Grids & Datums

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REPUBLIC OF UZBEKISTAN

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 Republic of Uzbekistan was originally printed in 1998 but contains updates to their coordinate system since then.

This month's topic features the Republic of Uzbekistan, an ancient country (1200 BC) that lies in the heart of Central Asia and is the center of the territory formerly known as Cimmeria, Bactria, and Turkestan. The oasis cities of Samarkand, Tamerlane, and Tashkent served as major cities on the Great Silk Road that connected China with Europe. Uzbekistan is one of the only two doubly landlocked countries in the entire world (the other is Liechtenstein). The Fergana Valley was converted from its millennia-old agricultural tradition of varied crops to only cotton when the Aral Sea was diverted to irrigate the Soviet dream of a cotton-exporting capital. Uzbekistan gained its independence from the former Union of Soviet Socialist Republics on 31 August 1991, and now celebrates its independence holiday on September 1st.

In 1839, the Russian Imperial Army moved into the area of Turkestan and completed its occupation in 1867. The city of Tashkent was selected as the capital of the newly formed Government General of Turkestan, which at the time comprised the two provinces of Syr Darya and of Semiryechinsk. Provinces added later were: Samarkand 1868, Bukhara '69, Amu Darya '73, Khokanda '75, Khiva '75, Fergana '76, Turkmenia '84, and Transcaspia 1888. Colonization and railroad projects required topographic surveys, resulting in the 1867 formation of the Military Topographic Department of Turkestan. The Physical Observatory of Tashkent was officially founded by the Department in 1878.

The first classical triangulation was conducted from 1871-1895 with scale established at the baselines measured at Miny Yuryukh, Tokacha, Samarkand, Chuamy, Nikolskiy, and Visokoye. These baselines were oriented primarily on Miny Yuryukh Datum and later on Tashkent Datum, retaining the astronomic azimuth from the NW to SE end point of the Miny Yuryukh baseline. That orientation was geodetically transferred to the Tashkent Observatory Meridian Circle. Triangulations of 1896-1929 were scaled to baselines measured by invar wires (Jäderin base apparatus) at Kazalinsk, Arys, Osh, and Kyzyl Rabat, and oriented on Tashkent Datum, Kazalinsk Datum, and Osh Datum.

Miny Yuryukh 1871 Datum was established at the NW Base Point (M) where: Φ_o = 41° 17' 47.70" North, Λ_o = 38° 57' 00.04" East of Pulkovo, (where the Pulkovo Observatory is 79° 46' 19.56" East of Greenwich). Scharnhorst executed the astronomic observations and referenced the datum to the Bessel 1841 ellipsoid of revolution where the semi-major axis a = 6,377,397.155 meters and the reciprocal of flattening ($^1/_f$) = 299.1528128. The defining azimuth was determined at the point of origin to the SE Base point (N) as: α_o = 114° 26' 34.6". The Russian geodetic surveys were measured in units of sazhens.

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For instance, the 1874 Samarkand Baseline was 1,605 sazhens or 3,424 meters.

The early baselines were measured with wooden rods, however no information is available on what kind of wood was used. In the United States during the same time period, Magnolia wood was used for leveling rods because it was believed to have the lowest coefficient of expansion (from variations in temperature AND humidity) of all wood species. Note that the Americans (Coast & Geodetic Survey) still boiled their wood in paraffin just to make sure. (There's an interesting geodetic story on boiled wood I'll have to tell someday about Palmdale, CA.)

In order to make a topographic survey at 1:4,000 scale of the City of Tashkent, a traverse net was established in 1885 by Pomerantsev. The revised coordinates of the Tashkent Observatory SW pillar used for the city survey are: Φ_o = 41° 19' 30.42" North, Λ_o = 38° 58' 00.99" East of Pulkovo, (or 69° 17' 39.54″ East of Greenwich). The vertical datum of Tashkent was determined by means of barometric observations at the Meteorological Station of the Military Topographic Department located in the residence of Colonel Zhemchuznikov. The transfer of this vertical datum point value to other horizontal datum origins with trigonometric leveling techniques produced geodetic problems of mind-boggling proportions!

