THE BOLIVARIAN REPUBLIC OF VENEZUELA

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Original inhabitants of modern Venezuela consisted of the Arawak, Caraïbe, and Chibcha peoples. Discovered by Columbus on 1 August, 1498, the coast of Venezuela was traced by the Spanish navigators Ojeda and de la Cosa in 1499, and Las Casas established the first European settlement at Cumaná in 1520. The present capitol of Caracas was founded in 1567. Venezuela was included in the viceroyalty of New Granada in 1718, and was made a captaincy-general in 1731. Led by "El Libertador" (The Liberator), Simón Bolívar, Venezuela declared its independence from Spain in 1811, but it was not assured until the battle of Campo Carabobo in 1821 near Valencia. Venezuela was part of Greater Colombia from 1819-1829 and formally separated in 1830. Bolívar's villa in the mountains is spectacular. The German town of Colonia Tovar was founded in 1834, and I recommend its cuisine.

Venezuela is more than twice the size of California; its terrain consists of the Andes Mountains and Lake Maracaibo Lowlands in the northwest; central plains (Llanos); and the Guiana Highlands in the southeast. The highest point is snowcapped Pico Bolivar (La Columna) at 5007 m (16,427 ft), and the Orinoco River is the third longest in South America.

Longitude observations were first made in the Caribbean port city of La Guaira by Humboldt in 1800 and later by the Spaniard Chief of Squadron, Don José Espinoza in 1809. The Comisión del Plano Militar (Military Map Commission) was founded in 1904. The first geodetic surveys were initiated by the Army in 1911 in support of the railroad construction project between Caracas and La Guaira, where the international airport for Caracas is now located. The origin point for this first system was established on the plateau of the city of Caracas below the Army's Cajigal Observatory, probably to facilitate measurement of the initial baseline. Initial observations at Cajigal started in 1905, followed the next year in January through March by Dr. Luis Ugueto and Dr. Felipe Aguerrevere who determined the latitude by the Talcott Method (invented by Captain Talcott of the U.S. Army Corps of Engineers). The Loma Quintana Datum of 1911 origin (located in the El Mirador subdivision, 23 de Enero District of Caracas), is: Φ_o = 10° 30' 24.680" North, Λ_o = −66° 56' 02.512" West of Greenwich, the defining azimuth to station Volcán (α_o) = 316° 01' 50.33", H_o = 1,077.54 m above mean sea level at La Guaira. (My son André still remembers "hangover soup," the local name for bouillabaisse served in a La Guaira beachfront restaurant). The ellipsoid of reference is the Hayford 1909 where the semi-major axis, a = 6,378,166.0 meters, and the reciprocal of flattening, 1/f = 297. The deflection of the vertical and geoid separation were defined to be zero at the origin. Interestingly, a later adjustment performed for the Provisional South American Datum of 1956 only changed the azimuth from station Loma Quintana to station Volcán to 316° 01' 50.30", which is quite a testimonial to the superb quality of the initial work. The original Loma Quintana Datum of 1911 was comprised of chains of quadrilaterals that eventually spanned the entire northern coast of Venezuela

from the border with Colombia in the west to include the Island of Trinidad in the east. The only national projection associated with the Loma Quintana Datum of 1911 is the Compensated Secant Conic. Originally published in 1940 by the Dirección Cartografía Nacional (National Cartographic Office), I became aware of the projection tables in 1980. Used for the topographic mapping, it is defined with a Central Meridian λ_o = −67 30' W, and standard parallels of φ_N = 9º N and φ_S = 4º N. This system baffled me for many years because I was unable to compute Lambert conformal conic developed meridianal distances to match the published tables. In June of 1988, the late John P. Snyder wrote to me and pointed out that he had found the same tables at the U.S. Library of Congress and the projection was actually the Equivalent Conic and not what I had thought to be the Lambert Conformal Conic! I subsequently discovered a constant +18.027 meter error in all of the tabulated developed meridianal distances. The nut was finally cracked with John P. Snyder's help.

