

# Grids & Datums

## UNITED REPUBLIC OF TANZANIA

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A Tanzanian gorge recently yielded a few bits of *Homo erectus*, but little is known about the country's really early history. Recorded history began around the first century BC, when various migrating tribes from West Africa first reached East Africa. While the country's coastal area had long witnessed maritime squabbles between Portuguese and Arabic traders, it wasn't until the middle of the 18<sup>th</sup> century that Arabic traders dared venture into the country's wild interior. European explorers began arriving in earnest in the mid-19<sup>th</sup> century, the most famous being Stanley and Livingstone. The famous phrase, "Dr. Livingstone, I presume," stems from the duo's meeting at the town of Ujiji on Lake Tanganyika.

During the late 20<sup>th</sup> century, Germany began colonizing Tanganyika - as the mainland was then known - by building railroads and commerce. The first railroad started construction in 1893 at Tanga on the coast and reached Moshi in 1911. A railroad from Dar es Salaam to Morogoro was begun in 1905 and was completed in 1907. However,

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The international boundary between Tanganyika and the Belgian Mandated Territories of Ruanda and Urundi was demarcated by the Tanganyikan Survey Department in the years 1922-1924. The secondary triangulation in connection with this Boundary Commission was the first piece of triangulation work undertaken by the Department. Triangulation in the East and West Usambara Mountains was surveyed from 1894-1911 and was recomputed in 1931. The Anglo-German Boundary Commission surveyed Zanzibar from 1902-1906 and the First-Order survey was started based on the coordinates of Vunta (on the mainland), where  $\phi = -4^{\circ} 28' 51.346''$  S,  $\lambda = 37^{\circ} 57' 37.954''$  E, and was referenced to the Clarke 1880 ellipsoid where  $a = 6,378,249.145$  m and  $1/f = 293.465$ . A Second-Order triangula-

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the *tsetse fly* provided a significant obstacle to greater participation in establishing a large colony in German East Africa. After the Germans lost WWI, the League of Nations mandated the territory of Tanganyika to the British. The British had already conquered the offshore island of Zanzibar, which for centuries had been the domain of Arab traders (*Lonely Planet*). All existing surveys have been subsequently performed by the British. Tanganyika became independent on December 9, 1961. The United Republic of Tanganyika and Zanzibar was constituted by a merger in April 27, 1964, and the name of the state was changed to the current United Republic of Tanzania on October 29, 1964.

Tanzania is bordered by Burundi (451 km), Kenya (*PE&RS*, June 2003) (769 km), Malawi (475 km), Moçambique (*PE&RS*, September 1999) (756 km), Rwanda (217 km), Uganda (396 km), Congo (*PE&RS*, June 2005) (459 km), Zambia (*PE&RS*, October 2004) (338 km), and has a coastline of 1,424 km on the Indian Ocean. Slightly larger than twice the size of California, the terrain consists of plains along the coast with a central plateau and highlands in the north and south (*CIA World Factbook*). The lowest point is the Indian Ocean (0 m), and the highest point is on Mt. Kilimanjaro recently determined by GPS observations at Uhuru Peak to be 5892 m, using the EGM96 geoid (*Professional Surveyor*, May 2000). The islands of Zanzibar and Pemba

tion was performed in East Usambara in 1893, south of Mombasa and west of Tanga.

Whitehouse performed some Third-Order triangulation along the southern shore of Lake Victoria in 1906-1907, which was based on the earlier Anglo-German Boundary Commission survey. Third-Order triangulation in 1898 was done by the Anglo-German Nyasa Boundary Commission and was based on a local Astro determination of latitude but used a value of longitude based on the Cape triangulation. The German-Portuguese Boundary Commission performed a survey in 1907 East of Lake Nyasa along the border with Moçambique (*Mitt. aus den Deutschen Schutzgebieten, Ergänzungsheft 23, Berlin, 1910, pp. 49-56*).

From 1922 to 1924, the Anglo-Belgian Boundary Commission for Ruanda-Urundi and Tanganyika performed a Second-Order triangulation that was part of the 30° Meridian Arc. This triangulation was carried across Lake Tanganyika and connected to a secondary chain originating from the Rhodesian Arc (now Zimbabwe). The Morogoro Net was surveyed from 1912-1914 and was a First-Order triangulation, as was the Pare-Moshi-Arusha Net surveyed from 1913-1914. Both were based on original German field observations that were recomputed in 1931. (Originally published by Dr. von G. Pinkwart of Hanover in *Allgemeine Vermessungs-Nachrichten, Nos. 11 et sequitur, 1926*.)

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The connection with the Rhodesian and Uganda Arcs were performed from 1932-1933 and were First-Order triangulations organized by the British War Office under the supervision of Major Martin Hotine, Royal Engineers. Note that Hotine later would be promoted to Brigadier and he would eventually direct the Directorate of Overseas Surveys (DOS) for its entire existence! Triangulation baselines measured with invar tapes included Ar dai (1932) @ 37,478.1519 ft  $\pm$ 0.0324 ft; Dodoma (1933) @ 31,784.861 ft  $\pm$ 0.00865 ft; Ulete (1933) @ 20,684.480 ft  $\pm$ 0.04482 ft; Seke (1936) @ 37,948/116 ft  $\pm$ 0.03684 ft, etc. – the miniscule errors between forward and back chainings are mind-boggling!

