Grids & Datums

Republic of Indonesia

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

"Beginning in the 1890s, paleontologists discovered fossil remains of creatures on the island of Java that, while probably not the direct ancestors of modern humans, were closely related to them. These Javan hominids, known by scientists as *Homo erectus*, lived 500,000 years ago and some possibly as long as 1.7 million years ago. Evidence of probable descendants of the Trinil *erectus*, known as *Homo soloensis* or Solo Man, was found at Ngandong, also in Central Java; these descendants are thought to have evolved between 500,000 and 100,000 years ago. Assemblages of stone tools have not clearly been tied to *Homo soloensis*, but there is evidence that these early *Homo sapiens* had a rudimentary social organization (small hunting and gathering bands) and used simple tools around 40,000 years ago. Although Indonesia is extremely diverse ethnically (more than 300 distinct ethnic groups are recognized), most Indonesians are linguistically--and culturally--part of a larger Indo-Malaysian world encompassing present-day Malaysia, Brunei, the Philippines, and other parts of insular and mainland Asia" (*Library of Congress Country Study*, 2009). The Dutch began to colonize Indonesia in the early 17th century; Japan occupied the islands from 1942 to 1945. Indonesia declared its independence after Japan's surrender, but it required four years of intermittent negotiations, recurring hostilities, and UN mediation before the Netherlands agreed to transfer sovereignty in 1949. Indonesia's first free parliamentary election after decades of repressive rule took place in 1999. Indonesia is now the world's third-largest democracy, the world's largest archipelagic state, and home to the world's largest Muslim population. Slightly less than three times the size of Texas, Indonesia is bordered by Timor-Leste (228 km), Malaysia (*PE&RS*, April 2009) (1,782 km), and Papua New Guinea (*PE&RS*, March 2005) (820 km). The lowest point is the Indian Ocean (0 m), the highest point is Puncak Jaya (5,030 m), and the region is tectonically unstable with some 400 volcanoes, of which 100 are active (*World FactBook*, 2009).

"In 1850 the Geographical Service was founded as a part of the Navy Department, and Mr. De Lange was sent from Holland in order to determine the geographical positions of various stations in the Archipelago by astronomical observations; de Lange was the first who made some elementary triangulations in the Netherlands East Indies. In 1857, Dr. Oudemans, afterwards professor in astronomy at the University of Utrecht, came to India (*Indonesia – Ed.*) in order to execute astronomical observations for surveying purposes, but soon he convinced the government of the necessity of a regular triangulation of Java, not only for the topographical survey, but also for scientific purposes. The primary triangulation of Java, started in 1862, was finished in 1880 and soon after that the Geographical Service was dissolved. The whole system has 114 points, situated on the highest mountains, and three bases (*Simplak [3,887.696 m.], Tangsil [5,040.73 m.], and Logantoeng [4,175.874 m.] – Ed.*). The coordinates of the Java triangulation-system are founded on a latitude-and-an azimuth determination at Genoek; for the computation of the longitudes the meridian of Batavia (former time-signal station) was taken as zero. (*Note that the origin of Goenoeng Genoek 1873 is where: Φ_o = –06° 07' 39.520" S, Λ_o = +106° 48' 27.790" East of Greenwich, deflections of the vertical where: ξ = –0.20", η =+11.0", and the ellipsoid of reference is the Bessel 1841 where: a = 6,377,397.155 m, $1/f$ = 299.1528128 – Ed.*)

"In 1883 a beginning was made with the survey of West Sumatra, and a Triangulation Brigade was founded as a part of the military Topographical Service. The primary triangulation in Sumatra consists of 118 points, its angles were measured with 27 cm micrometer-theodolites from Pistor and Matins, Wegener and Wanschaff. It consists of three sections, the triangulation of West Sumatra (1883-1896), that of South Sumatra (1895-1909) and that of the Residency of Sumatra's Eastcoast (1907-1916). The linear dimensions of Sumatra's Westcoast system are computed from the base line at Padang, measured in 1881 with steel tapes; those of South Sumatra are deduced from the Java-system, while in the triangulation-system of Sumatra's East coast a base line was measured at Sampoen in 1910 (*[6,666.476 m.] – Ed.*). This base was the first one measured with invar wires; since then 5 other bases were measured in this way in the Netherlands East Indies. The position of the West Sumatra-system on Bessel's ellipsoid was until now deduced from a latitude- and azimuth determination at Padang, the longitudes being calculated relative to the meridian of the western end of the base line (*[3,986.149 m.] – Ed.*). (*Note that the origin of Padang BP-A 1884 is where: Φ_o = –00° 56' 38.414" S, Λ_o = +100° 22' 08.804" East of Greenwich, H_o =3.190 m, and deflections of the vertical are where: ξ = –6.0", η = null, as computed in the Java system – Ed.*)

