THE LAST TAUT-WIRE SUN-AZIMUTH TRAVERSE

Locating Cagayan Sulu

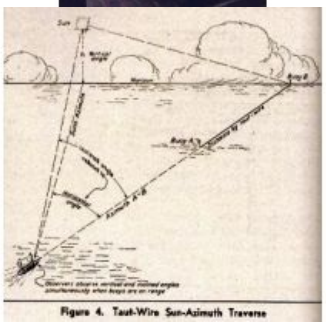
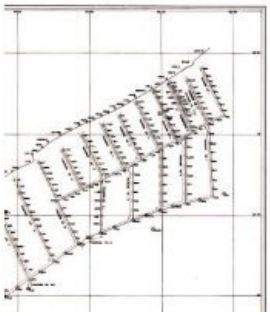


Figure 4. Taut-Wire Sun-Azimuth Traverse

TAUT-WIRE SUN-AZIMUTH TRAVERSE



A glance at a map of the Philippine Islands shows that the Sulu Sea is nearly an enclosed body of water: the Sulu Archipelago on the southeast; Palawan to the northwest; the main body of the Philippine Islands to the northeast; and Borneo on the southwest. Far in the southern reaches of the Sulu Sea, located almost midway between the Sulu Archipelago and Palawan and northeast of Borneo, are a small group of islands, the largest of which was known as Cagayan Sulu, today called Mapun. These small islands were among the most remote of the Philippine Islands and determining an accurate position of these islands for charting purposes was problematic. The position relied upon in the late 1930s was astronomically determined by British surveyors in 1889 but local navigators felt this position to be in error.

In 1939, the charting agency for the Philippines was the United States Coast and Geodetic Survey (USC&GS). The Survey had been working in the Philippine Islands for nearly 40 years at this time and had completed the triangulation of the main islands on the north, through the Sulu Archipelago on the east and down the spine of Palawan, across Balabac Strait, to Balabac Island on the west. Thus three sides of a great polygon enclosing the Sulu Sea had been completed. What remained was for the British to complete the triangulation of northern Borneo to enclose the Sulu Sea in a great trigonometric figure and allow for the adjustment of the total triangulation network of the southern Philippine Islands and northern Borneo.

Not coincidentally, completion of the triangulation of northern Borneo would have allowed a relatively easy tie to Cagayan Sulu. Accordingly, a request was made to the British Admiralty to complete the northern Borneo triangulation which was gladly agreed to. Orders were issued for the East Indies survey ship HMS *Scarborough* to execute this work. However, World War II intervened, and more important issues than the triangulation of northern Borneo determined that the ship and its crew would return to the Atlantic for convoy escort duty. This left the C&GS with the need to improvise, as not only were they planning on completing the polygon enclosing the Sulu Sea, but they also wished to better position Cagayan Sulu for control of hydrographic surveys in the southern Sulu Sea. An accurate geodetic position would have to wait until after the war, but a sufficiently accurate method to determine the position of these small islands for hydrographic surveying purposes was within the realm of possibility. This method was the taut-wire sun-azimuth method of measuring distance and direction between anchored survey buoys.

The taut-wire machine was invented by the English firm Telegraph Construction and Maintenance Company and it was first used by British hydrographers in 1921. The machine was originally used to determine the geographic positions of buoys that would provide visual control for surveys far offshore. Conceptually, the method was quite simple: a wire measured the distance between buoys and sextant observed sun azimuths provided azimuth control for determining position. In practice, this was a relatively complicated operation involving a high degree of teamwork. While conning the ship to stay on range with two buoys of an array, the sun's altitude was observed simultaneously with the inclined angle between the sun and a two-buoy range to obtain the direction between the buoys. In practice, this involved many personnel including an officer-in-charge conning the ship to stay on range between buoys, an assistant on the bridge recording various associated data, observers reading and checking the taut-wire sheave, the inclined angle observer measuring the angle between sun and buoys on range, vertical angle observer measuring altitude of sun, angle recorder, pelorus attendant reading directions of on-range buoys off compass stand (for a gross check on observed sun azimuth), a helmsman, and a fathometer attendant for recording depths.

