& GRIDS & DATUMS

TUVALU

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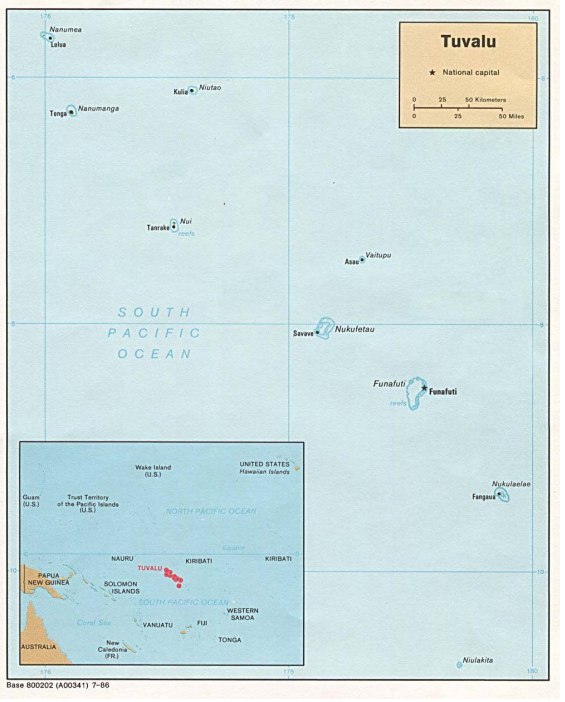
The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on Tuvalu was originally printed in 2001 but contains updates to their coordinate system since then.

Tuvalu comprises a chain, 580 kilometers long, of nine coral atolls in the Pacific Ocean just west of the International Date Line. The total land area of the densely populated group is only 26 sq km (10 sq mi); however, the islands occupy 1.3 million sq km (500,000 sq mi) of ocean between Kiribati and the Samoas. Five of the islands are low-lying coral atolls; the highest point on these (and the highest point in Tuvalu) is just 4.6m (15 ft) above sea level. The remaining four islands are pinnacles of land that rise up from the sea bed. On the islands, there are many reefs and salt-water ponds while the island of Nanumea hosts a fresh-water pond; rare for an atoll. Made mostly of eroded coral, Tuvalu has poor soil, no streams or rivers, and few remaining outcrops of forest. Coconut palms grow in abundance across all the islands, but otherwise there is only enough soil to support subsistence agriculture for about three-quarters of the population. All other food is imported. Water needs are met by catchment and storage facilities because the porous, low-lying atolls are unable to hold ground water. The only land animals are the Polynesian rat, chickens, dogs, and pigs — all introduced species. Niulakita has no lagoon, but has a swamp at its center. Because it has never had a permanent population, the southernmost island was not taken into account in the naming of the Tuvalu group. Tuvalu means "eight standing together." The climate is tropical, with an average temperature of 30°C (87°F) and little seasonal variation. The wet season is between October and March, and 350 cm (12 ft) of rain falls in a normal year. Cyclone (hurricane) activity is rare; there have been only four severe hits this century (but all since 1972).



Physiographically, Tuvalu belongs in Micronesia, but culturally, the islands belong to Polynesia. Language, traditions, and artifacts indicate that Polynesians from Tonga and Samoa in the southeast arrived in the island group early in the 14th century. In 1597, Don Alvaro de Mendaña y Neyra cruised through the coral atolls of Tuvalu. Further European contact came in the late 18th century, and the last of the islands were charted by 1826. They were named the Ellice Islands after the British member of parliament who owned the ship that first landed on Funafuti Atoll in 1819. In 1892, the islands became part of the Gilbert and Ellice Islands protectorate and, in 1916, became a Crown Colony. During WWII the U.S. used Tuvalu's northernmost atoll, Nanumea, as a base to repel the Japanese who were threatening the Gilbert Islands. Wrecks of air and sea craft remain on the island.

From the 1960s through 1977, Tuvaluans embarked on

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steady constitutional development. In 1974, the Polynesian Ellice Islanders voted to separate from the Micronesian Gilberts. They reverted to their precolonial name of Tuvalu and attained independence on 01 October 1978.

Hydrographic surveys were under-taken by the USS Sumner in 1943, the USS Hydro in 1944, and by the H.M.S. Cook from 1959-1963. Between 1962 and 1966 the HIRAN trilateration of the southwest Pacific was undertaken by the U.S. Air Force. A number of primary stations were established. These were originally expressed in terms of the WGS 60 Datum, the Australian National Datum of 1966, as well as being converted to the Fiji Datum of 1956 (*PE&RS*, October, 2000). The British Directorate of Overseas Surveys (DOS) carried out survey work between 1968 and 1973, expressing their values in terms of local astronomic datums for individual islands. Some stations were linked to the HIRAN survey and hence were expressed in terms of Fiji 56. In 1974, the Royal Military Survey of the U.K. decided that where possible island areas should be positioned on WGS 72; hence, where possible the Fiji 56 datums were converted to the WGS 72 Datum using cartesian shifts. In addition, shifts have been established between the local astro datums and Fiji 56 for some of the islands, but other values are held only in local datum terms for some island areas. In 1984 and 1985, the Australians carried out "Operation ANON." This provided 16 Doppler fixes to many points in the Tuvalu Group, yielding coordinates in terms of the WGS 72 Datum. The primary objective was to provide the government of Tuvalu with sufficient survey data to enable them to determine base points for the definition of their Exclusive Economic Zone.

