Grids & Datums

The Kingdom of The Netherlands

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The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on The Kingdom of The Netherlands was originally printed in 2003 but contains updates to their coordinate system since then.

The kingdom was established in 1815 by French Emperor Napoleon, and initially controlled Belgium and Luxembourg. Inhabited since Paleolithic time, the region has been subjected to influences from early Celts, Germanic peoples, and Romans. The Netherlands is located at the mouths of three major European rivers: the Rhine, the Maas or Meuse, and the Schelde. With an area slightly less than twice the size of New Jersey, the kingdom borders the North Atlantic Ocean to its north and west (451 km), Belgium to its south (450 km), and Germany to its east (577 km). The terrain is mostly coastal lowland and reclaimed land (lowest point is Zuidplaspolder at –7 m); there are some hills in the southeast and the highest point is Vaalserverg (322 m).

Willebrord Snell van Roijen (*Snellius*) was born in 1580 in Leiden, the Netherlands, and studied law at the University of Leiden although he taught mathematics there while he studied law. Snell's father was a professor of mathematics, and in 1613 he succeeded his father as professor of mathematics at the University of Leiden. The following year, he innovated the first classical triangulation based on his discovery of the Law of Sines. Using a brass Quadrant with a radius of 60 cm and by measuring an initial baseline of 328 m (total of five bases), he observed a quadrangle starting at Leiden and proceeded to complete a chain of quadrilaterals between Bergen op Zoom and Alkmaar. Later *Snellius* measured noontime shadows of towers in order to determine the length of a degree of the meridian. In 1617, he published *Eratosthenes Batavus De Terrae Ambitus Vera Quanitate*, which detailed his proposed techniques that established the science of Geodesy. He also discovered optical refraction (Snell's Law) and explored the loxodrome, a word he coined.

Before 1790, there was no systematic large-scale mapping in the Netherlands, either national or regional. The first mapping efforts, from 1791 to 1794 and from 1807 to 1811, were made to support cadastral mapping for taxation. In 1811, Napoleon

I decreed that the entire country be surveyed and registered for the establishment of a cadastre. The Dutch Cadastre was established in 1832 and remained in the Ministry of Finance until 1973. Between 1809 and 1822, complete topographic mapping coverage of the Netherlands at a scale of 1: 115,200 was achieved based on the first primary triangulation, published in 1861, on older cartographic materials, and on plane table foils. The Topografisch Bureau was founded in 1815 under the Ministry of Defense and was renamed Topografisch Dienst Nederlands (TDN) in 1931. The old triangulation and mapping was cast on the ellipsoidal Bonne projection where the latitude of origin $\Phi_o = 51^\circ 30'$ N, the central meridian was based on the (then) Prime Meridian at Amsterdam, and the scale factor at origin was unity. The ellipsoid of reference was the Bessel 1841 where the semi-major axis (a) = 6,377,397.155 m, and the reciprocal of flattening ($^1/_f$) = 299.1528128.(I think the old Amsterdam Datum of 1802 was first referenced to the Krayenhoff 1827 ellipsoid.) The kilometric grid squares on the old series are numbered over each 1:50,000- scale sheet 0 to 40 West to East and 50 to 75 South to North, and a reference coordinate is given by sheet number and square number. The graticule was referenced to Amsterdam. The TDN has used aerial photogrammetry for mapping since 1932.

