HI-FIX EVALUATION TRIALS
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IHB Note. — The author was in command of H.M.S. *Scott* during the trials discussed in this article.

From 12th to 14th June 1962, H.M. Surveying Ship *Scott* was employed in the Firth of Forth evaluating Hi-Fix equipment for use in the Royal Navy. All the tests which were carried out are not tabulated here as to some extent they overlapped the very successful trials by the Swedish Hydrographic Office in 1960 (see Supplement to International Hydrographic Review, Volume 2, 1961). Where the trials did overlap, the earlier findings were corroborated. In particular, instrumental repeatability was again shown to be better than $\pm$ 0.02 lanes.

Before the trials began, sites were selected and co-ordinated in the National Grid for the master station and both slaves. Both baselines were about 10 miles long, which was the maximum that could be obtained in this area if the essential requirement of accurate visual fixing from shore was to be maintained. The master station and pattern II slave were established on the north shore of the Firth at Elie Ness and Crail respectively, and pattern I slave on the south shore near North Berwick (figure 1). Theodolite observing stations were also selected and co-ordinated.

The position of each of the Hi-Fix comparison fixes tabulated here was calculated from either three or four theodolite intersections of the Hi-Fix receiver aerial and all of them are estimated to have been accurate to within $\pm$ 1 metre, and 90 % of them $\pm$ 0.5 metres.

Installation

Receivers were installed in the ship and in one of her 28-foot surveying launches. In both cases this proved to be a simple task which took less than one hour to complete, even though no preparatory work in the way of new fittings or power supplies had been done. The ship's receiver was secured on the bridge chart table. Its power supply (24 volts D.C.) was taken from the ship's 230 volt A.C. supply, through a small battery charger to a 24 volt battery. The receiver aerial, a light whip about 6 foot long, was clamped to the foremast truck.

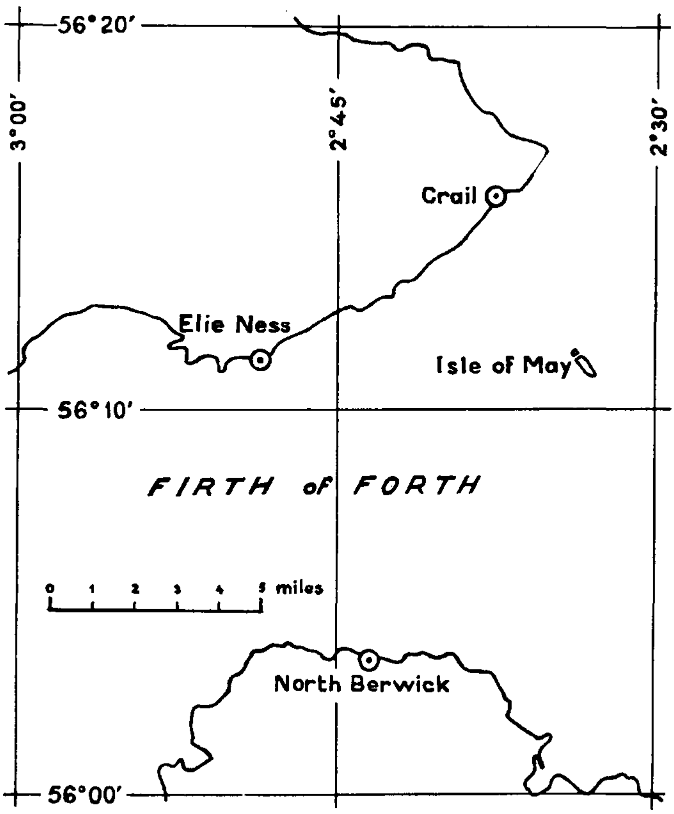

Fig. 1

In the survey launch the receiver was secured in the space which normally holds a wireless transceiver and the aerial was lashed to the top of a boat hook stave on the side of the canopy.

On the last day of the trials the master station at Elie was dismantled and installed in the ship in order to carry out various tests on the equipment in its two range role. The transmitter was set up in the surveying chart room, with its aerial, a 35-foot whip, on the deckhead almost immediately above. Separation between receiving and transmitting aerial was thus 125 feet (38.1 metres). Neither aerial was well sited; numerous whip, wire and dipole aerials were within 20 feet of the receiver aerial, whilst the transmitting aerial was only 10 feet forward of the large permanently installed Two Range Decca aerial. Even so, good results were achieved (Table II).

Had a suitable matching unit been available, use of the Two Range Decca aerial itself for Hi-Fix transmissions would have been a simple matter.

Monitoring

At the start of the trials a receiver was set up on the Isle of May, which was conveniently sited within the area of good coverage, to monitor both patterns. But once it had been established that small shifts in pattern readings recorded at the Isle of May were being faithfully reflected (to within ± 0.01 lanes) by the slave receiver readings, this monitor station was dispensed with and inter slave monitoring resorted to. That is, pattern I was monitored at pattern II slave received and vice versa.

