Grids & Datums

Republic of Kazakhstan

by Clifford J. Mugnier, C.P., C.M.S.

"Humans have inhabited present-day Kazakhstan since the earliest Stone Age, generally pursuing the nomadic pastoralism for which the region's climate and terrain are best suited. The earliest well-documented state in the region was the Turkic Kaganate, which came into existence in the sixth century *A.D.* The Qarluqs, a confederation of Turkic tribes, established a state in what is now eastern Kazakhstan in 766. In the eighth and ninth centuries, portions of southern Kazakhstan were conquered by Arabs, who also introduced Islam. The Oghuz Turks controlled western Kazakhstan from the ninth through the eleventh centuries; the Kimak and Kipchak peoples, also of Turkic origin, controlled the east at roughly the same time. The large central desert of Kazakhstan is still called Dashti-Kipchak, or the Kipchak Steppe. In the late ninth century, the Qarluq state was destroyed by invaders who established the large Qarakhanid state, which occupied a region known as Transoxania, the area north and east of the Oxus River (the present-day Syrdariya), extending into what is now China. Beginning in the early eleventh century, the Qarakhanids fought constantly among themselves and with the Seljuk Turks to the south. In the course of these conflicts, parts of present-day Kazakhstan shifted back and forth between the combatants. The Qarakhanids, who accepted Islam and the authority of the Arab Abbasid caliphs of Baghdad during their dominant period, were conquered in the 1130s by the Karakitai, a Turkic confederation from northern China. In the mid-twelfth century, an independent state of Khorazm along the Oxus River broke away from the weakening Karakitai, but the bulk of the Karakitai state lasted until the invasion of Chinggis (Genghis) Khan in 1219-21. After the Mongol capture of the Karakitai state, Kazakhstan fell under the control of a succession of rulers of the Mongolian Golden Horde, the western branch of the Mongol Empire. The horde, or ***zhuz***, is the precursor of the present-day clan, which is still an important element of Kazak society. By the early fifteenth century, the ruling structure had split into several large groups known as khanates, including the Nogai Horde and the Uzbek Khanate. The present-day Kazaks became a recognizable group in the mid-fifteenth century, when clan leaders broke away from Abul Khayr, leader of the Uzbeks, to seek their own territory in the lands of Semirech'ye, between the Chu and Talas rivers in present-day southeastern Kazakhstan. The first Kazak leader was Khan Kasym (r. 1511-23), who united the Kazak tribes into one people. In the sixteenth century, when the Nogai Horde and Siberian khanates broke up, clans from each jurisdiction joined the Kazaks. The Kazaks subsequently separated into three new hordes: the Great Horde, which controlled Semirech'ye and southern Kazakhstan; the Middle Horde, which occupied north-central Kazakhstan; and the Lesser Horde, which occupied western Kazakhstan. Russian traders and soldiers began to appear on the northwestern edge of Kazak territory in the seventeenth century, when Cossacks established the forts that later became the cities of Oral (Ural'sk) and Atyrau (Gur'yev)" (*Library of Congress Country Study, 2010*).

A major First-Order chain commenced in Kazakhstan at the Aral Sea near the town of Aral, it followed the Syr Darya River through Kazalinsk and the now present Baykonur Cosmodrome which was the old Tyuratam Ballistic Missile Silo Farm — (*a discomforting sight 40+ years ago when I saw it imaged by the Corona Program — Ed.*). and finally down to Tashkent, Uzbekistan

With an area of about 2,717,300 square kilometers, Kazakhstan is more than twice the combined size of the other four Central Asian states and is slightly less than four times the size of Texas. The country borders China (1,533 km), (*PE&RS*, May 2000), Kyrgyzstan (1,224 km), Russia (6,846 km), Turkmenistan (379 km), and Uzbekistan (2,203 km), (*PE&RS*, December 1998). The lowest point is Vpadina Kaundy (–132 m), and the highest point is Khan Tangiri Shyngy (*Pik Khan-Tengri*) (6,995 m). Because of a catastrophic idea of the former Soviet Union, the two main rivers that flowed into the Aral Sea have been diverted for irrigation, it is now drying up and leaving behind a harmful layer of chemical pesticides and natural salts; these substances are then picked up by the wind and blown into noxious dust storms (*World Factbook, 2010*).

In the early 19th century the Russian penetration began into the area between the Caspian Sea and Iran, Afghanistan, and China. In 1839, the Russian Army moved into the area of Turkestan which was for centuries an object of struggle between Turko-Iranian and Chinese influences and completed its occupation in 1857. In 1867, the Military Topographic Department of Turkestan was formed and was headed by a major or brigadier general. The Astronomic and Physical Observatory of Tashkent was founded officially in 1878. The city of Tashkent, now the capital of Uzbekistan, became the capital of Turkestan, and by 1888 the region of Transcaspia, now in southwest Kazakhstan was incorporated as a new province. Geodetic triangulation performed between 1896-1929 was based on base lines measured with Jäderin apparatus (invar steel and brass wires) at Kazalinsk and Arys in Kazakhstan and oriented on the Tashkent Datum. 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 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 where a = 6,377,397.155 meters, and $^1/_f$ = 299.1528128. The Indian

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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: ΔX = +530 meters, ΔY = –160 meters, ΔZ = –104 meters. (The fit of four points agrees to about 20 meters in each geocentric component.)