> ***"In the flat and swampy parts of Sumatra and Borneo (Kalimantan – Ed.), covered with primeval forests, a triangulation is practically impossible and would anyhow be too expensive. So the necessary fixed points for the surveying, which are chosen near the rivers, are determined astronomically."***

"The primary triangulation in Celebes (*Sulawesi – Ed.*) was begun in 1911. The angles of the primary system were measured as in Sumatra; three bases (Djeneponto 1911 *[10,476.168 m.]*, Tondano 1915 *[7,205.647 m.]*, Korodolo 1920 *[6,567.518 m.]*) were measured with the Jäderin apparatus (*used with 25 m. brass & invar wires – Ed.*). Its place on Bessel's ellipsoid was fixed by a latitude- and an azimuth-determination at Montjong Lowé P1, (*Note that the origin of Montjong Lowé P1 1911 is where: Φ_o = –05° 08' 41.42" S, Λ_o = +119° 24' 14.94" East of Greenwich – Ed.*) and a telegraphic longitude-determination at Makassar (*Ujungpadang – Ed.*) in 1891. *[Note: The French published the 1891 astronomic coordinates of Makassar as: Φ_o = –05° 08' 09.8" S, Λ_o = +119° 24'03.4" East of Greenwich (Annales Hydrographiques, 2e série, Tome Quatorziéme, année 1892, Paris, pp. 351-355) – Ed.*)

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Transverse Mercator, or any other projection having the same origin. The origin specifications of one such projection are an odd multiple of 10 minutes from the Equator; and odd multiple of 10 minutes from the meridian of Padang or that of South Sumatra (3° 15' West of Batavia).

"The *Topografische Dienst* designed numerous Bonne Grids for the various residencies of Java. These have been abandoned presumably because they were not of the conformal type and hence were awkward for survey work. All positions in Java are now expressed in terms of the Polyhedric Projection, as described for Sumatra. The origin is the intersection of the Equator with the meridian of Batavia.

"In Borneo, in addition to the Polyhedric coordinates, a system of Mercator coordinates, similar to that employed on Sumatra was used. The origin, however, is the intersection of the Equator with the meridian of 7° East of Batavia.

"The *Topografische Dienst* used a Mercator Grid in Celebes similar to that described for Sumatra, except that the origin is at the intersection of the Equator with the meridian of 15° East of Batavia. The longitudes of the sheet lines on Celebes likewise are based on the 15th meridian east of Batavia. In the Lesser Sundas, a Mercator Grid whose central meridian was 8° 15' West of Batavia was used. In Halmahera and Amboina, a Mercator Projection with the central meridian 22° East of Batavia was employed. The Prime Meridians used by the *Topografische Dienst* are as follows, all with reference to Greenwich: Batavia, +106° 48' 27.79" East; Padang, +100° 22' 01.42" East; South Sumatra, +103° 33' 27.79" East; Singkawang, +108° 59' 41.00" East; Middle Celebes, +121° 48' 27.79" East.

"The Netherlands East Indies Southern Zone covers Java and the Lesser Sunda Islands. Its specifications are: Projection: Lambert Conformal Conic; ellipsoid: Bessel 1841; Unit: Meter; Origin: 8° South, 110° East; False Coordinates of Origin: 550,000 meters East, 400,000 meters North; Scale Factor: 0.9997; Limits: North: From the junction of the zero Easting grid line of the zone and the loxodrome whose end points are 7° South - 104° 30' East and 5° South - 107° East; Northeast to end point at 5° South, 107° East; thence east on the parallel of 5° South to 117° 30' East; thence south along this meridian to 7° South thence east along this parallel to 137° East. East: Meridian of 137° East. South: West to 125° East on the parallel of 11° South; thence south along this meridian to 12° South; thence west along this parallel to 120° East; thence north along this meridian to 11° South; thence west along this parallel to the Zero Easting grid line of the zone. West: Zero meter Easting grid line of the zone. Early in 1942, DSvy (*UK Military Directorate of Survey – Ed.*) published some maps on Java on which this grid appeared with an increase of 3,000,000 meters to the Eastings and 1,000,000 meters to the Northings.

