It is indeed useful for the captain of a ship to be able to define usable space and have its limits drawn on ECDIS. But permanently available depth information on the screen is essential for the safety of navigation (both inside and outside usable space). Landmarks and other features on the screen allow positional checks.

More than 10 years ago, hydrographic offices started comprehensive surveys (sidescan sonars and multibeam echosounders may give 100 percent coverage of the bottom) on major sea lanes and approaches to harbours. In areas of comprehensive surveys the navigator has the guarantee that no danger to navigation has escaped detection. Those areas will help greatly to define usable space in the years to come. Route planning inside usable space belongs to the captain.

Having, as proposed by Dr Bianchetti, an EPNIS on one side and a paper chart on another, will not improve safety to navigation. The screen should display a synthesis of positional, navigational and hydrographical information with the possibility of selection. This is indeed the true ECDIS, which is far more than a chart in electronic form.

At the end of his paper, Dr Bianchetti is clearly asking for reactions from the readers. I would be grateful if you could publish my opinion in your *Journal*. I must add that I have already had an exchange of letters with the author when a similar paper was published in 1993 in *Lighthouse*, the journal of the Canadian Hydrographic Association.

REFERENCE

[1] Bianchetti, F. (1994). The ECDIS paradox: a controversial view on navigation, freedom and safety at sea. This *Journal*, **47**, 20.

KEY WORDS

1. Charts. 2. Electronic charts. 3. Display of information.

'The *Nautical Almanac*'s Faulty Calculator Instructions'

From Alastair D. Macfadyen

I read Mike Pepperday's article[1] in the January 1994 edition of the *Journal* with some interest, particularly the part at the foot of page 91, where he queries the need to set $X = 1$ if X is outside the range -1 to $+1$.

A number of years ago, having purchased a small programmable calculator, I decided to write a program for astro sight reduction as an exercise. When the program was complete, I tried a few test examples, all of which compared favourably with the corresponding answers from NP401. On a whim, I input a set of data which corresponded to a meridian altitude sight; that is, the GHA was the same as the DR longitude. The program ran for a while and then crashed.

For the uninitiated in computer jargon, 'crash' means that the program stops working properly (or even at all). This is usually because it has got into some irrecoverable situation, or sometimes that it has been asked to do the impossible. This latter, one might think, would be avoided by any competent programmer, but there are occasions when it can happen by unique combinations of operating conditions.

It was this latter situation that caused my problem: the program performed a series of trigonometric calculations and then worked out the inverse cosine of the result.

https://doi.org/10.1017/S0373463300012388 Published online by Cambridge University Press

Unfortunately, due to a series of slight errors in the calculations (even though the trig. functions were calculated to seven decimal places), the answer for the cosine of the azimuth angle (180° in this case) worked out at something like −1.000001. Computers aren't as clever as many people think, and most will get upset with data such as this; mine was no exception.

To get around the problem, I put a trap into the program to detect such situations and limit the value of the cosine, in exactly the same manner as in Mike's article. Presumably, the Royal Greenwich Observatory has experienced the same problem, and put in the same fix.

It might be crude, but it does work!

From J. M. Sharpey-Schafer

One would generally agree with Mike Pepperday's interesting article[1] in the January 1994 issue of the *Journal* on 'The *Nautical Almanac*'s Faulty Calculator Instructions', although those may have been left over from earlier years – the market in handheld computers from Psion, Sharp and Casio having moved on swiftly.

In 1975, the Nautical Almanac Office of the Royal Greenwich Observatory (RGO) provided, at an arm-twisting visit, the equations for calculating for '100 years' the Right Ascension and Declination for all the elements of the apparent motions of the Sun, Moon, the 4 Navigation Planets and the 20 Navigational Stars of 1·3 magnitude and brighter. For yachts, it is not worth bothering with the rest of the 57 stars in the *Nautical Almanac*, and barely so for ships.

From the equations, it was simple enough to write the algorithms and programs into a Texas TI.56 programmable calculator of 1K RAM, including up to 60 memories, stored on paper thin magnetic cards 7 × 3 cm, one of four card-stores being allocated to each of the Sun, Moon, Planets and Stars. Invaluable for yachting, the TI.56 has long-lasting, rechargeable batteries and spares.