Analysis of test runs

i) *Along baseline (hyperbolic)*

The Hi-Fix chain being tested had the following characteristics :

Frequency	:	1 900.00 kc/s
Wavelength	:	157.7105 metres
Lanewidth (two range)	:	78.8553 metres

A standard propagation speed of 299.650 km/sec was assumed throughout. Accurate shore fixing was not available over a sufficient range of clear sea path signal to make any conclusive observations as to the possible error of this assumption.

Table I below shows the results obtained from a series of fixes of a survey launch moving along pattern I baseline. The launch was stopped for each fix, and approached to within 2.3 lanes (about 181 metres) of the master station.

During this run pattern I slave was on a steady bearing which kept the slave/receiver signal over a clear sea path. On the other hand land length in the pattern II slave/receiver path altered rapidly with bearing.

Pattern I readings in this series, when allowance is made for monitor readings, give a standard deviation for individual observations of ± 0.007 lanes. Without reference to the monitor, this error becomes ± 0.012 lanes.

Pattern II readings have been affected by variable land in the slave/receiver path, but by applying a correction of 0.015 lanes per kilometre of land path the standard deviation of pattern II readings is also reduced to less than ± 0.010 lanes.

All these errors therefore represent a distance of less than 1 metre on the baseline.

The readings close to the master station (at 1514 hours) show no clearly identifiable effect due to the master transmitter induction field. The theoretical value of this effect is only 0.02 lanes at two lanewidths from the transmitter in any case.

TABLE I

Time	*Calculated Hi-Fix Reading*		*Excess of observed over calculated readings*		*Monitor readings*	
	Pattern I	*Pattern II*	*Pattern I*	*Pattern II*	*Pattern I*	*Pattern II*
13 58	32.915	14.375	0.685	0.555	0.93	
14 01	29.81	13.145	0.68	0.545	0.93	
05	27.22	12.135	0.69	0.53	0.93	
08	24.225	10.885	0.695	0.52	0,93	
13	21.18	9.605	0.69	0.505	0.93	
18	18.27	8.38	0.69	0.495	0,93	
22	15.10	6.845	0.685	0.46	0.93	
27	12.215	5.59	0.685	0.445	0.93	
30	11.30	5.27	0.70	0.43	0.93	
33	10.235	4.675	0.685	0.44	0.93	
36	9.11	3.725	0.695	0.415	0.93	
40	8.15	3.485	0.69	0.405	0.935	
43	6.95	2.75	0.69	0.40	0.94	0.60
46	6.115	2.425	0.695	0.395	0.945	
48	5.00	1.785	0.70	0.39	0.95	
52	4.08	1.325	0.70	0.39	0.95	
56	3.375	1.045	0.715	0.385	0.95	
15 14	2.305	0.94	0.70	0.405	0.96	
22	9.30	4.295	0.72	0.395	0.96	
24	10.335	4.83	0.72	0.415	0.96	
27	11.365	5.34	0.72	0.42	0.96	
29	12.32	5.75	0.715	0.425	0.95	
33	15.31	6.97	0.705	0.46	0.95	
36	18.335	8.34	0.715	0.47	0.95	
40	21.265	9.64	0.71	0.475	0.95	
43	24.20	10.71	0.695	0.495	0.95	

ii) *Calibration for locking constant and ship's electrical centre (two range)*

The master transmitting aerial was set up onboard 38.1 metres abaft the foremast truck. The foremast was also the site of the receiving aerial and the point intersected by the theodolites ashore.

The results in Table II were obtained for approximately every 15° of heading, whilst swinging the ship slowly at rest.

The results (D) found were analysed by least squares, in the first instance taking the two patterns separately and not assuming the electrical centre to lie amidships. Secondly, the results were combined assuming that the locking constants would differ but that the electrical centre must

Table II

θ is the angle, measured anti-clockwise, from the bearing of the slave to the direction of ship's head.

D is the excess of observed Hi-Fix readings over calculated Hi-Fix co-ordinates of the foremast (to 0.005 lanes).

$C = \alpha + x \cos \theta \quad (+ y \sin \theta)$

where : α is the locking constant in lanes

x and y are the co-ordinates of the electrical centre, in lanes, x abaft the foremast, y to port.

v = difference $D - C$.

