Field Research 101

Research Station
G.P.S. Mapping

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The Beaver Creek Field Research Station, Fall Creek, Wisconsin was mapped during the 2000-2001 school year using GPS and GIS systems. Better ways of using GPS and GIS to collect accurate data to make maps using Trimble Explorer GPS units, Arcview, Pathfinder Office, and differential correction files were developed. Experiments were conducted on using a variety of methods for collecting and projecting GPS field data. Accurate maps based on GPS data were projected with existing DNR data layers of the area.

History of GPS

The U.S. Navy made the first non-GSP satellite system for use of updating the position of U.S. submarines and to reset their inertial navigation system. The system only had five satellites and intervals of 100 mins before the next satellite would come within range. These satellites used measurements of Doppler shift in their signals broadcast. The process took between ten and fifteen minutes. To have a good reading the object that it was tracking had to be stationary or moving slowly. The satellites had to be in a well defined orbit around earth for the reading to be accurate.

In 1973 the Department of Defense (DOD) approved the basic architecture of the GPS satellite system. Then after five years the first beta satellite was launched in 1978. These were referred to as the 11 Block I beta satellites and were launched between 1978 to 1985. Currently there are three different types of fully functional satellites that currently make the GPS constellation. The first series of these satellites were the block II satellites. They were launched from February of 1989 to October of 1990. These satellites made by Rockwell International. They have four atomic clocks and have a life spawn of 7.3 years. The second series of satellites were the block IIA. These are a step up from Block II because they can run 180 days without contact from Control Segment instead of 14 days. Block IIA also had quit a big down fall do to the fact that the longer they don't have contact from Control Segment, the more the accuracy will degrade. These satellites were launched from 1990 to 1997. The last satellites in the series are called the Block IIR satellites. Lockheed Martin makes these satellites to replace the old satellites that don't work any more. Block IIR have fixed the downfall of the Block IIA satellites. It has the ability to be launched into any of to required GPS orbits at any time with a 60 day advanced notice. It can provide at least 14 days of operation without any contact from Control Segment. They also can run 180 days in autonav mode without their accuracy degrading. The Block IIR costs 33 percent less then the other satellites even with all these improvements. In 1995 the system was declared operational. The cost was around 10 billion dollars and has cost 250 to 500 million a year to maintain.

The main purpose of the system is primarily for the U.S. military to provide precise estimates of position, velocity, and time. Civil use was only a second objective of making the system.

GPS has found many ways to be used by military and civilians. Using lessons learned from Operation Desert Shield and Desert Storm, GPS is being integrated into the modern battlefield. Air controllers, pilots, tank drivers, and ground troops all use GPS to keep track of the battle and know were they are at so they don't get hit by friendly fire. Some civil fields are land transportation, civil aviation, maritime commerce, surveying, mapping, construction, mining, agriculture, earth science, telecommunication, and recreational activities. GPS is starting to become an every day part of our lives. It is estimated by the U.S. Department of Commerce that sales worldwide will reach 8 billion by 2000 and 16 billion by 2003.

What is GPS?

Global Positioning System. = (GPS) A system for determining position on the Earth's surface by comparing radio signals from several satellites. When completed the system will consist of 24 satellites equipped with radio transmitters and atomic Clocks.

Depending on your geographic location, the GPS receiver samples data from up to six satellites, it then calculates the time taken for each satellite signal to reach the GPS receiver, and from the difference in time of reception, determines your location.

You can break the process down in to 5 easy steps

1. Triangulation form satellites is the basis of the system
2. To triangulate, GPS measures distance using the travel time of a radio message
3. To measure travel time, GPS needs very accurate clock
4. Once you know distance to a satellite, you then need to know where the satellite is in space
5. As the GPS signal travels though the ionosphere and the earth’s atmosphere it gets delayed

The information that you receive is raw data. That needs to be corrected due to the movement of the rover unit and other sources of error. There are base stations that don’t move and collect constant data with accuracy down to millimeters. The closest one, the one that we use it in by Alma near the Mississippi River. (STP1) here data is constantly corrected because it doesn’t move and has data correcting equipment.

How Does GPS Work?

The GPS system works by timing, how long it takes a radio signal to reach us from a satellite and then calculating the distance from that time. The speed of Light (SoL) plays an important role in aiding us. Radio waves travel at the SoL, That is 186,000 miles per second. So if a satellite was directly over head and sent of a signal it would reach us in 6/100th of a second. GPS advanced timing is done in Nano seconds most of them. A Nano second look like this . 000000001 of a second. But with all that speed and timing you still have to know when the signal left the satellite at the exact moment that’s were Synchronize timing come into play and with this some the Pseudo random code. The satellites and receivers must generate the same code at the same time. The advantage of using a set of codes or in the case of our analogy, a string of number is that you can make the time measurement any time you want. This is a picture of the difference in time.

