Special Edition

Bicycle Navigation Using GPS
by George Root

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Message from the Editor

This is a Special Edition of the BAC eBulletin. Special Editions, such as this, will be issued from time to time. They will be devoted to a single topic which either requires more pages than will conveniently fit in the seasonal eBulletin, or which may not be of interest to all BAC members. This Special Edition, covering “Bicycle Navigation Using GPS” satisfies both of these criteria. By posting these Special Editions on the Club web site, we give the members the option of downloading them or not. Although I find it hard to believe, there are apparently a few members who are not thrilled with the prospect of reading all about GPS navigation. I hope the rest of you enjoy reading this issue and perhaps even find some useful information.

If you're reading this using Adobe Acrobat, you will find that the Table of Contents at the left is “live”. Just click on a topic to go to that page.

If you have an idea for an article that could be published in a future Special Edition, please write it down and send it to me, the Bulletin Editor. MS Word or plain text files sent via email would be most convenient. Photos and illustrations should be sent as JPEG or Photoshop (.psd) files. If you would prefer to use paper mail, that’s all right as well. Please send your submissions to:

George Root
1711 Golden Court
Bellingham, WA 98226-8770
BulletinEditor@BicycleAdventureClub.org
Have you ever been lost on a bike trip? Yeah, so have I. But it happens much less frequently now that I use a GPS to help navigate. I hardly ever have to look at a paper map and I get to spend a lot more time enjoying the scenery and less time navigating. If this sounds appealing to you, read on and I’ll tell you how I use my GPS to take the effort out of navigating on my bicycle.

This is a big topic so I’m going to divide this article into parts. In this, the first part, I’ll describe a little about the GPS system, but I’ll spend most of the time telling you about all of the great things you can do with one of the modern handheld GPS devices. Then, in subsequent parts, I’ll tell you how I set up my GPS to provide maximum utility while I’m actually on the bike. Finally, I’ll describe what you have to buy and give you an idea of how much all of this costs.

OK, So What is GPS?

GPS stands for “Global Positioning System”. This “system” consists of a couple dozen satellites circling the Earth and a small handheld receiver that captures signals broadcast from those satellites. These signals allow the receiver to compute its exact location on the Earth. At any time, there are 10-12 satellites above the horizon, and the GPS receiver must be able to “see” at least 4 of them to acquire a fix. Using the signals from 4 satellites allows the receiver to compute its longitude, latitude, elevation, and the precise time. Once a fix has been acquired, the GPS can continue to compute latitude and longitude using the signals from only 3 satellites. Most receivers can use the signals from as many as 12 satellites to get improved accuracy.

So, we already have one good thing and one bad thing about GPS. The “good news” is that you can use a GPS to set your watch! The “bad news”
is that GPS receivers won't work everywhere. They must be able to see at least 4 satellites and that means a pretty unobstructed view of the sky. GPS signals don't travel through buildings nor heavy tree cover, so if you're walking along Wall Street or cycling along a forest path under heavy trees, your GPS may not function. GPS signals do travel through glass, so you can use a handheld GPS inside your car if you hold it near the front window or the sun roof.

The photo at the left shows a GPS display indicating that eight satellites are being used to compute position with an accuracy of about ±20 ft. The rule of thumb is that altitude accuracy is about three times worse than position accuracy, so in this case the GPS elevation accuracy is about ±60 ft which is better than with a barometric altimeter. Altitude computed by GPS isn't affected by atmospheric pressure so there is no calibration needed. I should mention that some handheld GPS units, such as the Garmin eTrex Vista, also contain barometric altimeters and these are no more accurate than any other barometric altimeter.

Review of “Paper Map” Navigating

Conventional bicycle navigation requires three components: paper maps, trip sheets, and a bike computer to measure distance travelled. The trip sheet represents a series of "waypoints" along the desired route. These waypoints are generally placed at intersections or other places where critical decisions must be made. “Turn Right on Hwy 20 at mileage 39.4” would be a typical example.