	Pattern I				*Pattern II*			
Fix No.	θ	D	C	v	θ	D	C	v
1	159.5°	0.20	0.186	+ 0.014	056°	0.555	0.588	— 0.033
2	146	0.215	0.212	+ 0.003	042.5	0.655	0.631	+ 0.024
3	133	0.255	0.248	+ 0.007	029	0.64	0.665	— 0.025
4	119	0.32	0.296	+ 0.024	015	0.685	0.687	— 0.002
5	108	0.35	0.339	+ 0.011	003.5	0.715	0.694	+ 0.021
6	089.5	0.42	0.416	+ 0.004	347	0.68	0.689	— 0.009
7	073	0.485	0.484	+ 0.001	331	0.66	0.665	— 0.005
8	056	0.52	0.549	— 0.019	314	0.65	0.621	+ 0.029
9	044	0.57	0.588	— 0.018	302	0.59	0.581	+ 0.009
10	025	0.64	0.633	+ 0.007	283	0.54	0.507	+ 0.033
11	017.5	0.65	0.645	+ 0.005	274	0.465	0.469	— 0.004
12	356.5	0.655	0.656	— 0.001	252	0.355	0.377	— 0.022
13	342.5	0.63	0.645	— 0.015	243	0.35	0.342	+ 0.008
14	320	0.60	0.599	+ 0.001	220.5	0.27	0.268	+ 0.002
15	307	0.56	0.560	0.0	207	0.235	0.236	— 0.001
16	294.5	0.52	0.514	+ 0.006	195	0.205	0.218	— 0.013
17	279	0.46	0.451	+ 0.009	180	0.18	0.210	— 0.030
18	264.5	0.395	0.390	+ 0.005	166	0.205	0.217	— 0.012
19	248.5	0.33	0.324	+ 0.006	150	0.23	0.242	— 0.012
20	232.5	0.25	0.266	— 0.016	134	0.29	0.284	+ 0.006
21	216	0.21	0.217	— 0.007	120.5	0.33	0.329	+ 0.001
22	203.5	0.185	0.191	— 0.006	105.5	0.40	0.387	+ 0.013
23	188	0.17	0.173	— 0.003	090	0.47	0.452	+ 0.018
24	174.5	0.16	0.172	— 0.012	076.5	0.52	0.509	+ 0.011
25	159	0.18	0.187	— 0.007	060.5	0.58	0.572	+ 0.008
26	144	0.21	0.217	— 0.007	045.5	0.63	0.622	+ 0.008
27	128	0.255	0.264	— 0.009	029	0.66	0.665	— 0.005
28	113.5	0.315	0.317	— 0.002	014.5	0.68	0.687	— 0.007
29	099.5	0.37	0.373	— 0.003	000	0.69	0.695	— 0.005
30	086.5	0.445	0.428	+ 0.017	346	0.685	0.688	— 0.003
31	067	0.515	0.508	+ 0.007	326	0.65	0.653	— 0.003

be the same for both. Finally, the above three calculations were repeated assuming that the electrical centre must be amidships.

The six results are summarised below, standard errors being quoted in brackets. All values are in lanes.

The values given in columns C of the table were calculated from the last results.

	α	x	y
Pattern I alone, calculating y	0.413 (± 0.000)	0.243 (± 0.001)	+ 0.002 (± 0.001)
Pattern I alone, assuming $y = 0$	0.413 (± 0.000)	0.242 (± 0.001)	0
Pattern II alone, calculating y	0.452 (± 0.002)	0.247 (± 0.001)	— 0.001 (± 0.001)
Pattern II alone, assuming $y = 0$	0.452 (± 0.002)	0.247 (± 0.001)	0
Both patterns, calculating y	0.414, 0.452 (± 0.001)	0.245 (± 0.000)	+ 0.001 (± 0.000)
Both patterns, assuming $y = 0$	0.414, 0.452 (± 0.002)	0.245 (± 0.000)	0

The x and y co-ordinates of the centre point between the two aerials were 0.242 and 0.0 respectively, so it can be seen from the above that the poor siting of the aerials and the surrounding aerial arrays and metal obstructions had very little effect on the position of the electrical centre.

The small standard errors obtained in this series are highly satisfactory. Standard errors of individual observations were ± 0.010 and ± 0.018 for patterns I and II respectively. The higher error for pattern II is considered to be entirely due to a temporary defect affecting this slave during the test.

iii) *Other tests*

With the ship stopped, a series of 20 fixes at three minute intervals about the time of sunset failed to detect any skywave interference or errors whatsoever. The range of the slave station was about 10 miles.

A test run at medium range from the slave stations (about 20 miles) gave similar results to the previous runs, with no falling off in accuracy of repeatability.

General

The results tabulated under v of Table II represent range errors of only ± 1.5 metres in the case of pattern I. Even these small errors are to some extent systematic and would probably have been reduced by better siting of the aerials.

The instrumental repeatability of this equipment therefore gives an accuracy which is just about as high as can be appreciated from a floating platform, where such effects as steering error are liable to be much larger.

Unfortunately, time did not permit a systematic test of the effect of land in the signal path on the transmitted pattern, but a general correction of 0.015 lanes per km of land path gave good results in this area. The Decca Navigator Company's experience has been that 1 km of land path can alter the pattern by anything from 0.01 to 0.05 lanes, depending on soil conductivity.

No doubt this conductivity can change considerably with seasonal and meteorological conditions in some parts of the world and its possible effect on the transmitted pattern should not be forgotten.