GPS- use's no numbers but complicated digital codes; the receiver reads these codes and translates them in to coordinates that we can apply to a map. Seeing exactly were a house is or following a series of coordinates to see a trail or a pond. With the aid of pathfinder office we are able to look at these coordinates in a map form then apply then in arc view on to a map to see were every thing is.

Pathfinder office program- is a program developed by Trimble to be used with their receivers in aiding the process of retrieving data on the receiver units. This program allows you receive and transfer data with the rover and the computer. It also lets you create data dictionaries, which is a vital part in the data collection field. A data dictionary is a list of items that you wish to collect data on when placed in the right slot all data is nicely organized and is easily found, read, and comparable to other data. You also can save, load, and edit maps that are created in pathfinder all this is necessary for viewing data understandably. Transferring data and receiving data are two other functions of the pathfinder program. If you want data from the rover receiver all you need to do is hook up the necessary cables and select data transfer under utilities. Form here you can receive data from the rover, send data to the rover and identify files size. After you get all the files and view them you need to differential correct them to do this you need correction files from an Internet site with the correct time that the data was collected and with the correct date. Then you will get and accurate map that is not off by much.

Arc view is the next step in creating accurate map of the area that you are in. with the data that you collected from the field then transferred into the pathfinder program you now have a map but have nothing to compare it to. Once in the arc view program you can labels all the changes in the map by creating a legend. When you map starts to look like something you see in National geographic you know you're on the right track. Back to gps.

· The distance two a satellite is determined by measuring how long a radio signal take to reach us form that satellite.

· We assume that both the satellite and our receiver are generating the same Pseudo-Random code at exactly the same time.

· We know how long it took for the satellites signal to get to us by comparing how late its Pseudo-Random code is, compared to our code.

If the SoL is 186,000 MpS (miles per second) and we were off by 1/100th of a second that distance could be 1,860 miles. That is a largely considerable distance, but to fix it we need a very accurate timepiece luckily every GPS satellite has four. These are atomic clocks now they don't run off atomic power; they get their name form oscillations of a particulate atom as their metronome, which is the most accurate way of keeping time. Now if you want a clock that is never off and this is what you looking for maybe you should think twice each of these clock's carries a price tag of $100,000.00 ouch I think my Timex is good enough.

If the signals were off there are a few ways to check one is Trigonometry by using an extra satellite it could cause an imperfect sync, theoretically three satellites are plenty so there should be no error. Trig says, " if three perfect measurements locate a point in three dimensional space then four imperfect measurements can eliminate and offset timing. But to add another item in the mix, our receiver clocks are no were near an accurate as the atomic clocks on board the satellites.

Pseudo-ranges caused by fast clock. The Pseudo range is used in GPS circles to describe ranges that contain errors (usually in timing) the receiver get the measurements that are bad and uses algebra to find out how much it's off and corrects it self.

When the GPS system does not have four satellites above the horizon due to the formative years. You can integrate it with another navigation system the LORAN system. It gives near-GPS accuracy. Loran can semi-accurately record data when satellites are below the horizon. GPS systems when fully implements will consist of 24 satellites so at least four will be visible at all times. The need for four measurements has greatly impacted the way the receivers are designed. Now they have four channel receivers so one channel can be devoted to one satellite and no other interference can acquire. With a one channel receiver it takes a great deal of time to generate a position while it communicates with only one satellite at a time and each point takes two minutes and thirty seconds to compute, which although not to day is plenty of time to wait. Disadvantage- "system data message" a 30 second interrupts even in new satellite readings.