The main chain from the Aral Sea to India, together with attached triangulations, represents a geodetic work not planned in advance, but executed differently by time, purpose, and accuracy. The enormous difficulties faced by triangulators during the field work in the regions with dense overgrowth along the Syr Darya River and in Fergana Valley, but particularly in the glaciers of the Pamir Mountains, meant that the survey procedures many times deviated from the basic standards of that time. Consequently also, accuracy dropped far below the claimed 2nd Order. There are no published observations or sides and angles of the triangle net but only geographic coordinates which for the triangulation established in 1896-1924 are fragmentarily included in the Catalog of Kazakhstan. During the revolution (1917-1921), many records of the chains which should be attached to the adjusted Main Chain were lost. The remaining data is buried in the "secret" crates held at the U.S. Army Documents Depository in Mineral Wells, Texas. Supposedly, this is done to avoid offending the deceased officials of the long-defunct U.S.S.R.!

In the *Zapiski Catalog, Vol. 41, part. III, Section 5, page 13,* the 1880 Triangulation in Semiryechenska Province details 37 trigonometric points of the local system oriented on the astronomic point Gorohudzir that was determined in 1879 by the chronometric expedition of Schwartz with: Φ_o = 44° 07' 41.87" North, Λ_o = 49° 26' 41.01" from Pulkovo (Λ_o = 79° 46' 19.56" East of Greenwich). Near the astro point a base line was measured and its astronomic azimuth determined by observation of α *Polaris*. However, these points were not included in the Catalog of COL. Gedeonov in the *Zapiski Vol. 53, part II, pp. 229-288*. (*Note that these references to "**Zapiski Catalog**" are the Annals of the Czarist Russian Topographic Brigades starting with volume 1 in 1837 by General Schubert. – Ed.*)

In the *Anuario of the (Argentine – Ed.) Instituto Geográfico Militar, 3er Volumen, 1914*, a history of the Russian Geodetic and Topographic activities of the 19th century is offered *in Spanish*. An annex of that Argentine *Anuario* provides a map of all Czarist Russian Geodetic work until 1912. A major First-Order chain commenced in Kazakhstan at the Aral Sea near the town of Aral, it followed the Syr Darya River through Kazalinsk and the now present Baykonur Cosmodrome, which was the old Tyuratam Ballistic Missile Silo Farm – (*a discomforting sight 40+ years ago when I saw it imaged by the Corona Program – Ed.*), and finally down to Tashkent, Uzbekistan. An independent semi-circular arc of First-Order triangulation had been surveyed in the vicinity of Akmolinsk (*now Aqmola – Ed.*), a mineral rich region of the Kazakh steppes, and dozens of astronomic observations had been completed throughout all of Kazakhstan and along the border with China.

The main 1901 chain from Orenburg to Tashkent through Kazakhstan was based on a Second-Order triangulation in support of the railroad and the irrigation project of the Syr Darya Valley. The section from the Aral Sea to Kazalinsk is 163 km long and contains 68 triangles, from Kazalinsk to Arys is 675 km long and contains 138 triangles, and from Arys to Osh at the border between Uzbekistan and Kyrgyzstan is 547 km long and contains 72 triangles. From the Second-Order stations of the main chain, Third-Order stations such as churches, mosques, smokestacks, water towers, monuments and mountain peaks were included. This totaled 358 Second-Order stations and 105 Third-Order points. All the stations were provided with permanent markers but they were not all uniform. At the beginning of the triangulation survey in 1901, ceramic cylinders were used; later stones and stone pillars with lead bolts and chiseled crosses were utilized. Some triangulators used subsurface markers consisting of bricks with chiseled crosses, and some covered surface markers with heaps of stones or with soil. End points of base lines were marked with both surface and subsurface marks, where bolts of lead or brass with engraved crosses were set into stone pillars or bricks. The base lines were measured with the standard Jäderin brass and invar apparatus. Sections of the main chain were computed and adjusted independently where different starting points were used. The northwestern section of the Syr Darya Valley observed in 1901 to Ob was computed from the old 1888 triangulation surveyed by Zalesky. The Kazalinsk base line measured from station Sulutem to Karmyz was measured in 1907 and was 8,863.3094 m ±0.00152 m, or 1:4,900.000. The Arys base line exit side measured from May Tyube to Kur Say was measured in 1913 and was 8,521.440 m ±0.049 m or 1:173,907 (*Triangulation in Turkestan and its Connection with India, Army Map Service Technical Report Number 21, Andrew M. Glusic, 100 pp., 1957*).

In 1998, geodetic surveys commenced in the Caspian Sea area of Kazakhstan, and the Russian System 42 Datum was used where the origin is at Pulkovo Observatory: 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", and the reference ellipsoid is the Krassovsky 1940 where: α = 6,378,245 meters, and $^1/_f$ = 298.3. The local grid system used in that area of Kazakhstan is the Gauss-Krüger Transverse Mercator where: the Central Meridian (λ_o) = 56° 46' E, False Northing Latitude of Origin (ϕ_{FN}) = 00° 08' 00" N, False Easting = 300 km, and the Scale Factor at Origin (m_o) = unity. The 3-parameter transformation **from** System 42 **to** WGS 84 in the Caspian Sea area of Kazakhstan is: ΔX = +14.471 m, ΔY = –132.753 m, ΔZ = –83.454 m, and is based on an occupation at five stations: Bolat, Yesim Sevirne, Dlinnaya Dolina, Daralsai, and Aul. The 7-parameter position vector transformation **from** System 42 **to** WGS 84 is: ΔX = +43.822 m, ΔY = –108.842 m, ΔZ = –119.585 m, R_x = –1.455", R_y = +0.761", R_z = –0.737", and δs = +0.549 ppm. A test point provided for this transformation is **from** System 42: ϕ = 46° 30' 00" N, λ = 50° 00' 00" E **to** WGS 84: ϕ = 46° 30' 00.321" N, λ = 49° 59' 55.513" E., this solution is based on a mean of 13 stations along the entire Kazakhstan coastline of the Caspian Sea, and is considered good to ±2 meters. Thanks go to Phil Smart, M.R.I.C.S. of RPS Energy.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for GeoInformatics (C⁴G).