

Grids & Datums

KINGDOM OF CAMBODIA

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

Inhabited for millennia, the area's history was unrecorded until the Chinese chronicles of the last two thousand years. "Historians surmise that by the first century *A.D.*, a small number of Khmer (or Cambodian) states already existed on the fringes of the earliest recorded state in the region, the empire of Funan. Centered in the Mekong Delta of present-day Vietnam (*PE&RS*, May 2002), Funan derived its power from commerce. With its port of *Oc Eo* on the Gulf of Thailand, Funan was well-placed to control maritime traffic between India and China. According to Chinese annals, Funan was a highly developed and prosperous state with an extensive canal system for transportation and irrigation, a fleet of naval vessels, a capital city with brick buildings, and a writing system based on Sanskrit. The inhabitants, whose adherence to Indian cultural institutions apparently coexisted with Mahayana Buddhism, were organized into a highly stratified society. When the small Khmer states to the northwest of the Mekong Delta emerged into recorded history, it was to make war upon the declining empire of Funan. Between *A.D.* 550-650, these Khmer states overran their adversary, which fell apart, losing its tributary states on the Kra Isthmus and along the Gulf of Thailand" (*Library of Congress Country Studies*).

"Most Cambodians consider themselves to be Khmers, descendants of the Angkor Empire that extended over much of Southeast Asia and

The first mapping of Indochina of any importance was performed by the *Bureau Topographique* which was set up as a section of the General Staff after the French assumed control of the area in 1886. This organization started triangulation work in Indochina in 1902, and compiled topographic maps as well as boundary and river maps. The 1:500,000 scale series completed in 1899 was the most important of these maps. The major mapping organizations were the *Service Géographique de l'Indochine – SGI* (Geographic Service of Indochina); the *Institut Géographique National – IGN* (National Geographic Institute), in Paris; and the *Service Cartographique des Forces Terrestres d'Extrême Orient – F.T.E.O.* (Cartographic Service of the Far East Land Forces). The SGI was established as the topographic mapping agency in Indochina in 1899 and disbanded in April 1955. The *Service Cartographique des F.T.E.O.* was set up in 1949 as a bureau under the General Staff of the French Army in Indochina to serve as the military mapping agency of the country. These mapping organizations, principally *SGI*, have produced regular surveys, based on first- second- and third-order triangulation, for 55 percent of Indochina. The remainder of the area was covered by reconnaissance surveys. Cambodia achieved its full independence in 1954, and in 1955 the *Service Géographique de Forces Armées Royales Khmères (FARK) – SGK* (Geographic Services of the Royal Cambodian Forces) was organized as the mapping agency

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reached its zenith between the 10th and 13th centuries. Attacks by the Thai and Cham (from present-day Vietnam) weakened the empire, ushering in a long period of decline. The king placed the country under French protection in 1863 and it became part of French Indochina in 1887. Following Japanese occupation in World War II, Cambodia gained full independence from France in 1953. In April 1975, after a five-year struggle, Communist Khmer Rouge forces captured Phnom Penh and evacuated all cities and towns. At least 1.5 million Cambodians died from execution, forced hardships, or starvation during the Khmer Rouge regime under POL POT. Local elections were held in Cambodia in April 2007, and there was little in the way of pre-election violence that preceded prior elections." (*CIA Factbook*). Cambodia is bordered by Laos (541 km) (*PE&RS*, April 2007), Thailand (803 km), Vietnam (1,228 km) (*PE&RS*, May 2002), and has a coast line (443 km) on the Gulf of Thailand. The highest point is Phnum Aoral (1,810 m), and the lowest is the Gulf of Thailand (0 m).

