

# FREQUENCY MODULATED CONTINUOUS WAVE (FMCW) RADARS HAVE ADVANTAGES OVER PULSE DOPPLER RADARS FOR GROUND SURVEILLANCE

Ground Surveillance Radar can build a virtual wall around facilities or on a border. It provides operators and agents more response time to access, prioritize and apprehend intruders. It provides wide area surveillance and tracking over a large, 360 degree area, directing responders even after an intrusion has occurred. But, all GSR technologies are not the same.

There are two primary GSR technologies - Pulsed Doppler radar technology and Frequency Modulated Continuous Wave (FMCW) radar technology. Most Pulsed Doppler radars are derivatives of legacy military battlefield radar being applied for wide area surveillance, while a new generation of FMCW radar technology was developed for wide area surveillance, site security and force protection. It was specifically developed to detect and track walking personnel. FLIR Radars use FMCW radar technology.

## FREQUENCY MODULATED CONTINUOUS WAVE (FMCW) RADARS

FMCW radars operate on the imaging principle; that is, they break up the background into small segments, or resolution cells, and then measure changes in the signal return from each cell to detect small targets, such as walking people. Typical resolutions for long range FMCW radars are less than 1 meter in range and less than 1 degree in azimuth. The smaller the cell the easier it is to detect and track a target. FMCW operation is independent of the speed or direction of travel of the target, only its size with respect to the resolution cell in which it is located. Modern FMCW radars can detect people moving at near zero speed and walking in any direction with respect to the radar.

## PULSE DOPPLER (PD) RADARS

Pulse Doppler Radars operate on the Doppler principle, which states that all moving objects will exhibit a frequency shift from the transmitted signal to the received signal, which is proportional to the speed of the target in the direction of the radar. If a target is walking directly toward the radar at 3MPH, the radar will detect a frequency difference in the received signal and declare that a 3 MPH target has been detected. If the target is walking at 45 degree angle to the radar, the Doppler signal will be 3 MPH times the cosine of the angle, or about 2.1 MPH.

However, background clutter like trees and bushes also have some apparent speed when the wind blows. In order not to have a large number of false alarms, that low speed signal return from the clutter must be filtered out. A virtual velocity threshold (blind speed) is created below which targets will not be reliably detected. That means that some slowly moving targets could be filtered out along with the clutter. It also means that higher speed targets moving “across” the radar beam may be filtered out because speed only generates a Doppler signal proportional to the incoming or outgoing speed, which is called radial speed (approaching or receding in the beam).

## IMPLICATIONS OF USING DOPPLER AS THE DETECTION TECHNIQUE

A fundamental deficiency exists such that wide area surveillance systems using Pulse Doppler radars have large areas where “slow” targets will not be detected. In fact, if an intruder walks at a speed somewhat below the velocity threshold (defined as the “blind speed”) of the radar, it doesn’t matter in what direction the intrusion takes place, the intruder will likely not be detected at all – the intruder can simply walk through the perimeter or across the border and the radar will not detect the target. Alternatively, an intruder can walk between two radars spaced along a border and will be moving across the beams, or tangentially to

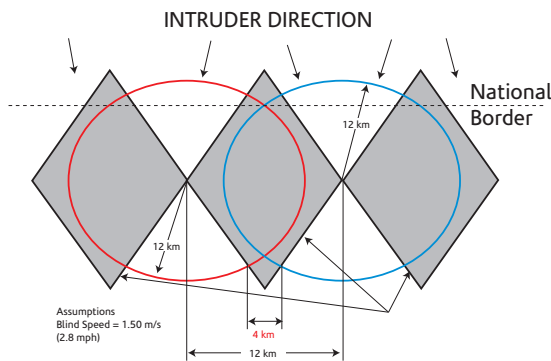
each radar, and therefore, can walk at a higher speed than the velocity threshold, and still not be detected. This deficiency gives the intruders a major advantage. Those familiar with border operations know that intruders learn to avoid areas where they are apprehended regularly. Thus, holes in coverage inherent to Pulsed Doppler radars will be found and exploited, nullifying the very purpose of the radars. Changing the spacing or offsetting radars in latitude will somewhat change the shape of the non-detect zones, but will not eliminate the deficiency.

In summary, PD radars have an inherent flaw when used in ground surveillance applications. There is a conflicting trade off between minimizing clutter returns and the minimum detection speed of the target. Most PD radars will never detect at speeds less than 1.5 miles per hour (a distinct probability with walkers carrying 50 pounds or more of contraband).

### THE FMCW ADVANTAGE - SUMMARY

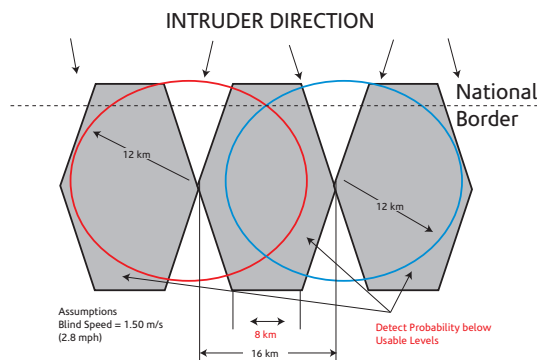
The STS-12000 radar has the advantage of being designed specifically for perimeter and border surveillance using the most optimum technology for this mission: frequency modulated continuous wave (FMCW). The benefits of FMCW over other technologies such as pulse Doppler (PD) are numerous:

- FMCW is less complex, safer and lower cost than PD
- FMCW gives low false alarm rates
  - Proven in Government testing - The only radars to pass stringent U.S. Air Force false alarm test
  - Less likely to alarm with wind blown objects --- grass and leaves, rain
  - One FMCW installation has 31 radars netted together using only one operator
- FMCW sees a higher percentage of valid targets
  - Won't miss slower targets or tangential ones – no holes in coverage – no one penetrates
- Smaller beamwidth for better pointing of cameras



Half the detection area has low doppler signature

Radars spaced 16 km apart (Typical Application)  
Minimum Target Speed = 2.25 mph



More than half the detection area has low doppler signature for slightly slower target

Radars spaced 16 km apart  
Minimum Speed = 2.2 mph

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