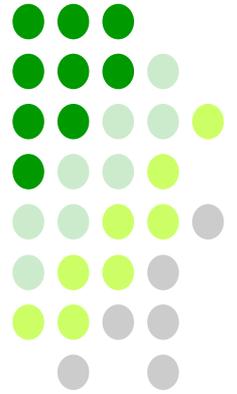


Recording Accurate, Reliable GPS Coordinates



by
Dave Kruger
(dak's Emu Mob)



Introduction

When people start geocaching, they are often so taken with the activity that they want to place their own cache as soon as possible. In general, this is a good thing, because it leads to a perpetuation of the sport, and allows people the chance to give something back to the geocaching community.

However, sometimes the new geocacher's inexperience results in a cache placement that is some distance away from the advertised coordinates. This not only frustrates the people trying to find your cache, but it also harms your reputation in the sport. Placing your first geocache is more involved than hiding a container, and pressing the 'mark' button on your GPS receiver. Geocaching.com gives the following advice to people placing their first geocache:

When you reach the location to place your cache, the hardest part (depending on the model of your GPS unit, the terrain, etc), is getting exact coordinates from your GPS unit. It all depends on how visible your cache is, but you'll need to get the coordinates as close as possible to the cache.

Some GPS units have the ability to do averaging, but if yours can't, the best suggestion is to take a waypoint, walk away from the location, then return and take another waypoint. Do this around 7-10 times, then pick the best waypoint (I've done this with a Garmin eTrex on a cache)

This is sound advice, but very basic. Recording accurate, reliable coordinates is a skill that is easily learned, but is rarely a simple matter. There is no shame in asking for help, and most established geocachers would be more than happy to give help and advice about any aspect of the sport. You only have to ask—the best method of contact is through the www.geocaching.com web site.

However, asking for help from strangers is not for everyone. This document outlines several tried and true methods for recording coordinates. The initial intention was to describe a general process for recording coordinates. To this end, I contacted twelve active geocachers from all Australian States, and asked them to write down their preferred method of recording coordinates. My plan was to describe a single process, based on the common components of each method.

It turned out that the methods varied so much that there wasn't a single 'approved' method for recording coordinates. So, I decided instead to describe some general principles of GPS operation and the conditions that affect the accuracy of readings, and then reproduce the methods that I received in response to my request, in the language used by each geocacher. All these methods are considered to be sound, and have been used by their various authors to place over 700 geocaches around Australia. Choose the method that suits you, and feel free to amend it, if you think you can improve on it.

I hope you find the document useful. If you have any criticisms, improvements, additions, or corrections, please contact me. I would be very pleased to receive any feedback that will improve this document.

Dave Kruger (dak)
dak's Emu Mob
dak@emuit.com.au

Version 1.0
10 November 2005

Acknowledgements

A project like this is rarely the result of one person's efforts, and this one is no exception. I'd like to thank the following geocachers for generously providing their method of recording coordinates: Biggles Bear, caughtatwork, dohertys, GeoMonkeys, Horus, Lyn Pat and Nathan, maccamob, muzza, Rabbitto, Rogainer, Tankengine (formerly ThomasS), and The 2 Dogs.

Thanks also to Robert Pepper for giving permission to use some of the material from his book, *GPS Vehicle Navigation in Australia*.

Before diving into the ways and means of recording an accurate set of cache coordinates, this section explains the theory of how GPS works, which is essential for understanding how to use GPS. You can read *The Basics* which covers the main points, and leave it at that, but it is worth reading *The Detail* as well to fully understand your receiver's capabilities—and limitations.

The Basics

Global Positioning Systems

GPS stands for Global Positioning System. The unit you hold in your hand is a GPS receiver (GPSr). It receives signals from up to 12 of 24 or so satellites orbiting the earth.

The GPS receiver knows how long the signals took to arrive from the satellites, and it knows where the satellites are, because that information is included in the signal. If the receiver can see three or more satellites then it can triangulate its position and tell you approximately where you are. That is a two-dimensional (2D, horizontal position) fix and not very accurate.

Four satellites are required for an accurate three-dimensional (3D, horizontal position and height) fix, usually accurate to within 5–15 metres. With a 3D fix your receiver will also tell you the approximate altitude above mean sea level.

The more satellites, the better the location fix. The GPS receiver needs a line of sight to the satellites; so it won't work well (if at all) indoors and won't work well in forests or with a hill blocking part of the sky.

The receiver can display its Estimated Position Error (EPE). This is how confident the receiver is of its accuracy. Some GPS receivers use the term 'accuracy' instead of 'EPE'. The important point is to understand the concept. If the EPE is 25m, then theoretically, your position could be anywhere with 25m of where you are standing. Obviously, the lower the EPE, the more accurate your recorded coordinates will be.

The Detail

Components

Three main parts or segments comprise the Global Positioning System:

1. **Space segment:** a constellation of satellites that broadcasts signals. This constellation is known as NAVSTAR, an acronym contrived from NAVigation, Satellite Timing And Ranging.
2. **User segment:** GPS receivers, those devices you buy and hold in your hand that pick up the space segment satellite signals.
3. **Control segment:** ground stations that monitor the health and position of the satellites.

There are 24 active satellites (and three spares); the actual number in use depends on things like maintenance schedules. The satellites are in one of six orbits angled at 55 degrees to the equator, with four satellites spaced more or less equally in each orbit. Their orbits are such that at any time, anywhere on the globe, you should have at least five in view, unless the US military is playing with the orbits. The orbit height is 20,200km and each orbit takes 11 hours and 58 minutes. In simple terms, there are lots of satellites orbiting the earth and you should always have enough overhead to get a location fix.

A Desert Analogy

How GPS receivers determine their position is best explained by means of an analogy. Imagine you are in the middle of a flat, featureless desert. You have a radio device in your hand. In the distance is a tower. Your radio device picks up a broadcast from the tower that says that at exactly 11:15:00 they will play a time signal.

You also have an atomic clock that displays the time with nanosecond accuracy. You decide that at exactly 11: 15:00 you too will play a time signal.

Now, the time signal you hear over the radio is a little behind your signal, because the radio broadcast takes time to travel to you. The two signals are not quite in synch, and the difference is the travel time from the tower to your device. Understanding this is a critical part of GPS operation.

You know how fast the radio signal travels—the speed of light—so your device can work out how far away you are from the tower. In this example it tells you that you are 20km away. At this point you don't know exactly where you are, but you know you are 20km away from the tower. We can draw a circle of possible positions as shown in Figure 1.

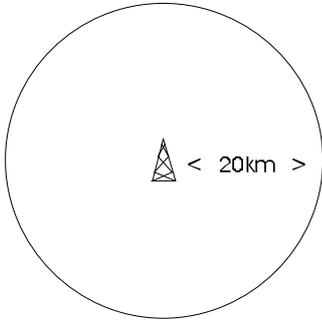


Figure 1: You do not know where you are, but you do know it is 20km away from a reference point. The list of possible positions is a circle.

Back in the desert you see a hill, which is also transmitting the time signal you need. You use your device to determine that the distance to the hill is 10km. Now your potential positions are considerably fewer as shown in Figure 2. In fact, there are only two places you can be in that desert and they are the intersections of the two circles.

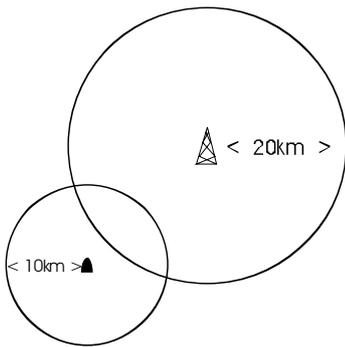


Figure 2: Two reference points give you two possible positions in 2D. These are the intersections of the two circles.

You then see a tree in the distance, which is also transmitting the time signal you need. Again you determine the distance to the tree. This time you are 15km away. Now, you can be in only one location, provided you have correctly measured the distances.

