

GRIDS AND DATUMS OF THE WORLD

This month's topic features Asia and, specifically, the former British Crown Colony of Hong Kong. The British occupied the Island in 1839. The Treaty of Nanking was signed in 1842 which ceded Hong Kong to Great Britain. The Convention of 1860 added Stonecutter's Island and in 1898, the New Territories were leased to Great Britain. The 99-year lease expired on July 1, 1997, and Hong Kong was restored to the People's Republic of China as a separate administrative region.

Triangulation stations first appeared on a map of Hong Kong produced in 1845 by Lt. Collinson of the Royal Engineers. Additional maps were produced in 1899/1900 and 1903/1904 with triangulation stations shown, but survey records no longer exist for those triangulations. The 2nd Colonial Survey Section of the Royal Engineers (Survey of India) did basic triangulation in 1924; others adjusted the observations in 1928-30, and again in 1946. This was adopted collectively as the main triangulation of Hong Kong.

Early planimetric plane table mapping was at 1:600 scale in Hong Kong and Kowloon. The Hong Kong New Territories Datum of 1924 (HKNT24) is defined on the Clarke 1880 ellipsoid where $a = 6378249.145$ meters, $1/f = 293.4650$, and 1 meter = 3.280869330 Hong Kong feet. Trig "Zero" was 38.4 feet due south of the transit circle of the Kowloon

Royal Observatory on Victoria Peak such that the datum origin was: $\Phi_0 = 22^\circ 18' 12.82''$ N, $\Lambda_0 = 114^\circ 10' 18.75''$ E, and azimuth from "Tai Mo Shan" (Trig 67.2) to "Au Tau" (Trig 94) = $292^\circ 59' 46.5''$. The Cassini-Soldner Grid system was used with its origin the same as the HKNT24 datum and with coordinates of 5.18 Ft. North and 0.38 Ft. East. Such strange-looking coordinates for a Grid origin are common for the 19th and early 20th centuries, and large areas of Hong Kong actually had negative coordinates.

In 1963, a re-triangulation was carried out because the HKNT24 network could not meet the accuracy requirements for large-scale mapping and cadastral surveys. The Hong Kong Datum of 1963 (HK63) was defined on the **older** Clarke 1858 ellipsoid where $a = 6378235.6$ meters, and $1/f = 294.2606768$. HK63 Datum, again with its origin at Victoria Peak, was used to develop a new Cassini-Soldner Grid with the false origin southwest of Lantau Island so that the coordinates in the Hong Kong New Territories were all positive values. The False Easting was 120,000 Ft. and the False Northing was 50,000 Ft. Subsequent mapping was performed at 1:1,200 scale. As mentioned previously in this column, the Cassini-Soldner is one of the old (but popular) **aphylactic** projections. The reader will recall that an **aphylactic** projection is not conformal, it is not equal-area, and it is not azimuthal. It was easy to construct with very simple tools and with

modest projection tables, and it was popular for British colonial and "expedition" mapping.

In 1963, the standard computational tool of the geodetic surveyor (and photogrammetrist) was an electric-powered mechanical calculator which was equipped with the very fancy square-root keys (the cost was 4 - 6 months pay). A rotary "pepper mill" Curta calculator (made in Liechtenstein and costing 2 - 3 weeks pay) would do just fine in a tent. (Note that the IBM 1620 electronic computer was the ultimate prize of a private geodetic survey corporation. Sometimes those computers had as much as 8K of ferrite-core memory. The equivalent British machine used in Hong Kong was the I.C.L. 2970 computer.)

In the 1960's, the **aphylactic** projections were still commonly used cartographic projections, including the polyconic used in the U.S., but they were a nightmare for the control surveyor. When I used to do control surveys with a T-2 theodolite and an electronic distance measuring (EDM) instrument or an invar tape, a significant correction for systematic error was (and still is) for the "scale factor" — the difference between true (geodetic) distance and map (grid) distance. Although such computations are straightforward with a conformal projection, **with an *aphylactic projection the scale factor varies as a function of the azimuth of the line being measured.*** Things were just dandy for the cartographer and the photogrammetrist with such grids, but the

field surveyor was perpetually immersed in exasperating daily calculations because of the HK63 Grid.