The main disadvantage of paper map navigating is that there is frequently no way to determine exactly where we are on the map. If we inadvertently miss a waypoint, for example if we don’t “Turn Right on Hwy 20”, we could cycle for miles before discovering that we’re lost! This is exactly the problem that GPS navigation solves. With a modern GPS device, you will see a map of the roads, where you are on those roads, and the locations of each waypoint. You can still get lost if you fail to follow the directions when you arrive at a waypoint, but that’s a lot harder to do when you can see where you are on the map.

Three Generations of GPS Devices are Available

The first generation of handheld GPS receivers had very limited capabilities. They basically told you your latitude and longitude. Not very useful while riding a bicycle! Modern versions of these devices are still available and they are generally the least expensive, but don’t be tempted to buy one of them. They won’t give you much help while navigating on your bike.

The second generation of handheld GPS devices represented a major leap forward. The primary advantage of second generation devices is that they can display maps of streets and roads and show your position on those maps as you travel. This is just what we need for navigation! These devices also have the ability for you to set up “waypoints” along your desired route. So, not only will they show you where you are, they will also show you when you have arrived at a critical decision point on your route. You still need a paper trip sheet to tell you what to do when you arrive at each waypoint.
Two more characteristics of second generation devices are that they generally have black and white LCD displays and they only support "Straight Line Routing". I’ll explain what that means in a moment.

The third generation of handheld GPS devices is just coming into existence. These generally have color displays and most importantly, they provide "Follow the Roads Routing". They are basically small versions of automobile navigation systems complete with turn-by-turn directions. You don’t need a paper trip sheet with third generation devices. Even though you don’t need one, you should still carry a paper trip sheet in case your GPS fails to operate properly. As with any navigation “aid”, always carry a back-up!

"Straight Line" vs “Follow the Roads” Routing

A “route” is just a path that connects all of the waypoints and arrives at your final destination for the day. Second generation GPS units can only do “straight line routing” (sometimes called “direct routing”). As the name implies, these units draw a straight line between waypoints as illustrated in the top figure at the left. This figure shows a simple route consisting of only 3 waypoints named, creatively, 01, 02, and 03. Imagine for a moment that you were starting out on your bike from waypoint 01 and trying to find your way to waypoint 02. Notice that the straight routing line indicates the general direction to waypoint 02, but it doesn’t give you any specific information as to which roads to follow in order to get there. So, with this type of routing, you still need a paper trip sheet with instructions describing what to do to get from 01 to 03. Of course, with this simple example, the correct route is pretty obvious, but on a real BAC trip, that’s rarely the case.

With “follow the roads” routing, the exact path between waypoints is displayed on the GPS unit so you will know at every instant whether you are on the right road or not. The figure at the left shows the same waypoints 01 to 03, but now they are connected with a “follow the roads” route line. Now there is no doubt about which roads to take!

In addition to the map display showing the path to your destination, you also get a list of explicit instructions as illustrated in the bottom figure at the left. Notice that these directions give instructions for every turn along the route, not just at waypoints. You can print these directions and have a ready made paper trip sheet complete with accurate mileages to use as the backup you should carry with you. Trip leaders could make very nice trip sheets this way even if they do not use a GPS for navigating!

You Need a PC to Make All This Work

When you rush out and buy your mapping GPS you may be disappointed to discover that it doesn’t come with maps! Oh, they all contain a “base map”, but that’s generally a very crude map of the entire world. Trying to navigate using...
these built in maps would be like trying to navigate using, well, a map of the world. In order to get the detailed maps you need to navigate on a bike trip, you have to buy them separately. Here’s a very important point. You MUST buy the maps from the same vendor that made the GPS unit. There are a number of mapping products sold, but only those published by the GPS maker can be downloaded to that maker’s GPS units. So, when shopping for a GPS, make sure that you will be able to get the maps you need from the same vendor.

Another BIG disappointment for a rabid Mac user such as myself, is that none of the GPS mapping products currently sold work on Macintosh computers. So, you must have a PC in order to use the GPS maps and to download them to your handheld GPS receiver.

