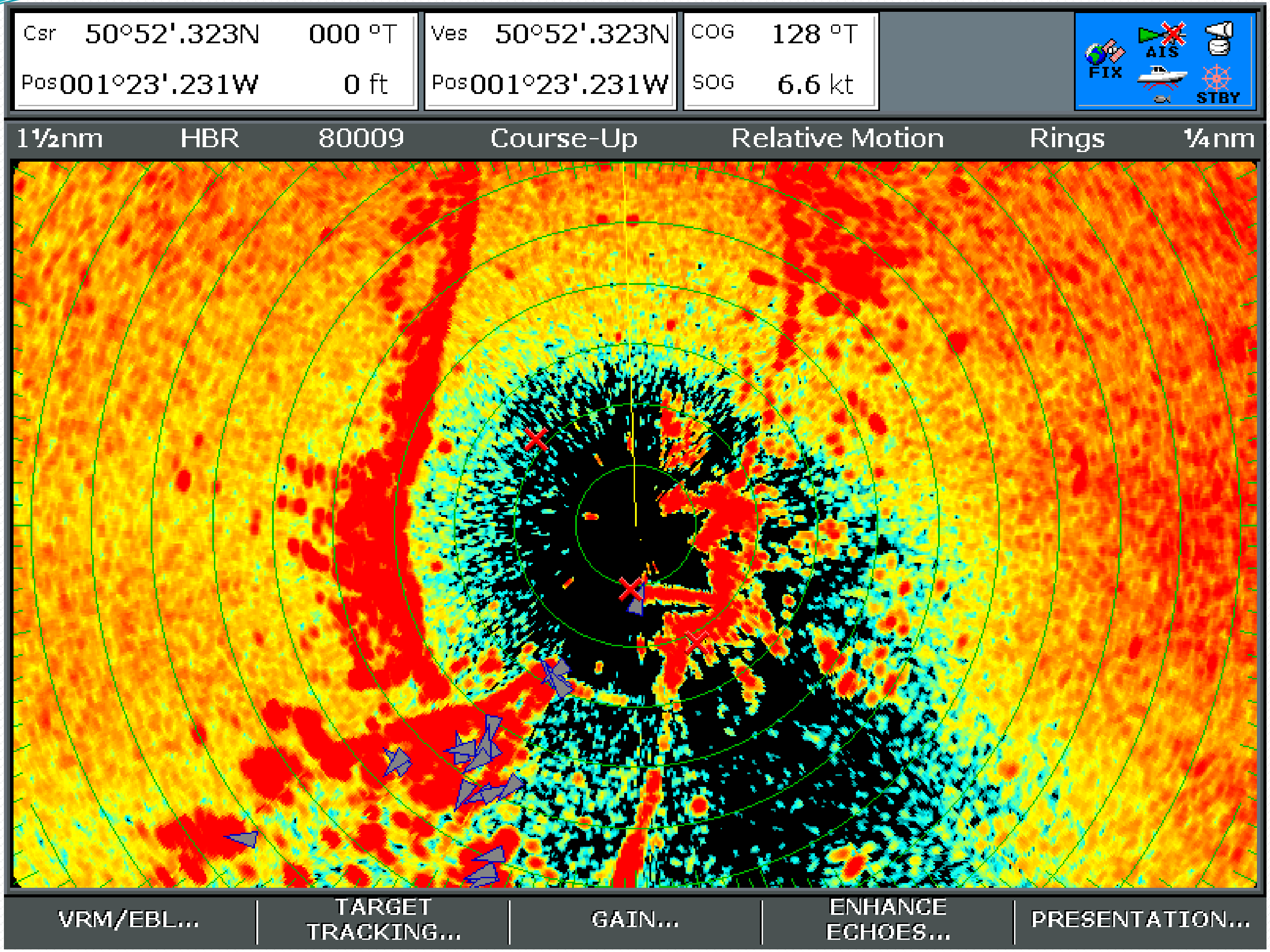


Transition to digital processing

- Analogue, logrithmic amplifiers.
- Introduction of DSP chips.
  - Better S/N ratio so more sensitive
  - Relative level information retained
  - Colour palette on display can be used
  - Differentiates rain
- Advanced signal processing “super HD”
  - Beam sharpening



