Maximum Unambiguous Range

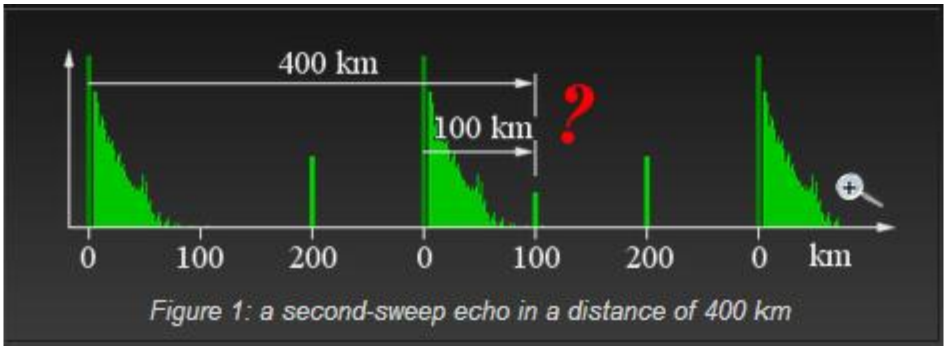

Figure 1: a second-sweep echo in a distance of 400 km

It becomes obvious that we cannot send out another pulse until a time window has passed, in which we expect to see a return echo. The maximum measuring distance Rmax of a radar unit isn't orientated only at the value determined in the radar equation but also on the duration of the receiving time.

The radar timing system must be reset to zero each time a pulse is radiated. This is to ensure that the range detected is measured from time zero each time. Echo signals arriving after the reception time are placed either into the

- following transmit time where they remain unconsidered since the radar equipment isn't ready to receive during this time, or
- into the following reception time where they lead to measuring failures (ambiguous returns).

The maximum range at with a target can be located so as to guarantee that the leading edge of the received backscatter from that target is received before transmission begins for the next pulse. This range is called maximum unambiguous range or the first range ambiguity. The pulse-repetition frequency (PRF) determines this maximum unambiguous range of a given radar before ambiguities start to occur. This range can be determined by using the following equations:

$$R_{max} = c_0 \cdot (PRT - PW) / 2 \quad (1)$$

$R_{max} \approx$ (PRT - PW) in [μs] in [km] / 6.66 μs (2)

Where c0 is the speed of light with 3·108 m/s. The pulse width (PW) in these equations indicates that the complete echo impulse must be received. If the transmitted pulse is very short, e.g. one microsecond can be ignored. But some radars uses very long pulses (up to 800 microseconds) and the backscattered signal must be compressed in the receiver; in the first place it must be received in full length therefore.

The pulse repetition time (PRT) of the radar is important when determining the maximum range because target return-times that exceed the PRT of the radar system appear at incorrect locations (ranges) on the radar screen. Returns that appear at these incorrect ranges are referred as ambiguous returns or second-sweep echoes.

By employing staggered PRT the target ambiguous return isn't represented any more by small arc. This movement or instability of the ambiguous return is represented typically as a collection of points in certain equipment because of the change in reception times from impulse to impulse. With this distinction, a computer controlled signal processing can calculate the actual distance.

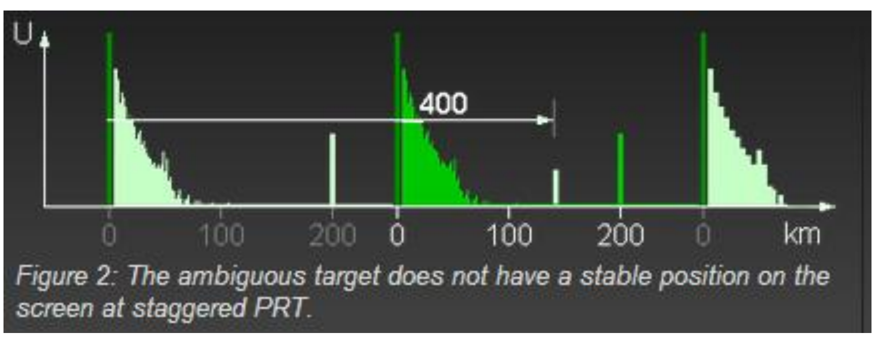

Figure 2: The ambiguous target does not have a stable position on the screen at staggered PRT.

- unambiguous target
- ambiguous return

Figure 3: Unambiguous returns

(thin longer arc – IFF Reply; thick shorter arc – return by the primary radar) and ambiguous IFF-reply by using a staggered PRT (collection of points).

More modern 3D- radar sets with a phased array antenna (like the RRP-117) don't have this problem with an ambiguous range. The system computer steers the transmitted beams so that ambiguous returns from the previous pulses are not received while the antenna beam points in another direction.

Figure 3 shows a target return by the primary radar (thick shorter arc) and an IFF answer reply of the IFF interrogator (thin longer arc) and a second sweep answer of the IFF by using staggered PRT on an PPI-scope. Here you can see as well, that the interrogator doesn't use every primary synchronous-pulse. (The appearance of too many ambiguous IFF-returns can be reduced by using a decreased Tx-power of the interrogator.) Now by using fixed PRT one would expect to see ambiguous returns confusably similar to the unambiguous returns (arcs).

Source: http://www.radartutorial.eu/01.basics/Maximum%20Unambiguous%20Range.en.html