Radar Guns, Bolts, and Limits

When a radar gun measures the speed of a moving object, it sends out a signal. The signal reflects off of the moving object and bounces back to the radar gun. The gun measures how long this round trip took, and can then calculate the distance to the moving object. A few moments later, this process is repeated all over again to find a second distance. Using the difference between the two distances and the time between measurements, the radar gun can then calculate the speed of the moving object.[1]

1. Assume that a car is speeding along at a constant speed and then sees the speed trap as it crests a hill. The driver hits the brakes just as the first signal from the radar gun strikes the car. Draw a graph of distance versus time to represent this situation.

2. What quantities actually get measured by the radar gun (as opposed to calculated)?

3. Is the speed reported by the radar gun an exact value, or only an estimate? Why? If the speed is an exact value, the speed corresponds to what point in time (when the first signal hits the object? The second signal? Somewhere in between)? If the speed is an estimate, what can be done to improve the estimate?

Don't jump ahead. We'll spend a lot of time talking about the above situation.

Let's say you run a bolt manufacturing company. You have contracts with lots of different companies, and as you might expect, everyone's needs are different. Bolts that you provide for home construction have to be of good quality, while bolts that you provide for NASA to be used in the space shuttle have to be of exceptional quality. For simplicity, let's look at only one component of bolt quality: length[2]. Bolts for home construction that are supposed to be, say, 4 inches long can be a little more or a little less than 4 inches. But bolts for the space shuttle that are supposed to be 4 inches long have to be in a much smaller target range to be acceptable. The length of the bolt depends directly on how much raw material we put in the machine according to some function.

What can we do to create bolts that we know will be of a length that falls within our target range?

[1] It's a bit more complicated than this in real life (since the signal that is sent out is a wave), but the principle is similar.

[2] And let's assume that all of the other attributes of the finished bolts, like diameter for example, stay the same throughout the problem.