Coast showing in red, rain in blue, note two (red) targets in rain

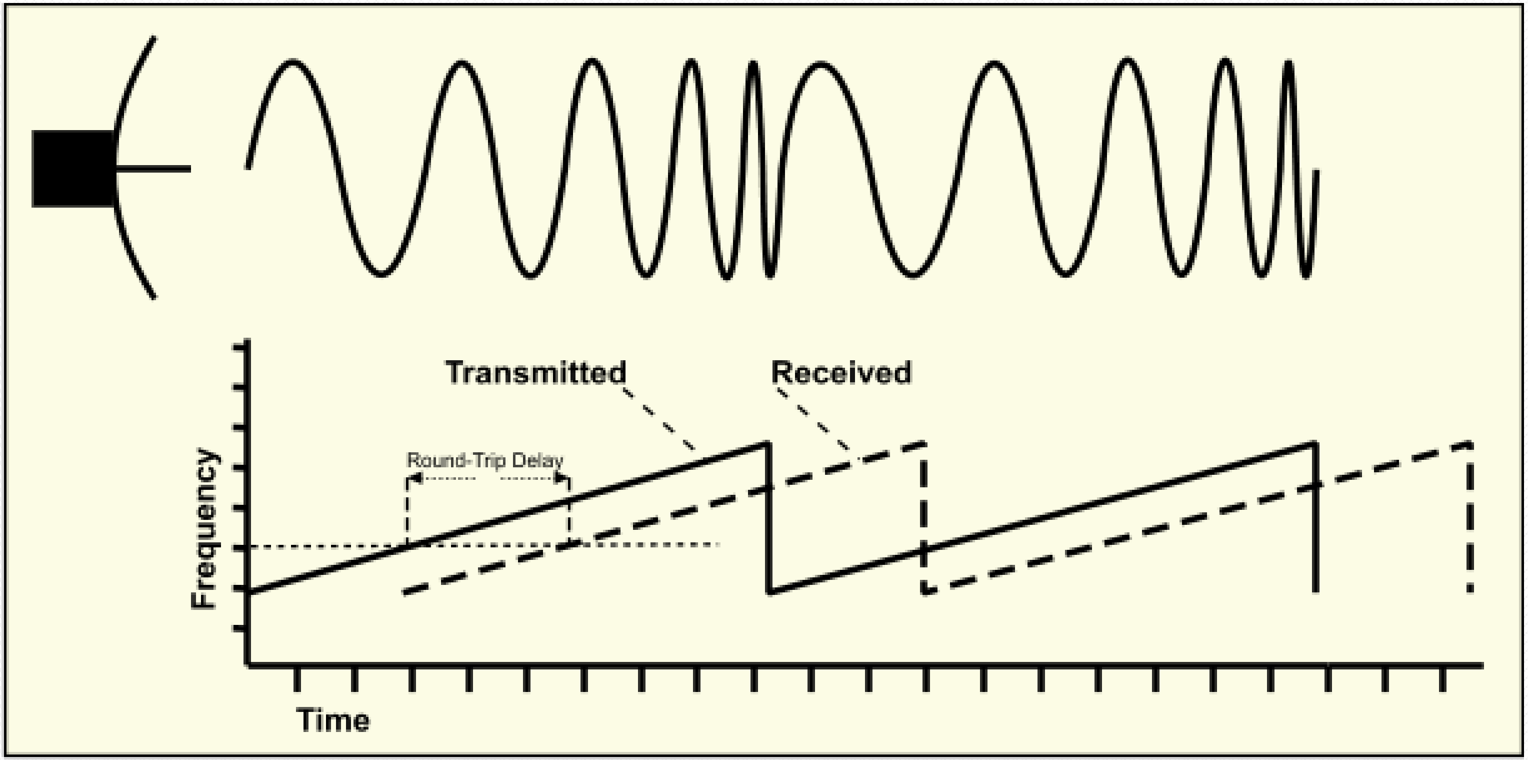


Wanted targets still visible in torrential rain

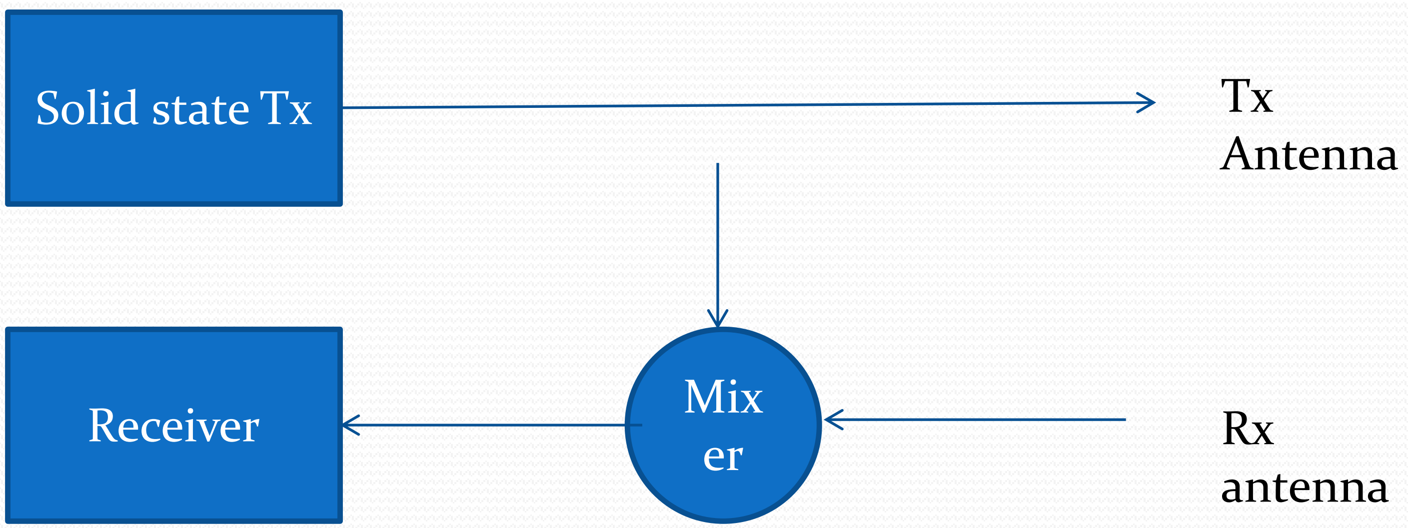
Broadband radar

What is it

- FMCW (frequency modulated continuous wave)
- Very long pulse, so can be low power
- Simultaneous receive and transmit
- Two antennas
- Solid state.



Range calculated by measuring frequency difference between tx and rx.



Mixer produces difference between Tx and rx frequency which equates to range.

Compared to pulse

- Better
  - Very short range performance
  - Range discrimination
  - Weight and reliability (solid state)
- Worse
  - Won't trigger Racons
  - Range performance beyond 15 miles
  - Performance in rain
  - Sensitivity to objects close to the scanner.