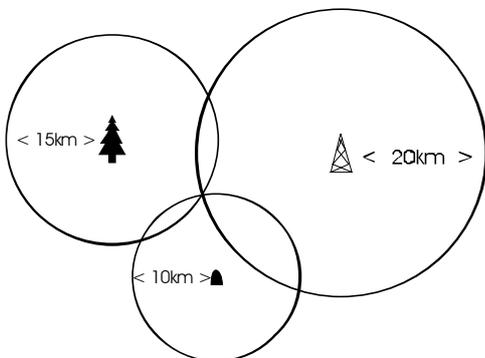


Figure 3: Three correctly measured reference points in 2D can only intersect in one place. That is your location!

You now know you are 20km from the tower, 10km from the hill, and 15km from the tree. But where is that?

Fortunately, your device has been pre-programmed with the location of various landmarks which includes the tower, hill, and tree. That means it can work out the coordinates of your location as shown in Figure 4, at right.

The device knows, thanks to its pre-programming, that the tower is at F5, the hill at D6 and the tree at C4. Which puts you at D5.

This is perfect. Now you know your grid reference, which you can look up on the map. The map does not need to have the locations of the tower, hill, and tree marked, but it does need to use the same grid as the one the receiver used to determine its position.

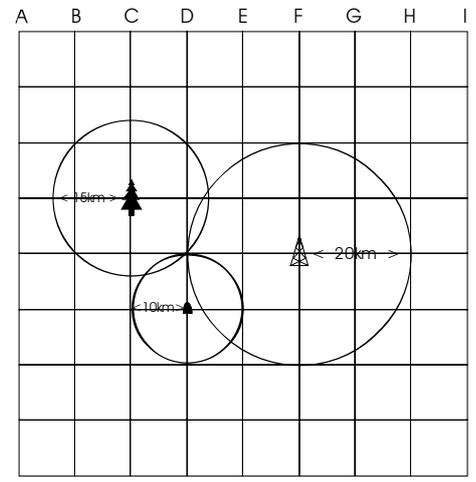


Figure 4: If a grid is overlaid, then our position can be read off as being at D5.

The Real World: Three Dimensions

The analogy above only deals with two dimensions on a horizontal plane. Real life GPS has to deal with three dimensions, with height being the third one. GPS signals are transmitted in all directions.

Imagine a giant sphere, with a GPS satellite at the centre. The surface of the sphere represents the range of possible positions if you are a given distance away (the radius of the sphere) from the satellite. So, if your receiver can see only one satellite, your potential position could be anywhere on the outside of the sphere.

When a GPS receiver can see three satellites, it is said to have a '2D' fix (not to be confused with the analogy above, which is also 2D). This is because it knows where it is horizontally, which is two dimensions, but not vertically, which is the third.

In terms of the desert analogy, that is like seeing only two reference points and it means there is more than one possible position. The receiver definitely needs another reference point.

In theory, GPS needs only three satellites for an exact fix, provided its clock is known to be accurate. Unfortunately as is explained shortly, GPS receiver clocks are not sufficiently accurate, meaning we need a fourth satellite.

If you have a fix on four satellites then you have only one possible location, in the same way that three fixes in our desert analogy gives you one possible location. Four satellites or more gives you a '3D' fix, and it is the only fix you should work with.

The Time Problem

Of course, all that is theory and it is all true, but simplified. The major simplification was the time. Back in the real world the GPS signal travels at the speed of light, which is about 292,792 kilometres per second in a vacuum. It's slightly slower in air, but still reasonably rapid.

The satellites' locations vary as does yours, but say the satellite is 25,000 km away. The time for the signal to get from the satellite to the GPS receiver is about 85 milliseconds. If the timing is even a millionth of a second out that is a potential error of about 300m! That's enough to prevent you from finding the cache!

The solution is having a super accurate clock at both ends: the satellite and the receiver. The satellites have four atomic clocks and are regulated from the ground, so we can assume their clocks are accurate. The time problem is at the GPS receiver end. Instead of an atomic clock your GPS receiver has a quartz clock which is cheap, portable, and wildly inaccurate compared with an atomic clock. An atomic clock is accurate to about 1 second in a million years. Quartz clocks are not.

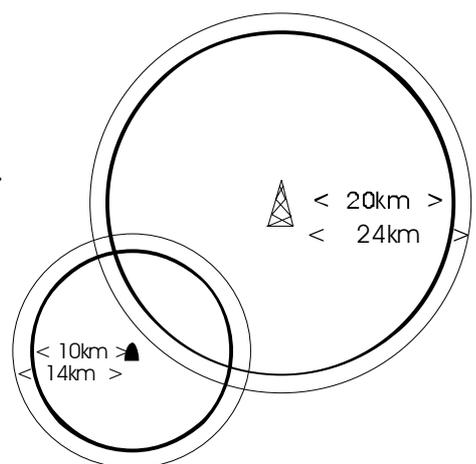


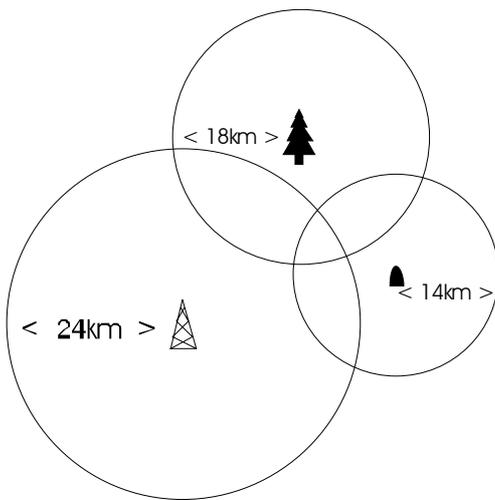
Figure 5: The reality is you are 20km away from the tower and 10km from the hill, but because your clock is slow compared with that of the signal sender, you appear to be 24km and 14km away, respectively.

To return to the desert again, remember that you are measuring the time the signal takes to arrive. What happens if your clock is inaccurate—for example if it's a little slow? It will seem that the signal takes longer to arrive. The result of a slow clock is shown by the thinner circles in Figure 5. You appear to be further away from the reference points than you really are.

There is nothing to contradict this. It makes sense. You *could* be that far from each and have no way of knowing otherwise. We are relying on our clock to be accurate and there is no check on its accuracy.

This is exactly the same situation as having three satellites in view with a GPS receiver, or a 2D fix. The problem is that you are relying on accurate time on the receiver which we know we cannot do, so we cannot be certain that the timing, and therefore, the distances are correct. That is why a GPS receiver is properly accurate only with four satellites, or a 3D fix.

With a 2D fix the GPS receiver uses the centre of the earth as a 'fourth' satellite and it guesses its altitude. Some receivers can use the altitude value to make 2D fixes more accurate and to speed up a fix. The algorithm used varies from receiver to receiver: some guess, some use the last known altitude, and so on.



Back to the desert. You know that what you need to do is add a third measurement and that will tell you which of the two locations you are actually at and ensure that any timing errors are discovered. See Figure 6.

Unfortunately, what we now have is an impossible situation. You cannot be 24km from the tower *and* 14km from the hill *and* 18km from the tree.

Clearly, there is an error. It could be one of the following:

1. The time at the reference station is incorrect.
2. The positions of the reference stations are incorrect.
3. The time at the device is incorrect.

Figure 6: Adding a third measurement proves something is wrong. We cannot be the measured distance away from the three reference points.

Point 1: The reference stations have four atomic clocks and are measured from the ground too.

Point 2: The reference stations have known positions, measured very precisely.

Point 3: A cheap quartz clock.

Clearly the most probable error is the clock on the receiver. It is probably out by a few thousandths of a second. Now how do we fix it?

The receiver adjusts its clock so that there is a solution. It realises that if it moved its clock a second backwards then that would make it 20km from the tower, 10km from the hill, and 14km from the tree. The receiver does this, and hey presto, all three circles now meet, and we have an exact location.

The same problem arises if the clock is too fast. In that case, your location seems to be closer. This situation is even worse because none of the circles intersect, so as soon as a second reference point is used it is immediately apparent the clock is out. But the error is not known. Again, adjusting the clock will work out a distance measurement where all three circles intersect.

