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TECHNICAL MEMORANDUM
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FACTORS GOVERNING THE CHARACTERISTICS OF SYSTEMS
FOR SHORT DISTANCE H.F. TARGET LOCATION

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S U M M A R Y

The accuracy of direction finders depends critically on the distance to the target, a prime factor which must be taken into account when solutions to direction finding problems are sought. Comparisons are made between Adcock, single station location and airborne direction finders.

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1. INTRODUCTION

The conventional Adcock-type ground based high frequency direction finding (h.f.d.f.) systems, when used on skywaves, must be sited a considerable distance from the target. If the distance to be target is short, the skywaves arrive at steep angles and the vertical response of the vertical antennas used is poor on these steep waves. Unsatisfactory d.f. results. The error parallelogram of such networks is large due to the long baselines and distances involved. Single station location systems may be operated quite close to the target using very steep skywaves and, if steps are taken to correct for ionospheric tilt, significantly better results are obtained when compared with Adcock networks.

When airborne d.f. is used a direct wave is available at distances which depend on the height of the aircraft, but it is important not to make the distance unnecessarily large or accuracy will suffer.

This paper is based on one presented to a conference in November 1970.

2. ERROR PARALLELOGRAM

The accuracies obtained with various h.f. location systems may be deduced from the characteristics of the basic observations such as standard deviation (SD) of bearing or SD of eastings and northings of position measurement, coupled with the geometrical considerations involved(ref.1,2). For short distance tactical systems and geometrical considerations are just as important as the basic radio observations and may have a catastrophic effect on the overall performance of the various systems in certain circumstances.

A simplified case of a two station d.f. system is shown in figure 1. The d.f. stations located at R_1 and R_2 observe bearings ϕ_1 and ϕ_2 of the target with a standard deviation of $d\phi$. For the simple case of a target near the perpendicular disector at a distance, D , and making an angle of cut K between the two strings the area of the error parallelograms which encloses 67% of the results is approximately

$$A = 2D^2 \tan^2 d\phi \cot \frac{1}{2}K$$

This expression is equally applicable to ground based d.f. or to airborne systems when two stations (or two airborne readings from different locations) are involved.

When more than two stations are used the improvement in accuracy depends again upon the various geometrical considerations and on the various accuracies appropriate to the individual stations; for stations of equal weight and geometry, the bearing measurements improve in accuracy approximately in proportion to the square root of the number of stations.

3. ADCOCK DIRECTION FINDERS

The Adcock, or similar h.f.d.f. system using vertical receptors, has a typical $d\phi$ of 3 degrees(ref.3) when operating under favourable ionospheric conditions on easy targets (but a figure of 6 degrees is more realistic in a difficult tactical situation) provided the distance to the target exceeds 300 km. At shorter distances the skywaves arrive at steep angles and the accuracy of such direction finders which use vertical receptors may be approximated by the expression

$$d\phi = d\phi_0 \tan \theta / \tan \theta_0$$

where $d\phi_0$ is the standard deviation (SD) of bearings at elevation angle θ_0 and $d\phi$ is the SD of bearings at elevation angle θ .

4. COMPARISON OF ADCOCK, SINGLE STATION LOCATION AND AIRBORNE SYSTEMS

This simplified analysis has been used to produce the h.f.d.f. and airborne d.f. results given in the attached table. Also given in the table are accuracy values for the Short Cell equipment (taken from figure 2 attached) using tilt and distance correction techniques(ref.4).

From the table it may be seen that the accuracy of the s.s.l. system is comparable with ground based d.f. at 300 km, provided the d.f. system is sited so that the angle of cut is favourable; the s.s.l. is significantly better at all distances less than 300 km. The accuracy of airborne d.f. at 50 km is about the same as s.s.l. but the accuracy of the multiple-shot fly-by system of airborne d.f. at 10 km stand-off distance is easily the most accurate system considered.

As far as cost is concerned it should be noted that an s.s.l. system does not require any additional outstations and may be colocated with the control station. As a result the productivity of such an s.s.l. station should be expected to approach 75% whereas any station served by a radio flash network often has a productivity of considerably less than this, perhaps 25%. The cost per result for an s.s.l. station may be expected to be some one tenth that of a h.f.d.f. network and an even more significant factor compared with 50 km airborne d.f. used for this purpose.