As practiced in the United States during the 1930s, taut-wire surveys were used extensively to establish buoy locations for visual control of surveys along the mid-Atlantic coast and Gulf coast of the United States. These were areas of wide continental shelf with low coastlines that made it impossible to carry traditional land-based visual control to the edge of the shelf. Radio acoustic ranging was also infeasible as the acoustic signal generally dissipated in the shallow water. The buoy arrays established in these areas were quite extensive. One array

on the Texas coast had over 250 buoys planted in 1938 during the course of a survey season. When reaching the edge of the continental shelf, radio-acoustic ranging sono-buoys would then be placed for surveying in the deeper offshore waters.

The first step in implementing a taut-wire survey in the southern Sulu Sea was to purchase and install on the ship *Research* (formerly the *Pathfinder*) a taut-wire device and two reels of wire, each reel containing 140 nautical miles of piano-wire. Two plans were considered for positioning an 'initial' buoy. The first of these considered placing it in a location where a three-point sextant fix could be observed between triangulated peaks on Palawan, Balabac, and Banguey islands. A second plan was developed to position the initial buoy somewhere on the line of position determined by measuring the single angle between the peaks on Balabac and Banguey islands near the limit of their visibility and measuring a sun azimuth to one or both of these peaks from the location of the initial buoy. This plan had the advantage of shorter traverse length coupled with a belief that this shorter length would afford greater overall accuracy. The first plan had the following disadvantages:

1. because of clouds shrouding its high peaks, there would be an uncertain wait for observing the high Palawan peaks;
2. use of the Palawan peaks would necessitate placing the initial buoy much farther north than was desired;
3. the further north position would lengthen the line of intermediate buoys and would also reduce the availability of observing on Balabac and Banguey; and
4. conservation of wire was imperative. Thus selection of the second plan was dictated by the circumstances of the project.

Because the two ends of the traverse were not inter-visible, a final step was to establish a string of buoys placed at 5 to 7 mile intervals between the initial buoy and a 'terminal' buoy at the southeast end of the traverse. The terminal buoy was located by simultaneously observing theodolite angles from three triangulation stations on Cagayan Sulu and two small outlying islands. The total traverse length was 38.4 nautical miles and was taut-wired in both directions. The two measures allowed treatment of the traverse as a closed loop. Extra care was taken in calibrating the taut-wire sheave (in this instance, the calibrated value was 1.86737 metres per revolution of the sheave) and accounting for eccentricities of intermediate buoys which were moored in an average depth of 40 fathoms. Also, reciprocal sun azimuths were measured between buoy pairs in each direction, and the distance between initial buoy and terminal buoy was measured as a continuous run in each direction without break. All of these precautions resulted in an overall closing accuracy of 0.6 metre per nautical mile (approximately 1 part in 3,000), a result more than adequate for the follow-on hydrography that was to be conducted. As a result of this traverse, the position of Cagayan Sulu was shifted 1,150 metres southward in latitude and 2,500 metres westward in longitude. This confirmed the suspicions of mariners navigating these waters that the islands were not charted in the proper location.

In retrospect, the technologies and methods used to determine positions for hydrographic control far offshore prior to the era of electronic navigation systems and today's GPS seem almost heroic. The skill level, knowledge required, seamanship, and teamwork of hydrographers using this methodology was impressive. However, this was the last taut-wire sun-azimuth survey ever run by C&GS hydrographers and marked the end of an era. As with their British counterparts, the United States would soon be drawn into World War II. Early in 1942, the *Research* was lost to a Japanese bombing raid ending a career of 40 years in the islands. Lieutenant Commander Carl Egner, the commanding officer of the *Research* during the taut-wire survey described above, remained in the Philippines and was incarcerated at Santo Tomas prison during the Japanese occupation of the islands. However, C&GS charts, geodetic positioning, and tide predictions were used by US forces in the liberation of the Philippine Islands. New technologies such as electronic navigation methods and electronic distance measuring devices made far offshore visual surveys unnecessary and taut-wire surveys obsolete. The Philippine Islands attained their independence following the war and USC&GS officers returned to assist in training a new organisation, the Philippine Bureau of Coast and Geodetic Surveys. Today the functions of that agency have been incorporated into the Philippine National Mapping and Resource Information Authority (NAMRIA).

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