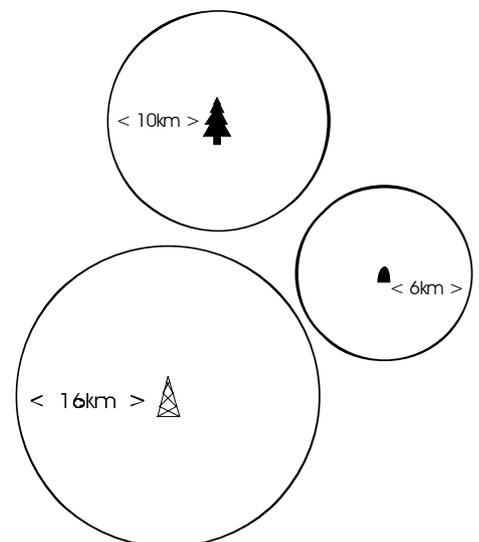


Figure 7: Another impossible location.

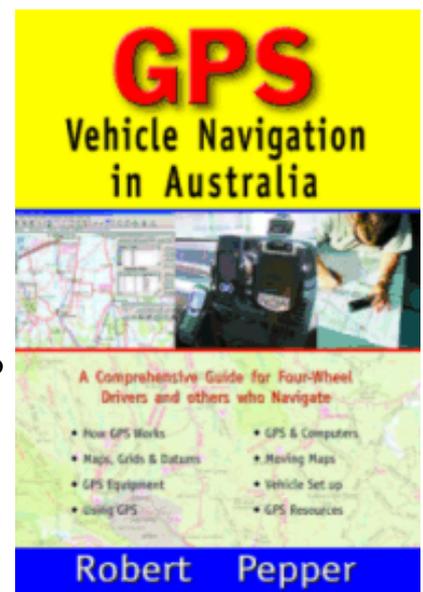
How many satellites?

The exact same principle applies back in the real world with GPS, except you add an extra measurement, as the real world is in 3D, not 2D like the desert analogy. To recap:

- **One satellite is useless by itself.** You could be anywhere on a virtual sphere that represents the distance you are from the satellite.
- **Two satellites are no use.** Your range of positions are now limited to a circle where the two virtual spheres intersect. It is like only having the tower. And that assumes your clock is perfectly accurate!
- **Three satellites are useful (2D fix).** That is like having the tower and the hill. You know you are in one of two locations. The GPS receiver can usually discount one of those two. However, you have no way of knowing that your timing of the signal is correct so you cannot be too sure about your location. You have to rely on your clock to be accurate. You have a 2D fix in GPS terminology and it could be a long way out. A 2D fix relies on the receiver clock being accurate, and we know it is not.
- **Four satellites are what you want (3D fix).** This is when you add the tree and realise there is no way you could be where you thought you were; but by adjusting your distances by changing your clock you can have an exact position. That is now a 3D fix and is reasonably accurate, usually to a few metres.
- **Five is better and six is just fantastic.** Your receiver is now spoilt for choice but being a 12 channel unit it will use them all (well, depending on the receiver's internal algorithm, but it could use all 12 if it could see them).

In summary, every GPS receiver is actually an atomic-precision clock. This also explains why you cannot set the time on a GPS receiver, just the time zone.

The information in this section is a summary of parts of Chapter 2 of *GPS Vehicle Navigation in Australia*, by Robert Pepper. Used with permission. Refer to that book for a fuller explanation of how GPS works, and for more valuable information about mapping, moving map navigation, and setting up a vehicle for GPS navigation. The book has a companion website at www.gpsvehiclenavigation.com.



General Information about Coordinates and Mapping

Acquiring a GPS Fix

The four diagrams below show a typical GPS receiver as it acquires a fix on a number of satellites.

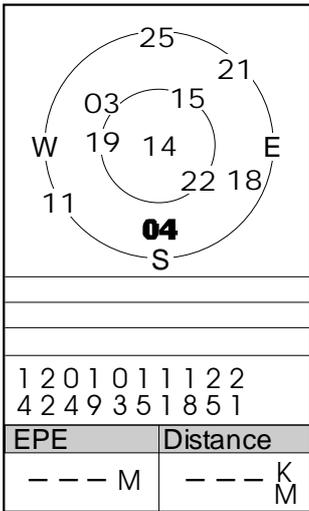


Figure 8: The unit has just been switched on. It has acquired no satellites yet, but it has remembered what satellites were available when it was last used. It assumes that its location has not changed since.

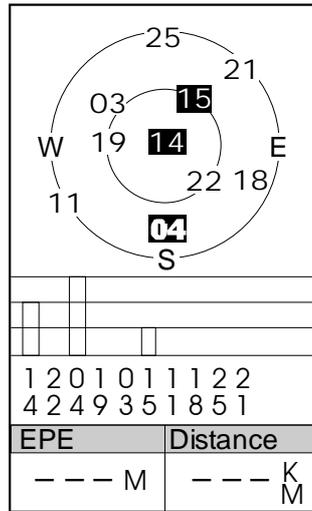


Figure 9: It has now located satellites 04, 14, and 15. The hollow bars indicate that the satellites have been located, but the signal has not yet been acquired.

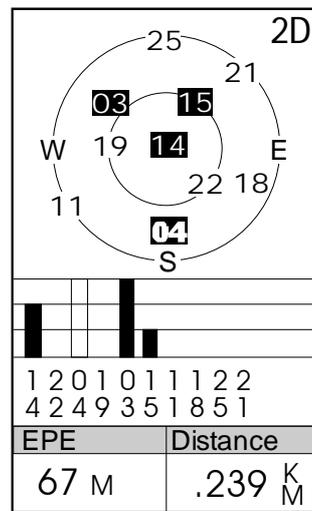


Figure 10: Satellites 03, 14, and 15 have been acquired, and a fourth, 04, is being acquired. These three satellites are enough for a 2D fix. EPE for this fix is high at 67m, indicating poor accuracy.

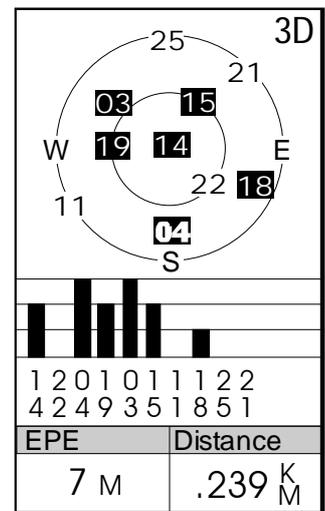


Figure 11: Four satellites are required for a 3D fix, and we have acquired six. Note that the EPE has now decreased to 7m.

GPS satellites transmit a radio signal in the Ultra High Frequency (UHF) band, specifically, at 1,575.42 MHz. Radio signals at these frequencies work best when the transmitter and receiver are in a direct line of sight of each other.

Obstructions that intrude themselves between the satellites and your GPSr degrade the signal, and cause inaccuracies in the displayed coordinates. Examples are heavy cloud cover, tree foliage, the rooves of buildings (that is, you're inside), multi-storey buildings, tunnels, rock ledges, cliffs, and so on.

Also, the radio signals don't always make their way through the atmosphere at a consistent speed (the speed of light). In fact, the Earth's atmosphere slows the electromagnetic energy down somewhat, particularly as it goes through the ionosphere and troposphere. The delay varies depending on where you are on the Earth. Problems can also occur when radio signals bounce off large objects, such as buildings, hills, rock faces, and so on, giving a receiver the impression that a satellite is farther away than it really is.

GPS is very good at solving some of these difficulties, but it can only do so much. When the obstructions degrade the GPS signal the EPE increases. If the obstructions are too great, the GPSr loses acquisition altogether.

Coordinate Systems

A few pages back we introduced the subject of coordinates as a means of locating your position on a map. This, of course, assumes that the map has been calibrated with some sort of grid system that enables us to find our location, using a given set of coordinates. A coordinate system can be as simple as a letter-number grid that is used in street directories, but this is useless for geocaching, and has no relevance for GPS receivers. Coordinate systems commonly in use with GPS receivers are latitude/longitude (lat/lon) and Universal Transverse Mercator (UTM).

The term 'GPS coordinates' has no relevance, but is often used to describe the coordinates of a cache location or a waypoint.

Both lat/lon and UTM are based on imaginary lines drawn on the surface of the Earth. Your GPS receiver can tell you how far you are from these lines. In Australia, the South coordinate tells you how far south you are from the Equator; the East coordinate tells you how far east you are from the Prime Meridian.