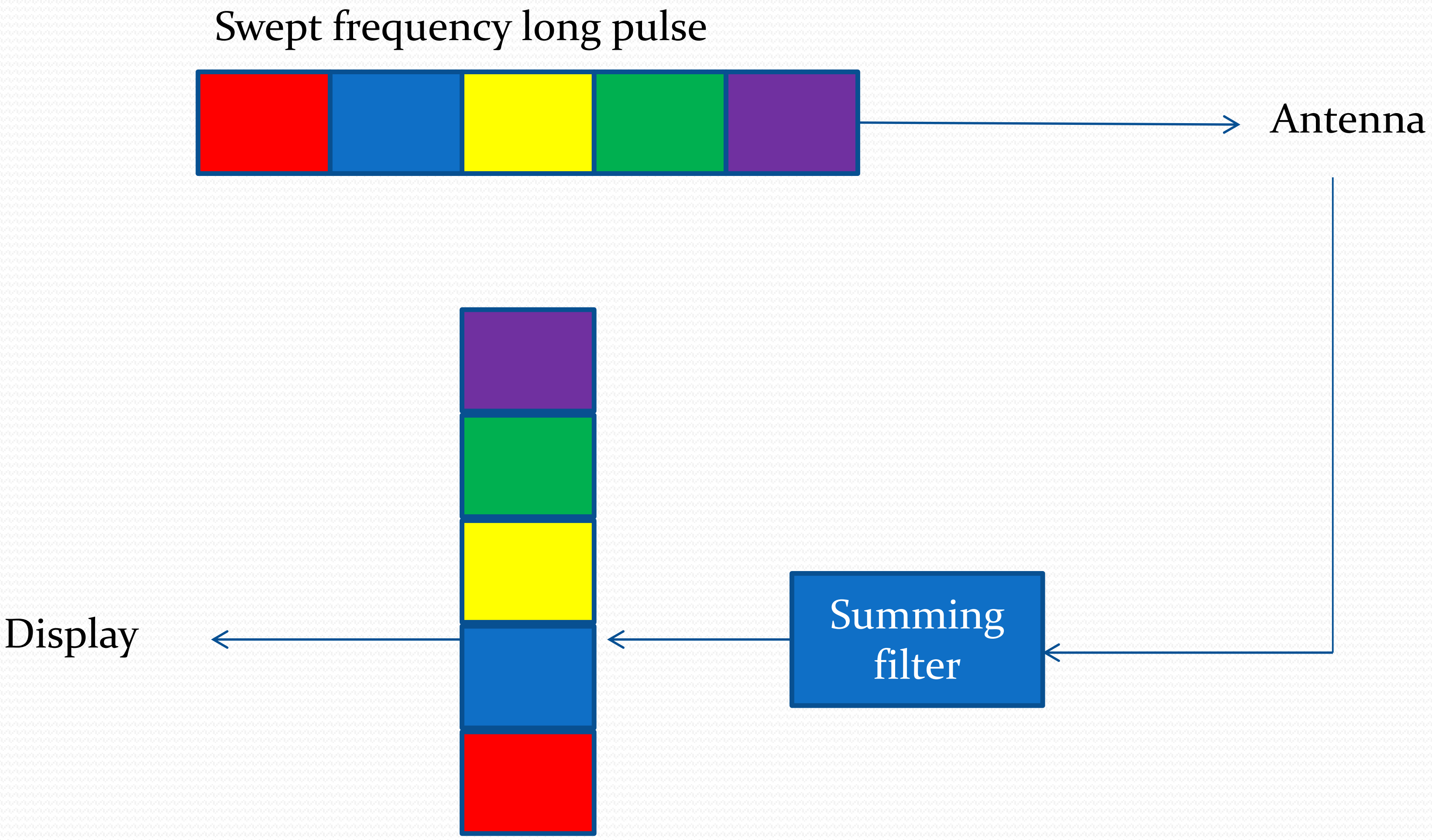
Where next on broadband?

- Software improvements
- Antenna isolation limiting factor
- Increase in tx power but then receive problems
- Best of both worlds will be the solid state pulse compressed radar.

Pulse Compression

How it works

- Solid state low power
- Transmits long swept frequency “chirp” pulse
- Processed to simulate short high power pulse in the receiver.
- Range resolution determined by “short” pulse



Long pulse effectively converted to short high power in the receiver.

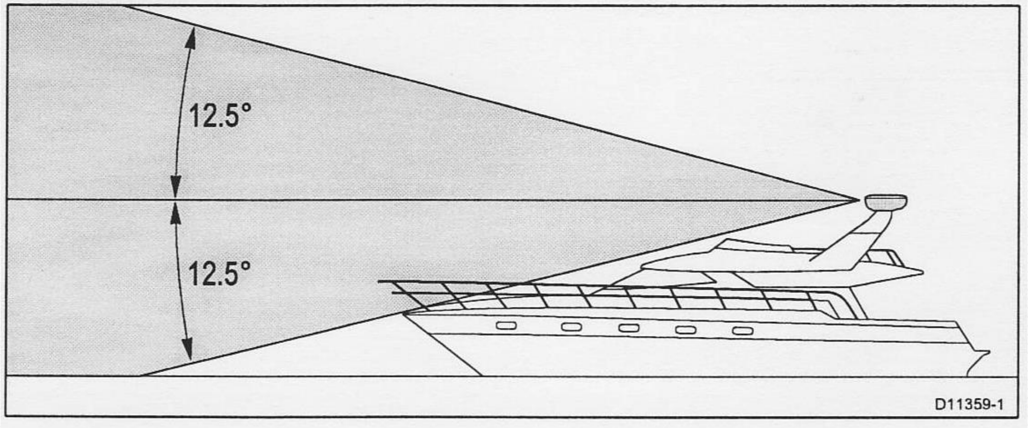
Compared to pulse.

