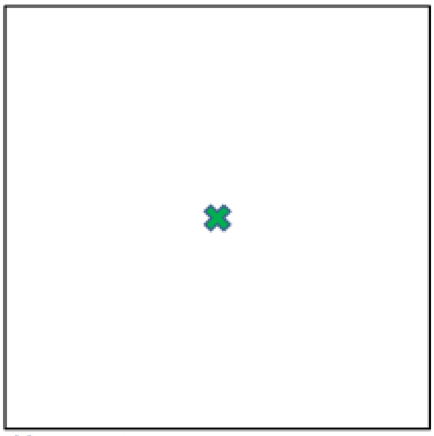
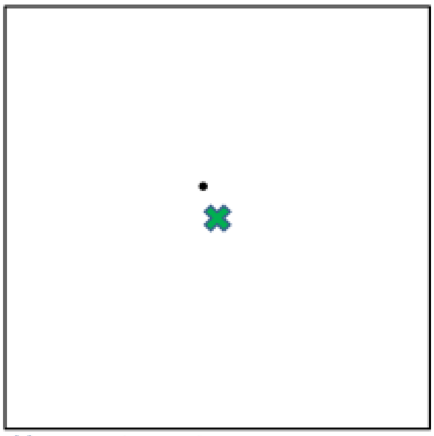
What is... accuracy?

Surveyors talk a lot about the accuracy of their measurements. It seems to be their main concern. So what is accuracy in the sense that surveyors use it? And why is it important to understand, what they mean? This document shall give you a short introduction to accuracy.



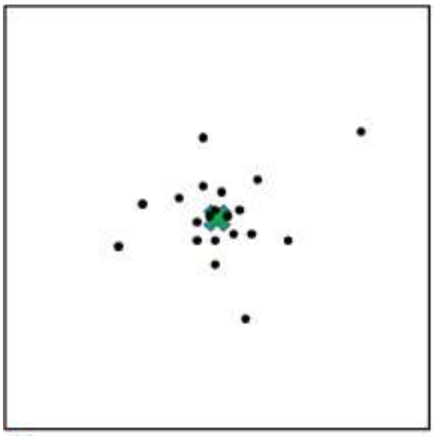
✖ true x/y

The green cross (✖) on the left represents an object that needs to be surveyed in order to put it on a map. It can be a tree, an electricity pole, the corner of a building or your favourite restaurant. The green cross shows the exact location of the object in the real world. When we want to draw the object on the map, we want to assign exactly these coordinates. So how do we get them?



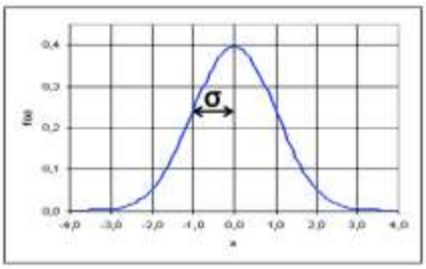
✖ true x/y • x/y GPS1

As we have a GPS, we'll use that. But, unfortunately, the GPS coordinates (●) we get will not be 100% exact, they differ from the true coordinates (✖). This is due to atmospheric interferences, the speed of the satellites and so on.