Geocaching uses latitude/longitude to describe the position of caches. Latitude and longitude can be represented in several ways (D = degrees, M = minutes, S = seconds):

DDD.DDDD	-37.931850°, 145.071850°
DD MM.MMM	S 37° 55.911, E 145° 04.311
DD MM SS.SS	S 37° 55 54.66, E 145° 04 18.66

Cache coordinates are expressed as DD MM.MMM. Incidentally, the UTM coordinates for the above position are:

55H E 330549, N 5799993

Use the Right Datum

In surveying and geodesy*, a datum is a reference point or surface against which position measurements are made, and an associated model of the shape of the earth for computing positions. Most GPS receivers support many datums: WGS84, NAD27, AUS66, EUR79, SAM69, to name a few.

The World Geodetic System defines a fixed global reference frame for the Earth, for use in geodesy and navigation. The latest revision is WGS 84 dating from 1984, which will be valid up to about 2010. For geocaching, latitude and longitude coordinates are expressed using the WGS84 datum.

Make sure your GPS receiver is set to use the WGS84 datum. Check the user manual for your GPSr to find out how to check and set this. Failure to use the correct datum can result in wildly inaccurate coordinates. For example, let's assume you're standing at the above coordinates—S 37° 55.911, E 145° 04.311 (WGS84)—but your GPSr is set to use the NAD27 datum. You would record the following set of coordinates:

S 37° 56.145, E 145° 04.397 (NAD27)

Now, if a fellow geocaching team goes to your coordinates with their GPSr set to use WGS84, they would be over 450 metres away from your cache!

Magnetic North and True North

If you thought there was just one North, you would have been wrong! In fact, there are two Norths that you need to know about: Magnetic North, and True North. Magnetic North is that which is indicated by a compass or the magnetic pole of the Earth. True North refers to the direction of the North Pole relative to the navigator's position—all lines of longitude point to True North. (There is also Grid North, but this relates to the direction northwards along the grid lines of a map. Grid North is not relevant to a GPS receiver.) Your GPSr can be set to either Magnetic North or True North.

The North Reference setting of your GPSr is not significant when recording coordinates. However, some geocaches require you to *project* a set of coordinates from a known position, and if you use the wrong reference, your projected coordinates could be out by some way. The North Reference setting is also significant if you are projecting a set of coordinates in a 'poor reception' situation (see *Overcoming Poor Reception Problems* on the next few pages).

GPS receivers are usually set to True North by default, however, if you require someone to project a waypoint to find your cache, take careful note of the North Reference setting of your GPSr, and make it clear in the cache description what North Reference they need to use for the projection.

* Geodesy, also called geodetics, is the scientific discipline that deals with the measurement and representation of the earth, its gravitational field and geodynamic phenomena (polar motion, earth tides, and crustal motion) in three-dimensional time varying space.

Points of the Compass

A compass is a navigational instrument for finding directions on the Earth. It consists of a magnetised pointer free to align itself accurately with the Earth's magnetic field. A compass provides a known reference direction, which is of great assistance in navigation. The cardinal points are North, South, East, and West.

North is considered to be 0° ; East is 90° ; South is 180° ; and West is 270° . There are other compass points in common use also; some of them are illustrated in Figure 13, below.

Some cache descriptions require you to proceed in a particular direction, for example, 285° Magnetic. As the compass needle always points to Magnetic North, you can then rotate the housing of the compass so that the 0° mark on the degree dial lines up with the North-pointing end of the magnetic needle, usually painted red or black. Now you can read the direction you need from the markings on the degree dial. Given the information above, a bearing of 285° is a little North of West.

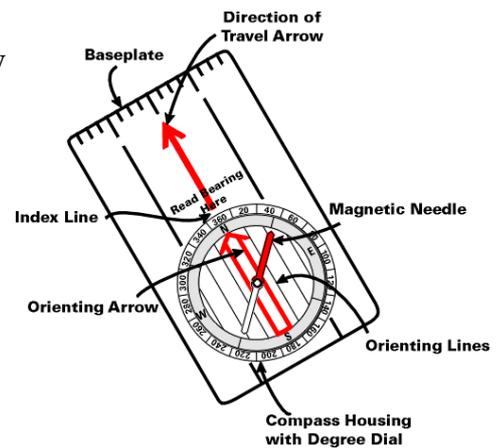


Figure 12: A simple compass can be a useful addition to your geocaching kit. Sometimes you will be required to use a compass to find the direction of the cache.

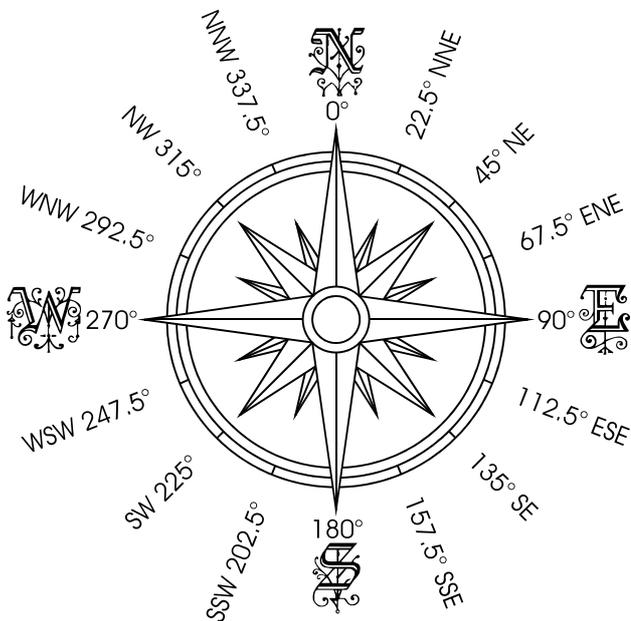


Figure 13: The four cardinal points of the compass are North, East, South, and West, representing 0° , 90° ; 180° ; and 270° , respectively. Other commonly used compass points are also shown here, along with the degrees that they represent.

A compass is also useful if you are projecting a set of coordinates in a 'poor reception' situation (see *Overcoming Poor Reception Problems* on the next few pages).

What About WAAS?

The Wide Area Augmentation System (WAAS) is a system of satellites and ground stations that improves the precision and accuracy of GPS signals. It can improve the accuracy of the GPS signal by approximately 5 times. WAAS relies on ground stations, which are located in the continental United States. The European Geostationary Navigation Overlay System (EGNOS) is the European equivalent of this system. In Asia, the equivalent is the Japanese Multi-Functional Satellite Augmentation System (MSAS).

None of these systems is of any use to us in Australia. However, some people have reported that their GPSr sometimes displays 'WAAS Averaging', or something equivalent. This is an anomaly, as the WAAS ground stations are too far away for their signals to be picked up by a GPSr in Australia. In fact, if your GPSr is capable of using WAAS signals, it is best to turn the feature off, as it could contribute to false readings. Refer to the user manual for your GPSr for instructions on how to disable WAAS support.

Overcoming Poor Reception Problems

Wouldn't it be good if every cache location had a clear and uninterrupted view of the sky, and you were able to acquire strong signals from 12 satellites, covering the sky in complete symmetry? The only obstruction would be that flock of pigs crossing the sky.

Unfortunately, in the real world we have to contend with tree cover, tall buildings, heavy clouds, and so on. This section attempts to provide some advice on overcoming these difficulties.

Dilution of Precision

First, let's consider symmetry of satellites. As previously discussed, you need four or more satellites to get a 3D fix. However, the resulting coordinates will be more accurate and reliable if the constellation of satellites are evenly distributed across the sky, with a combination of some being directly overhead, and some being towards the horizon. For example, consider the GPSr display in Figure 14. Although we have acquired four satellites, and have a 3D fix, all satellites are in the southern sky. This indicates a severely restricted view of the northern sky—the GPSr is probably at the base of a cliff, or in the shadow of tall building.

The error introduced by a poor alignment of satellites is called Dilution of Precision (DOP). Few satellites close together gives high DOP (poor accuracy); many satellites equally spaced gives low DOP (high accuracy).

