THE COMPUTER CORNER

No. 257: You and Your GPS

Stan Kaplan, WB9RQR, 715 N. Dries Street, Saukville, WI 53080-1664
(262) 268-1949 wb9rqr@att.net

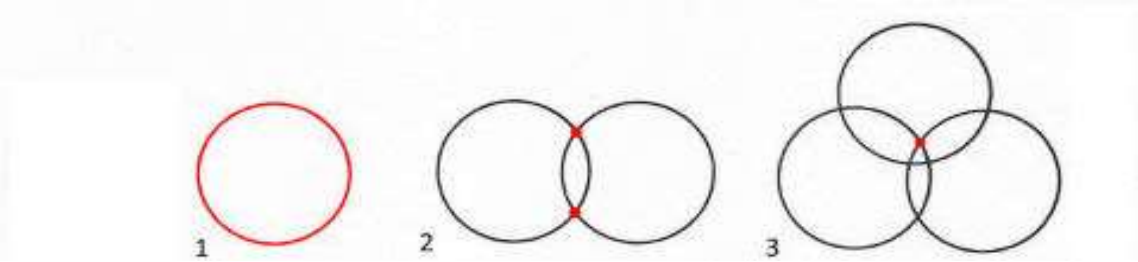
Did you ever wonder how your GPS or device with a GPS in it (smartphone, laptop, desktop, tablet, car or even running shoes) knows where you are (i.e., can pinpoint your location)? It is an amazing feat of modern electronics and space technology. By the way, GPS stands for Global Positioning System.

Until recently, 31 satellites cover the entire earth at any one time. Originally, it was thought the best way was to fly the satellites in geosynchronous orbit, which means they are each positioned about 22 miles above a single fixed point on the surface of the earth, never changing that distance or speed with relation to that point. So, if one were directly above Milwaukee right now, it would continue to be directly above Milwaukee 12 hours from right now, and 24 hours from now as well. No easy feat to fire one up there the right distance and speed to do this! Like many existing concepts in technology, a geosynchronous orbit was first conceived by a science fiction writer – Arthur C. Clarke (1917-2008) – back in 1945.

But a geosynchronous orbit is not how it is done now (thanks, Ben Evans, for catching this error in an earlier draft). Rather, they fly in medium Earth orbit at 12,550 miles up and each satellite circles the Earth twice a day. Flown by the US Air Force, at least 24 of these "birds" were needed to maintain complete coverage of the globe, and 31 was the magic number to include service and decommissioned units. Recently, they juggled and adjusted flight paths so that only a 27-slot constellation improved coverage in most parts of the world, and users can view at least four from any place on the planet.

Every thousandth of a second, they broadcast a signal that identifies themselves and the time the signal was sent. A ground station constantly updates this info and applies corrections to the satellite's time signals to keep them ticking correctly.

On earth, your GPS device listens to these signals coming from different satellites, and how long each signal took to get to it. Now, look at this sketch:



If the signal was broadcast from a single satellite (a single point), it would cover a circle on the earth as shown in 1. This is a circle whose radius has the overhead satellite at its center and whose circumference shows all the possible locations of the receiver (your GPS) on the earth. All these possible locations are shown in red (the entire circle), since there are an infinite number of locations around the circle of possible positions.

On the other hand, if two satellites are involved as in 2, there are only two possible positions, and these are shown as red points. Your GPS could be at either point. This is a much smaller area than the whole circle circumference shown in 1, but it is still not a very accurate description of your location.

On the other hand, with three satellites as in 3, there is only one point (the red dot) where all 3 circles intersect. This pinpoints your position to within a few yards. Since any point on earth has at least 4 satellites "visible" at any one time, we can add a fourth or even a fifth satellite to improve accuracy to within a few inches or less. How cool is that?

Next time you are tooling down the road in your car, glance at the little car (you) on your GPS screen. Watch it moving down the road as you do. Think about the 4 or more satellites, 20+ miles above your car, that are transmitting data to your GPS to make that possible. Wow! Happy Computing!