"The remainder of the East Indies, except for a small section of New Guinea south of 7° South, is covered by the Netherlands East Indies Equatorial Zone whose specifications are: Projection: Mercator; ellipsoid: Bessel 1841; Unit: Meter; Origin: Equator, 110° East; False Coordinates of Origin: 3,900,000 meters East, 900,000 meters North; Scale Factor: 0.997; Limits: North: Along the parallel of 7° North to the meridian of 98° 40' East; thence south along this meridian to 4° 40' North; thence loxodrome to point 103° 50' East - 0° 30' North; thence east along the parallel of 0° 30' North to 105° East; thence north along this meridian to 7° North; thence east along this parallel to 119° 30' East; thence south along this meridian to 5° North; thence east along this parallel to 165° East. East: Meridian of 165° East. South: Along the parallel of 5° South to the meridian of 153° 30' East; thence south along this meridian to 7° South; thence west along this parallel to 117° 30' East; thence north along this meridian to 5° South; thence west along this parallel to 107° East; thence loxodrome to point 104° 30' East - 7° South; thence along parallel of 7° South to 94° East. West: Meridian of 94° East" (*Notes on East Indies Maps, Theater Area T, Army Map Service, pp. 149-157, March 1945*).

According to *TR8350.2*, **from** Djakarta (Batavia) or Genuk Datum **to** WGS84: ΔX = –377 m ±3m, ΔY = +681 m ±3m, ΔZ = –50 m ±3m. However, according to the *EPSG v.6.18*, "Note: The area of use cited for this transformation (Sumatra) is not consistent with the area of use (Java) for the Batavia (Genuk) coordinate reference system and was derived at 5 stations." An *EPSG v.6.18* alternative is **from** Djakarta (Batavia) or Genuk Datum **to** WGS84: ΔX = –378.873 m, ΔY = +676.002 m, ΔZ = –46.255 m, reportedly "used by ARCO offshore NW Java area." Another *EPSG v.6.18* alternative is **from** Djakarta (Batavia) or Genuk Datum **to** WGS84: ΔX = –377.7 m, ΔY = +675.1 m, ΔZ = –52.2 m, reportedly "used by PT Komaritim for Nippon Steel during East Java Gas Pipeline construction." Also according to *TR8350.2* for Banga and Belitung Islands, **from** Bukit Rimpah Datum **to** WGS84: ΔX = –384 m, ΔY = +664 m, ΔZ = –48 m, however no accuracy estimate is available. According to Bakosurtanal, **from** ID74 Datum **to** DGN95 Datum: DX = –1.977 m ±1.300 m, ΔY = –13.06 m ±1.139 m, ΔZ = –9.993 m ±3.584 m, R_x = –0.364" ±0.109", R_y = –0.254" ±0.060", R_z = –0.689" ±0.042", δs = $-1.037 \times 10^{-6} \pm 0.177 \times 10^{-6}$, and the model is defined as a ***Coordinate Frame Rotation***. According to *TR8350.2*, **from** ID74 Datum **to** WGS 84: ΔX = –24 m ±25m, ΔY = –15 m ±25m, ΔZ = +5 m ±25m. According to the *EPSG v.6.18*, for the area of south west Sulawesi, **from** Makassar Datum **to** WGS 84: ΔX = –587.8 m, ΔY = +519.75 m, ΔZ = +145.76 m. According to *TR8350.2*, **from** Gunung Segara Datum **to** WGS 84: ΔX = –403 m, ΔY = +684 m, ΔZ = +41 m. According to the *EPSG v.6.18*, **from** Gunung Segara Datum **to** WGS 84: ΔX = –387.06 m, ΔY = +636.53 m, ΔZ = +46.29 m, as originally obtained from Shell Oil Co. Furthermore, for northeast Kalimantan **from** Gunung Segara Datum **to** WGS 84: ΔX = –403.4 m, ΔY = +681.12 m, ΔZ = +46.56 m, also from Shell. For east Kalimantan - Mahakam delta area, **from** Gunung Segara Datum **to** WGS 84: ΔX = –404.78 m, ΔY = +685.68 m, ΔZ = +45.47 m, from Total Indonesia. These variations of transformation values from one datum to another are normal because of the variability of systematic errors encountered with classical geodetic datums. The large number of such published values for the Republic of Indonesia is due to the historical level of interest for the exploration and production of natural resources.