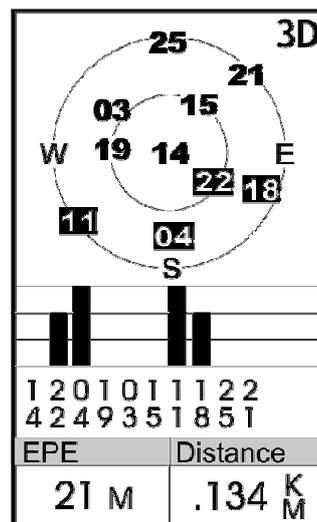


Figure 14: Four satellites acquired and a 3D fix, but EPE is relatively high, owing to a poor spread. DOP is high.

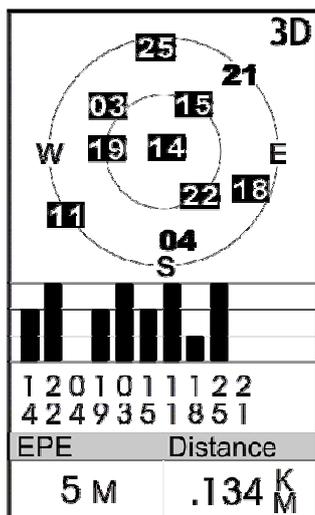


Figure 15: Having eight satellites and a low EPE is a good start, but having them spread over the sky, with some directly overhead and some on the horizon leads to a low DOP.

overcome the problem. You can move to the centre of the street, if you can do this safely, and use projection to determine the real coordinates of the cache. Alternatively, you can place the cache, record the best set of coordinates you can, and use a mapping program like MapSource, MapSend, or OziExplorer to confirm the location of the cache, and then give sufficient hints in the cache description to allow people to find the cache.

The GPSr in Figure 14 has poor DOP, because all satellites are in a straight line

On the GPSr display, the inner circle represents 45° to the horizon. The outer circle represents the horizon. It is far better to have an even spread of satellites in all sections of the sky, as illustrated in Figure 15.

When the time comes to record the coordinates of your cache, pay attention to the spread of the satellites, as well as the number of them. If the constellation of satellites is not ideal because of geological features, then you might consider some of the techniques below. If there are no specific obstructions, but the constellation of satellites is still not ideal, it could be because certain satellites are off air for maintenance, or some other reason that is beyond your control. In this case, be aware that your readings might have low accuracy, and plan to return later in the day, or preferably, on a different day, when the satellites are more favourably located.

Tall Buildings

Your GPSr can only acquire satellites that it can see in the sky. If you intend placing a cache in a Central Business District, you might find it very difficult to get a lock on enough satellites to provide reliable readings, because city buildings will restrict your view of the sky, especially if your cache is against a building wall, which it most probably will be.

There is not much you can do about this, but there are a couple of techniques you might consider to overcome the problem. You can move to the centre of the street, if you can do this safely, and use projection to determine the real coordinates of the cache. Alternatively, you can place the cache, record the best set of coordinates you can, and use a mapping program like MapSource, MapSend, or OziExplorer to confirm the location of the cache, and then give sufficient hints in the cache description to allow people to find the cache.

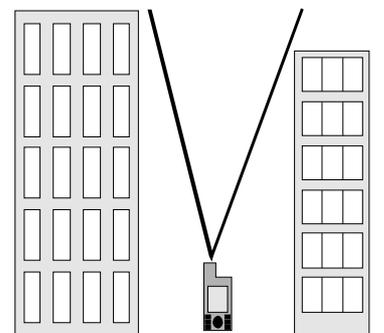


Figure 16: In the CBD, your GPSr may have a very restricted view of the sky, and therefore, may suffer from high DOP.

Projecting Coordinates

Sometimes the cache is located in a place with less-than-ideal GPS coverage: under a rock ledge, in a cave, under a veranda, under heavy tree cover, and so on. Such a situation is depicted in Figure 17. You *could* persist with recording the coordinates, but a better solution is to move to a place with a clear view of the sky, and record the coordinates there. Once you have a reliable set of coordinates, you can do a projection to determine the real location of the cache.



Figure 17: The cache is under the heavy foliage of the tree. Satellite lock is available, but EPE is high.

This technique is only useful when you can find a clear view of the sky relatively close to the cache location. It is not practical to project a set of coordinates from 100 metres away. Anything up to 25 metres should produce reliable coordinates.

The idea is to place the cache, and move away to the clear area. Take your set of readings by whatever method you have decided upon, then record the distance from your current position to the cache location. If you have a measuring tape for this, so much the better, but pacing it out should also be accurate enough.

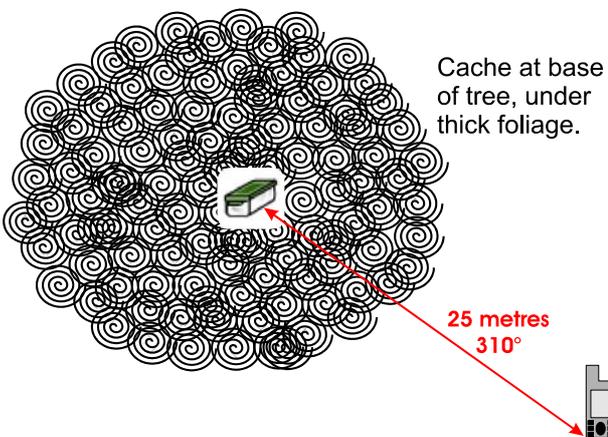


Figure 18: This is the view from above. In this scenario the cache is located at the base of a tree with thick foliage. GPS reception is poor at the cache location, but a clear view of the sky is available just 25 metres away. Record the coordinates of the clear location, using your normal procedure. Measure the distance from the clear location to the cache. Use a compass to determine the bearing from the clear location to the cache. Some GPS receivers have an inbuilt compass, but any decent navigational compass can be used. The compass needs to have a degree dial that enables you to read the bearing to an accuracy of 5° .

So now you have a set of coordinates, say S $37^\circ 55.920$, E $145^\circ 04.324$; a distance, 25 metres; and a bearing, 310° . With these three parameters you can determine the coordinates of the cache. If your GPSr has a projection facility, then you can use that to do the projection for you. However, some GPS receivers don't allow you to enter distances as exact as 25 metres, and might restrict you to using 20 or 30 metres.

Fortunately, technology is at hand to assist with this task. A Windows application called GeoCalc can do the projection for you, as well as a host of other things. And the good news is that it's free! The following comes from the GeoCalc web site:

GeoCalc allows simple conversion of coordinates to various formats. It takes coordinate strings in a variety of formats and generates copy-and-paste versions of those coordinates in a variety of other formats.

GeoCalc also does high-accuracy distance calculations and projections using the Vincenty method for calculating distances on an ellipsoid. These calculations are much better than you can obtain from your GPS unit or most other software out there.

You can download the latest version of GeoCalc from the following web site:

<http://www.fizzymagic.net/Geocaching/GeoCalc/GeoCalc.html>

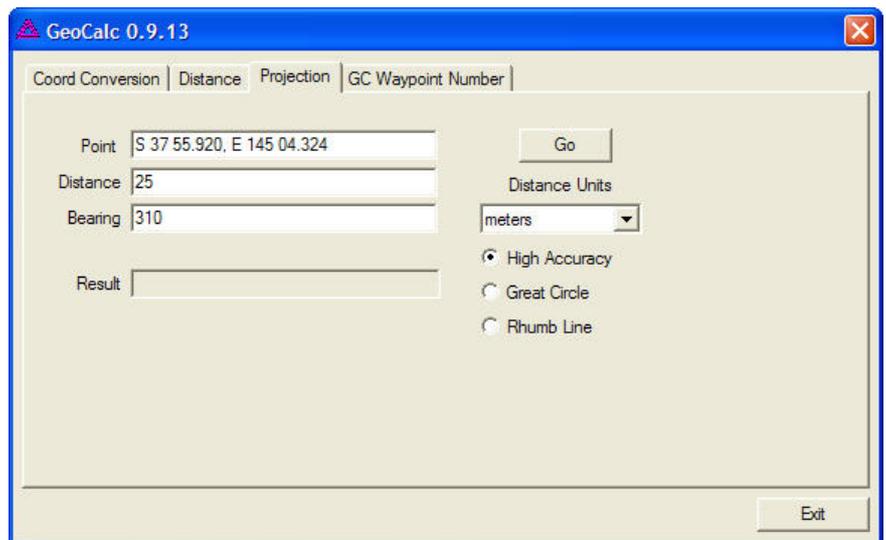
The download is a simple executable file; no installation file is necessary. Just download it, place it in a folder that you use for your geocaching utilities, and double-click on the .exe file.

