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APPLICATION NOTE

TITLE: Causes of a short range radar unit registering a lower speed than a long range radar unit.

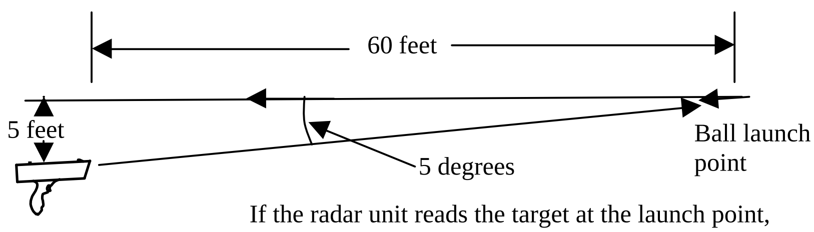
There are 2 main reasons why a short range radar unit may display a lower speed on a target than a long range radar unit, 1. the cosine affect, and 2. the actual target speed.

1. COSINE EFFECT

The Cosine effect for doppler radar units, is the reduction of registered speed by the value of the cosine of the angle between the radar unit boresight* and the line the target is traveling. In other words, the displayed speed will be the actual ball speed times the cosine of the angle. *see definitions, boresight is not necessarly the line the radar unit is pointing.

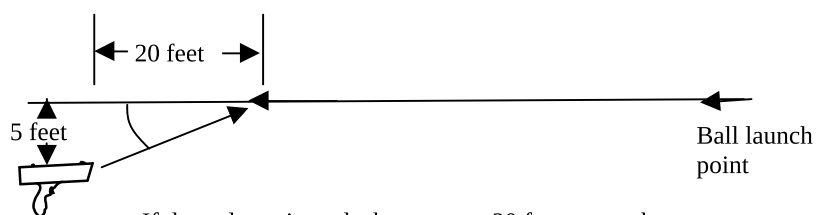
The following pictorials illustrates why a short range radar unit may display a speed less than a long range radar unit based on the cosine effect.
Assume both radar units are positioned the same, for example, 5 feet away from the line of ball travel, and 60 feet away from the ball launch point, and the ball is traveling 100 MPH.

A. A long range radar unit



If the radar unit reads the target at the launch point, the angle would be about 5 degrees, and the value of the cosine is 0.9965. The displayed speed would be 100MPH times 0.9965, or 99.7MPH (which would round up to 100MPH).

B. A short range radar unit



If the radar unit reads the target at 20 feet away, the angle would be about 14 degrees, and the value of the cosine is 0.9703. The displayed speed would be 100MPH times 0.9703, or 97MPH

2. ACTUAL BALL SPEED

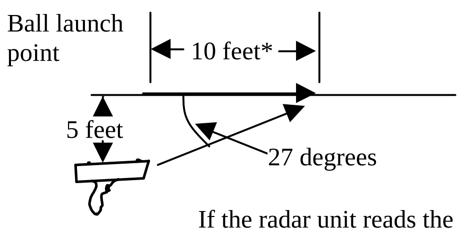
In almost all instances, the ball speed will be the greatest at the launch point, and decrease in speed as it travels.
Referring back to the pictorials, the long range radar unit may register the speed at the launch point (or within the acquisition distance of the launch point). The short range radar unit will register the speed after it has traveled some distance, and has slowed down.

A lot of factors contribute to how much deceleration is applied to the ball, and a complete discussion is out of the scope of this document. In general, it would not be unusual to see a 5% reduction in ball speed from the points where short range and long range radar units can register the speed.

HOW TO REDUCE THESE EFFECTS:

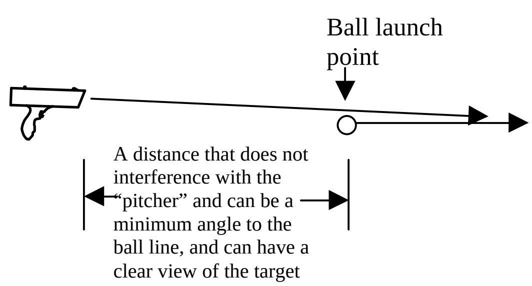
1. For the Cosine effect, reducing the distance between the line of the boresight and the line of the ball will reduce the cosine effect. In the example, if the 5 feet were reduced to 3 feet, the angle would be about 8 to 9 degrees, and the cosine would be 0.99, or in general, only a 1% error.
2. For the actual ball speed, by moving the radar unit closer to the launch position or from behind the launch position (so it reads the ball going away) should provide for readings when the actual ball speed is maximum. Be careful, about the cosine angle when doing this, if you are next to, and offset from the launch point, the angle can be greater. If measuring the ball going away, move behind some distance, and keep the angle to a minimum. The following pictorial shows how the cosine can be a large factor if the radar unit is “beside” the launch position. This will affect both long range and short range radar units about the same.

Large Cosine value, with the radar unit next to the launch point.



If the radar unit reads the target after it has traveled 10 feet, the angle would be about 27 degrees, and the value of the cosine is 0.89. The displayed speed would be 100MPH times 0.89, or 89MPH
*Reference notes regarding acquisition distance.

To reduce this, move behind the launch point and keep the radar unit in the line of ball travel.



Definitions (as reference to this document):

1. Long Range radar unit: minimum distance the radar unit can register the speed on a moving target is 100 feet.
2. Short Range radar unit: maximum distance the radar unit can register a speed on a moving target is 40 feet
3. Boresight: the line between the radar unit and the target when the speed is recorded. Note that this may not be the line the radar unit is pointing. Doppler Radar units do not need to be pointing directly at a moving target to register the speed. The area in front of a speed radar unit where the radar unit can "see" a target, and register its speed looks like an "ice cream cone". Figure 1 shows a typical radar transceiver field of view. For purposes of calculating the cosine factor, the boresight line is the line between the radar unit and the line of the ball WHEN the speed is registered. See figure 2.
4. Acquisition distance (or time): How much distance (or time) the moving target must be in the radar units field of view to calculate a speed. This is also called the acquisition time, due to the fact that some signal processing techniques require a minimum time in order to calculate the speed. A time oriented detection method will typically require a minimum distance, where as a frequency oriented detection method will require a minimum time to be able to acquire the targets speed. Both techniques are commonly used for speed detection radar units. The difference in the two detection methods is a cost / performance trade off. Where frequency detection methods such as Digital Signal Processing with FFT's can provide high accuracy and long range, the costs can be equally as high. And the acquisition of a signal is based on a time factor. Digital Signal Processing in the time domain typically consists of counting, or timing Doppler cycles which can be considerably less in costs, but the performance is sacrificed in both accuracy and range. A time based system is typically consistent with the distance a target is within the field of view rather than the time.

FIG 1

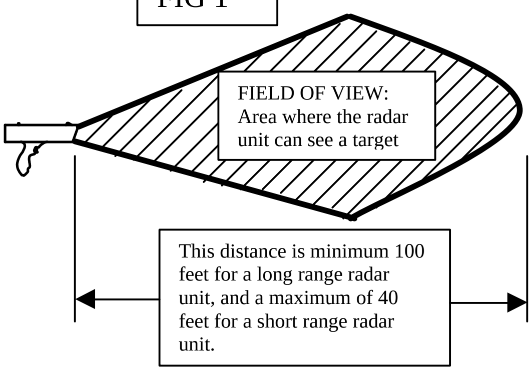


FIG 2