Ten years later in Boston, my brain used to go numb just punching out square roots of the diagonals of variance-covariance matrices one or two days a month for photo-block merges. Cadastral survey computations were pure drudgery in Hong Kong back in the 60's on a **daily** basis! In line with the metrication policy of the 1970's, the British Imperial (Cassini-Soldner) Grid was converted to metric units of measure in 1975-77 with the Grid origin further shifted 3,550 meters to the west such that False Easting = 33,016 meters, and False Northing = 15,240 meters. Some 3,000 sheets were also converted to 1:1,000 scale. A Photogrammetric Unit was formed in the Lands Department in 1976.

With the introduction of EDM instruments to Hong Kong in the late 70's, the distances between hilltop triangulation control points were resurveyed in 1978-79 to improve the consistency and accuracy of the control network. In this resurvey and adjustment, a new geodetic datum called Hong Kong 1980 (HK80) was adopted. The definition of the new datum was now referenced to old Trig 2 on Partridge Hill where: $\Phi_0 = 22^\circ 18' 43.68''$ N, $\Lambda_0 = 114^\circ 10' 42.80''$ E, and the azimuth was re-referenced from old Trig 67 (now lost) to Trig 94 turned as $292^\circ 52' 58.4''$. The Hayford (International) 1909 ellipsoid was adopted where $a = 6,378,188$ meters and $1/f = 298$. The **conformal** transverse Mercator pro-



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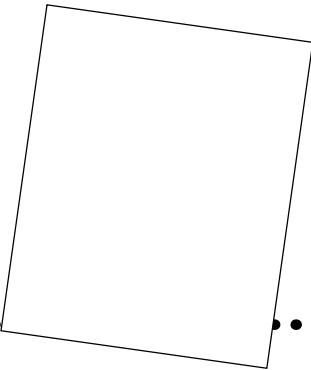
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Kimberly Tilley
Executive Editor, *PE&RS*
5410 Grosvenor Lane
Suite 210
Bethesda, MD 20814
301-493-0290, ext. 27
fax: 301-493-0208
email: kimt@asprs.org



jection (Gauss-Krüger) was used for the new rectangular grid system and was known as the Hong Kong 1980 Grid. The new False Easting = 836,694.05 meters and the new False Northing = 819,069.80 meters were referenced to the new datum origin. The scale factor at origin was unity ($m_0 = 1.0$), the same as the implicit definition of any Cassini-Soldner Grid.

Since the miserable aphylactic grid was gone forever, the Cadastral Land Surveyor's life was lifted from "sweat shop" conditions. The reobservation of the control network of Hong Kong had been accomplished by laser Geodimeter® model 600 positioning of survey points by trilateration rather than by microwave Tellurometer® or by Electrotape® observations because of nearby "radio jamming." A total of 162 lines had been measured, and the standard deviation of the combined network residuals was 0.45 parts per million.

In 1990, the Survey and Mapping Office, Lands Department, started to apply the GPS technique for fixing positions of survey control points. A territory-wide observation on a network of 15 stations (12 of which are at existing trig stations) was carried out by the No. 512 Specialist Team, Royal Engineers of the U.K. Military Survey using GPS (NAVSTAR) and Doppler (TRANSIT) satellite techniques. The network was adjusted with high accuracy results. This survey provided a rigid link between the local HK80 Geodetic Datum and the global WGS84 Datum. Currently, the WGS84 Datum is used with a UTM Grid for tourist and hiking

maps. The cadastral and engineering surveys continue to use the HK80 Datum for day-to-day use, although aided by differential GPS.

In Hong Kong all heights and levels on land refer to the Principal Datum which was formerly known as the Ordnance Datum. The HKPD was originally determined by observation of the tides from 1887-1888. A later observation of the full metonic cycle (18.6 years) was performed by the Royal Observatory from 1965-1983 at North Point, Victoria Harbor. "Mean Sea Level" is approximately 1.23 meters above HKPD. The original monument was "Rifleman's Bolt," a copper bolt fixed in the Hong Kong Naval Dockyard by personnel from H.M. Surveying Vessel "Rifleman" in 1866. It is now preserved for its historical value at the eastern wall of Blake Block in H.M.S. Tamar.

The Chart Datum, formerly known as the Admiralty Datum, is approximately the level of Lowest Astronomical Tide and is adopted as the zero point for Tide Tables since 1917. The Chart Datum is approximately 1.38 meters below HKPD. The Royal Engineers determined WGS84 ellipsoid heights in 1991. In general, the WGS84 heights are 2.4 meters higher in the west and 0.4 meters in the east of Hong Kong. The accuracy of this geoid separation is estimated to be better than ± 0.15 meters.

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