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A new triangulation was surveyed from 1886 to 1913 and published in *Triangulation du Royaume Des Pays-Bas*, the first volume in 1903 and the second volume in 1921. The origin of the Rijksdrihoeksmeting van het Kadaster of 1918 Datum (RD 1918) at the *Lieve Vrouwe* (Holy Virgin) Church tower in Amersfoort is $\Phi_o = 52^o\ 09'\ 22.178''$ N, $\Lambda_o = 5^o\ 23'\ 15.5''$ East of Greenwich, ($0^o\ 30'\ 15.522''$ East of Amsterdam), and $h_o = 0$ m. The ellipsoid of reference for RD 1918 is the Bessel 1841, and the Schreiber Stereographic double projection was chosen for the kingdom. The Stereographic Grid origin is at the RD 1918 origin; the False Easting is 155 km, the False Northing is 463 km, and the scale factor at origin is unity. The result of this particular choice for the false origin is that no East to West reference can be more than 280 km, and no North to South reference can be less than 300 km. A comparison was made by the Dutch between values of 12 trigonometric stations along the border, as determined by the new Dutch triangulation on the Bessel ellipsoid and the new Belgian (*PE&RS*, October 1998) values on the Hayford ellipsoid. The Dutch triangulation lies 2.95 and 10.0 centesimal seconds South and East, respectively, of the Belgian triangulation. According to Jacob A. Wolkeau of the U.S. Army Map Service, these differences were mainly due to residual differences in the respective Datum origins and the reduction of the triangulations on different ellipsoids of reference. Comparisons made by the Belgians showed varying differences of 4.4″ to 5.2″ in latitude and 6.1″ to 10.2″ in longitude. The figures used in the 1950s British map series revision of the Dutch maps to the adjacent Belgian maps were 4.6″ in latitude and 10.2″ in longitude determined from a number of primary stations along the border. The transformation of the RD1918 Datum to WGS84 Datum is defined by a seven-parameter Bursa-Wolfe shift using the standard NIMA *right-hand rotation* sign convention: $\Delta X = +565.036$ m, $\Delta Y = +49.914$ m, $\Delta Z = +465.839$ m, $R_x = +0.4094''$, $R_y = -0.3597''$, $R_x = +1.86854''$, and $\delta s = -4.0772$ ppm. A test point offered by Maarten Hooijberg in Practical Geodesy, 1997 is $\varphi_{RD1918} = 51^o\ 59'\ 13.3938''$, $\lambda_{RD1918} = 4^o\ 23'\ 16.9953''$, $h_{RD1918} = 30.696$ m$\rightarrow \varphi_{WGS84} = 51^o\ 59'\ 09.9145''$, $\lambda_{WGS84} = 4^o\ 23'\ 15.9533''$, and $h_{WGS84} = 74.312$ m. Incidentally, Hooijberg also states that the WGS84 coordinates of *Lieve Vrouwe* tower are $\varphi_{WGS84} = 52^o\ 09'\ 18.62''$, $\lambda_{WGS84} = 5^o\ 23'\ 13.9327''$, and $h_{WGS84} = 43.348$ m. The reader is cautioned that the parameters given above are expressed in the standard NIMA *right-handed rotation* sign convention. European software commonly utilizes a left-handed rotation sign convention that appears to be mysteriously favored by NATO countries *in lieu* of the standard that is recognized and used by the United States, Australia, and most (I guess) of the Western Hemisphere. The best explanation I have heard for this curious disparity is a certain senior geodesist in the U.S. National Geodetic Survey once mused, "They probably didn't understand the math!"

The RD 1918 was recomputed on the European Datum of 1950 (EU50) and referenced to the Hayford 1909 (International 1909) ellipsoid where $a = 6{,}377{,}388$ and $^1/_f = 297$. To transform from EU50 to WGS84, NIMA lists the three-parameter values as $\Delta X = 87 \pm 3$m, $\Delta Y = -96 \pm 3$m, $\Delta Z = -120 \pm 3$m, and the mean solution was based on 52 stations. To transform from EU79 to WGS84, NIMA lists the three-parameter values as $\Delta X = -86 \pm 3$m, $\Delta Y = -98 \pm 3$m, $\Delta Z = 119 \pm 3$m, and the mean solution was based on 22 stations.

The first known elevation benchmark in Europe was the Amsterdam City Watermark (*Amsterdams Peil* or *AP*). Although now lost, the original was set in 1684! In 1707, the city watermark (*AP*) was already indicated on a water gauge near Bilderham — 25 km from the original mark. Extensions of precise levels were not performed until Napoleonic times. General C.R.T. Krayenhoff supervised the extension of the vertical datum from Amsterdam to the rivers Rhine, Meuse, and Ijssel, and along the coast of the Zuiderzee. Ramsden's leveling instrument was used which utilized a spirit level vial attached to a telescope. Krayenhoff's initial point was the water gauge at Amstel Lock. The AP was decreed to be the general datum plane of the Netherlands in 1818, and by 1860 the AP was published as the datum reference for some 550 benchmarks of the Prussian Railroad system. In 1876, a level loop was run among the original five stones and the deviation from the mean height for these 200-year-old benchmarks amounted to a maximum of 4 mm! Because of subsequent confusion with various levelings carried into Germany, the Dutch introduced new leveling results in January of 1891 as *Normaal Amsterdams Peil*, or *NAP*. At that same time, the Germans changed the name for their usage to *Normal-Null*. By 1928, the German and Dutch levels were compared anew with the result being *NN* = *NAP* – 0.021 mm. The NAP is now extended from Lapland to Gibraltar and from Scotland to Sicily, based on the original Dutch work in 1684.

The Kingdom of The Netherlands Update

Detailed information on updates to the geodetic coordinate systems of the Netherlands can be found at:

Reference Systems for Surveying and Mapping

http://gnss1.tudelft.nl/pub/vdmarel/reader/CTB3310_RefSystems_1-2a_print.pdf

National Report of the Netherlands 2019 - EUREF

http://euref.eu/symposia/2019Tallinn/05-16-Netherlands.pdf

EUREF Permanent GNSS Network

http://www.epncb.eu/_networkdata/siteinfo4onestation.php?station=DELF00NLD

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