Grids & Datums

Guatemala

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

Guatemalan history dates to proof of human settlers as far back as 10,000 *BC*, with possible human activity as far back as 18,000 *BC*. Predominantly hunters and gatherers, these original inhabitants only began to establish permanent settlements from 2000 *BC* to 250 *AD*. From 250 *AD* to 900 *AD*, the first nation states and cities were formed with the large scale architecture that characterized the ceremonial ancient Maya. From 900 to 1500 *AD* the important early Maya cities flourished during this time, including El Mirador. It was not only the most populated pre-Colombian city in the Americas, but also the region's first politically organized state. During that latter period, Teotihuacan, found near present day Mexico City replaced El Mirador as the prime Mesoamerican power. The greatest Maya cities from this era were Tikal, Palenque (Mexico) and Copán (Honduras). By then, the Maya had already established the most advanced form of writing in the New World, as well as they developed their mathematic and artistic genius. By 1500 *AD*, the ancient Mayan civilizations begin their mysterious fall and as the Aztecs begin their domination of Mesoamerica, the coming of the Spanish conquistadors changed everything (Destination360, 2008).

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"When Pedro de Alvarado came to conquer Guatemala for the king of Spain in 1523, he found the faded remnants of the Mayan civilization and an assortment of warring tribes. The remaining highland kingdoms of the *Quiché* and *Cakchiquel* Maya were soon crushed by Alvarado's armies. Their lands were carved up into large estates and their people were ruthlessly exploited by the new landowners. The subsequent arrivals of Dominican, Franciscan and Augustinian friars could not halt this exploitation, and their religious imperialism caused valuable traces of Mayan culture to be destroyed. Independence from Spain came in 1821, bringing new prosperity to those of Spanish blood (creoles) and even worse conditions for those of Mayan descent. The Spanish Crown's few liberal safeguards were abandoned. Huge tracts of Mayan land were stolen to cultivate tobacco and sugar cane, and the Maya were further enslaved to work that land. Since independence, the country's politics have been colored by continued rivalry between the forces of the left and right - neither of which has ever made it a priority to improve the position of the Maya (Lonely Planet, 2008)."

Guatemala is bordered by Belize (266 km), El Salvador (203 km) (*PE&RS*, July 2005), Honduras (256 km) (*PE&RS*, July 1999), Mexico (962 km), the North Pacific Ocean and the Gulf of Honduras – Caribbean Sea/Atlantic Ocean totaling 400 km. The lowest point is the Pacific Ocean (0 m), and the highest point is Volcán Tajumulco (4,211 m). My youngest daughter, Alyce Marie was born in Guatemala.

The country was originally mapped in 1527 by Fernando Colón, the son of Christopher Columbus and was known as *"Mapa Español Oficial"* (Official Spanish Map). The name Guatemala first appeared in a 1529 map by Rivero. The country was mapped in outline form by 1600, and this cartographic convention continued into the 20th century. By 1930, planimetric sketch maps were virtually the only maps available of Guatemala with the exception of a 1923 map prepared by Ing. Claudio Urrutia who employed various scientific instruments that were not identified. In 1934, the Geographic Branch of the U.S. Army issued a 1:250,000 scale map of the country. The Guatemala-Honduras boundary extends between the Caribbean Sea and the tri-point (φ = 14° 25' 20.06" N, λ = 89° 21' 28.46" W), with El Salvador on Cerro Monte Cristo (mountain). That tri-point in Honduras is in the Departamento de Ocotepeque (state or province). Boundary disputes between Honduras and Guatemala began shortly after the dissolution of the Federation of Central America in 1843. In accordance with the terms of the Treaty of Arbitration that was signed in Washington in 1930, the disputed line was submitted to the Chief Justice of the United States for a decision on the delimitation of the boundary. Because available topographic data were inadequate for the boundary work in many of the disputed areas, the Tribunal directed the making of an aerial photogrammetric survey. Chief Justice Hughes appointed Sidney H. Birdseye of the U.S. Coast & Geodetic Survey (USC&GS) as Chief of the boundary demarcation commission after Mr. Birdseye completed the photogrammetric mapping of the area. Birdseye's commission erected 1,028 pillars and completed its work between 1933 and 1936. The award of the Special Boundary Tribunal was based on the principle of ***uti possidetis*** as of 1821. Thus, the award referred to the territory under the administrative control of Guatemala and Honduras at the time of their independence from Spain. Furthermore, El Salvador, Guatemala, and Honduras signed a protocol on 26 March 1936 accepting Cerro Monte Cristo as the tri-point of the boundaries of the three states. A fascinating aspect of the Guatemala-Honduras boundary is that part of the boundary is "established on the right banks of the Tinto and Motagua rivers at mean high water mark, and in the event of changes in these streams in the course of time, whether due to accretion, erosion or avulsion, the boundary shall follow the mean high water mark upon the ***actual right banks of both rivers.***" (*Emphasis added – Ed.*). Boundaries commonly do not change with avulsions. Apparently, this was intended to avoid future squabbles. On the other hand, the 9 April 1938 Guatemala-El Salvador boundary treaty contained an Article II in which: "No change in the bed of frontier rivers, whether due to natural causes such as alluvium deposits, landslides, freshets, etc. or to artificial causes such as the construction of public works, the deepening of channels for water-supply, etc., shall affect the frontier as determined at the time of demarcation, which shall continue to be the international boundary

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The four chapters in *Transport-related Impervious Surfaces* are representative of the range of techniques for road extraction and pavement characterization. In *Roof-related Impervious Surfaces*; however, the content is a bit less unified, with two of the chapters dealing with building extraction, which is not necessarily a negative. The chapter provides an excellent blend of different platforms and sensors, including lidar, SAR, and digital optical imagery.