Most original mapping of Cambodia was accomplished during the period 1886-1954 when the French controlled the area, then called Indochina. The French mapping agencies were considered "official."

for the Royal Cambodian Government. On *SGI* sheets geographic coordinates are in grads or degrees or both. Longitude values in grads are referred to Paris, and those in degrees are referred to Greenwich. Both Degrees and grads are given on the *SGI* 1:25,000 scale and 1:100,000 scale series. The *SGI* 1:25,000 scale, 1:100,000 scale and 1:400,000 scale series and some sheets of the 1:50,000 scale series carry the ellipsoidal French Indochina Bonne grid, a relic of the 19th century. Some of the later editions of all series by *SGI* and all reprints by the U.S. Army Map Service carry the UTM grid (*Foreign Maps, TM 5-248*).

"In 1993-1994, monumented GPS control points were established in and around Phnom Penh city for a mapping project by IGN-France International. The horizontal datum connection for this survey was made from Taiwan with the coordinates being in GRS 1980 datum (*sic*). Extensive documentation on the observations and adjustments are available. A primary network of 9 stations was established surrounding Phnom Penh using Ashtech dual-frequency GPS receivers. Coordinate accuracies of less than 0.01 meter at 95% confidence level were achieved. A further 85 lower order stations were established

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within the primary network to provide control for aerial photography and terrestrial network traverses.

"In 1994 the Government of Finland granted funds to undertake the mapping of the Mekong River in Cambodia. As part of this project a GPS network was established to provide accurate horizontal and vertical control for the mapping. The project established monumented GPS points along the Mekong and Bassac South of Phnom Penh and along the Mekong to Kampong Cham and along the Tonle Sap and the highway to Kampong Chhnang. The network was then extended through to the Vietnam border and then on to the South China Sea. A horizontal datum connection was made from South Laos. It was the intention that this network be based on the Indian 1975 datum, however lack of any network at the southern end of the traverse made it difficult to undertake any adjustment. It is believed that there will not be any practical problems in the use of the 'Mekong datum' in the relative proximity of the network along the river.

"The GPS stations used for the transformation parameter computations were distributed within a narrow longitudinal area in the vicinity of the Mekong River and within this area it is believed that the transformation parameters will be correct. With the deterioration of the geodetic system in Cambodia, the European Commission agreed to provide assistance, to re-establish a geodetic network. In 1997 survey work commenced on establishing a geodetic network, with an aim of having at least one primary network point in each province. This network was based on the WGS84 datum. Following the establishment of this primary network, consisting of 22 stations, a number of secondary networks were established in Pailin, Siemreap and Battambang. In the first two provinces the control was funded through other aid projects but in Battambang the provincial government provided the funding. In 1998, through a program funded partly by the Australian Government, GPS observations were undertaken to strengthen the 1997 network. It was part of the Asia Pacific Regional

Geodetic Project 1998, Geodetic Observation Campaign (APRGP98). The Australian Land Information Group (AUSLIG), a group within the Australian Federal Government, was the coordinating agency on behalf of the Permanent Committee on GIS Infrastructure for Asia and the Pacific Region (PCGIAP).

"The observations were conducted between 19-29 November 1998. Geodetic agencies in the region contributed data from continuous tracking GPS, from GPS observations on key national geodetic stations and other high precision geodetic techniques such as Side Looking Radar (SLR) and Very Long Base Interferometry (VLBI).

"The project was designed to coincide with a worldwide campaign. The objects of the campaign were to; (i) strengthen the precise regional geodetic network; (ii) assist in establishment of a regional datum; (iii) assist in monitoring the tectonic motion of the network sites; and (iv) to assist with the development of transformation parameters for national datums.

In Cambodia, a bracing network was observed using Phnom Penh as a focus with observations also being made at stations in Sihanoukville, Svay Rieng, Stung Treng and Siemreap. All GPS observation data was transferred to AUSLIG, in Australia, for archiving and processing. In all there was data for 80 sites in 16 nations. Processing of the data was completed in mid 1999 and the results were presented at a workshop in Vietnam in July 1999. The results of the adjustment of the GPS observations were included in the reports presented during the workshop. The adjustment information and the final coordinates for the 5 points observed in Cambodia as part of the APRGP98 program provide an excellent basis from which to undertake future geodetic activity in Cambodia. (*However, the actual coordinates of any collocated points have not been publicly released. - Ed.*) From the reports and data, it would appear that the network that has been established provides a sound base from which to establish future control networks and from which to base GPS observations for the project required for controlling

aerial photography and terrestrial traversing” (Chris Lunnay, Director, Land Equity International, Australia).