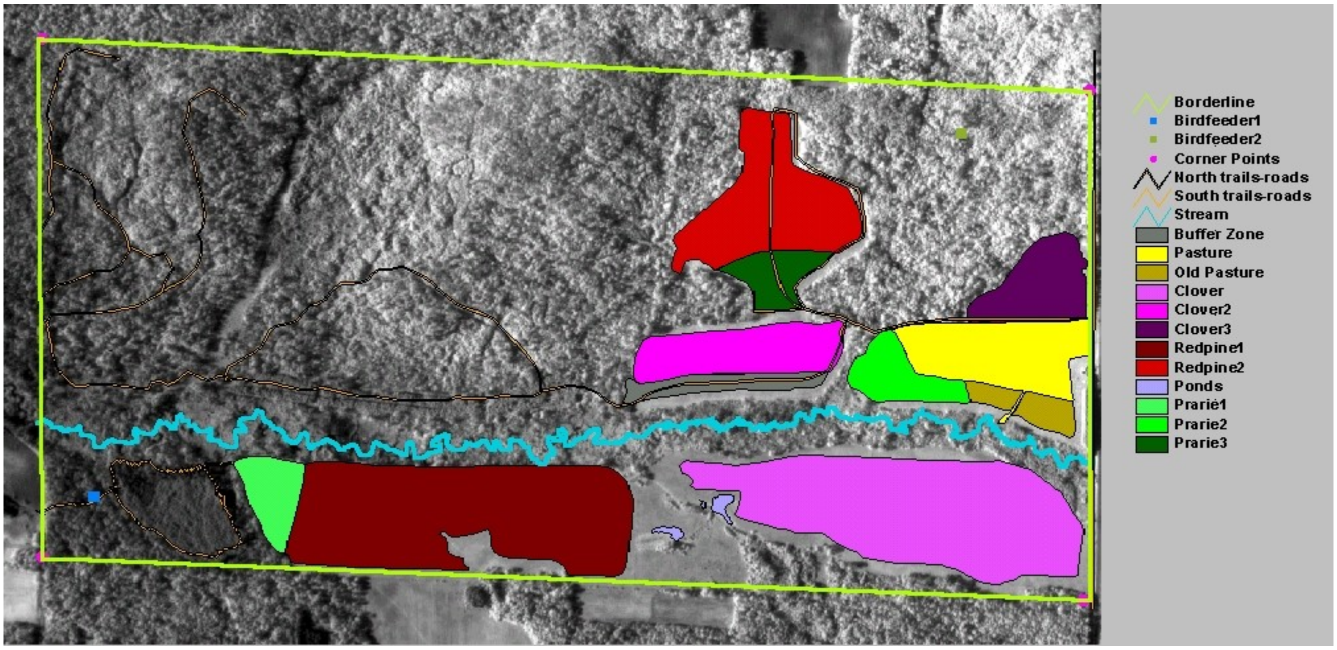
· Accurate timing is key to measuring distance to satellites.
·Satellites are accurate because they have atomic clocks on board.
·Receiver clocks don't have to be perfect because of trigonometry trick can cancel out receiver clock errors.
·The trick is to make a fourth satellite range measurement.
·Needing four measurements affects receiver design.

Satellite position, satellites are 11,000 miles above the earth putting them clear of the atmosphere, make orbits precise so they can be easily tracked. The air force puts the satellites on orbit in precise locations according to the GPS master plan. Some ground receivers have an " Almanac" programmed into them, so they know were any satellite is at any given time. DoD- departments of defense are constantly monitoring satellite movement and function. They run on a non-geosync orbit time, passing over the DoD twice a day to accurately measure altitude, position, speed and satellite health. Their looking for "Ephemeris errors" caused by little gravitational pulls from the moon, for sun by solar radiation pressure. Then after computing all the data the DoD send the necessary information for the satellites to correct the orbits.

Methods & Materials

Our method for gathering data is to check and see what kind of data accuracy we will have with a program called Quick Plan. We need to do this before we go out to the field station. When we go out to the field station, we have to decide what land we have left to map. Then, we have to decide what would be the most efficient area of land to collect the data from . The first equipment we use is Quick Plan. This program can tell us how many satellites will be available and how fast we can receive data at any time of the day or night. After we find out when there will be high and low levels of satellites, we can go to the field station. We have two GPS receivers at our disposal to gather data with. Then we take the data and download it onto a laptop computer. After we download the data, we put it into our map. The two programs we use are Pathfinder Office and Arc View. Pathfinder is a program that lets us configure the GPS unit with data dictionaries and is used to take the data off the GPS unit. Arc View is a powerful program that we use to make a detailed map with. These are the two tools that you need to make a professional looking map of high quality.