The 3 figures on page 4 showing the straight line and follow the roads routing and the turn by turn directions are screen shots taken from my PC using the mapping software published by Garmin. Other GPS makers have similar software.

A Word About GPS Vendors

Handheld GPS receivers and the associated mapping software are available from at least three vendors: Garmin, Magellan, and Lowrance. I use Garmin products, so all of the illustrations in this article will be specific to Garmin, but there are equally fine products available from each of the vendors. Please don’t assume I’m recommending Garmin products. In fact, I would strongly recommend that you do not buy a Garmin GPS Map60C (3rd generation) for bicycle navigation. I have had a lot of trouble with mine and I wouldn’t want you to have the same problems! On the other hand, I have used a Garmin eTrex Legend (2nd generation) for a number of years and I consider this model to be a great product. You remain the sole judge of which products will best meet your needs.

Downloading Maps to Your GPS

Using a GPS for navigating on your bicycle saves a lot of time while on the bike, but it does require that you spend some time setting everything up before you leave on your trip.

The first thing you must do is to select and download the maps you will be using. The maps and associated software come on CD ROMs that you can buy from the manufacturer of your GPS unit. From Garmin, there are CDs that contain essentially all of the roads in the USA and others that contain essentially all of the roads in Europe. In Europe, all of the “yellow” and “white” roads on Michelin maps are contained in the CD database, and in the US even some dirt farm roads are included. In addition to roads, these CDs also contain the locations of numerous “points of interest” such as restaurants, hotels, and rental car agencies. This makes it easy to navigate directly to your hotel when you get to your destination for the day, or to find the nearest McDonald’s in case you get a “snack attack” in the middle of your ride.

As you might guess, it takes a lot of data to describe “all” of the roads in the USA or Europe. Handheld GPS units don’t have enough memory to hold all of these data at once, so it is necessary to select a subset of maps that covers the area in which you will be cycling. This is done on
your PC computer. The entire CD map database is divided up into small regions. You just click on regions, adding them to the set of maps you will download until you have covered all the roads you will be cycling. Once that's done, you just connect your GPS to the computer (using the supplied cable) and click "Download Maps".

That's all you have to do in order to get started navigating by GPS. If you are exploring a new area, or if you don't have a specific travel itinerary planned, that's about all you can do before getting on your bike. This would be like starting on a trip with just a set of paper maps, but with one very important difference. The GPS will tell you exactly where you are on those maps. That makes getting lost a lot more more difficult.

As you cycle along, you will see a small triangular symbol in the center of the GPS display. This represents your current position and direction of travel. This symbol moves along the map roads just as you are traveling along the real roads.

Because the GPS map display shows only a small area at one time, I find it very useful to carry a set of real paper maps that I can refer to in order to get "the big picture". For safety, you should always carry real maps just in case your GPS fails or the batteries run out. Always carry spare batteries! GPS units use "non-volatile RAM". Wow! All that means is that you don't lose any data even if your batteries do fail. Just pop in new batteries and continue on your way. I can generally travel for 2-3 days between battery changes. I take along a supply of Alkalines, but you can also use rechargeable batteries.

A GPS with appropriate maps loaded provides a couple of capabilities that you don't get with paper maps. One is the ability to "mark" your location. If you are at a particularly important point - one you may want to find again, such as where you parked your bike before setting off on foot to explore, you can "mark" that point by clicking a button on the GPS. In addition, when you move, the GPS leaves a "trail of bread crumbs" on the map display showing where you have been. These two features let you find your way back to some marked point or back to where you started in case you become disoriented. I find this particularly useful in towns or larger villages where there are a lot of streets and it's easy to get lost.

But the most useful capability provided by GPS map navigation is the ability to "see" where you are going. Even using a GPS, it sometimes happens that I come to an intersection and am not sure which of the roads I see is the one I want. I just pick one and start riding along it. Within a couple hundred feet, I can tell on the GPS display which road I'm on. If it's the right road I just continue. If it's not, I can backtrack and take the correct road losing only a minute or two. With paper maps, I might cycle for miles before recognizing that I'm on the wrong road.