The "fly-by" system is less costly and more accurate per result than the "fly-towards" system since the fly-by system can obtain many more shots per task and is more accurately navigated. To obtain the maximum accuracy, for geometrical reasons it is necessary to stand off less than 10 km; this implies that the aircraft should be tasked having already obtained a good estimate of the position of the target (preferably within 10 km).

5. CONCLUDING REMARKS

These factors suggest that a cost-effective system of h.f. target location for tactical purposes is a complementary system comprising a ground based s.s.l. and a fly-by airborne d.f. with a 10 km stand off distance.

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3.	Gething, P.J.D.	"High frequency direction finding." Proc. I.E.E. Vol. 113, No. 1, p 49, January 66.
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TABLE 1. LOCATION ACCURACY OF VARIOUS TACTICAL SYSTEMS

Type of system	Stand off distance (kilometres)	Bearing error SD (degrees)	Angle of cut (degrees)	Position finding error + s.s.l.SD (kilometres)	Approx. size of target location area (67% confidence) (square kilometres)
h.f./d.f.	50	36	30	-	10,000
	100	18	45	-	4,800
	300	6	30	-	2,200
	300	6	45	-	1,500
s.s.l.	30	-	-	8	250
	50	-	-	9	320
	150	-	-	12	570
	200	-	-	14	790
	300	-	-	18	1,300
Airborne d.f.	10	10	45	-	15
	10	10	90	-	1.0*
	35	10	45	-	200
	50	10	45	-	370