Data & Results



Discussion

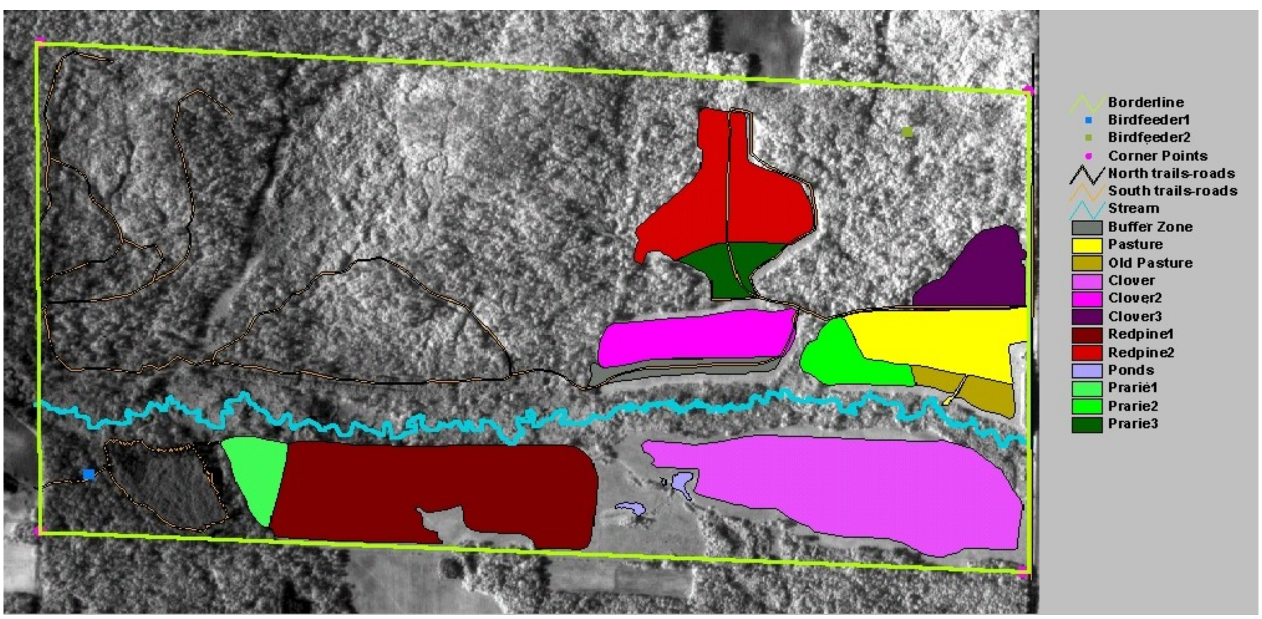
We made an accurate map of the Field Reasearch Station. The fields, trails, and streams were all mapped.

We didn't have a clue as how to make a map like this. Niether one of us had done this before. We had to come up with what needed to be on our map. We started with colored lines and points and had to turn them into something that people could use in the Field Research Station. We needed to provide boarders, trails and fields so people could read and understand the map. After studying other maps, reading material on what constituted a map, and researching how they were made, we had no trouble with making our own map.

Before we could make the map we had to gather the data. In the winter time we had trouble with the deep snow. It was to the point we were spending more time trying to get to where we needed do be for the days work than actually gathering data. We did have snow shoes, but when the snow was waist deep it didn't help much. Maybe a little experience in that area would have served useful. There was another factor that contibuted to collecting data. During the middle of the school year, Nick had the flu and Denver had mono. It made a difference when we were both working out in the field, as far as discussing what we needed to map. It helped sort things out when we could discuss them between us. Besides these minor pitfalls, collecting data was time consuming but easy. Each day we collected a little data. By the end of the year we had compiled quite a bit of data. Keeping the data organized once we gathered it was important. One day we couldn't find the laptop computer only to find that someone took it and erased all the data on it. We had been backing up our data which was a good thing but still lost one months worth of data. We had to back track and try to fill in that time again. That was a difficult task and we were not able to recover all our data that was lost. Despite the little data that was lost and not recovered, we had enough good data to make our map.

Conclusion

During our mapping of the Field Research Station we have found that using GPS is not that hard. It's like using a simple handheld computer that navigates by menus to different features. Pathfinder Office is also fairly simple. You use it mainly to transfer data between the computer and the GPS unit. It’s also used to differential correction your data and to make data dictionaries to load onto the GPS unit. Arc View takes time to learn. It was worth the time and effort to learn because it gave us so much freedom and so many options. Arc View is not a good recommendation for someone to start with but it’s okay to use once you’ve taken the tutorials for it. It is very complicated to new people and it is not the kind of program that you can teach yourself how to use. Thankfully, we had the benefit of online tutorials. With some time, they taught us to easily use the features that we needed. The Field Research Station was a very nice place to learn. There were many habitats to work in and nice trails to travel on. Some of the habitats included: hills, forests, ponds, and streams. Along with collecting map data, there was wildlife to see. We saw grouse, deer, and different kinds of birds.



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GPS A Guild to the Next Utility

Links

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