### GPS Provides Data in Addition to Maps

Up till now I've been describing the GPS map display, which is the primary navigation tool I use, but the GPS also provides a wealth of other interesting data. In addition to the "Map" display, there is also a "Trip Computer" display. This display has 8 windows in which I can display any one of about 30 different parameters such as: distance traveled, time moving, current speed, average speed, distance to the next turn, elevation, estimated time to arrive at the next turn, estimated time to arrive at final destination for the day, local time, vertical rate of climb.
etc, etc. Everything a bicycle computer would show and much more. I have a cycling computer on my bike, but only as a backup in case the GPS should fail. I never have to look at it for navigation information.

### Setting Up Waypoints and Routes

Downloading maps is all you have to do in order to get started navigating by GPS, but the job will be a lot easier if you set up “waypoints” and “routes” for your trip. A “waypoint” is just a point you have selected “along the way” to your destination. These would typically be at road intersections and other decision points along your route. A “route” is a collection of waypoints arranged in the order you will come to them as you travel. You set up waypoints and routes on your PC and then download them to your GPS along with your selected maps.

I generally set up a route for each day’s travel, so that my routes might be named “Day1”, “Day2”, and so forth. I also name the waypoints, “D101”, being the first waypoint on Day 1. It’s best to keep waypoint names short because they will be displayed on the GPS as you ride and will obscure part of the map. I’ll go into a lot more detail describing how I do all of this in Part 2.

Once I have waypoints and routes loaded into my GPS, then at the start of the day I simply tell the GPS to navigate route “Day N” and it computes the route and displays a purple highlight along the roads that I am to take to get to my destination.

### Navigating on the Bike

The figure at the top left shows the GPS map display shortly after the start of the simple route from waypoint 01 to waypoint 03 that I have been using as an example. The black arrow near the center of the display show my current position and direction of travel. The instructions at the top of the screen tell me what I should be doing at this point along the route - going south to Eagleridge Dr in this case. Now, all I have to do is cycle along the roads highlighted in purple and I’ll eventually get to my destination for the day.

When I approach a turn, at roughly 500 feet from the turn, the GPS beeps to get my attention and the display changes to one like that in the middle figure at the left telling me how far away the turn is and what to do when I get there. The distance will count down until I’m around the turn, at which point the display will return to whatever I was looking at before the turn. Once again, all I have to do is keep the little black triangle inside the white arrows and I’ll stay on course. The audible alarm really comes in handy when I’m cycling along day dreaming. I can let the GPS keep track of where I am while I concentrate on more important things. I rarely have to stop to look at a map. I can devote all of my energy to riding and enjoying the scenery.

The GPS even has a built in trip sheet as shown in the bottom figure at the left. This display has a scrolling list of all the turns between where I am and my destination. It shows distances to those turns and an estimate of how long it will take to get to each one. I rarely look at this display while I’m on the bike.
Using the GPS to “Find” Stuff

Sometimes I get hungry while I’m riding, and that’s where another neat feature of the GPS comes in handy. The map data that you buy from your GPS vendor contains more than just maps. It also contains the locations of millions of “points of interest”, hotels, gas stations, markets, and, most importantly, places where you can buy food and drinks. To get to this information while riding, I just push the “Find” button and that brings up the display shown in this photo. I could find the nearest motel, or find a route to a specific address. But in this case I select “Food & Drinks” and the next display gives me a list of the nearest places with the one closest to where I am at the top of the list.

This display, shown in the middle figure, tells me that the nearest McDonald’s is 3.65 miles SW of my present location. At this point I can click on “Go To” and the GPS will compute a route from where I am to the restaurant or the hotel or whatever I have “Found”. Unfortunately, the database of points of interest is not always up to date. But you can generally count on it to find the nearest McDonald’s.

A GPS is the Trip Leader’s Friend

Up till now I’ve been describing what a GPS can do for someone riding on a BAC tour. But the GPS and it’s associated software can make a BAC trip leader’s life a little easier as well.