Also associated with the Loma Quintana Datum of 1911 (LQD 1911) are the "Oil Grids" developed in association with petroleum exploration and development activities. This collection of Polyhedric plane projection coordinate systems has understandably baffled novices and experts alike for almost a century. There are four major families of Oil Grids referenced to the LQD 1911: Maracaibo, Barcelona, Maturín, and Dabajuro. The **Maracaibo Grid Family** consists of: the Maracaibo Cross Grid (1945-1981), Cruz Morillo Grid (1917-1983), Altagracia Church Grid (1920-1951), Alto de Escuque Grid (1957), Bloque B Grid (1953-1954), Boca Grita Grid, El Cubo Grid (1916-1961), Mene Grande Grid (1914-

1982), El Mojón Grid (1927-1930), Monument "A" Río de Oro Grid, La Rosa Grid (1917-1982), El Mene de Marua Statue Grid (1927-1972), Iglesia de Santa Barbara Grid (1915-1986), Plaza Bólivar de San Cristóbal Grid (1939-1955), and the Barinas Grid (1953-1970). The **Barcelona Grid Family** consists of: the Barcelona Grid (1913-1920), Plaza de Calabozo Grid, Chaguaramas Grid, Clarines Grid (1949-1958), Punzón Grid, Sabana de Uchire Grid, Santa Maria de Ipire Grid (1939-1974), El Sombrero Grid, Valle de la Páscua Grid (1939-1982), Areo Grid, Barbacoas Grid (1948-1980), and the Barinas West Base Grid (1946-1980). The **Maturín Grid Family** consists of: the Maturín Grid (1918-1988), Irapa Grid, Tucupita Grid (1939-1966), Uracoa Grid (1966), and the Chaguamaral Grid (1955). The **Dabajuro Grid Family** consists of: the Dabajuro Grid (1921-1963), La Vela de Coro Grid (1924-1981), Piritú Grid (1949), Iglesia Valera Grid (1928), and the Pedregál Grid. Every one of these Grids is on the Polyhedric Projection, which is mathematically identical to the Local Space Rectangular system used in computational analytical photogrammetry.

Other grids associated with the LQD 1911 include the Venezuelan Gauss-Krüger Transverse Mercator where the Central Meridian λ_o = −63° 10' 48" W, the False Northing Latitude of Origin (φ_{FN}) = 9° 45' 02" N, the Scale Factor at Origin (m_o) = 0.9996 (same as UTM), and both the False Eastings and False Northings are 200 km. The Lake Maracaibo Tangent Lambert Conformal Conic Grids are defined with a Central Meridian λ_o = −71° 36' 20.224" W, the False Northing Latitude of Origin (φ_{FN}) = 10° 38' 34.6780" N, the Scale Factor at Origin (m_o) = 1.0 where the Latitude of Origin is φ_o = 10° 10' 00", and both the False Eastings and False Northings are *either* 200 km or 500 km, depending on the oil company.

The Cartografia Nacional signed a cooperative agreement with the Inter American Geodetic Survey (IAGS) in 1948. The following year the Director of La Dirección de Cartografía Nacional, Dr. Adolfo C. Romero, initiated the gravimetric survey of the origin point and vicinity of the planned Provisional South American Datum of 1956 (PSAD56). The origin was in the town of La Canoa, Anzoátegui Province, Venezuela where Φ_o = 08° 34' 17.170" North, Λ_o = −63° 51' 34.880" West of Greenwich, and the defining azimuth to station Pozo Hondo (α_o) = 40° 22' 45.96". Subsequent relative gravity surveys were performed at many of the origin points for the Polyhedric Grids. The triangulation net of Venezuela was extended to its borders, and connections were made with Colombia to link to the Bogotá Datum of 1948. Subsequently the entire collections of chains were recomputed in a simultaneous adjustment that formed the basis of the PSAD56 that was conveniently referenced to the Hayford 1909 (International 1924) ellipsoid. The Compensated Secant Conic projection was dropped, and the Universal Transverse Mercator was adopted as the standard grid for the new datum.

In the early 1980s, an enormous hydrocarbon field was discovered off the eastern coastlines of Venezuela and Trinidad. Although a treaty existed between the two sovereign nations for the division of the mineral resources of the continental shelf, the treaty only covered the Gulf of Paria – not the Atlantic Ocean. The coordinate systems of the region were known to be unusually complex; Trinidad and Tobago utilized both the Old Trinidad Datum of 1903 with the Cassini-Soldner Grid and the Naparima Datum of 1972 with the UTM Grid, and Venezuela utilized both the Loma Quintana Datum of 1911 with the Compensated Secant Conic and the Provisional South American Datum

of 1956 with the UTM Grid. Furthermore, PSAD56 was known to exist in parts of Trinidad also. Registering various maps of the region to each other was a cartographic nightmare of disparate grids and datums. The prospect of a new boundary treaty (with coordinates) being signed between the two countries without *prior* documentation of the relation of the various coordinate systems was disturbing to contemplate.