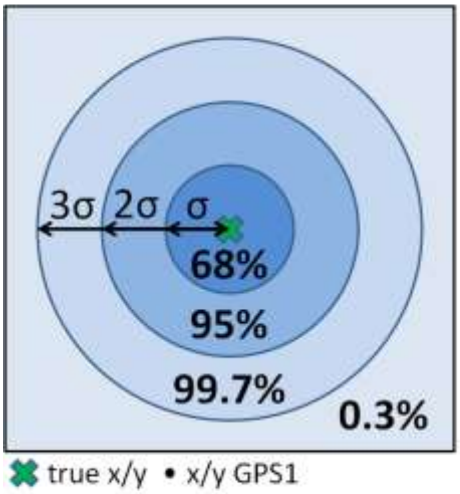


✖ true x/y • x/y GPS1

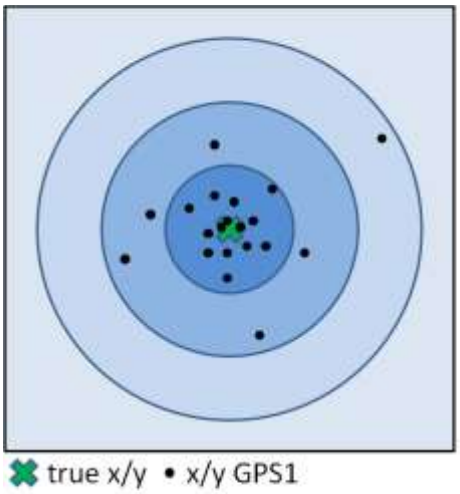
If we take several measurements at the exact same location at independent points in time (after 2min, 1hour, half a day etc.) we get different coordinates. The distance to the true coordinates is small for most of them, but some have a bigger offset.



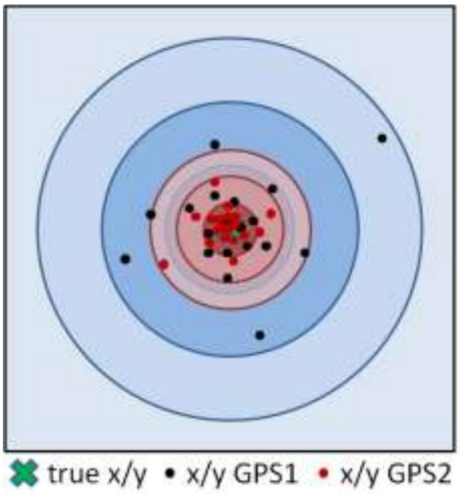
If you measure the distance between your GPS coordinates and the true coordinates, and make a statistic of this, you will get a curve like the one shown on the left: most coordinates are close to the true coordinates, only few have big discrepancies. Statisticians call this a **normal distribution** or **Gaussian distribution**.

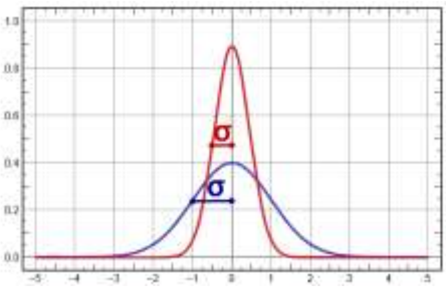


The Greek letter **σ** (a lower case Sigma) marks the turning point of the curve. When you start at bottom left, the curve mounts steeper and steeper until at σ the increase gets smaller, even though the curve is still ascending. This point is also known as the **standard deviation**. 68% of your measurements will be within a 1σ distance from the true coordinates. 95% will be within 2σ and 99.7% will be within 3σ.



So if you are measuring 20 coordinates (● as shown on the left), 14 points (68%) are within σ, 19 are within 2σ and only 1 is between 2σ and 3σ. However, these are statistical values. It could very well be, that your coordinates are among the 0.3% that are even further off than 3σ. If you have a 1000-sided dice, it is quite unlikely to roll a 998, 999 or 1000 – but it is not impossible!





Usually, surveyors will refer to accuracy as 3σ. If you ask them to provide you coordinates with a maximum of 1m difference to the true coordinates, they will take this as 3σ, so most of the coordinates are much more accurate.

Since your GPS has a given accuracy, the only way to improve the accuracy of your coordinates are to a) buy a GPS with another receiver and therefore better accuracy or b) change your measure method to DGPS (differential GPS), Tachymetry etc. In the image to the left, σ of GPS2 is smaller (<) than **σ** of GPS1, but the distribution scheme (68%, 95%, 99.7%) stays the same (check the two curves below).

Since the true coordinates (✖) remain unknown, manufacturers sometimes talk about **RMS** or root mean square, which is practically the same as **σ**.

Please be careful when checking technical specifications of GPS receivers. Most often, the accuracy specified by the manufacturer is 1σ. So if you want 99.7% of your points within 1m, you'd need a GPS receiver with a 1σ accuracy of 33cm!