A Plea for Simplicity

G. G. Bennett

I believe that it is timely that Dr. B. D. Yallop, Head of HMNAO, has responded[1] to criticisms and the discussions surrounding the inclusion of 'Sight Reduction Procedures' and 'Sight Reduction Tables' beginning with the 1989 edition of the *Nautical Almanac*. As my name was mentioned by Dr Yallop, I would like to set out my own views on some aspects of those discussions because I believe that both the 'theoreticians'' and the 'practitioners'' positions have become too polarized.

The inclusion of Sight Reduction Procedures in the *Nautical Almanac*, in my opinion, is not warranted. The main purpose of the *Nautical Almanac* is to provide ephemeral data for celestial navigation and not information related to the programming of computers. Nowadays it is often difficult to distinguish between instruments that are called 'programmable calculators' and those called 'computers', however, the name 'calculator' is invariably reserved for instruments that require separate key strokes for each mathematical operation and have very little memory. It was unfortunate that the word 'calculator' was used in explanation of those Sight Reduction Procedures because I believe that it was not intended to convey the idea that the operations described were to be executed with a calculator. If one is interested in programming a computer then there are many sources of information, such as journal articles, textbooks etc. and, of course, the excellent series of *NAO Technical Notes* available from HMNAO. In addition, a fruitful source of information on the simultaneous determination of latitude and longitude by timed altitudes using the method of least squares will be found in a host of articles published over the last half-century in British, French, Australian, New Zealand and South African geodetic and surveying journals as well as textbooks. To pass from the land-based to the marine environment is no great hurdle. The appropriate place for Sight Reduction Procedures is not in the *Nautical Almanac* but in *Compact Data for Navigation and Astronomy*, where it has been included in the last two issues.

One can advance a more convincing argument concerning the inclusion of Sight Reduction Tables than Sight Reduction Procedures in the *Nautical Almanac*. For the latter, one would only have very occasional need, but for the former they could very well be used on a regular basis if a navigator made observations frequently and chose that tabular method of sight reduction. I am not suggesting for one moment that celestial observations should be the navigator's position fixing mainstay – GPS has revolutionized all that. Retaining a modicum of skills in celestial navigation is recommended.

I would like to make a plea for simplicity in sight reduction procedures, especially when assessing the results of calculations. In his original contribution Mr Pepperday[2] refers to five commercially available 'pocket computers' that were available in the mid-eighties and also states that 'One brand limits a fix to forty sights: the others set no limit on the number of sights per fix.'. As I wrote the software for the computer that was singled out I should explain the reasons for limiting the number of sights. The program calculated the 'least squares fix' and then went on to display the residual or correction (-error) for each sight. The operator could then decide on a basis of the nature of those residuals what further action, if any, should be taken. This approach is unlike that of the other computer programs referred to and also that set out in the *Nautical Almanac* and *Compact Data*. To be able to provide this facility it was necessary to store the computed azimuths and intercepts which naturally limited the number of sights that could be

processed without re-entering data. So, rather than calculate the 'variance of unit weight' (i.e. the sum of the squares of the residuals divided by the number of degrees of freedom, etc., which does not place a limit on the number of sights processed), the individual residuals were displayed. This was done simply by finding the distance and azimuth (R, θ) between the DR position and the Fix position and then

$$v_i = I_i - R\cos(\theta - A_i)$$

where v_i, A_i and I_i are the Residuals, Azimuths and Intercepts respectively. This has the virtue that one may inspect the v_i, which are automatically output by my program, then:

(a) If any residual is larger than one expects under the circumstances pertaining at the time of observation then that observation could be rejected, without re-entering any data, and the fix re-calculated.

(b) If it is suspected that a constant systematic error was present in the altitudes, *all* position lines could be displaced by a constant amount either *all* towards or *all away* from their sub-stellar points. An examination of the position line plot, *an essential operation for all fixes*, may then reveal such a situation.

Any further calculations, such as the determination of the size and orientation of the error ellipse, with set confidence limits, is seldom warranted because statistics based on small sample sizes are notoriously unreliable or even misleading. The navigator is the best judge of the reliability of the fix and the quality of the observations.

The least squares method as applied to marine astronomical position fixing is but a convenient routine when there are superfluous data. Mathematical models with their associated variance/co-variance matrices in many respects are somewhat conjectural when one considers the variability in the physical conditions surrounding the observations.

The residuals from the data given in C. DeWit's paper (U.S. Journal of the Institute of Navigation Vol. 21 No. 4 1974–1975) have been calculated and are shown in the accompanying table; their distribution in azimuth, size and sign indicate to me that the fix was of good quality.

Observation	Intercept I_i	Azimuth A_i	Residual v_i
1	3·5′	30°	0·1′
2	4·5	80	0·1
3	1·5	145	−0·3
4	−3·0	198	0·1
5	−4·5	280	0·5
6	−2·0	305	−0·6

REFERENCES

[1] Yallop, B. (1996). The *Nautical Almanac* and the changing role of HM Nautical Almanac Office. This *Journal*, **49**, 274.

[2] Pepperday, M. (1994). The Nautical Almanac's faulty calculator instructions. This *Journal*, **47**, 89.

KEY WORDS

1. Astronomical navigation. 2. Computers. 3. Sight reduction.