It is those '100 year' equations that should be published in the *Nautical Almanac*, with very clearly defined variables, not in academic symbols but in navigation-speak; that is, Lat, Long, Dec, RA, HA, Az and PZX. *Vide* the January *Journal*[1] equation (p. 91), where Ho, Hs, h, HP are undefined and will mean nothing to many; something for editors and referees to watch out for (please define these symbols, repeating the equation).

Meanwhile, yachts should still be capable of sextant sights, owing to potential loss of their electricity supply, even if an expensive GPS or Loran receiver is fitted. They cannot conveniently carry a boxed star globe, nor easily use the awkward, large, star-finding diagrams.

It being essential to plan the day before one's star session for some four to five available heavenly bodies during the 20-minute bustle of twilight, the equations for finding the objects by altitude and azimuth should be published. Beware, the azimuth may give a little trouble for identifying the correct quadrants 000°–360°, using ArcTrig functions. Polar coordinates have been suggested.

From Cornelis de Wit (*Delft University of Technology, retired*)

After reading Mr Pepperday's criticisms in the January issue of the *Journal*[1], I would like to add the following comments.

https://doi.org/10.1017/S0373463300012388 Published online by Cambridge University Press

On page 279 of the *Nautical Almanac* the azimuth of the observed celestial body is calculated in a rather unusual way. Denoting $S = \sin \mathrm{Dec}$ and $C = \cos \mathrm{Dec} \cos \mathrm{LHA}$ the altitude H_c follows from:

$$H_c = \sin^{-1}(S \sin \mathrm{Lat} + C \cos \mathrm{Lat}).$$

The azimuth A is then calculated by evaluating its cosine:

$$\cos A = (S \cos \mathrm{Lat} - C \sin \mathrm{Lat}) / \cos H_c$$

Although correct, this method is most unconventional, as it uses four(!) elements of the parallactic triangle. A more customary way is to use the basic elements Lat, Dec and LHA with:

$$\tan A = \sin \mathrm{LHA} / (\cos \mathrm{LHA} \sin \mathrm{Lat} - \tan \mathrm{Dec} \cos \mathrm{Lat}).$$

Mr Pepperday then evaluates A from:

$$A = \tan^{-1}(\tan A) + 180°$$

which is not quite correct. I propose the following alternative. Recollecting that the $\tan^{-1}$ function has a domain from $-\infty$ to $+\infty$ and it ranges from $-90°$ to $+90°$ (calculator in the degree mode), the azimuth can be calculated from:

$$A = \tan^{-1}(\tan A) + 90°(1 - \mathrm{sgn} \tan A) + 90°(1 + \mathrm{sgn} \sin \mathrm{LHA})$$

Examples:

(1) Taking Lat $= +50°$, Dec $= +30°$, LHA $= 320°$, we find $\tan A = -2{\cdot}97827$. With $\mathrm{sgn} \tan A = -1$ and $\mathrm{sgn} \sin \mathrm{LHA} = -1$ we find $A = -71{\cdot}4° + 90°\ (1+1) + 90°\ (1-1) = 108{\cdot}6°$.

(ii) With the same latitude and declination, but LHA $= 40°$, the object is now west of the local meridian. We find $\tan A = 2{\cdot}97827$, $\mathrm{sgn} \tan A = +1$, $\mathrm{sgn} \sin \mathrm{LHA} = +1$, so $A = 71{\cdot}4° + 90°\ (1-1) + 90°\ (1+1) = 251{\cdot}4°$.

As to computing the fix from a set of azimuth & intercept pairs, the unweighted least square method is a bit oversimple.

For a more solid and (perhaps too) sophisticated method, taking account of estimated variances in the main partial observing errors, including possible bias or 'systematic errors', I refer to my paper in this *Journal*, (Vol. 44.2, May 1991, pp. 126–133).

The Author Replies

To Commander Sharpey-Schafer

There was a stream of ever-better scientific calculators and hand-held computers through the seventies and into the mid-eighties, then development halted and, since 1989, when the RGO's instructions appeared in the *Nautical Almanac*, there has scarcely been a new one. Those instructions are not left over from earlier years; they never were correct.

100-year almanacs are the logical basis for a navigation computer and the basis of the successful commercial models. Of course the *Nautical Almanac* ought to be publishing

https://doi.org/10.1017/S0373463300012388 Published online by Cambridge University Press