cations of situations which could give rise to collision. . . .' How much more productive the above 'self-analysis' might have been if carried out round a table in the company of fellow navigators and experienced teachers, leading to a better and more universal understanding of these 'implications'; leading perhaps to the beginnings of an explanation of why, as Figs. 6 and 8 in Captain Cockcroft's *Statistics of Collision*[6] admirably illustrate, not a few collisions look, with hindsight, almost as though they were contrived.

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Saving Money by Cutting Corners

J. D. Proctor

THIS note assesses the savings in (time- and fuel-dependent) direct operating costs that are possible if every turning point on an airway is passed on the inside. Figure 1 shows a route with turning points at A, B and C. If a pilot follows the standard procedure of flying along AB until he is sure that he has passed B, his total track distance is $(c+d+a+b)$.

To simplify the mathematics let us assume that he turns instead through half the required angle at a distance d before he reaches B and completes the turn after passing B abeam (and very close). His track distance will be $(c+e+f)$. The difference in distance δ, representing the saving, is therefore $(d+a+b)-(e+f)$.

In Fig. 1:

$$x = a\cos\theta$$

$$e = 2d\cos\theta/2$$

$$b \simeq y$$

$$(x+y) = (f+d) \simeq (a\cos\theta + b)$$

$$\therefore\ \delta = d + a + b - 2d\cos\theta/2 - a\cos\theta - b + d$$

$$= a(1-\cos\theta) + 2d(1-\cos\theta/2) \qquad (1)$$

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Also

$$m = d \sin \theta/2 \qquad (2)$$

where m is the distance from the turning point at the closest point of approach.

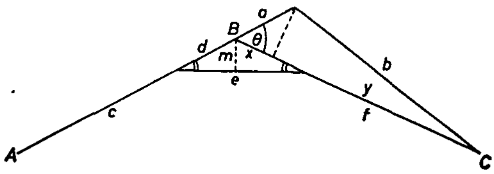

FIG. 1

If the turning point is defined by DME or if the aircraft is equipped with a Decca moving map, a can be smaller than if VOR or ADF has to be used to define the turning point. Here it is assumed that $a = 10$ miles and $d = 15$ miles (that is about two minutes at cruising speed). The results are shown in Table I.

TABLE I. DISTANCE SAVED AND CLOSEST POINT OF APPROACH

θ (deg.)	δ (n.m.)	m (n.m.)
0–9	0·05	0·6
10–19	0·56	1·9
20–29	1·58	3·2
30–39	3·11	4·4
40–49	5·10	5·7
50–59	7·52	6·9
60–69	10·32	8·0

Some of the tabulated values for m may appear unacceptably high, but this is on the assumption of instantaneous turns: in practice m would be rather less. In any case the suggested procedure keeps the aircraft nearer to the centre line of the airway than the old method of overflying the beacon. Of course there may be a special reason, such as terrain clearance, for passing right over a beacon.

An examination of 26 BCAL long haul routes for which navigation logs were available showed an average saving of 2·08 miles per clock hour or 0·0048 miles for mile flown for B707's and VC-10's. Random samples of 24 BAC111 and 25 long haul 'Plogs' show a saving of 9·4 miles per Plog/hour for BAC111's and 0·0081 miles per mile for B707's and VC-10's. The samples may have included too many little used routes, but a separate analysis of more frequented routes gave substantially the same results.

An analysis of an actual flight (LGW–LAX and back) showed a potential saving of 11·3 miles in 4874 miles for the outward flight but only 4·1 miles in about 5000 miles for the return flight. This was because of the longer straight lines allowed by the American ATC. In all these estimates the first and last turns of a route were ignored as they are generally at low altitude and speed.

The total saving in costs that could be achieved in the course of a year's operations by a fleet of aircraft may be estimated as in Table II.

TABLE II. TOTAL ANNUAL SAVING

Aircraft	Assumed saving (miles per mile flown)	Cruising cost per hour £	Planned hours	Fleet Saving £
BAC111–200	0·015	102	14,100	21,600
BAC111–500	0·015	119	33,000	58,900
B707	0·004	206	34,350	28,300
DC10	0·004	252	7400	7500
				116,300

Matthew Flinders and Ship Magnetism

W. F. J. Mörzer Bruyns

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READERS of Captain Cotter's paper under this title in the April 1976 issue of the *Journal* may be interested in some evidence that Dutch seamen in the seventeenth century were aware of this phenomenon of ship magnetism.

Abraham de Graaf in *De seven Boecken van de Groote Zeevaert*, published at Amsterdam in 1658, warns ships' officers taking bearings with the compass that metal objects in their clothing can seriously deflect the compass, and mentions iron buttons and buckles. This was an important contemporary work on navigation and de Graaf was an examiner of officers of the Dutch East Indies Company from 1679 to 1714.

From Pieter van Dam's *Beschryvinge van de Oost Indische Compagnie*, completed in 1701 (reprinted 1927–54), we find that large East Indies Company ships from 1671 onwards were armed with two bronze cannon near the compass. These were not the only bronze cannon on board, but it was clearly stated that the cannon near the compass had to be bronze and not iron. I have not made a study of the subject and there may be further evidence that some Dutch seaman in the second half of the seventeenth century was fully aware of the danger of iron near the compass.