

# Grids & Datums

## REPUBLIC OF PARAGUAY

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

Discovered by Spanish conquistadors in 1524, Paraguay had been populated by semi-nomadic Chaco Indian tribes for millennia. “Although few relics or physical landmarks remain from these tribes, the fact that 90 percent of Paraguayans still understand the indigenous Guaraní language is testament to Paraguay’s Indian lineage. The Spanish conquistadors arrived in 1524 and founded Asunción in 1537. Paraguay’s colonial experience differed from that of neighboring countries such as Bolivia and Argentina, because it did not have what the Spanish were searching for – gold or other large mineral deposits.” (*Library of Congress Country Studies*) First influenced by the Jesuits, indigenous society was converted to Catholicism until the Jesuits were expelled in 1767. A succession of dictators eventually resulted in only 79 persons owning half of the country’s land by 1900. After wars in the 18th and 19th centuries, including the disastrous War of the Triple Alliance (1865-70) between Paraguay and Argentina, Brazil and Uruguay, Paraguay lost two-thirds of all adult males and much of its territory. More war in the 20th century combined with a continued succession of dictators has left the country lacking in substantive economic growth. The current democratically elected administration seems to have garnered some international support for progress, but Paraguay’s legacy of political instability may persist.

cast on the Paraguay Gauss-Krüger Transverse Mercator projection where the national Grid has four Belts: (1)  $\lambda_o = 63^\circ$  W, False Easting F.E. = 4,500 km, (2)  $\lambda_o = 60^\circ$  W, False Easting F.E. = 5,500 km, (3)  $\lambda_o = 57^\circ$  W, False Easting F.E. = 6,500 km, (4)  $\lambda_o = 54^\circ$  W, False Easting F.E. = 7,500 km. All four Belts have a scale factor at origin ( $m_o$ ) = unity and the False Northing = 10,002,288.299 m. The ellipsoid of reference is the International 1924 where:  $a = 6,378,388$  meters,  $1/f = 297$ . Note that this is an extension of the Argentine TM Grid.

In January 1962, with the help of the Inter-American Geodetic Survey (IAGS), IGM concentrated its forces for the establishment of basic vertical and horizontal control and for the training of its personnel in the various phases of geodesy and cartography. In October 1965, IGM acquired a photographic laboratory. Chua Datum is defined by the 1966 astronomical observation reduced to the Bureau International de l’Heure (BIH) pole, specifically,  $\Phi_o = 19^\circ 45' 41.16''$  North,  $\Lambda_o = -48^\circ 06' 07.56''$  West of Greenwich. Although used in Paraguay, astro station Chua is actually located about 720 km East in Brazil just west of the Uberaba airport and north of the Grande River. Curiously, the South American Datum of 1969 (SAD69) origin is defined by the same astronomical observation reduced to the Conventional International Origin (CIO) pole, specifically,  $\Phi_o = 19^\circ 45' 41.34''$  North,  $\Lambda_o = -48^\circ 06' 07.80''$  West. Furthermore, the SAD69 geodetic value for Chua is:  $\Phi_o = 19^\circ 45' 41.6527''$  North,  $\lambda_o = -48^\circ 06' 04.0639''$  West. The ellipsoid of reference remains the same, thanks to John W. Hager, 1992.

***“I am informed by the National Geospatial-Intelligence Agency (NGA), that TR8350.2 is not considered obsolete as it is currently still in use. I stand corrected.”***

Slightly smaller than California, Paraguay is landlocked and is bordered by Argentina (1,880 km) (PE&RS, December 1999), Bolivia (750 km), (PE&RS, July 2001), and Brazil (1,365 km). The lowest point in the republic is the junction of Rio Paraguay and Rio Parana (46 m), and the highest point is Cerro Pero or Cerro Tres Kandu (842 m). Paraguay is comprised of grassy plains and wooded hills to the east of Rio Paraguay; the Gran Chaco region west of Rio Paraguay is mostly low, marshy plain near the river and dry forest and thorny scrub elsewhere (*CIA Factbook*).

Although some small-scale maps of Paraguay were privately compiled in the 18th and 19th centuries, the majority of mapping was produced by the Office of Municipal Engineers in Asunción (*Oficina de Ingenieros Municipales de Asunción*) until the establishment of the Military Geographic Institute (*Instituto Geográfico Militar - IGM*) in 1941. Until 1962, IGM was dedicated to low-order surveys with the exception of a period of four years when with the help of an Argentine Technical Mission, IGM reproduced four topographic map sheets at a scale of 1:50,000 for the metro area of Asunción. These sheets were

The classical triangulation arcs of Paraguay consist of Brazil – Alegre (1:1,350,000 error), Pastoreo – Alegre (1:448,000 error), Asunción – 5H07 (1:1,130,000 error), 5H07 – Paraguari (1:875,000 error), Paraguari – Caaguazu (1:493,000 error), Caaguazu – Cerrito (1:311,000 error), Cerrito – Meza (1:297,000 error), Caaguazu – Pastoreo (1:543,000 error), Cerrito – Pilar (1:425,000 error), 5H01 – Alberdi (1:420,000 error), Alberdi – Pilar (1:540,000 error), Pilar – Diaz (1:675,000 error), Asunción – San Pedro (1:306,000 error), and San Pedro – Caaguazu (1:297,000 error) (*DMATC Geodetic Memorandum No. 1683, May 1973*).

In 1977, James W. Walker of the Defense Mapping Agency Topographic Center (DMATC – same place as the original Army Map Service where I was stationed about 10 years earlier) published two sets of

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transformation parameters for Paraguay. The Seven-Parameter Transformation **from** NWL9D **to** Paraguay's Chua Datum is:  $\Delta X = +160.35$  m,  $\Delta Y = -229.67$  m,  $\Delta Z = +28.88$  m,  $dS = -0.52029 \times 10^5$ ,  $R_x = +1.62926''$ ,  $R_y = +1.58638''$ ,  $R_z = -1.47279''$ , and the gross total positional error was estimated at  $\pm 3.64$  m. The corresponding transformation **from** NWL9D **to** SAD69 in Paraguay is:  $\Delta X = +80.68$  m,  $\Delta Y = +8.83$  m,  $\Delta Z = +36.14$  m,  $dS = -0.80233 \times 10^5$ ,  $R_x = +1.27144''$ ,  $R_y = +0.56022''$ ,  $R_z = -2.28029''$ , and the gross total positional error was estimated at  $\pm 3.56$  m.

James A. Slater published a paper describing "A New GPS Geodetic Control Network for Paraguay" (*S&LIS*, 1993), in which a mapping project was sponsored by the World Bank for the establishment of approximately 170 GPS stations. No transformation parameters were offered in the paper, though. The old TR8350.2 parameters from Chua Astro (Paraguay) to WGS84 are:  $\Delta X = -134$  m,  $\pm 6$ m,  $\Delta Y = +229$  m,  $\pm 9$ m, and  $\Delta Z = -29$ m,  $\pm 5$ m, and that is based on 6 stations. I am informed by the National Geospatial-Intelligence Agency (NGA), that TR8350.2 is not considered obsolete as it is currently still in use. I stand corrected.



The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for Geoinformatics (C<sup>4</sup>G).

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