Table II. GMT of sunset, latitude and longitude for on board sunset. Read from below for aircraft heading east

Latitude	GCT Sunset	Longitude
4°31´.5	0718:45	159°19´
4°32´.0	0718:56	159°16´
4°32´.5	0719:07	159°13´
4°33´.0	0719:18	159°10´
4°33´.5	0719:30	159°07´
4°34´.0	0719:41	159°04´
4°34´.5	0716:07	159°01´
4°35´0	0720:03	158°58´
4°35´5	0720:14	158°55

For longitudes west of 159°07´ arrival for sunset is early. For longitudes east of 159°07´ arrival is late. Match is at simultaneous means of time and longitudes rows.

4.2. No Time error of Chronometers

Whatever algorithm is followed, be it H.O.208, any logarithmic gonio table, or e.g. the Douwes-Borda formula, the here recomputed endogenous outcomes remain constant: the Earhart to Herald Tribune Offices, New York, June 30, 1937 cable, reading in part: *"..In addition FN has been unable* [electric breakdown at Malabar radio station. auth.] *account radio difficulties to set his chronometers lack knowledge their fastness or slowness.."* later outdated since the 071930 GMT, 0720 by radio communicated time-coordinates group is inviolably interconnected by mathematical precomputation with heliographic time as exogenous parameter which made a structural time error impossible: the on board chronometers [and Longines hack watch] must have been perfectly synchronous with a record of the Greenwich time and for that matter: a navigator would never reset two [of three] chronometers on his own initiative, knowing thereby activating Spode´s Law [3] in its deadly configuration.

4.3. The accuracy of the Sunset Fix

In the course of time mathematicians have developed more precise algorithms for loxodrome sailing; an advanced prescription for true course Ct in Mercator sailing is:

$$Ct = \tan^{-1}\left[\frac{3.143\,(Long_1\text{-}Long_2)}{180\,\{[\ln\tan(45° + ½\,L_2) - \ln\tan(45° + ½\,L_1]\,\}}\right]$$

[4] with for distance $D_{nm} = 60[L_2 - L_1]$. Sec C_t and the latitude of arrival $L_2 = \{[D_{nm}\cdot \cos C_t] / 60\} + L_1$. By insertion of the here applicable figures we obtain Ct = 81°26´02", D_{nm} 295.4, D_{sm}341, Lat.of arrival 04°30´00", this time computations by electronic calculator, with outcome that for air navigation the of the era calculation methods were of a sufficient if not excellent degree of exactness: in the thirties the enclosed circle of uncertainty for an aeronautical sundown – sunrise fix had a 6 st.mls radius if the sextant was operated by an experienced air navigator, hence the precalculation´s quality was better than the obtainable precision of observation.

5. The Sunset Observation in Practice

Table II charts the practical solution of the sunset fix. Note that westwards of the 159°07´ meridian the aircraft´s velocity was too great, whereas eastwards it was too small for having sun´s centre in the crosshairs of the sextant´s artificial horizon at the instant of sunset for the longitude. Evidently, the aircraft piloted as steadily as possible, Noonan acquired collimation, the bubble sextant preset +53´ [5], green filter, at plusminus 071930 GMT watch time for the 159°07´- 04°33´.5 closest coordinates of his running fix diagram, upon which he advised Amelia to communicate his findings about the closest coordinates pair and she so did at 0720 GMT according to the radio logbook of Lae Airport held by Harry Balfour. Shortly afterwards the aircraft´s radio changed from 6210 to the ´night time´ 3105 kcs channel as a result of which the operator never heard KHAQQ again. It was neglected that the 864 miles eastwards, over New Guinea sun was still largely [10°08´] above the Lae horizon so that the wave front quenched [8] before reaching airport´s aerials [6]: the 0720 fixed position remains the one and only on record.

