The Final Transformation Type – The TwoStep

This newsletter is the final newsletter in the "series" of newsletters which describe in some detail the theory behind the 3 different transformation types which are available both on System1200 sensors and LGO. This newsletter will cover the theory of the **TwoStep** transformation.

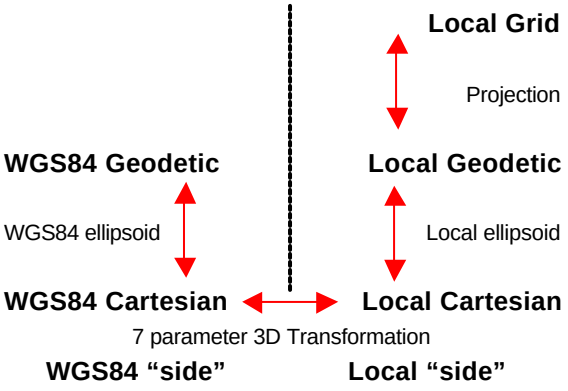
A future newsletter will bring all this theory to life with practical examples and also look in greater detail at combining GPS and TPS measured data.

Quick Recap

The Classic 3D Transformation

The last but one newsletter described how coordinates are converted between WGS84 coordinates and local grid coordinates using the **Classic 3D** transformation.

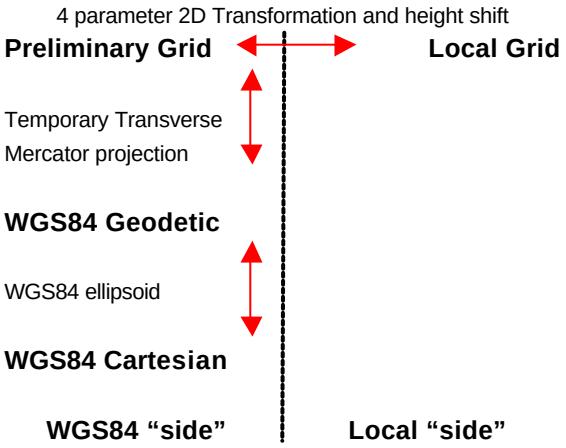
This conversion process was summarised with the diagram below – remind yourself of the different steps and coordinate types.



The advantage of the **Classical 3D** transformation is that it is the most rigorous transformation type - it is a similarity transformation, which keeps the full geometrical information. The disadvantage is that that knowledge of the **local ellipsoid** and the **map projection** is required and all common points have to be known in **position and height**.

The OneStep Transformation

The last newsletter described how coordinates are converted between WGS84 coordinates and local grid coordinates using the **OneStep** coordinate system. Again, remind yourself of the different steps and coordinate types with the diagram below.



The advantage of the OneStep coordinate system is that it is not necessary to know the local ellipsoid and projection, which makes it ideal to use in areas which use a completely arbitrary coordinate system. Additionally, it is possible to use common points for which the coordinates are known in only position or height.

The disadvantage of the OneStep transformation is that it is limited to areas of about 10km square.

The TwoStep Transformation

The **TwoStep** transformation combines the advantages of the two approaches. It allows common points to be used which are known only in position or height, but is not restricted to smaller areas.

However, as for the Classic 3D transformation, it is necessary to know the local ellipsoid and map projection.

How Does The TwoStep Work?

As the name would suggest, there are two steps in converting coordinates from WGS84 to local coordinates.

In the first step the **WGS84 Cartesian** co-ordinates are shifted closely to the local datum using a given Classical 3D **Pre-Transformation** to give **local Cartesian** coordinates. (This pre-transformation is entered by the user - see later).

The **local Cartesian** coordinates are then converted to **local geodetic** coordinates using the known local ellipsoid and then converted to **preliminary grid**, but unlike the OneStep transformation which uses an arbitrary Transverse Mercator projection, the TwoStep transformation uses the true map projection on which the local points are based. So far this is basically the same as converting coordinates from WGS84 to local grid.

So far we have converted our GPS measured points to local grid – we can now match these grid coordinates to the known grid coordinates of the local control points – this is the second step of the TwoStep coordinate system.