I was retained to travel to the region and acquire the necessary data to compute the relations among all existing classical coordinate systems in late 1986. Since boundary problems were (and continue to be) a sensitive subject in Venezuela, it was felt that local inquiries could be somewhat hazardous to the investigator (me). Although I was to travel with my wife and six children as a professor on a "working holiday" during the holiday season, a local prominent attorney was retained on my behalf to get my family out of the country if I was "detained" by the Secret Police. On 13 December 1986, we arrived in Port of Spain for a few days of stay and local travel. The morning of 17 December we arrived in Caracas, we checked into the hotel and I telephoned the local attorney I was instructed to contact. The following morning I went to La Dirección de Cartografía Nacional (DCN), and managed to get an audience with the Director. I explained my objective was to obtain the complete "Trig Lists" of the chains of quadrilaterals from both Venezuelan Datum origins to the island of Trinidad. In return, I said I was willing to give a copy of all the software published by the U.S. National Geodetic Survey (NGS) and to train some of their geodetic staff in the operation of that software. I had a brand-new laptop computer with me; a new dual-floppy drive Zenith Z-181 and I demonstrated some of
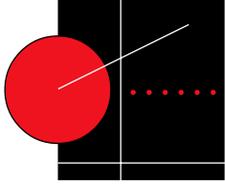
the NGS "MTEN" software to the Director while I spoke. The Director said my proposal had merit and he agreed to the "trade," but he said it would take several days to amass the data I wanted. He inquired if I would be around that long, and I replied that I was on a working holiday with my rather large family and I expected to stay for as long as it took to acquire the data. I spent the remainder of the week downloading and installing the NGS software into the DCN computers and training some of their geodesists. One afternoon when I returned to the hotel, I was summoned by the desk clerk and asked if everything was all right. I then asked, "Why the question," and he told me that the Secret Police had been there that day and had inquired about my family. I then asked, "what happened?" Seems that they took the two members of the Secret Police outside near the pool, pointed out my family, and watched them count my children. The desk clerk said police seemed satisfied and just left without another word. The next day I went to the DCN, nothing was said about the incident and I did not ask. That weekend was spent sightseeing in Caracas and nearby towns in the Andes; the following Monday I met with the retired Dr. Adolfo Romero, father of the PSAD56. The interview was fascinating and Dr. Romero preferred to use his English rather than put up with my Spanish. The datum shift methods used by the DCN were Helmert transformations and were localized to metropolitan Caracas for cadastral changes from Loma Quintana 1911 to PSAD56. On Tuesday, 23 December 1986, I was successful in obtaining the Trig List coordinates on the last working day of the year for the DCN. I telephoned the attorney and happily informed him that I was not going to need his services and left Venezuela with my family shortly after that.

The results of the Datum relations subsequently computed were as follows: **From** Old Trinidat Datum of 1903 **To** PSAD56, $\Delta X = +84.70$ m, $\Delta Y = -180.65$ m, $\Delta Z = +96.90$ m, scale $= -17.79 \times 10^{-6}$, $R_X = -7.99"$, $R_Y = +5.66"$, $R_Z = +25.19"$, and was based on a solution of 61 collocated stations. **From** Loma Quintana Datum of 1911 **To** PSAD56, $\Delta X = -43.50$ m, $\Delta Y = +96.14$ m, $\Delta Z = -15.18$ m, scale $= +16.70 \times 10^{-6}$, $R_X = -1.43"$, $R_Y = -0.65"$, $R_Z = -0.33"$, and was based on a solution of 79 collocated stations. **From** Naparima Datum 1972 **To** PSAD56, $\Delta X = -27.69$ m, $\Delta Y = +40.01$ m, $\Delta Z = -17.56$ m, scale $= +7.85 \times 10^{-6}$, $R_X = -11.33"$, $R_Y = +4.34"$, $R_Z = +17.83"$, and was based on a solution of 61 collocated stations. The treaty between the High Contracting Parties on "the delimitation of marine and submarine areas was DONE in the City of Caracas, on the 18th day of the month of April, One Thousand Nine Hundred and Ninety in duplicate in the English and Spanish languages, both texts being equally authoritative. . . . The positions of the aforementioned points have been defined by latitude and longitude of the 1956 Provisional South American Datum (International ellipsoid 1924)."

"Venezuela, as it has been established in Official gazette no. 36.653 of date 03-03-99, has a new geodetic network called **SIRGAS-ReGVen** (Venezuelan GPS Network), which is a very precise network." PATVEN-07 Transformation Parameters are **From** PSAD56 (Canoa) **To** ReGVen: $\Delta X = -270.933$ m, $\Delta Y = +115.599$ m, $\Delta Z = -380.226$ m, scale $= -5.108 \times 10^{-6}$, $R_X = -5.266"$, $R_Y = -1.238"$, $R_Z = +2.381"$.

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