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"The primary triangulation in the Small Soenda Archipelago was extended in the period 1912-1918 eastward over Bali and Lombok. The primary triangulation only contains 11 points. The primary triangulation in Bangka consists of an isolated system of 14 points. At Bakem a base line was measured (1926) with the Jäderin apparatus and invar wires (*[5,221.763 m.] – Ed.*), while longitude, latitude and azimuth were determined (1926) at Bukit Rimpah. (*Note that the origin of Bukit Rimpah 1926 is where: Φ_o = –02° 00' 40.16" S, Λ_o = +105° 51' 39.76" East of Greenwich – Ed.*) A beginning with this triangulation was made in 1917, but from 1921–1926 the work was temporarily stopped.

"Triangulation computations were carried out in the projection of Mercator and from the coordinates in this projection the geographic coordinates and those in the polyhedral projection are derived. In the flat and swampy parts of Sumatra and Borneo (*Kalimantan – Ed.*), covered with primeval forests, a triangulation is practically impossible and would anyhow be too expensive. So the necessary fixed points for the surveying, which are chosen near the rivers, are determined astronomically." (*Excerpted from: Geodetic Survey in the Netherlands East Indies, Schepers, J.H.G., and Schulte, Capt. F.C. A., Topographische Dienst, 1931, 17 pages*). There are two classical Indonesian datum origins on Borneo: Gunung Serindung Ep. A 1962 where: Φ_o = +01° 06' 10.60" N, Λ_o = +105° 00' 59.82" East of Greenwich, and Gunung Segara P5 1933 where: Φ_o = –00° 32' 12.82" S, Λ_o = +117° 08' 48.47" East of Greenwich, both referenced to the Bessel 1841 ellipsoid. For Timor, Koepang (Kupang) Datum is known to exist.

A major geodetic network commonly used in the 1980s "that stretches from North Sumatra through to Java and the Lesser Sunda Islands is the Genuk Datum with origin at Gunung Genuk P-520 where: Φ_o = –06° 26' 53.350" S, Λ_o = +110° 55' 05.836" East of Greenwich, H_o = 716.700 m. In an attempt to provide a means of connection between individual datums, and to provide a means of readjustment for geodetic data into a single datum the Indonesian Government adopted the parameters of the Geodetic Reference System of 1967 (GRS-67) as that of the Indonesian National Spheroid (INS). These parameters were referenced to the Datum Point at Padang in West Sumatra and the geodetic and Cartesian coordinates, obtained from satellite observations at the Datum Point, were used to compute Cartesian coordinates for a spheroid having the approximate GRS-67 parameters. The two sets of coordinates were differenced to provide a set of transformation constants between WGS72 satellite datums and the adopted geodetic datum ID-74. The Indonesian National Spheroid (INS or ID-74) is defined where: a = 6,378,160 m, and $^1/_f$ = 298.247"" (*A Report on the State of Geodesy in Java by L.J. Quilty, Jakarta, 1995*). The Indonesian Datum 1974 coordinates of the origin "Padang BP-A 1884" are: Φ_o = –00° 56' 37.980" S, Λ_o = +100° 22' 08.467" East of Greenwich, $h_o = H_o$ = 7.500 m *[Datum Geodesi Nasional 1995 (DGN-95) Yang Geosentrik, Subarya, C, Matindas, R.W., Bakosurtanal, 27 pages, 1995].*

"The *Topografische Dienst* has employed several grids and projections in mapping the Netherlands Indies. On Sumatra they employed a Mercator Grid the specifications of which are believed to be as follows: Origin = Equator, meridian of Padang, Scale Factor = none, False coordinates of origin = none. The *Topografische Dienst* also may have employed another Mercator Projection originating at the Equator and the Meridian of South Sumatra, 3° 15' West of Batavia. The *Topografische Dienst* used these projections to compute the positions of some of their third-order points. Generally the Mercator coordinates were transformed to another projection, the Polyhedric. This projection is really a series of projections each covering a 20×20 minute quadrilateral and having as its origin the center of the quadrilateral. Each quadrilateral corresponds to a sheet of the 1/100,000 map series of the Netherland Indies. The projection used to cover one sheet is considered to be a Lambert Conformal, but in practice, over so small an area, it is absolutely indistinguishable from a Polyconic,

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