* 9 shots fly-by system

+ Reference 4

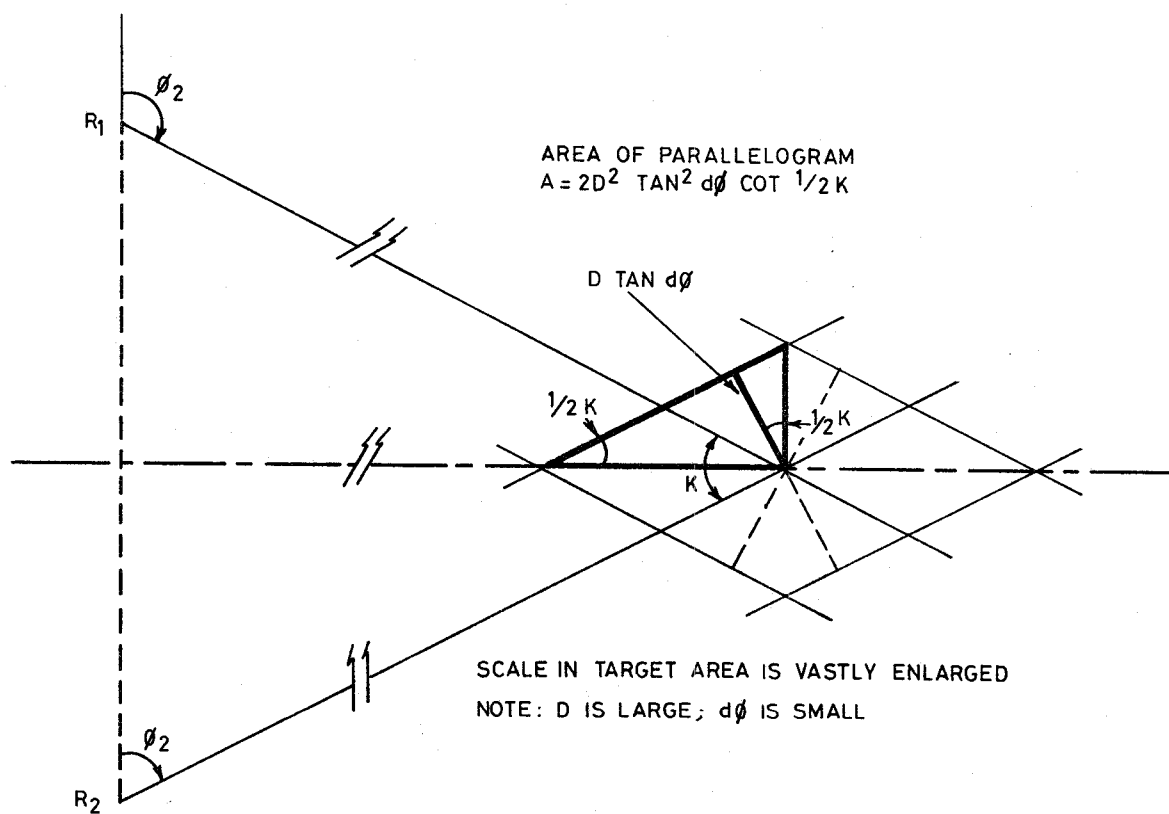


Figure 1. Error parallelogram

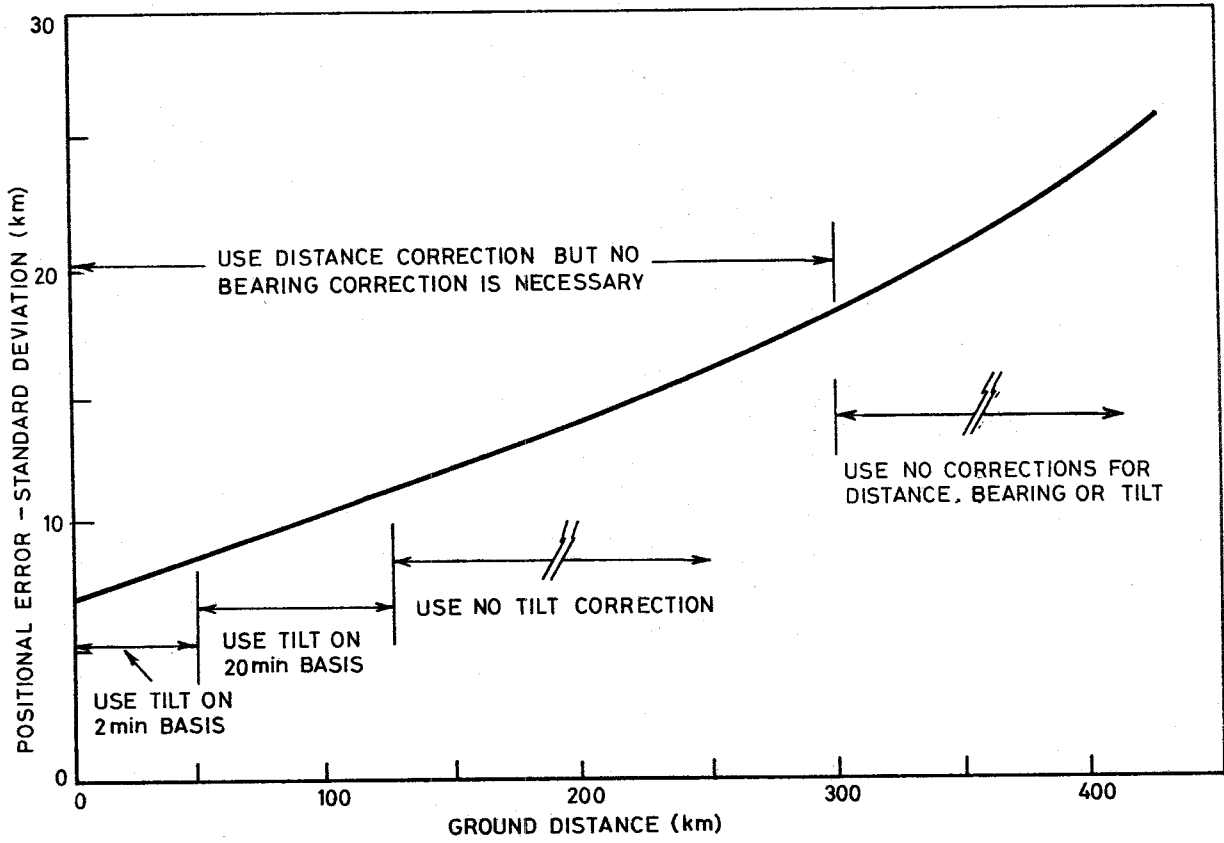


Figure 2. Accuracy of short cell

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