“The Struve Arc is a chain of survey triangulations stretching from Hammerfest in Norway to the Black Sea, through 10 countries and over 2,820 km. These are points of a survey, carried out between 1816 and 1855 by the astronomer Friedrich Georg Wilhelm Struve, which represented the first accurate measuring of a long segment of a meridian. This helped to establish the exact size and shape of the planet and marked an important step in the development of earth sciences and topographic mapping. The original arc consisted of 258 main triangles with 265 main station points. Otto Stuve, son of F. G. W. Stuve, was keen to carry forward the ideas of his father. Sir David Gill took over as Her Majesty’s Astronomer at the Cape of Good Hope in the late 1870s, and had the dream of connecting with Struve’s Arc. In 1879, Gill started the triangulation northward, and by 1892 all of its length in South Africa was complete together with two of the four baselines. 1897-1901 saw much of Southern Rhodesia (Zimbabwe) completed by Simms except for a small piece around 21°-22° south which was filled in later. 1903-1906 saw Rubin complete most of Northern Rhodesia (Zambia), and in 1908-1909 Jack and T.G. McCaw (*Hotine’s Mentor – Ed.*) did a section in southern Uganda. Thus between 1879 and 1909 the great majority of the triangulation from South Africa to the Equator was completed. The gap was from 10°S northward to 1°S. This was partly completed by Hotine in 1931-1933 and the rest by the Tanganyika Survey Department in 1936-1938. Looking now from the Mediterranean Sea southwards, Egypt was covered between 1907 and 1930 and much of the Sudan at varying periods between 1901 and 1951. This left one last section of around 600 miles in southern Sudan and Northern Uganda which was the most difficult of all because of the terrain in the Sudd. This was finally filled in with the assistance of the U.S. Army Map Service during 1952-1954” (*The Connection Between the Struve Geodetic Arc and the Arc of the 30th Meridian, Jr. R. Smith, FIG, September 2005*). That historic

connection was surveyed by William Parkhurst, my mentor, who got me my first job as a Junior Map Draftsman at Offshore Navigation, Inc. in 1963 in New Orleans. I recall later sitting in Bill’s living room in Metairie, Louisiana and looking at the snapshots of him seated in a saddle on a camel during his surveys in the Sudan. (My late mother was a close friend of Bill’s wife, Hazel – small world ...).

A variety of astronomical observations have been performed in Tanzania, and the data has been graciously provided by John W. Hager: for Pemba Island (1957) at Observation Spot + Mpigangoma,  $\Phi_o = 5^\circ 02' 41.656''$  S,  $\Lambda_o = 39^\circ 39' 02.465''$  E. Reference, East Africa - West Coast of Pemba Island, H.M.S. Owen, 1957 and H.M.S. Owen 1958, H.12/1299, 15 August 1958. For Ras Shangani Observation Spot  $\beta$ ,  $\Phi_o = 6^\circ 09' 45.82''$  S,  $\Lambda_o = 39^\circ 11' 04.72''$  E.,  $a_o = 358^\circ 54' 39.2''$  to Mangapwani Lighthouse (G), Clarke 1880. H.M.S. “Rambler” 1900. I have a pencil note on the ellipsoid “from 1951 or earlier?”. The British Admiralty usually used Clarke 1858 so I wonder (now) if I suspected a change in ellipsoid. Weti (code WET), at South End of Weti Base,  $\Phi_o = 5^\circ 03' 48.31''$  S,  $\Lambda_o = 39^\circ 43' 00.00''$  E,  $a_o = 71^\circ 13' 50.35''$ . I’ll bet that the astro longitude wasn’t very good or they were very lucky. New Pillar Zanzibar (code NPI) at Observation Spot New Pillar.  $\Phi_o = 6^\circ 09' 45.82''$  S,  $\Lambda_o = 39^\circ 11' 04.72'' \pm 07.5''$  E,  $a_o = 358^\circ 54' 31.4''$  to Northern Lighthouse, Clarke 1858; possibly by Sir David Gill, 1905. The longitude was transferred to Igurua in Uganda. My original list had a New Pillar datum and a Zanzibar datum. I am now combining the two to have code NPI as New Pillar Zanzibar.”

The grid systems known to exist in Tanzania include: the Tanganyika Territorial Transverse Mercator Belts (F-J) where the Central Meridians are from 27° 30' to 42° 30', the Latitude of Origin is the Equator, the Scale Factor at Origin is 0.9995, the False Easting is 133,333.333 meters, and the False Northing is 3,333,333.333 meters; the East Africa Transverse Mercator Belts G and H are where the Central Meridians are 32°30' and 37°30', same False Origins as the Territorial Belts, and the South African Belts have Central Meridians of 35° to 41° at 2° intervals with a Scale Factor at Origin of Unity and have False Eastings of 250 km and False Northings of 500 km. Current papers describing coordinate systems used in Tanzania refer exclusively to the standard UTM Grid with no reference to the older TMs used by the British.

TM 8350.2 offers transformation parameters **from** the Arc 1960 Datum as realized in Tanzania **to** WGS84 as:  $\Delta X = -175$  m  $\pm$ 6m,  $\Delta Y = -23$  m  $\pm$ 9 m, and  $\Delta Z = -303$  m,  $\pm$ 10 m. Thanks again to John W. Hager for the elusive Astro positions of Tanzanian Datum Origins and to the late Hazel Parkhurst for the memories.