It is impossible to address all the application areas in a single volume such as this. The editor, however, did an excellent job of selecting representative thematic areas. There are a couple areas that might have been considered for inclusion in the applications chapter; however, such as urban heat island effects, best management practices for preserving rural character, addressing imperviousness in site plans, or inclusion of impervious surface stipulations in land use regulations, to name a few. Also, a chapter or two authored by the principals involved with some of the more prominent or successful impervious surface "programs" – such as the NLCD 2001 impervious surface product, the NOAA Coastal Services Center's Impervious Surface Analysis Tool, or the National NEMO (Nonpoint Education for Municipal Officials) Network – would have been further illustrative of various other methods and applications.

Overall, the book is well-organized and the chapters well-written. The editor has taken measures to ensure consistency among the chapters, in the formatting of the narrative, tables, and figures. Color plates are used sparingly (12 pages), yet effectively. Though much of the content can be found elsewhere in the published literature, *Remote Sensing of Impervious Surfaces* brings a representative body of the state-of-the-art under a single cover. The book will serve as a comprehensive treatment for impervious surface remote sensing neophytes, as well as a valuable reference for veteran researchers and practitioners.

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even though a stream may have completely abandoned its original bed." This boundary commission completed the construction of 530 monuments and pillars in 1940.

The Ocotepeque Datum of 1935 was established at Base Norte where φ_o = 14° 26' 20.168" North, λ_o = 89° 11' 33.964" West of Greenwich, and H_o = 806.99 meters above mean sea level. The defining geodetic azimuth to Base Sur is: α_o = 358° 54' 21.790", (*Memoria de la direccion General de Cartografia, Guatemala, Sept. 1957*), and the ellipsoid of reference is the Clarke 1866 where a = 6,378,206.4 meters and $^1/_f$ = 294.9786982. The corresponding astronomic observations at that mountainous location are: Φ_o = 14° 26' 13.73" North (±0.07"), Λ_o = 89° 11' 39.67" West (±0.045"), and the defining astronomic azimuth to Base Sur is: α_o = 358° 54' 20.37" (±0.28") (*Informe Detallado de la Comisión Técnica de Demarcación de la Frontera entre Guatemaly y Honduras*). The difference between these two sets of coordinates is due to the local gravimetric deflection of the vertical. There was no Grid system associated with this Datum, although that's not surprising since Mr. Birdseye was with the USC&GS. Their custom was to compute their chains of quadrilaterals in geodetic coordinates.

Various surveying and mapping commissions were created in Guatemala for the boundary surveys of the 1930s. In 1945, the *Departamento de Mapas y Cartografía* (Dept. of Maps and Cartography) was formed and then in 1964 was renamed the *Instituto Geográfico Nacional de Guatemala* (National Geographic Institute of Guatemala). On 7 November 1946, the Inter-American Geodetic Survey (IAGS) of the U.S. Army Map Service established the Guahonels Project which included Guatemala, Honduras and El Salvador. In April of 1950, the IAGS reorganized the project in Guatemala. The IAGS established two Lambert Conformal Conic zones for the Republic of Guatemala: Guatemala North Lambert Zone - Both zones use the same Central Meridian (λ_o) = 90° 20' 00" West of Greenwich and False Easting of 500 km. Zone Norte has a Latitude of Origin (φ_o) = 16° 49' North, the False Northing = 292,209.579 m, and the scale factor at origin (m_o) = 0.99992226. Zone Sud has a Latitude of Origin (φ_o) = 14° 54' North, the False Northing = 325,992.681 meters, and the scale factor at origin (m_o) = 0.99989906. For those facing the conundrum of the British definition of secant Lambert Conical Orthomorphic zones, I am told that the latest (*free*) version of NGA's **GeoTrans** will indeed accommodate such defining parameters even though many high-priced GIS packages will not. (*Hint, hint – Ed.*)

After Hurricane Mitch devastated a large area of Guatemala, the U.S. National Geodetic Survey established three Continuously Operating Reference Stations in the country to assist in disaster recovery. Those stations have been helpful in establishing the SIRGAS reference system for Latin America. No transformation parameters have been published from either the Ocotepeque Datum of 1935 or the North American Datum of 1927 to the WGS84 Datum.

I have been informed that Guatemala may have adopted the Transverse Mercator projection – no idea on the number of zones. No information is available from the Guatemalan government, but since SwedeSurvey has recently provided assistance for a cadastral mapping program and since the Swedes now have a fondness for TM systems, … I suppose they might have something to do with that possible adoption. The old 1:50,000 scale series of Guatemalan topographic maps are based on the two Lambert zones with the UTM Grid overprint. Someday the government may release such transformation parameter information to the general public and join the rest of the free world! Until then, I suppose Guatemala will remain a closed society, at least from a cartographic/geodetic point of view.