The physical connection between the Tashkent Datum of 1875 and the Indian Datum of 1916 in the Pamir region was made by an exploratory triangulation party of the International Geodetic Union. The expedition was led by Professor Finsterwalder in the early part of the 20th century. The 3-parameter shift from Tashkent to Indian is: dX = -223.632 meters, dY = –281.310 meters, dZ = +304.059 meters. (The fit of two points agree to better than a meter.) The Tashkent Datum of 1875 origin (at the Meridian Circle) is: Φ_o = 41° 19' 30.42" North, Λ_o = 69° 17' 39.54″ East of Greenwich. The defining azimuth at the point of origin to the North Stone Pillar (probably the mire) of the Observatory is: α_o = 00° 52' 08.25", and the ellipsoid of reference is the Bessel 1841. The Indian Datum of 1916 origin at Kalianpur Hill Station is: Φ_o = 24° 07' 11.26" North, Λ_o = 77° 39' 17.57″ East of Greenwich. The defining azimuth at the point of origin to station Surantal is: α_o = 190° 27' 05.10". The ellipsoid of reference is the Everest 1830, where a = 6,377,276.345 meters, and $^1/_f$ = 300.8017.

The Kazalinsk Datum of 1891 origin at the finial Cross on the Town Church is: Φ_o = 45° 45' 46.450" North, Λ_o = 62° 06' 01.66″ East of Greenwich). The defining azimuth at the point of origin to station Sulutan is: α_o = 20° 34' 07.34". The ellipsoid of reference again is Bessel 1841. The 3-parameter shift from Kazalinsk 1891 to Tashkent 1895 is: dX = +530 meters, dY = – 160 meters, dZ = – 104 meters. (The fit of four points agrees to about 20 meters in each geocentric component.)

The Osh Datum of 1901 origin is defined at Point II, Northwest Base as: Φ_o = 40° 37' 16.670" North, Λ_o = 72° 56' 11.175" East of Greenwich). The defining azimuth at the point of origin to Point I, Southeast Base is: α_o = 152° 54' 01.86". The ellipsoid of reference again is Bessel 1841. The 3- parameter shift from Osh 1901 to Tashkent 1895 is: dX = – 146.633 meters, dY = +472.553 meters, dZ = +508.352 meters. (The fit of seven points agrees to 4.19 meters in each geocentric component.)

In order to better model the shift and reduce the fit errors, I decided to try a Bursa-Wolfe 7-parameter shift. The results yielded an average fit error in Latitude of 0.48 meters, the error in Longitude was 1.09 meters, and the error in Height was 0.09 meters. The parameters that give this fit are: dX = +26.82 meters, dY = –183.11 meters, dZ = – 186.25 meters, scale = 39.25 x 106, R_z = – 07.79", R_y = +2.48", R_x = +21.49". As a computational "check point," Point II, Northwest Base on the Tashkent Datum of 1875 has the geodetic coordinates: φ = 40° 36' 55.740" N, λ = 72° 56' 22.880" E.

Uzbekistan has only one Grid system, and that is based on the Russia Belts, a series of Gauss-Kruger Transverse Mercator projections that use the exact same rules and parameters as UTM with two exceptions. The Krassovsky 1940 ellipsoid is used everywhere in the former USSR where a = 6,378,245.0 meters, and 1/ f = 298.3. The scale factor at origin is 1.0 rather than the 0.9996 scale factor used for UTM. The single unifying datum used in all of the former USSR is the "Coordinate System 1942," a consistent marvel that is the largest classical datum in the world! This datum is often improperly referred to after its origin, Pulkovo Observatory, where: Φ_o = 59° 46' 18.55" North, Λ_o = 30° 19' 42.09" East of Greenwich. The defining azimuth at the point of origin to Signal A is: α_o = 317° 02' 50.62". The latest 3-parameter shift values published by the National Imagery and Mapping Agency for the vicinity listed as Kazakhstan is from System 42 to WGS84, such that: dX = +15 meters, dY = – 130 meters, dZ = – 84. The stated accuracy is 25 meters in each component, which is the maximum error useable for 1:50,000 mapping, and that was based on only two points.

Update

A recent publication by Mirmakhmudov, E., Prenov Sh., Magdiev, Kh., and Fazzilova, D. on (the) ***Intermediate reference frame for Uzbekistan topographic maps,*** United Nations/Russian Federation Workshop on the Applications of Global Navigation Satellite Systems, Krasnoyarsk, 18-22.05.2015 states that Fazilova found in 2002 the transformation parameters **from** CS-42 **to** WGS84 are: ΔX = +23 m, ΔY = – 125 m, ΔZ = – 87 m. However, no accuracy estimate is offered.