

## Exercise 4: GNSS coordinates transformation to the official UTM coordinates

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Handed out on:  
Submission deadline:

### 1 Learning objectives

Transformation of GNSS measurements to the official UTM coordinates. Applying coordinate transformations and understanding the basic concepts of different reference coordinate systems, reference frames, reference surfaces, geodetic datum and cartographic projections.

### 2 Task overview

The task of this exercise is to process the GNSS Ground Control Points (GCPs) or targets used for absolute georeferencing of laser scanning data from Exercise 3. The original GNSS coordinates are already transformed from WGS84 3D Cartesian coordinates  $(X, Y, Z)_{WGS84}$  into the European Terrestrial Reference System ETRS89. Transformation parameters between the WGS84 and the ETRS89 are frequently sent to the GNSS receiver over the internet connection so the transformation was made directly in the receiver. The task of the exercise is to transform the given ETRS89 coordinates into the official German coordinates (E,N,H). Facts to consider when solving the task:

- For easier interpretation on Earth surface, Cartesian coordinates  $(X, Y, Z)_{ETRS89}$  are usually transformed to ellipsoidal coordinates  $(\varphi, \lambda, h)_{ETRS89}$  based on the reference ellipsoid (GRS80).
- The official coordinates are separated by position (2D) and height (1D). The position is metric value and height is physical instead of ellipsoidal height.
- Official UTM coordinates in Germany are defined with ETRS89 datum using GRS80 ellipsoid in position and with GCG2016 datum and quasi geoid in height.
- In the case of North Rhine-Westphalia, all coordinates are within UTM zone 32N with central meridian  $9^\circ$ .

### 3 Prior knowledge and references

- Chapter 5 of lecture , GE-01, Coordinate Systems
- Kavanagh, B., Mastin, T.: Surveying. Principles and Applications, Pearson: USA, 2014
- Ogundare, J. O.: Precision Surveying: The Principles and Geomatics Practice, Wiley: London, UK, 2015
- P. Misra und P. Enge (2001): Global Positioning System – Signals, Measurements and Performance, Ganga Jumana Press, Lincoln, Massachusetts, USA, ISBN: 0- 9709544-0-9

### 4 Detailed description of task

1. Convert coordinates of the ground control points used for TLS georeferencing given in Table 1 from  $(X, Y, Z)_{ETRS89}$  to  $(\varphi, \lambda, h)_{ETRS89}$
2. Calculate 2D position in UTM coordinates (E,N) for the points given in Table 1.
3. Calculate normal height (H) for the points given in Table 1.

**Important notes:** For equations see lecture: *Chapter 5 - Transforming Geocentric Coordinates to Official Coordinates*. Calculate geoid undulation using the following webpage: Onlineberechnung von Quasigeoidhöhen mit dem GCG2016 (<http://gibs.bkg.bund.de/geoid/gscomp.php?p=g>):

- input:  $(\varphi, \lambda, h)_{ETRS89}$  (latitude – Breite, longitude – Länge)
- output: H, N

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**Table 1.** List of GNSS Ground Control Points (X,Y,Z)<sub>ETRS89</sub> With GRS80 ellipsoid

Point	X	Y	Z
1	4014691,4807	499159,7804	4914504,1202
2	4014693,4921	499129,1514	4914505,1480
3	4014702,3128	499118,6732	4914512,3298
4	4014690,7547	499107,1642	4914509,2009
5	4014680,8076	499093,7247	4914519,0356
6	4014679,6316	499104,9021	4914525,2361
7	4014666,1035	499126,5710	4914527,9093
8	4014655,0456	499085,6978	4914540,6428
9	4014695,5991	499072,5812	4914522,4115
10	4014697,7315	499063,3252	4914508,7475
11	4014688,1154	499069,7835	4914514,9929
12	4014712,5857	499080,5118	4914494,2050
13	4014712,8517	499110,1905	4914504,5892
14	4014694,4077	499085,9941	4914505,3307
15	4014706,9163	499100,2373	4914502,3367
16	4014713,8478	499066,5770	4914494,4486
17	4014726,5028	499120,1749	4914478,4482
18	4014737,4048	499082,2721	4914473,1388
19	4014700,2781	499114,4736	4914499,0416

**4. Upload to eCampus**

- Single zip file including:
  - The programming code used for solving the task (preferred MatLab or Octave)
  - Ascii file with UTM coordinates (E,N,H)
  - Print Screen of coordinates uploaded to Google Earth
- Uploaded file should be properly named. (Example: Exercise\_4\_Pavlic.zip).