Fred Noonan's PanAm Memo.

This is an internal Pan American Airways memorandum written by Fred Noonan in 1935 describing the navigational methods and procedures he used in guiding the first Pan Am round-trip survey flight from California to Hawaii..

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MEMORANDUM

DATE April 29, 1935

FROM Operations Manager

DEPT Pacific Division

LOCATION Alameda, Calif.

FROM Navigator, Pan American Clipper

DEPT Operations

LOCATION Alameda, Calif.

SUBJECT Hawaiian Flight of NR 823-M
April 16-17 and 22-23, 1935
Navigation:

Surface navigation is known, to the profession, as an inexact science. Frequent groundings of vessels equipped with the most modern navigational equipment, and manned by officers highly skilled in their profession, justifies this description of the art.

The factors which contribute to inaccuracies in surface navigation - currents other than anticipated or estimated, lack of sights, inaccurate radio bearings, etc. - are all encountered in aerial navigation and commonly in intensified form. Hence is it impossible on an extended flight to obtain consistently accurate "fixes" by any single method, or by any combination of methods. But by an understanding of the weaknesses of each method, it should be possible to greatly minimize the errors inherent in all of them.

An analysis of the navigation of the NR 823-M during the flights from Alameda to Honolulu and return reveals some interesting information. Pointing out, as it does, weaknesses of the different methods, and human errors possible, it can be of assistance in formulating navigational procedure tending to minimize both.

The inaccuracies of direction finding bearings can be very definitely cataloged: twilight effects, faint signals, wide splits of minima, and inaccurate calibration. The latter, being of a temporary nature, may be ignored. The error, due to twilight effects, may be negligible and again so erratic as to render the bearings valueless. This seems to be substantiated by bearings plotted on the two charts covering the flight. Reference to the westbound chart will show that bearings from Alameda during the evening twilight period were consistently steady. On the return trip, bearings from Kaneohe Peninsula during the twilight period were very erratic. Afterwards they steadied up considerably. Inasmuch as the ship was on approximately the same bearing at all times, the error would not seem to be due entirely to inaccurate calibration.

Under conditions such as existed when leaving Oahu; that is, bearings generally showing a large set off the track, no means of checking drift angle, and the only heavenly body visible affording no means of determining change of latitude, the navigator must rely upon his judgment. In the instance mentioned, after obtaining a line of position from the sun at 0340 G.C.T., a glance showed that if the 0328 bearing were advanced to cross the line of position the ship

would be considerably ahead of her D.R. position for the short time out from Land. Doubting the ship was making the drift and speed so indicated, the course was maintained. Subsequent bearings and sights showed the ship to be to the southward, rather than the northward, of her required track.

With respect to faint signals and wide splits of minima, the plotted long range bearings straddled the ship's position fairly equally; hence, a mean of such bearings should give the navigator a fair bearing from the station.

Another condition which may cause the navigator to be doubtful of his exact position is such as existed during the return flight while between the 145th and 155th meridians. Sights consistently showed the ship to be to the southward of the original great circle track. Some few D.F. bearings agreed with the "fixes" so obtained, but the majority placed the ship varying distances to the northward. Due to the facts that the observations were made during slightly rough air conditions, and that the bearings, although generally placing the ship to the northward, were not uniform, it was at first difficult to definitely decide which method was more reliable. During this period, to minimize any divergence from the required track, it was assumed the ship was on a track approximating the mean of the two methods.

Subsequent observations were made under smoother flying conditions, and they, plus additional D.F. bearings and the courses and distances flown, showed the earlier "fixes" to have been approximately correct. By "approximately correct", accuracy within ten to fifteen miles is implied. The writer's experience has shown that a "fix" within that distance of the true position is about the average accuracy which can be expected in aerial navigation.

It is impossible to lay down hard and fast rules by which one may determine the reliability of observations. However, after some experience a navigator "senses" whether or not a sight is reliable. If the ship is noticeably in horizontal flight, differences in a run of altitudes and times are fairly uniform, and, if the "feel" of good sights exists, the resultant "fix" will in all probability be more accurate than a position determined by long range D.F. bearings. Successive "fixes" in agreement should definitely establish the ship's position, irrespective of other indications; such as, D.F. bearings, to the contrary.

If observations are not reliable, the fact should be readily discernible by the lack of agreement in "fixes".

Illustrative of the degree of error possible when sights are taken under adverse conditions is the 1124 G.C.T. "fix" on the eastbound chart, determined by observations of *Polaris and * Altair. These sights were obviously unreliable and consequently were discarded, but were plotted on the chart for demonstration purposes. During the hours between approximately 0900 and 1200 G.C.T., it was difficult to obtain reliable sights due to the movement of the plane. Under such conditions a record of the ship's position must be obtained by a combination of dead reckoning and the mean bearing determined by any group of D.F. bearings.

In connection with the difficulty experienced in taking observations while the plane was not in smooth flight, it was interesting to note that much more reliable observations were obtained while the ship was flown manually than

was possible while the robot pilot was used. Also, that better results were obtained from observations of bodies nearly ahead or astern than from bodies abeam.

The human error, which is difficult to eliminate, and for which no "mean" can be determined, was also apparent. The first instance concerned the intercept for the observation of * Sirius at 0427 G.C.T. on the westbound flight. The observed altitude of this star was less than the computed altitude, hence the intercept should have been applied away from, or to the eastward of, the assumed position. By error it was applied to the westward. The position obtained by reason of this error confirmed the estimated ground speed. But for the error, the decrease in ground speed would have been apparent at that time and subsequent D.R. positions would have been more accurate.

A somewhat similar error was made by the Radio Operator. This consisted of incorrect application of the goniometer calibration correction to bearings taken on either or both of the steamships "Malolo" and "Monterey" at approximately 1200 G.C.T. during the westbound flight. The resulting incorrect bearings gave a position so obviously wrong they were discarded.

Although such errors are made under all conditions, it is believed a reduction of paper work during flight would tend to reduce such errors. Such reduction of paper work could be obtained by shortening the position reports to a statement of latitude, longitude, track desired, and ground speed, and leaving the compilation of the log data (excepting cloud formations) to be completed on the ground after each flight. The information necessary to do this could be obtained from the flight engineer's report.

A very definite check on ground speed may be obtained by goniometer D.F. bearings of surface vessels when abeam or nearly so. Short distance bearings obtained by the goniometer proved to be very reliable, but distant bearings - for example, from Los Angeles - were not accurate.

An Analysis of the entire navigational data of the subject flights indicates that it is impossible to determine consistently accurate positions during extended over-water flight, but that a degree of accuracy which will insure safe navigation and reasonably direct tracks may be obtained by careful consideration of existing conditions when utilizing dead reckoning, radio direction finding, or celestial navigation. With respect to the errors in the D.F. bearings, if they can be kept within the limits of those appearing in the bearings received from Alameda during both stages of the flight, they may be considered as negligible. While the use of bearings will not insure extreme accuracy in navigation, they are nevertheless of inestimable value and will always serve as a dependable homing device.

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