The two sets of grid coordinates are matched in exactly the same way as described last week with the OneStep transformation. The final part of the transformation is therefore a **2D positional transformation** and **height shift**.

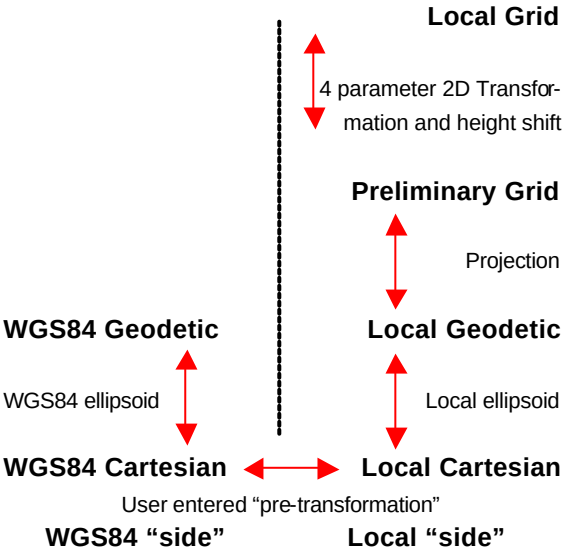
The full TwoStep coordinate conversion process is shown in the following diagram.

Why Use A TwoStep?

This probably sounds all very complicated, so why use a TwoStep transformation?

Compared to the OneStep transformation, the first step of the TwoStep transformation (when the WGS84 coordinates are converted to the preliminary grid) avoids any distortions due to the fact that the preliminary grid co-ordinates are built on a different ellipsoid to the local points. Even more importantly the influence of the scale factor of the map projection is now taken into account before the final 2D transformation is done.

For these reasons the transformation will fit much better over larger areas than a OneStep transformation. The height part is independent of the position transformation and is identical to the approach taken for the OneStep.

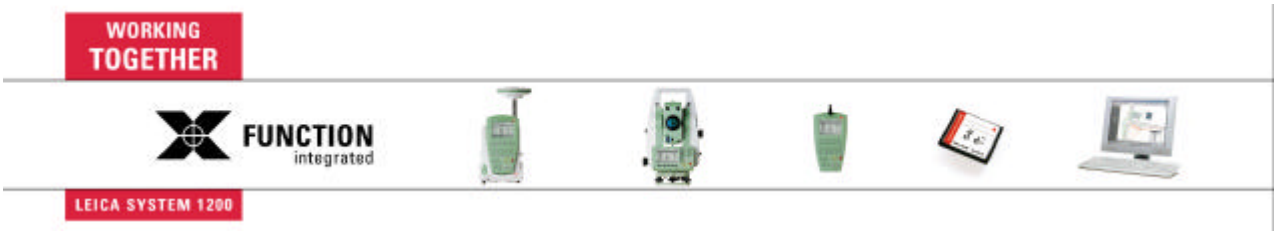


Note, when using a TwoStep transformation it is not possible to see the "preliminary grid" coordinates either in LGO or on the System1200 instruments. Only the final local grid coordinates are shown. This is correct since the "preliminary grid" coordinates have no practical use.

Which Pre-Transformation To Use?

So far, we have only briefly mentioned the pre-transformation – as shown in the diagram above, this is the 7 parameter transformation which is used to convert from WGS84 Cartesian coordinates to local Cartesian coordinates. The actual parameters may be known and can then simply be entered as a transformation on both System1200 instruments and LGO.

However, even if transformation parameters are not known it is still possible to use the TwoStep transformation. Create and select a



"null" transformation (zero shifts, rotations and scale) – this then gives you the advantage from the benefits of using the TwoStep transformation!

REMEMBER

The main advantage of the TwoStep transformation is that unlike the OneStep transformation, it is not limited to smaller areas and common points can be matched in **position and height**, in **position only** or **height only** to compute the transformation.

It is necessary to know the local ellipsoid and projection and also necessary to select a pre-transformation to use (although this may be a null transformation).

Please contact your local Selling Unit or local Leica dealer if there are specific topics you would like covered in these newsletters.

We welcome all suggestions for TPS1200, GPS1200, specific applications or LGO. We look forward to receive your ideas.