6. Conclusion

During the to Howland flight of the Earhart-Noonan crew, an observation of sunset with the bubble sextant, [A/c @ 7000 ft, no optical horizon] at 0719:30 GMT followed by the 0720 GMT radio announcement placed the aircraft close to if not spot on the coordinates pair 159°07´-E; 04°33´.5-S, 27 miles southwestwards of the Nukumanu Islands, which is unconditional proof that the originally for the March, 1937 Howland to Lae, New Guinea, precomputed great circle trail running 13 stat.miles northwards, prerequisited in many if not all current publications on the subject, was not flown during the in reverse sense voyage of July 2. The primary rationale for this statement is that the eastwards flight to a very small open ocean target was a notoriously more dangerous venture than the original one from Howland to Lae with the vast mainland of New Guinea, or occasionally the numerous Solomon Islands, extending ahead after an at random landfall. On the ship Ontario, on station halfway the great circle at 165°06´-E; 03°09´-S with watch kept and appointments made, no aircraft was heard and no radio call received whereas the aircraft´s alternative progression line ran 100 mls south-eastwards at 1000 GMT: continued mysteriousness. In addition the aircraft´s radio signals were on the air from 1030 GMT when they were heard at Nauru, but great circle chord coordinates, ranking first for safety, were not transmitted. Due to the rather elaborate precomputations, necessary to deal with a sunset fix and other navigational adaptations it is to be expected that the resolution for not flying the great circle has been taken a substantial time, at least days before takeoff, with exception for the case that an alternative [composite sailing via Nauru – Nikunau] was a priori deployed. It must have been with respect to the eventual flight plan that Noonan, answering superintendent of civil aviation for New Guinea J.Collopy´s question about expectations, said that he was at ease about finding the island. The optimism did not come true: most probably by using the marine sextant for the sunrise fix next morning in the roads of Howland, without 3^m50^s [7] correction for the with regard to the bubble sextant different reference line, whereas the mean sun was the watch time standard [1], an erroneous [westward] position line was flown along and Howland, at ETA 1912 GMT 16 mls on the port bow in lieu of below the APL and of another category than, e.g., the Hawaiian Islands, remained beyond visual range.

References [selection from 108 entries]

- S.P Howell, Practical Celestial Navigation. Susan Peterson Howell Memorial Fund, 1987.
- US Naval Institute, Annapolis Md, Navigation and Nautical Astronomy, B.Dutton USN, 7th Ed. C.H.Cob, 1942.
- Norie, J.W., Nautical Tables, Imray, Laurie. Norie & Wilson Ltd. London 141.
- USGPO, H.O.Pub.no.208 Navigation Tables for Mariners and Aviators, Dreisonstok. Washington 1936.
- US Hydrographic Office, H.O.no.9, P.II Useful Tables, USGPO Washington DC, 1940.
- Radler de Aquino, Brasil.N., Sea and Air Navigation Tables. US Naval Institute, Annapolis Md, USA.

Notes

[1] "Where to Search for the Earhart Lockheed Electra". EJN Vol.6 no.2. July 2008.

[2] 1937 Nautical Almanac: Sun July 2, Decl. 83134".8, shift per 24^{hrs} (-) 261".9. Eq.of Time 0000 GMT $221^s.62$, shift per 24^{hrs} (+)$11^s.42$, 0000 GMT Appar.Right Asc. of sun $24129^s.01$ = $6^h42^m09^s.01$, shift $247^s.97/24^h$, Lae 10 hrs ahead of, Nauru 11 hrs ahead of, Howland US Navy 11 ½ hrs slow on GMT.

[3] Spode´s Law: "Thrown away information will be the most needed in future".

[4] I borrow this formula from S.P.Howell, viz.references.

[5] 37´ refraction, 16´ semi diam.

[6] Conflict of thought: due to lack of radio experience and knowledge Amelia took the night time channel indication for literal; Balfour hurriedly tried to hold back to transmit the latest weather forecast on 6210 kcs but he was too late.

[7] The equation of time, true sun slow, at sunrise happened to be 3^m50^s likewise, it is therefore possible that it was considered that the obligatory addition was already accounted for by this figure alone. As a result the course for the one line approach may have been set at 1754:53 GMT instead of at 1758:43 GMT, 10 mls westwards of the initial turning point.

[8] HF spectrum radio signals of the 2,000 – 4,000 kcs frequency suffer absorption by sunlight in the lower troposphere and up to the 60 miles level of the stratosphere.