Grids & Datums

Republic of Singapore

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A Malay city of importance in the 13th century, the area now known as Singapore was destroyed by the Japanese in the 14th century, and remained a ruin until re-founded by Sir Thomas Stamford Raffles in 1819 for the British East India Company. Singapore became the capital of the Straits Settlements in 1833. (*Webster's Geographical Dictionary*) It joined the Malaysian Federation in 1963 but separated two years later and became independent on August 9th. The islands of Singapore have a total area of 693 km^2, and the republic is slightly larger than 3½ times the size of Washington, D.C. The terrain of Singapore is lowland, and has a gently undulating central plateau containing water catchments and a nature preserve. The lowest point is the Singapore Strait (0 m), and the highest point is Bukit Timah (166 m). (*CIA Factbook*)

The Singapore Survey Department commenced its operation in 1826. It was then under the administration of the Assistant Engineer of the British Army Garrison who was the Surveyor and Registrar of Titles. Officers of the local Garrison conducted Land Survey work until 1847. For the next 20 years, the supervisory control was passed to the Surveyor-General of Bengal (Survey of India). In 1879, the department was incorporated with the Public Works Department and was under the direction of MacCallum, the Colonial Engineer, assuming the office as Surveyor-General. In 1881, he instituted the practice of marking boundaries with granite stones. Some of those original monuments can still be found in rural areas. From 1942 to 1945, the department functioned as part of the Property Department of the Municipal Administration. In 1946, the department was separated from the survey departments of the Federation of Malaya. From 01 June 1959, the administration of the department came under the charge of the Chief Surveyor, Singapore. Except for a brief period from 16 September 1963 to 09 August 1965 when Singapore was part of Malaysia, the department was under the portfolio of the Minister for Law. The department was re-organized in June 1965 in preparation for fulfillment of its role as an autonomous agency in April 1996. With the re-organization, four technical sections, namely Control Survey Section, Inspection Survey Section, Survey Services Section, Mapping and Records Section together with Administration Section were formed to carry out its functions. (*Singapore Ministry of Law*)

Geodetic triangulation in Singapore by British Royal Engineers was initiated in 1904 as part of the "Primary Triangulation of Malaya," published in 1917. According to A.G. Bazley in "Geographical Positions in Malaya and Siam," (*Empire Survey Review, No. 30, "Malaya*. -The geographical positions of points were dependent upon latitude and azimuth determinations at Bukit Asa (*Asa Hill near the Lower Pierce Reservoir – Ed.*), and on the longitude of Fort Cornwallis Flagstaff in Penang, the latter being supposed to be 100° 20' 44.4" E. This value was obtained by Commander (later Admiral) Mostyn Field in H.M.S. *Egeria* (in) 1893, by the exchange of telegraphic signals with Mr. Angus Sutherland at Singapore, Old Transit Circle. The longitude, 103° 51' 15.75" E., accepted for Singapore in order to arrive at this determination of Fort Cornwallis Flagstaff, was based upon that of an Observation Spot, 103° 51' 15.00" E., fixed in 1881 by Lieutenant Commander Green, United States Navy, by meridian distance from the transit circle of Madras Observatory; the corresponding longitude of the latter being taken as 80° 14' 51.51" E.

"In 1894-96 another value of the longitude of Madras, 80° 14' 47.06" E., was determined via Potsdam, Teheran, Bushire, etc., which value was later increased by 1.635 seconds of arc as a result of Albrecht's adjustment of European longitudes, the accepted longitude of Madras thereby becoming 80° 14' 48.69" E.; this is 2.82 seconds of arc, if the Green meridian distance across the Bay of Bengal and the latest astronomical longitude are accepted. After applying this correction, the geodetic longitude of the mark at Singapore Government Offices becomes 103° 51' 07.96" E., whereas the astronomical longitude depending upon the same position of Madras is 103° 51' 05.28" E., the respective meridian distances between Government Offices and Fort Cornwallis Flagstaff being: Geodetic … 3° 30' 26.38"; Astronomical … 3° 30' 23.70".

"The possibility of a junction with Siam on the north and with the Dutch East Indies on the south, combined with the fact that it had in many cases been found difficult to account for the differences between modern standard traverses and the triangulation used to control them, resulted in the old 1917 triangulation being superseded by another which does attain to the degree of accuracy expected of a modern survey.

"*The Geodetic Survey of Malaya*. – The new triangulation, details of which were published in 1931, extends from Kedah, including Penang, to Singapore, with a secondary chain through Kelantan. The latitudes and azimuths depend upon new determinations at Kertau, but the longitudes depend upon the value of Kertau from the F.M.S. (1917) (*possible meaning is "Fundamental Malayan Survey of 1917"–Ed.*) data–which, as already stated, was based on Fort Cornwallis Flagstaff–the value being 100° 20' 44.4" E. If the same (1917) figures for Kertau are accepted, however, the new triangulation places the flagstaff in longitude 100° 20' 44.09".