The survey work for Operation ANON in 1984 and 1985 used 11 points from earlier surveys by the Australians. Because all field work was carried out on the WGS 72 Datum, the points were converted to the WGS 84 Datum using the standard NIMA WGS72 to WGS84 transformation: $\Delta X = 0$ m, $\Delta Y = 0$ m, $\Delta Z = 4.5$ m, $k = 0.219$ ppm, and $R_z = 0.554''$.

On Nanumea, the northernmost of Tuvalu's atolls, the origin of the Nanumea Sodano Astro Datum of 1966 at Laken Island is $\Phi_o = 05° 39' 04.59'' S$, $\Lambda_o = 176° 04' 31.09''$ East of Greenwich, and the ellipsoid of reference is the International 1924 where a = 6,378,388 m, and $^1/_f = 297$. The vertical datum is based on readings of the tide levels made on the ocean side (at the seaward end of the LST wreck) and in the lagoon (at NME 25), and these two staff gauges were connected by height traversing and also to the Post Office. From the Nanumea Sodano Astro Datum to the WGS84 Datum, $\Delta X = +225$ m, $\Delta Y = -114$ m, and $\Delta Z = -148$ m; the accuracy of this transformation is estimated to be ±2 meters in each of Eastings and Northings. The Nanumea TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator ($\varphi_o = 0°$), the Central Meridian $\lambda_o = 176° 06'$ E, the False Easting = 45 km, and the False Northing = 8,000 km. The Scale Factor at Origin is unity ($m_o = 1.0$).

On the island of Nanumaga, the origin of the NMG 1 Astro Datum of 1974 is $\Phi_o = 06° 17' 15.04'' S$, $\Lambda_o = 176° 18' 52.86''$ East of Greenwich, and the ellipsoid of reference is the International 1924. The vertical datum is based on heights observed as part of the traversing. They have been related to mean sea level by two days of readings on a staff gauge set up in the boat channel. Two tide poles were erected on the reef opposite the Government flagstaff, and continuous observations were obtained for 2.5 days. From the NMG 1 Astro Datum of 1974 to the WGS84 Datum, $\Delta X = +204$ m, $\Delta Y = -31$ m, and $\Delta Z = +113$ m; the accuracy of this transformation is estimated to be between ±2 m and ±26 m in each of Eastings and Northings. The Nanumaga TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator ($\varphi_o = 0°$), the Central Meridian $\lambda_o = 176° 19'$ E, the False Easting = 35 km, and the False Northing = 7,000 km. The Scale Factor at Origin is unity ($m_o = 1.0$).

On the atoll of Nukufetau, the location of the WWII airfield on Motulalo Island, the origin of the NFT 1 Astro Datum of 1974 is $\Phi_o = 08° 01' 40.28'' S$, $\Lambda_o = 178° 18' 48.37''$ East of Greenwich, and the ellipsoid of reference is the International 1924. From the NFT 1 Astro Datum of 1974 to the WGS84 Datum, $\Delta X = +200$ m, $\Delta Y = -83$ m, and $\Delta Z = +96$ m; the accuracy of this transformation is estimated to be ±7 m in Eastings and ±21 m in Northings. The Nukufetau TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator ($\varphi_o = 0°$), the Central Meridian $\lambda_o = 178° 22'$ E, the False Easting = 40 km, and the False Northing = 6,000 km. The Scale Factor at Origin is unity ($m_o = 1.0$).

On the solitary coral island of Niulakita, I guess that the origin of the Niulakita Astro Datum of 1965 is $\Phi o = 10° 47' 21.6059'' S$, $\Lambda_o = 179° 27' 51.7081''$ East of Greenwich, and the ellipsoid of reference is the International 1924. From the Niulakita Astro Datum of 1965 to the WGS84 Datum, $\Delta X = +184$ m, $\Delta Y = -465$ m, and $\Delta Z = +119$ m; the accuracy of this transformation is estimated to be ±10 m in Eastings and ±19 m in Northings. The Niulakita TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator ($\varphi_o = 0°$), the Central Meridian $\Phi_o = 179° 28'$ E, the False Easting = 15 km, and the False Northing = 3,000 km. The Scale Factor at Origin is unity ($m_o = 1.0$). A century ago workers excavated guano here for commercial fertilizer. Later an Australian company used the island as a coconut plantation, and in 1944 the British government purchased the island and gave it to overpopulated Niutao, which relocated a few families there.