Warning: It is inherently unsafe to download a .exe file and execute it, unless you trust the file implicitly! As far as I know, GeoCalc.exe contains no malicious code, but you would be well advised to scan the file with your virus checking application before double-clicking it.

So, now that the warning is out of the way, how can GeoCalc help you to determine the real location of

your new cache? The GeoCalc screen offers four major operations: Coord Conversion, Distance, Projection, and GC Waypoint Number. Choose the 'Projection' tab and enter your parameters into the appropriate fields:

Figure 19: Enter the coordinates you took in the clear area, the distance to the cache, and the bearing from your recorded coordinates to the cache.



Press the 'Go' button, and GeoCalc displays the projected coordinates:

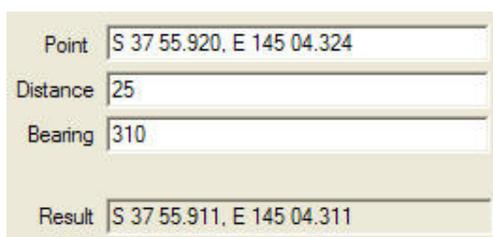


Figure 20: When you press the 'Go' button GeoCalc displays the projected coordinates in the 'Result' field.

Of course, there may be other applications you can use to project a set of coordinates from a given position, with a bearing and a distance. GeoCalc is known to produce accurate projections and distances. Use the method that you are comfortable with, but be sure of the accuracy!

Methods for Recording Accurate, Reliable Coordinates

The remainder of this document details no less than thirteen methods for recording coordinates. These methods are not listed in order of effectiveness or preference. They are simply listed in the order in which I received the responses from those I asked. Some are simple (deceptively so); some are complex; some are based on mathematical principles; but *all* are based on experience in the field under many conditions, and have been formulated by the best geocachers in Australia. They are presented in the language used by their own authors, with little or no editing.

Choose a method that you are comfortable with (I suggest one of the more comprehensive ones to start out with), and test it out for yourself, as follows: Go to an existing geocache that you were able to find easily, and that has satisfied you as to the accuracy of the coordinates. Choose one that has been around for a while, and therefore, has had a good variety of visitors; read the logs to make sure there are no comments about inaccurate coordinates. Prefer one that was placed by an experienced geocacher—if you don't know who is experienced, choose one of those listed on page 2 in the acknowledgements. Ignore the advertised coordinates, but use your chosen method to record the coordinates of the actual cache location. Imagine *you* are placing this cache. Once you have a set of coordinates, compare them with the advertised coordinates—they should be pretty close. (You can use GeoCalc to calculate the distance between the two sets of coordinates.)

Good luck, clear skies, and have fun geocaching!

Method One

I actually vary/lengthen the method depending on the quality, reliability, and repeatability of the results as I go. Essentially, if the results I get when recording each snapshot vary a lot, or the EPE is high, then I tend to work further and further down my list. If I get good repeatable results with little variation, I tend to take fewer samples and don't worry about some of the options further down the list.

On each sample, I record the coordinates, the EPE, and other info such as resetting my GPSr, whether I did a 'walk in' (see Sampling Step 4, below), length of the averaging, and so on, in order to be able to later evaluate how reliably the coordinates should be regarded.

Sampling Steps

1. Initially, let the GPSr settle for a few minutes. Check out how many satellites are visible and whether they are spread well or clustered. Change the direction the GPSr is facing or the vertical inclination (or both) to get the best reception possible.
2. After this, record a few samples after it has averaged for a couple of minutes (at least). Often, I am hiding the cache itself or preparing it, so the averaging may go on for much longer. Wait 20–30 seconds minimum between samples.
3. Switch off the GPSr, turn it back on, and let it average for at least a minute, before taking a few more samples. Repeat if necessary.
4. Walk away 10–20 metres (try to find an area with good EPE), let it settle for a minute or so, then walk back in and record a sample. Let it average for a minute or so and take another one or two samples. Repeat as often as is necessary.
5. If the results so far are still fluctuating a lot (either in N/S, E/W, or both directions), then leave it a while (at least half an hour—the longer the better) and come back and try again. If there are still fluctuations, try to come back another day.

If there is no consistency showing up at this stage, give up, (or at least give a warning on your cache page and ensure that there is a reliable encrypted clue to lead finders to the cache).

Evaluation of Samples.

1. Eliminate samples that are way off the norm. Unless the samples are completely all over the place, there should be a rough area that most co-ordinates are somewhat close to. Get rid of the odd one or two that are nowhere near, especially if its just after a reset.
2. Place less trust in samples with a high EPE relative to the others or eliminate if too high.
3. Look to coordinates in both N/S and E/W that occur the most often. (I think these are called the Modes in mathematical terms).
4. Look for coordinates in both directions for which 50% of samples lay above, and 50% lay below (the mathematical Medians).
5. Average the samples in both directions (the mathematical Mean).
6. Using my powers of mathematical deduction and logic, my geocaching know how, sticking my wet finger in the air, checking my star sign for the day (and inherently the phase of the moon), and finally throwing a dart at the dart board, I derive what I feel is the best guess for the coordinates.

It doesn't always work, but if you do the sampling correctly and sufficiently (based on the results as they are being recorded) and record all the details of each sample, then you've got the best chance of success.

Method Two

When we place a cache we only use one GPS. We place the cache then take a walk. Not far, but we do this about three to four times. It sometimes takes about 20 minutes to do this. Most finders usually tell us that our coordinates are spot on and of course that is exactly what we want.

We do find that new cachers want to be in there with theirs but they are so taken up with the moment that they forget to check and recheck their figures, and also the datum that they are using. A well-known caching team found a cache near us, and using their brains realised that the datum was wrong.

Those extra minutes and extra circles around a cache pay off with exact figures.

Method Three

My method was formulated for the reason that I believe that ground zero (GZ) is more often than not, at least slightly shielded from an accurate GPS reading. By nature, in geocaching, GZs are generally under trees, on hills, near buildings, and so on, and the GZ needs to be established by gaining information from the surrounding area which is generally less shielded or at least differently shielded.

On the day of reconnaissance, I always start off the same way by going to GZ and average for a while then record the coordinates.

After this I test the coordinates. I walk away from GZ for around 20 to 50 metres and return, then in another direction and continue for as many different ways as possible up to about four. Then if possible, I circle the area. All the while, I am watching the arrow direction and distance.

Generally, I can eyeball the programmed GZ and gauge its difference to the actual GZ. I will make a manual adjustment to the programmed coordinates and then repeat the process until I am happy that I can walk back and forth from GZ and around GZ and have the arrow pointing more or less to GZ. As a final test, I go back to GZ and watch the 'float'. By this I mean watching the arrow/distance and its changing relationship to actual GZ. I would expect the programmed GZ to float fairly close to the actual GZ a number of times over the space of a few minutes.

On the day of placing the cache, I usually take a different member of the team to carry the GPSr with coordinates loaded and get them to take me where the cache should be. Adjustments are made only if necessary, but usually the accuracy is fairly good.

The final step after launch is to carefully watch the first few cache logs for any signs of difficulty.

Method Four

I have my own method for getting hopefully accurate fixes for my caches. I figure that the accuracy of the current GPS reading depends a lot on the alignment (and number) of satellites you can see at the time. The alignment changes over time (say a half hour plus). So what I do is try to get the best accuracy reading on the GPS, and mark the location. I will then repeat that every five minutes for up to half an hour, depending on the variation I'm getting. During the five minutes, I usually walk away from the spot, and then come back—then waiting a minute or so before taking the next reading. If the variation I'm getting is large, I continue the process for longer. I can, but don't use averaging—as I expect you would have to average for half an hour or more before it becomes accurate, and even then, if the satellites are badly aligned, you wouldn't know.