I’ve already described how the GPS mapping software can print out detailed, turn-by-turn, trip sheets complete with mileages. In fact, there are some stand alone mapping applications, such as those published by DeLorme (bottom figure at left) and Microsoft, that can help plan routes and print out trip sheets even though they cannot download maps or routes to the GPS receiver. These stand alone programs are generally much less expensive than the maps you buy from the GPS vendors. If you’re a trip leader, you might want to check out one of these products even if you have no interest in using a GPS for navigating.

The GPS receiver itself can be a great help while scouting a trip. Just take the GPS with you as you drive or ride your proposed route. Whenever you come to a “point of interest” such as a turn, or a restaurant or the hotel you plan to use, just click on the “Mark” button. This will record a waypoint in the GPS memory. It will be most convenient for you to have a notebook to jot down the waypoint number (assigned automatically by the GPS) and what it is: “Turn Left onto Hwy 652” or “Convenience Store on Right”. Whatever. There is no need to write down mileages and in fact you don’t even have to Mark your waypoints in any particular order. When you get home, you would download all of your collected waypoints to your PC. Then assemble those waypoints into routes for each day’s travel. Once you have the waypoints sorted into the correct order, you click on “Compute Route” and the software will produce a trip sheet complete with accurate mileages. You still have to correlate the waypoint numbers with what they represent, “McDonald’s on the Left” for example, by hand, but all in all this is a lot easier than trying to measure mileages in the field.

Caveats

Well, after hearing all of the wonderful things that a GPS can do for you, you might be wondering if there’s anything it can’t do. As a matter of fact there are several potential problems that you should be aware of.
As I have mentioned, GPS receivers don’t work everywhere. In order to work, the GPS receiver must be able to “see” at least four satellites. This means that it needs a pretty unobstructed view of the sky. It won’t work inside buildings or in your pocket. It can’t see very well through heavy tree cover. If you’re in a city with tall buildings that obstruct your view of the sky, your GPS may not work. You should always have a backup method for navigating with you.

Although handheld GPS devices are “receivers”, they also emit low level radio frequency interference which may cause a wireless bike computer to work erratically. If your wireless speedometer registers 35 mph while you’re standing still, the GPS may be at fault. This is not a problem with all GPS units and it depends upon the distance between the GPS and the computer. I put mine as far apart as possible. I have also gone back to an “old fashioned” wired bike computer.

Handheld GPS units have limited memory. This means that you can download only a limited number of maps at one time. For most trips this isn’t a problem, but if you’re going on a cross-country expedition, you won’t be able to get all of the necessary maps into the GPS at one time. The only work around is to take the CD with all of the maps along with you and hope to find PCs along the way that you can use to download additional maps as you need them.

Finite memory also limits the number of waypoints and routes you can download at one time. No more than 20 routes and no more than 50 waypoints in any route with a total of 1000 waypoints for all routes combined is all that the Garmin eTrex Legend can hold. This means that you may have to break some days with a lot of waypoints into shorter segments “Day1-1” and “Day1-2” for example. Long trips with more than 20 days of riding will require that you find PCs along the way so that you can download more days routes as you travel. This is becoming less of a problem with newer devices because they have much more memory than earlier units. The Garmin Map 60C has 56 MB of memory compared to only 8 MB for the eTrex Legend.

Although modern GPS receivers can compute your location to within a few feet, the map databases are sometimes less accurate. Your display may show that you aren’t on a road, when you can see the pavement below your wheels. I have noticed this particularly with the road database for Canada. This makes navigating more problematical if you are in a congested area where there are many roads and you can’t tell from the GPS which one you’re on. I have not had this problem with the maps of the USA and Europe.

Buying a GPS receiver and the necessary maps and software is not cheap, but how much is your time worth when you’re on a vacation? Saving time and reducing the stress of navigation is worth something and you can amortize the cost over many trips. And, if you have even a little “geek” in you, navigating by GPS can be fun.

Although a GPS can make navigating really easy, always carry backup maps, compass, and a cycling computer just in case the GPS fails (or gets stolen) when you’re miles from nowhere.

In the next installment, I’ll describe in more detail how I set up my GPS with waypoints and routes and some of the issues involved in shopping for a GPS.