"The principal station at Singapore in the new survey is Mt Faber, situated 50.62" south and 2' 00.88" west of Government Offices,

while at Fort Cornwallis the trigonometrical station is 0.403" north and 0.631" east of the flagstaff; allowing for these connexions, we find that the new geodetic meridian distance between Singapore Government Offices and Fort Cornwallis Flagstaff is 3° 30' 26.02".

"In addition to the different datums for latitude and longitude used in the 1931 triangulation, between the old and the new geodetic work there are differences in azimuth varying from 1 to 3 minutes, together with small differences of varying amounts in scale, on the average about 1 foot in 40,000 feet. The latitudes and longitudes of the 1931 survey appear to be respectively 2.5 and 9 seconds of arc too great, and are to be investigated further."

The Kertau Datum was revised for West Malaysia and Singapore the same year that the Timbalai Datum was published for East Malaysia by the Survey of India. The origin point for the Revised Kertau Datum of 1948 is: Φ_o = 03° 27' 50.71" N, Λ_o = 102° 37' 24.55" East of Greenwich; the deflection of the vertical components are: ξ_o = 3.47", η_o = –10.90". The ellipsoid of reference is the Everest 1830 (revised) where a = 6,377,304.063 m, $1/f$ = 300.8017. The plane coordinate system associated with this datum is the Singapore Cassini-Soldner Grid such that the origin is the Flagstaff at the Empress Place Building where: the Latitude of Origin, (ϕ_o) = 1° 17' 15.08" N, the Central Meridian, (λ_o) = 103° 51' 10.78" E, the scale factor at origin, (m_o) = 1.0, both the False Easting and False Northing = 30 km. The datum shift parameters listed in the now-obsolete *DMA/NIMA TR8350.2* **from** Kertau 1948 Datum **to** WGS84 Datum are: ΔX = –11 m ±10 m, ΔY = +851 m ±8 m, and ΔZ = +5 m ±6 m, and six points were used in the 1987 solution. NATO lists the datum shift parameters as a 7-parameter Bursa-Wolf transform, *herein modified to the Standard American Rotation Convention* as: ΔX = –366.94 m, ΔY = +719.29 m ±8 m, and ΔZ = –88.93 m, δs = +9.093, R_x = +2.498", R_y = +2.142", Rz = –12.057", however NATO does ***not*** state the accuracy of the transformation parameters nor do they indicate the number of collocated points used for their published solution!

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There's a new geocentric datum in town for Singapore, originally termed the SVY-95 Datum and now renamed as "SVY-21." The "origin" is listed as being at BASE7: ϕ_o = 1° 22' 02.915414" N, λ_o = 103° 49' 31.975227" E, h_o = 26.824 m, H_o = 17.113 m, however no explanation is offered regarding how a geocentric datum can have a datum origin! The plane coordinate system is now based on a Transverse Mercator projection where: ϕ_o = 1° 22' 00" N, λ_o = 103° 50' 00" E, Scale Factor at Origin (m_o) presumably is unity, False Easting = 128,001.642 m, and False Northing = 138,744.572 m. Presumably, the mapping equations are the Gauss-Krüger, but it really doesn't make a difference considering the size of Singapore. The parameters have been chosen so that coordinates in this new datum will be close to the Cassini-Soldner coordinates but with an additional 100,000 m to both the Northings and Eastings. The resulting "1" prefix is intended to easily distinguish between the Cassini-Soldner coordinates and the Integrated Survey Network (ISN) coordinates.

The new SVY-21 Datum geodetic coordinates of the Flagstaff at the Empress Place Building are: ϕ = 1 17' 15.5294" N, λ = 103° 51' 10.8046" E. The Flagstaff is one of three fiducial points held for the readjustment of the new datum. Bin and Chai published a paper titled, "Improving Cadastral Survey Controls using GPS Surveying in Singapore" in *Survey Review*, **3**3, 261 (July 1996). In that paper, the authors state that they used the Leica "SKI" software package to derive auxiliary parameters to convert GPS vectors into the Revised Kertau Datum. Since that Swiss package uses the European Rotation convention, those *four* parameters converted to the American Standard Rotation convention **from** Revised Kertau Datum of 1948 **to** SVY-21 Datum are as follows: δs = +0.9475 ppm ±0.23 ppm, R_x = –6.4227" ±0.34", R_y = +3.8310" ±0.21, R_z = +7.2881" ±0.16". "The average difference for 58 stations in both latitude and longitude is 0.0006" or 0.018 m." Note that the equations for all of the transformations described herein are in the ASPRS *Manual of Photogrammetry, 5th* edition.