Additionally, if the cache is going to be particularly challenging, and I really want to make sure I'm accurate, I usually come back the following day, and take more readings (if the site is not too remote!). By then the satellites have well and truly changed. In the end I might have as many as 10 points on the GPS. Usually two or three will be way out, and the others will be clustered together. I then choose a point in the middle of the lot as my final coordinates.

Having said all that, I do vary that a little from time to time. If the cache is in a difficult spot, say at the base of a small cliff or other tricky location, I will bias my choice of final location to err on the side that geocachers should approach from. That is, if the top of the cliff was to the north, and the cache was at the base, I would favour the southern points, as it would increase the probability of searchers seeking in the correct area.

Of course I would make sure to take the reading from the top of the cliff/boulder, and so on, to make sure I didn't introduce errors due to reflected signals. I have used the 'walk-in' method as well. In one of my caches a waypoint was between two buildings, where it was all but impossible to get a decent satellite lock. However, 100-200m away from the buildings there was a perfectly good signal, so I would walk from 200m away in a straight line stopping at the waypoint location. I would repeat this a number of times, load the track plots into OziExplorer, and then choose the final point.

Finally, I check my selected location on a 1:25000 (or at least 1:100000) map, to see that it looks right. Recently I was looking for a cache which was about 100m out—the hint was "water water everywhere" so I

swam about in the lake between the mainland and a small island for ages with my GPSr. There was a rope with buoys nearby, so I thought it might have been attached. In the end it turned out to be on the island! A quick check on a topographic map would have showed the cache hider that he was way out!

Method Five

There are lots of factors that alter coordinates.

1. The US military messes with the system sometimes, and you can be 150km out. One weekend there was something going on and we lost all satellites except two for about an hour. It can be maintenance or war troubles. It's their system so they can do as they want.
2. Hills will affect the accuracy. If you place a cache or try to find one on a hill you can get 30m error easily. Sometimes you can lose the satellites too, but I'm not sure why.
3. Rocks, granite, and tombstones affect the signal and cause bounce so coordinates tend to wander more than usual.
4. Trees and tree cover make the signal weak so caches placed under them are less likely to be accurate, and as you have the same trouble finding them, you can get 30m error.
5. Low batteries in your GPSr can be a major problem just before they stop working: our Magellan compass goes out by 180°!

To get good coordinates we just sit and let it average for about 5 minutes but during this time we write the figures out. That way we can see if they are dragging one way or the other. If they are consistent, we trust them. If they just keep moving, we often place the cache in a new place or give a good hint so it can be found.

Some teams decide that its good to hide a film canister under tree cover buried under leaf litter. The area to be searched is often 10m or more in size. Way too much of the ground/plants/rocks and bushland in general get moved and damaged. To us its irritating, but its their decision. We just choose not to find many of their caches as we disagree with the hiding techniques of them. We don't tell them not to do it but if they asked we would say what we thought about it. Mostly we like our caches to be found, so ours are easy to find but often hard to get to. That's our own style but everyone does it differently so make sure you do it as you like.

Generally we find our caches are within a few metres of what others say, so we consider that good, but some people have reported 12m error. We have rechecked (1 year later and with our same GPSr) and our GPSr said 3m. So GPS receivers vary in accuracy too.

Walking up to the area doesn't improve accuracy, as most GPS receivers work best with averaging (some older ones don't). Garmins read faster than Magellans so we often slow down before we get to a cache with our Magellan unit but this just means going slow for the last 30m. It doesn't make it more accurate when placing it in the first place.

You can look at the screen on your GPSr that tells you the locations of the satellites your unit is seeing. If you have a good spread around the horizon with a couple in the 45° range, then you get better accuracy. If they are all overhead only, then be prepared for large faults. Hence, open sky, flat land, no trees or rocks, top of hills, and so on are all the best places.

Method Six

My method is fairly simple. I average (by deduction not maths) from several readings taken from the one GPSr over 20–30 minutes.

- I search out the location with the GPSr running.
- Once the location is found I mark the location once.
- I wait five minutes and take a second reading.
- Then I walk away from GZ 15 metres or so, and return and stand and wait, then take another waypoint. I do this from at least two differing directions.
- I take more readings if the location is particularly bad for GPS reception due to narrow visible sky or reflected signals from cliffs and so on.

This all takes about 20 minutes, so the readings are taken from satellites in varying positions, as they have moved.

Once I'm home I write down the coordinates and guesstimate the median of all the Southings and Eastings in turn.

For example, the three decimals for a location may be .789, .786, .790. I record the location as being at x.788 and this puts most hunters within the 5-metre accuracy of their GPSr.

Then I use my median coordinates to return on another day and do a cache check. I see where I wind up, and make corrections if I deem the difference or margin for error to be too high.

Method Seven

I have a couple of methods, depending on where I am. My plan of attack using my Garmin eTrex:

1. I look at the satellite arrangement I have and check the EPE.
2. If I have most of the satellites in use and the pattern of the satellites is relatively symmetrical, then I use the following method:
3. I mark the waypoint into the GPSr.
4. I walk away 20–30 metres to a compass point then follow the GPSr back to the newly marked waypoint and mark the position again.
5. I repeat the steps, walking all four compass points (N, S, E, W) so I end up with five waypoints being marked: the initial, plus all four compass points.
6. Using these waypoints, I determine how much the most insignificant digit varies.
7. If they are within 1–2 of each other, I consider this to me satisfactory.
8. I estimate that at my latitude each insignificant digit is 1.6 metres, so a difference of .002 would be around three metres out.
9. I discard any obviously inaccurate readings as well as the highest and lowest.
10. If they are more than .002 apart from each other, then I manually average them out to determine the most likely middle point of all of the waypoints marked.

If I am under tree cover*, if there are buildings in the way**, if I'm getting a less than optimal number of satellites*** or the arrangement of the satellites is not nicely symmetrical**** I use the following method:

1. I firstly determine whether I can actually get a good reading, and check the EPE.
2. If I get a good set of satellites when I am stationary, but lose a couple when I am moving, then my accuracy is diminished and on occasion I will revisit at another time or day to see if I can get better reception.
3. I mark the waypoint into the GPSr, and use the same method as above.
4. I then use the same method as above, but as an additional step, cycle the power on the GPSr both at the start and the end of each compass point.
5. This gives me 13 waypoints: initial, four compass points, four compass points cycling the power before I walk in, and four compass points cycling the power once I have arrived.
6. Using these waypoints, I determine how much the most insignificant digit varies.
7. If they are within .001 or .002 of each other, I consider this to be satisfactory.
8. I estimate that at my latitude each insignificant digit is 1.6 metres, so a difference of .002 would be around three metres out.
9. I discard any obviously inaccurate readings as well as the highest and lowest.
10. If they are more than .002 apart from each other, then I manually average them out to determine the most likely middle point of all of the waypoints marked.

* I know my Garmin eTrex does not perform well under heavy tree cover, so in general I don't plant caches there using a single GPSr.

** A cache close to a building when trying to take coordinates may mean that a satellite or two is being shielded by the building.

*** I consider six satellites to be a minimum when planting a cache.

**** A straight line of satellites across the horizon is not symmetrical for this purpose. I like to have at least two satellites in each third of the sky, preferably not just above the horizon.

Sometimes I feel this is overkill, especially when the hide is plainly obvious. For micro caches I feel that this is justified.

I know that I hate it when coordinates are significantly out and you're chasing your tail, so I try to get the best readings I can. The game is about finding the cache at the coordinates, not some 20–30 metres (and an hour) away.

Method Eight

All we do is average the reading for between two and five minutes depending on the EPE at that location.

Author's Note: This method seems deceptively simple. However, the caching team that uses this method is very experienced. The key statement is "... depending on the EPE at that location". Obviously, obstructions, terrain, weather, and so on, all play a part in determining the EPE. An experienced geocacher may be able to estimate the effect of these phenomena when determining the repeatability of the coordinates; beginners probably cannot. My experience with this team is that their coordinates are very accurate, however, I believe this owes mainly to their experience, rather than the simplicity of their method of recording coordinates. This comment applies to several methods presented here.