“There is a plan to complete (within 2008-2010), the 1st order GPS network (about 100 points) to the existing GPS network that has been established since 1997. There were 31 points of 1st order and 92 points of 2nd order that have been installed in Kampong Chhnang, Pursat and its adjacent areas. The study on improving parameters for converting from Indian 1960 datum to WGS84 is also started.” (Chharom Chin, Senior GIS/RS Officer, Geography Dept., Ministry of Land Management, Urban Planning and Construction, Cambodia, 22-24 February 2007).

The legendary “origin” of the Indian Datum as defined in 1900 and labeled as Indian 1916 origin at Kalianpur Hill Station: $\Phi_0 = 24^\circ 07' 11.26''$ N, $\Lambda_0 = 77^\circ 39' 17.57''$ East of Greenwich, the initial azimuth to Surantal from south is: $\alpha_0 = 190^\circ 27' 05.10''$. The ellipsoid of reference is the Everest 1830 where $a = 6,377,276.345$ m, and $1/f = 300.8017$. John W. Hager tells me that, “In 1954, the triangulation of Thailand was adjusted to Indian 1916 based on 10 stations on the Burma border. In 1960, the triangulation of Cambodia and Vietnam was adjusted holding fixed two Cambodian stations connected to the Thailand adjustment of stations from the Cambodian-Vietnam adjustment. Various regional ‘adjustments’ in the 20th century have been performed on the Indian Datum of 1916 that have resulted in a garbled mish-mash of discordant coordinate systems that have little to no continuity across national borders much less even with countries such as Cambodia. Some of these “datum adjustments” present daunting challenges to the mapping professional charged with the task of ‘making sense of the situation.’”

A close friend of mine is Malcolm A. B. Jones of Perth, Australia. Mal, or “Geodesy Jones” as he is commonly known, sent to me his best guess as to a set of transformation parameters from “Indian Cambodia” to “WGS84,” based on his extensive personal geodetic holdings: $\Delta X = +225\text{m}$, $\Delta Y = +854\text{m}$, $\Delta Z = +301.9\text{m}$, $R_x = R_y = R_z = 0$, $\delta s = 0.38$ ppm. An example “Test Point” is Phnom Anlong Svay (1512) where for “Indian Cambodia” datum, $\phi = 14^\circ 22' 32.1733''$ N, $\lambda = 103^\circ 44' 36.8591''$ E, $h = 0.0\text{m}$. For WGS84: $\phi = 14^\circ 22' 38.2868''$ N, $\lambda = 103^\circ 44' 23.6058''$ E, $h = -25.022\text{m}$. Test points are always nice to have as a reassuring tidbit of data for one’s transformation software ... however, I was provided a data set of classical triangulation data points (a “Trig List”), for Cambodia sometime in the past and *lo and behold*, a point therein is listed as “PN ANLONG SAI” for “Indian 54,” where: $\phi = 14^\circ 22' 32.3966''$ N, $\lambda = 103^\circ 44' 36.9339''$ E, and $h = +457.10\text{m}$ – **that’s over seven meters difference!** Cambodia has a Database of Land Mine Fields, and when the United States Army Corps of Engineers (in 1968), *graciously* provided me with the Officer Candidate School Engineer Demolition training to become a “Sapper,” I was inculcated with the knowledge that a 64th of an inch between one’s fingers (when on one’s hands and knees) can make the difference in a mine field between life and death! Seven meters uncertainty just is not going to fit into one’s “comfort zone” in Cambodia. The Kingdom of Cambodia certainly has the history to be paranoid about invaders, but maintaining secrecy about datum transformations is not going to provide encouragement for foreign workers to come in to provide assistance in decommissioning land mine fields! My advice is to stay on the paved roads until the government releases their transformation parameters for Cambodia!



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