HOW DOES SATNAV WORK?

SatNav stands for 'Satellite Navigation'—one of the principal uses for GPS—the Global Positioning System. Other uses include the targeting of bombs and missiles—but we won't go there! During the last 20 years, SatNav has transformed our ability to locate our position and to find our way around.

This technology had its origin at the end of the second world war, when bombers flew to their target along one radio 'beam', and knew they had reached it when they intersected a second 'beam'. These methods were developed into the Decca Navigator and LORAN navigational systems, which were expensive, difficult to use, not particularly accurate, and generally only used by aircraft and ships. The GPS system was a huge improvement—it was developed for the US military, but was made available to the general public in 1994. It still exists in two versions—'military' and 'civilian'—the military version being much more accurate. Originally, the civilian version was even less accurate than it needed to be, to prevent its use by terrorists, but this reduction in accuracy ('selective availability'), was removed in 2000. Nowadays, for under £100, you can get a device which will give your position to within 10-20 metres, anywhere in the world. GPS receivers are used by motorists ('SatNav'), by aircraft and ships, and in the form of hand-held units, by hikers. Some mobile phones are also able to use the GPS system.

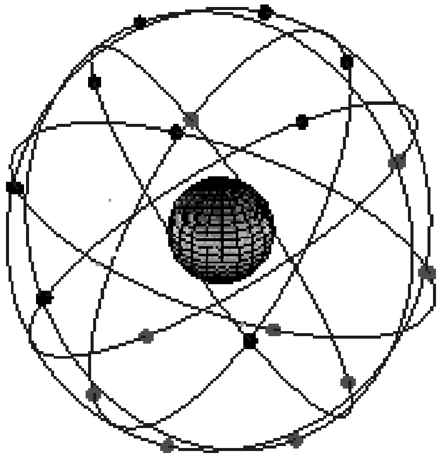

Fig 1: The GPS satellites—Wickipedia.org

Before describing how the GPS system works, let us dispel a myth. Many novels, films and television programmes give the impression that GPS units 'communicate with satellites', and in doing so they tell 'the government' exactly where you are. This is entirely untrue—a GPS *receiver* is just that—it only receives, and does not transmit. Using it only tells you where you are, nobody else! Systems which communicate with satellites are available, and are used by spies, and for tracking wild animals, but they are entirely different from 'common or garden' GPS receivers (and much more expensive)!

The GPS system uses 24 satellites, in six groups of four. There are also some 'spares', which provide additional accuracy, and can substitute for one of the 24, if it goes wrong. The satellites in each group of four chase each other round the earth in the same orbit, orbiting the earth twice a day. The six orbits are spaced around the earth 60 degrees apart (fig 1). This spacing means that from any point on the earth's surface, there are always several satellites in the sky—typically about eight. They are too small, and too high, to be seen by the naked eye.

Each satellite transmits a signal, every 30 seconds, giving the exact time (determined by an onboard atomic clock) and information about its orbit, so that the receiver can calculate exactly where the satellite was when the signal was sent. Since the signal travels at the speed of light, it arrives at the receiver slightly later that the time at which it was sent. However, since the receiver doesn’t also contain an atomic clock, the signal received from one satellite is of little use. If a signal is received from a second satellite, the difference in delay between the two satellite signals can be measured, but this still doesn't give the location of the receiver. Receiving a signal from a third satellite allows two things to happen: the actual time given by the atomic clocks on the satellites can be worked out, and the location of the receiver can be determined, limited to just two possible locations. If one of those is at ground level in West Sussex and the other far out in space, this should be all that is needed, but most GPS receivers won't commit themselves until they see a signal from a fourth satellite, which clinches the location. If, as is usually the case, even more satellite signals are received, the receiver will average all the calculated positions, to come up with the best estimate. In order to measure position to an accuracy of 10-20 metres, the receiver needs to time the signals to better than a ten-millionth of a second—an amazing achievement!

Having worked out where you are, the next job of the SatNav is to work out your best route to wherever you want to go. This varies between one make of SatNav and the next, but in general terms, the SatNav contains a digital ‘map’ of wherever you happen to be, which includes all the roads, the likely speeds along them, and the layouts of all the road junctions. Having told it where you want to go, it tries out various possible routes and picks the one that best matches the criteria you have selected (generally, ‘fastest’). It is well known in computer circles that trying to find the ‘best’ way from one place to another in a complicated network, such as the road system, is an almost impossible problem once the network exceeds a certain size. Thus, SatNav systems have to make various assumptions and approximations, to come up with a route. For this reason, the route selected may not actually be the best one, but it shouldn't be too bad! A human navigator can often come up with a better route than the SatNav, but if you don't have a navigator with you, the SatNav will generally get you to where you want to go. Of course, nothing is perfect! You hear horror stories about SatNav systems directing large lorries down cart tracks, or cars onto ferries that aren't at the dock! When driving in New Zealand, my SatNav directed me across a marsh, on a road that hadn't been built yet! These should be taken as cautionary tales; although the systems are incredibly useful, they aren't infallible, and must be used with caution!