Introduction to How GPS Works

Hi, you're back with the GPS guys. I'm Carl.

And I'm Aaron.

And our topic is introduction to GPS.

The purpose of this segment of the training is to provide some background knowledge regarding global positioning systems or GPS that will facilitate your understanding and use of the GPS receiver. We're gonna cover some topics today including how the GPS works.

That's a real important topic Aaron because if, if people have a sense of, of what's going on behind the scenes with GPS it can really help them troubleshoot, some issues they may be having in the same way that if they understand what's going on under the hood of a car can help them be a more active and engaged driver.

We're also gonna be talking about some of the factors that affect GPS reception accuracy. Why do you think that's important to teach, Carl?

Well it really helps people get the most out of their equipment and also makes the most of their time in the field.

And we're also gonna be talking WAAS or the wide area augmentation system.

That's a really, handy feature of GPS. It can help folks reap a little extra, accuracy dividend from their equipment and it doesn't take any extra work and doesn't take any extra investment.

Nice. We're also gonna be talking about coordinate systems and datums, which I think is really important.

You're right, Aaron. Knowing about coordinate systems and datums can make you much more effective at integrating your GPS data with existing GIS data sets and in working with other GPS practitioners.

I think it also gives you the ability to avoid a couple of watch-out situations that can throw your accuracy off by as much as a third of a mile. Now that you know what topics we are going to cover through the rest of this lesson, let's get into how GPS works.

HOW GPS WORKS

Topic One: How GPS Works. GPS has three components: The space component, the control component, and the user component. The main job of

the control component is to monitor, analyze and adjust the orbits and the clocks of the GPS satellites. There are five monitoring stations scattered across the earth in fairly exotic places like Ascension Island in the Atlantic Ocean, Diego Garcia in the Indian Ocean, Kwajalein in the Pacific Ocean, Hawaii, and in Florida. They gather information from the satellites about their orbital position, their trajectory, and the status of their clocks, and forward that information on to the Master Control Station in Colorado Springs. The Master Control Station does the analysis and comes up with the adjustments that need to be made to the satellite orbits and clocks, and uplinks those back to the satellites. The satellites in the space component broadcast GPS signals that GPS receivers can use to determine what their location is. The third component is the user component, that's you and me out on the ground with the GPS receiver and it consists of a wide variety of civilian, commercial and military applications. So let's see how GPS really works behind the scenes. The concept is called Trilateration and for instance, if you know your distance from one satellite, it would be safe to say that you are somewhere on the surface of that sphere. Got the satellite at the center, you know what the distance is, that puts you somewhere on the surface of that sphere. If you happen to know your distance from two satellites, you are now simultaneously on the surface of two spheres and you can only be on the surface of two spheres at the point where they intersect, right on that ring there. It's sort of like when your kids are in the bathtub and those two soap bubbles come together, that ring right where those two soap bubbles meet. I think you can see where this is going. If you know your distance from three satellites, now your

position is narrowed down to only two possible locations. And if you know your distance from four satellites, those four intersecting ranging spheres or lines of positions cross at one single point, and that's where you're at.

So Carl, to get a really good signal on your GPS receiver, you need to have information from four good satellites.

Absolutely. Four is the minimum number that you need. Anything more than four is gravy.

Nice.

Okay. Well, Trilateration is a pretty easy concept to get across, but it depends on a GPS receiver knowing its distance or its range from at least four satellites. How is it possible for that little gadget the size of a Snickers bar to calculate what that distance is? Well, when everything is working perfectly, GPS receivers and GPS satellites each generate an identical week-long code in perfect synchrony with one another. So that GPS receiver in your hand and the GPS satellites 12,000 miles away are each generating this code perfectly synchronized. So what the GPS receiver in your hand does is it examines that incoming code from each one of those satellites and calculates what that time distance is. So for instance, in our illustration here, this represents the code from the GPS receiver in your hand, this represents the code from the GPS satellite, and you'll notice

there's a little bit of time delay here because of course that signal from the satellite has to travel 12,000 miles to get to your receiver, while your receiver can say hey, I just generated that little bit of code just a little while ago and it can calculate what that time delay was and multiply that by the speed of the light and come up with a distance to the satellite. The concept is a lot like when you calculate the distance to lightning by seeing the flash of lightning, counting the seconds until you hear the clap of thunder, and then multiplying by the speed of sound in air.

I like to think of the GPS receiver being the most accurate clock down to the nanosecond that you'll probably ever own.

That’s right. No need to buy Rolex. So that just leaves one question left to answer. How does the GPS receiver that probably has a relatively inexpensive clock within it get synchronized with those satellites that have atomic clocks? Very, very, very accurate clocks, how is it possible for it to do that? Well, just by definition, if you remember in our last slide, all of those lines of position had to cross at a single point. If the GPS receiver can't resolve all those lines of position at a single point, it either advances or retards its own generation of that code until all of those lines come to a single point solution, and then by default it’s code generation is perfectly synchronized with the satellite.

Now that we've covered how GPS works, we’re going to look at some of the factors affecting GPS accuracy.