Method Nine

My method of obtaining coordinates is nowhere near as sophisticated as some others—in fact it is downright primitive, but it seems to work.

I turn my trusty Garmin GPS12 on and make sure I have a good fix before heading off to the potential cache location—this just ensures it has a chance to settle down. I'm not sure about the modern GPS units, but mine has a lot of trouble getting an initial fix if I am moving when it's trying to get its first lock.

When looking for a potential cache location, I keep an eye on the reported accuracy (EPE) to make sure it is not bouncing around—once I find a site, I place the GPS unit at the site and then start averaging.

I leave the unit averaging while I stuff around with the cache—put things in the container, take photos, think of a name for the cache, fill in the log book, and so on. This process can take around 10 minutes—by this time, my reckoning is that the coordinates are good enough and that's that- it gets recorded.

People have managed to find all the caches I have placed—some easier than others, but that is more to do with the location rather than coordinate accuracy. Occasionally someone will log their coordinates for the cache and if others write that they have trouble finding it, then I will go and re-check the coordinates. Only once I think I have adjusted the coordinates on the web site for a cache I have placed. It is a tricky situation, particularly if some have no difficulty finding the cache.

If I think tree cover could be an issue for finders, I try to leave hints that make it easy to find. My attitude with caches is that, yes this is a kind of hide and seek game, but the main point of the whole thing is to get people out to your location. Once there, they shouldn't have to spend an hour rummaging around and destroying the vegetation; the cache site should be reasonably obvious (to cachers anyway).

So I guess my advice to beginners would be don't try to be too clever initially, find a reasonably obvious, but out-of-sight-from-general-public location for the cache and give hints. This may mean the cache has a difficulty of only one star but so be it—we have to walk before we can run.

I guess ideally we should have somebody check the coordinates before posting the listing. As we get confidence with the GPS unit and also people have no difficulty finding the caches we have already placed, then we can start to get a bit more tricky.

Method Ten

Geocaching is becoming increasingly popular in my area. This has led to an influx of new caches by new cachers. Whenever I find a cache I try to make a note as to the accuracy of the coordinates, and generally the errors have occurred with a new cacher's first few caches. After that something must "click" and they seem to be more accurate. I try to make a comment in the log if the coordinates are out, just to bring it to

the placer's attention, and of course if they are way out I'll submit an alternative set for future finders to have a go with.

I'm afraid I have no words of wisdom for you regarding the marking of cache coordinates because all my marking consists of, is letting the GPSr sit on the cache spot for as long as I can while I prepare the cache for placement, that is, filling out the log book with a welcome note and so on, then pressing the "mark waypoint" button! Making sure of course that it's sitting in the clearest area it can and not sticking my big boofy head over it when I press the button to mark the spot.

I don't know if my eTrex has any kind of averaging at all, there is nothing in the manual about it, so I figure what I am doing is the best I am going to achieve with the equipment I have at hand. I don't bother walking out and then going back and trying to find the cache—the satellite geometry is going to be the same so the accuracy will be the same, and the satellite geometry is what is going to give you accuracy. I think if you wanted to be really fussy, and you lived near to the cache, going back on a day when you have a better satellite constellation would be a useful thing, but other than that I can't think of anything that is going to improve things.

Method Eleven

I'm fortunate enough to own four GPS receivers: one Magellan (my preferred unit) and three Garmins. So, when I decide to mark an accurate set of coordinates, I use all four units.

The Recording Stage (in the field)

- I switch on all four units and place them at the cache site. I don't do 'walk-ins'.
- I wait until all four of them have acquired a 3D fix, then I start timing. After two minutes of averaging, I record the coordinates and EPE on all units.
- During this time, I do any last minute preparation of the cache container, assuming that I'm placing the cache now. (In fact, I usually place the cache on a different day.)
- I repeat this process at least four times, so I end up with 20 readings.
- Sometimes, the averaging period lasts longer than two minutes, but at a minimum, the whole process takes around 30 minutes.
- If the cache location is particularly open, and EPE is consistently low (around 7m or less), I might take fewer readings.
- If the readings are particularly inconsistent, I'll take more sets of readings, and I'll plan other visits to the cache location on different days and at different times of the day.

The Decision Stage (at home)

- I enter the last three digits of all coordinates into a spreadsheet: east coordinates in one column, and east coordinates in another column.
- I sort each column, and delete the highest and lowest reading in each column.
- Then I use the `average()` function to average the readings.

The Cache Placement Stage (in the field)

Once I have the final coordinates and have prepared the cache I go back to the cache location. I use my final coordinates to find my way to the cache site. Assuming I am taken to within 3–5 metres of the cache location, I'm satisfied. If the coordinates place me more than 5 metres from the cache location, I'll cycle the power on my GPSr and try a couple more approaches. If I'm still not satisfied with the accuracy of my first set of coordinates, I'll take another set of readings as outlined above, and add the new readings to the 'pool', and calculate a new average

Method Twelve

I have a Magellan Meridian Platinum, so I make use of its auto-averaging feature. I take a number of readings averaged for at least three minutes each. After the first three-minute average, I save the averaged waypoint and cycle the power off then on again and start a new three-minute average.

This time, I also set the first saved waypoint as a goto so I can see how far away the first point is from the new reading, which I also save after three minutes or more. The magnitude of this variation between

successive averages is a guide to the reliability of the coordinates on the day. If this distance is low (say three or four metres), you can safely assume that the coordinates are reliable.

I repeat the process once more to give three saved sets of averaged coordinates which I'll then average mathematically to give the coordinates I'll use. If the goto shows a larger variation between averaged sets, I'll take more averaged readings to compensate.

In bad cases, where the variation is say 15 to 20 metres, I may finish up with six or seven averaged readings. In these cases I will then plot them on a graph in Excel and may discard any that are way off before averaging the remainder for final use.

In extreme cases, where the variation between successive averages is very large, I might even come back another day to see if conditions and consistency between readings improve.

Sometimes, terrain shielding limitations or tree cover might make obtaining reliable coordinates at the cache site extremely difficult. One way to overcome this problem is to move away from where the cache is placed to a spot where reliable reception is available (assuming you don't have to move too far, of course). Then use the previous method to obtain reliable coordinates for this offset spot. Then (and here is where the Platinum comes into its own) take a compass bearing from where you are to the cache and measure the distance to the cache (pacing it out is usually good enough). Using the known coordinates, bearing and distance, you can now use the GPSr (or OziExplorer) to project a waypoint at the cache location.

Method Thirteen

There is a snippet on Geocaching.com: "Hiding your First Geocache": <http://www.geocaching.com/about/hiding.aspx>. (See *Introduction on page 2—Ed.*)

This is essentially the approach that I use as I don't have a GPS that does averaging. Basically, I collect a lot of waypoint readings at the location. What happens then really depends on how much time I have.

If I need to decide straight away, I then stand at the spot and use the GPS nearest feature to decide on the waypoint that comes up as nearest.

With more time:

1. Try to come back a few times over a period of a couple of weeks to get more readings under different satellite configurations.
2. Download all the waypoints into Excel along with their UTM coordinates.
3. Cross plot them to get a feel for the overall spread of the waypoints. (This generally tells you a lot more about the quality of readings compared to the displayed EPE on the unit). I also like to know whether there is any obvious clustering in the readings. You can do this in a mapping program provided you can zoom in enough.
4. Get rid of any obvious outriders.
5. Average the remainder to get the final reading.
6. Based on the overall spread of the coordinates used, let this drive how much of a hint or not I need to add. Ultimately I want people to find my caches so if I have a spread of 40 metres in the readings, then I add a bigger hint.
7. Once I even got carried away and downloaded a program to calculate PDOP's (Predicted Dilution of Precision) to see if a particular day/time would have good satellite coverage or not.

All in all, very fiddly, but necessary I believe to get both a better set of coordinates and an understanding of the possible error in those coordinates. No different to any normal scientific observation process really.

I guess the most common mistake that people are going to make is that they assume if their unit says "Ready to navigate. 4m accuracy", then that is the accuracy. I am not sure what the EPE really represents, but I think its more a marketing number than anything else. There must be at least some form of probability or confidence interval associated with the reading that is not disclosed.