On the atoll of Niutao, the origin of the NTO 1 Astro Datum of 1973 is $\Phi_o = 06° 06' 29.25'' S$, $\Lambda_o = 177° 19' 59.16''$ East of Greenwich, and the ellipsoid of reference is the International 1924. The vertical Datum at NTO 2 is based on a personal estimate of probable mean sea level! From the NTO 1 Astro Datum of 1973 to the WGS84 Datum, $\Delta X = +219$ m, $\Delta Y = -198$ m, and $\Delta Z = -92$ m; the accuracy of this transformation is es-

timated to be ±15 m in Eastings and ±4 m in Northings. The Niutao TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator (φ_0 = 0°), the Central Meridian λ_0 = 177° 20′ E, the False Easting = 30 km, and the False Northing = 5,000 km. The Scale Factor at Origin is unity (m_0 = 1.0).

The atoll of Nukulaelae is the easternmost of the Tuvalu islands and was the first island to accept Christianity. Because of rising sea level, Nukulaelae is threatened by salt water seeping into the taro swamps. For Nukulaelae, the origin of the Nukulaelae Astro Datum of 1965, actually on Fanagua Island, is unknown, but the ellipsoid of reference is the International 1924. From the Nukulaelae Astro Datum of 1965 to the WGS84 Datum, ΔX = +254 m, ΔY = –238 m, and ΔZ = –234 m; the accuracy of this transformation is estimated to be ±13 m in Eastings and±14 m in Northings. The Nukulaelae TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator φ_0 = 0°), the Central Meridian λ_0 = 179° 50′ E, the False Easting = 25 km, and the False Northing = 2,000 km. The Scale Factor at Origin is unity (m_0 = 1.0).

On the atoll of Vaitupu, the educational center of Tuvalu, I guess that the origin of Vaitupu Atoll Datum is at point VTZ 1 Astro: Φo = 07° 29′ 24.710″ S, Λo = 178° 41′ 52.31″ East of Greenwich, and the ellipsoid of reference is the International 1924. From the Vaitupu Island Datum to the WGS84 Datum, ΔX = +193 m, ΔY = +61 m, and ΔZ = +201 m; the accuracy of this transformation is estimated to be ±23 m in Eastings and ±26 m in Northings. The Vaitupu TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator (φ_0 = 0°), the Central Meridian λ_0 = 178° 41′ E, the False Easting = 10 km, and the False Northing = 1,000 km. The Scale Factor at Origin is unity (m_0 = 1.0).

On the capital atoll of Funafuti, the coordinates of the origin of the UF5 Astro Datum of 1973 are unknown but the ellipsoid of reference is the International 1924. The vertical datum is based on an automatic tide gauge situated on the main jetty at Fongafale, and 48-hour readings were obtained. The gauge is run by the University of Hawaii. From the UF5 Astro Datum of 1973 to the WGS84 Datum, ΔX = +189 m, ΔY = +783 m, and ΔZ = +256 m. The Funafuti TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator (φ_0 = 0°), the Central Meridian λ_0 = 179° 08′ E, the False Easting = 50 km, and the False Northing = 9,000 km. The Scale Factor at Origin is unity (m_0 = 1.0).

The only Micronesian community in Polynesian Tuvalu is on Nui. Nui is 255 km northwest of Funafuti Island. On the atoll of Nui, the coordinates of the origin of the Nui Astro Datum of 1965 are Φ_0 = 07° 13′ 40.09″ S, Λ_0 = 177° 09′ 47.26″ East of Greenwich and the ellipsoid of reference is the International 1924. The vertical datum is based on ocean and lagoon tide levels read over four weekends. The ocean staff gauge was off the Maneapa and the lagoon gauge was at the Government station. The two gauges were connected by height traverse to the local control and to the Post Office for height of the Meteorological Service mercury barometer. From the Nui Astro Datum of 1965 to WGS84 Datum, ΔX = +259 m, ΔY = +217 m, and ΔZ = –246 m. The Nui TM Local Grid is based on the Transverse Mercator projection where the Latitude of Origin is at the equator φ_0 = 0°), the Central Meridian λ_0 = 177° 09′ E, the False Easting = 20 km, and the False Northing = 4,000 km. The Scale Factor at Origin is unity (m_0 = 1.0).

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Update

The Pacific Islands Geospatial and Surveying Strategy 2017-2027 is a 10-year regional plan for developing geospatial and surveying capacity. The Tuvalu Geodetic Survey Project 2016—Phase I was supported by Government funding and consisted of 4 weeks for field surveys on 3 islands: Vaitupu, Nukufetau, and Funafuti.

In 2017, completion of Phase II of the Geodetic Survey for the four northern Islands (Nanumea, Nanumaga, Niutao and Nui) included Geodetic survey, Cadastral survey, Topo survey, UAV/Drone survey, Tide Monitoring to establish mean sea level or MSL, lowest astronomical tide or LAT, and highest astronomical tide or HAT on these 4 islands.

2018 saw completion of the last Phase III of the Geodetic Project on Nukulaelae, Niulakita and on Funafuti again.

http://ggim.un.org/meetings/GGIM-committee/7th-Session/side_events/2%20-%20Faatasi%20Malologa.pdf

https://tuvalutrustfund.tv/wp-content/uploads/2018/03/2018-TUVALU-NATIONAL-BUDGET.pdf

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