- Better
  - Range resolution.
  - Short range performance
  - Sensitivity
  - Power consumption
  - Weight
  - Less sensitivity to nearby objects than FMCW

Looking to the future

- Radars will go solid state, no magnetron
- Emphasis will be on software not hardware.
- Antenna size will still be important
- Will still need training and experience.

Horizontal and vertical beam widths

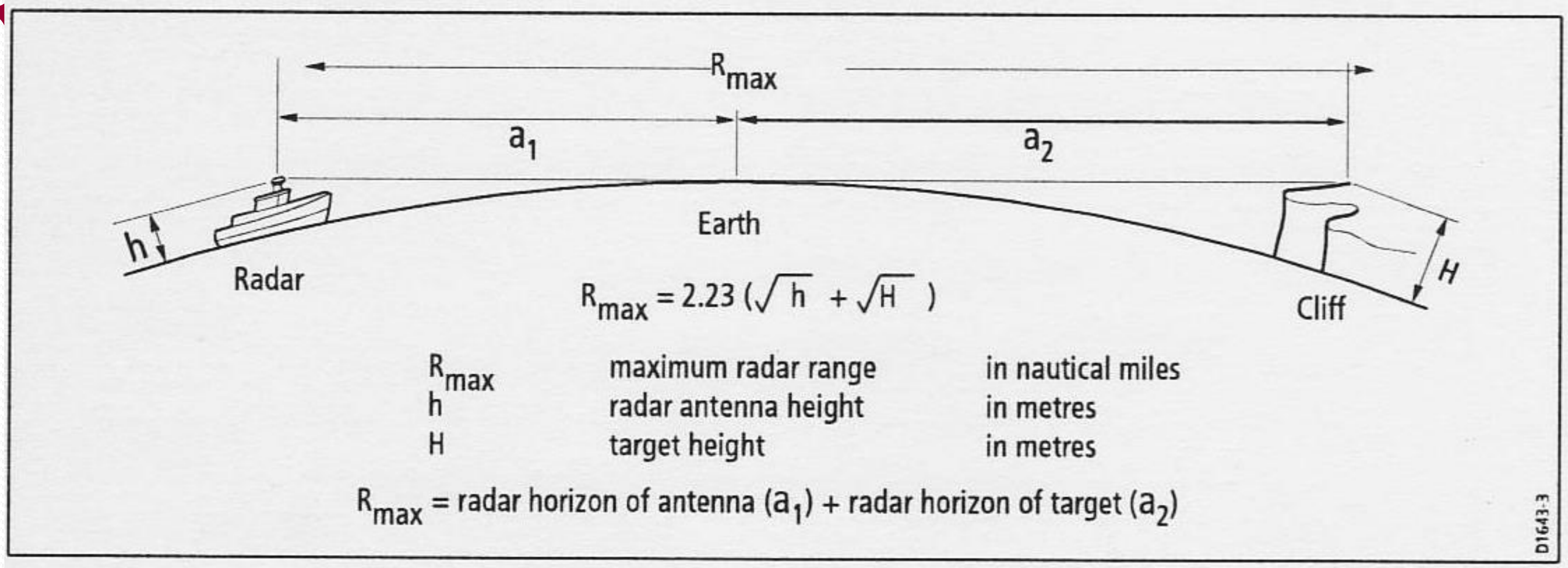


Vertical

Horizontal

18 inch scanner	5 degrees
24	4
48	1.75
72	1

Range



Range depends on scanner and target height

Buoys to 5 miles
Ships to 12 miles
Coast to 20 miles

Your radar can be detected further than you can detect

Low RCS vessels