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DECCA AS A POSSIBLE REPLACEMENT FOR SHORAN IN CANADIAN AERIAL SURVEY

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ABSTRACT

It has been suggested that Decca could replace Shoran in some roles in which radar is used as an aid to aerial survey. The limitations and advantages of the Decca Navigator system are discussed for all three applications at present in use: viz., geodetic survey by trilateration, aircraft guidance on photographic survey flights, and the provision of control for map compilation from aerial photographs.

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GEODETIC SURVEY

The fixing of positions of points on the earth's surface, such as is obtained by trilateration using Shoran line crossings, cannot be performed with the same accuracy by Decca. It seems most unlikely that any change in this situation will result from developments in either the Decca equipment or the techniques of use. Any of the proposed techniques can not compensate for variations of the velocity of propagation with varying soil conductivity.

FLYING CONTROL

The navigational problem of achieving gapless coverage, and maintaining the correct overlap with the best utilization of aircraft time, would be greatly assisted by Decca. The accuracy of Decca for such a service could be essentially equivalent to that using Shoran and a Straight Line Flight Computer. Moreover, the Decca airborne equipment is much lighter and simpler to operate, and Decca has the advantages that it operates with no liaison between air and ground personnel, and is usable by any number of aircraft simultaneously. To employ a Decca system, the maps in use must show sets of hyperbolic lattices for the particular station locations involved. This would entail considerable extra work in the provision of flight-plan information. The flight plans could be either: (a) the 1:506,880 maps with flight lines marked thereon, modified by the addition of the Decca hyperbolic lattices, or (b) Decca track graphs (inverse lattice charts on which the Decca grid is rectangular) with curved flight lines and at least the salient topographic features plotted thereon.

More accurate and much easier precise navigation is possible if the Decca Flight Log is used. The distinctive special charts which are required are again dependent upon the ground station positions. The provision of such charts with the flight lines drawn thereon would require somewhat more work than maps with Decca lattice over-rulings.

MAPPING CONTROL

The use of Decca to provide the location of sufficient points recognizable in the existing photo coverage for mapping control seems feasible under certain conditions. The Decca system has specific characteristics which offer possibilities of its use in many techniques. Essentially, there is nothing to prevent the positions of points on the earth being located by the Deccometer readings of receiving equipment located on the spot in question, or in a helicopter hovering over it, or in an aircraft at any altitude above it.

The position determined by the values of the Decca coordinates, as in the case of that determined by the use of Shoran, is the plumb point on the earth's surface. Thus, except in the case of zero altitude, any discrepancy between the point sighted below and the true plumb point must be resolved. With increasing altitude more exacting requirements must be laid down for both the equipment and its operation, if satisfactory accuracy is to be maintained. For altitudes of 5000 feet and upwards, use is made of a carefully calibrated aerial survey camera, a continuous overlapping set of exposures is made, and the tip and tilt resolved out by careful use of photogrammetric equipment. The elimination of this phase, as well as the reduction of the number of cases of impossible or incorrect identification of detail in photographs, would show a striking advantage in the use of Decca on the ground or in a helicopter hovering at very low altitudes.

The factors affecting instrumental accuracies of Decca and Shoran are quite different in nature. For the former, the phase-angle-indicating element, the Deccometer, can certainly be read to 1/200 of a revolution, or 0.005 lanes. However, the recommended value of the "instrumental plus random" error of the overall system[1] is 0.01 mean lanes, this representing approximately 5 meters on the baseline. The corresponding error in position at a strong point in the pattern (equidistant to master and both slave stations) would be approximately 3.2 times this[2], or 16 meters. The only test data available which apply to operation in an aircraft is that quoted[3] for a trial operation over the Thames Estuary, and for this the value of error shows a somewhat larger figure. The standard deviation of the eastings is 66 feet, that of northings 89 feet; this gives a position error of 110 feet, or 33 meters. The best possible adjustment

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1 Sect. 2, p.1, The Decca Navigator as an Aid to Survey, Issue 3, Jan., 1953.

2 Ibid., p.4.

3 Ibid., p.5.

for systematic error had been made by removal of the bias (mean deviation).

Since Shoran requires an airborne operator who lines up pips along a trace on a cathode-ray oscilloscope, the instrumental accuracy may be taken as limited by the dexterity and visual acuity of this operator. Errors caused by goniometer non-linearity or gearing backlash can, in general, be deduced experimentally, and corrections made to compensate for them. Under static conditions it can be demonstrated that with extreme care settings can be made to 0.001 mile — even though this represents only 1/100 inch on the oscilloscope trace. However, it would be realistic to allow a probable error of 1/32 inch for operation in a moving aircraft. Pip alignment cameras, when photographing the same trace, have been found to pick up only errors considerably greater than this, and thus add little to the precision. The above error, equivalent to 16.5 feet in each distance, would cause, at a strong part in the pattern (on the right bisector of the baseline and half its length away) a standard deviation of position of 10 meters.

Both Shoran and Decca are subject to other errors than those described, and these will be usually the important sources of uncertainty. In Shoran the main sources of error are probably day-to-day variations in the operation of the equipment, and in the propagation characteristics of the radio wave paths. To date no satisfactory technique of compensating for these is available. For the Decca system the only important source of error is uncertainty as to the velocity of propagation along the path. Because of the very low frequencies involved, all, or most, of the transmission is by ground wave, and hence is very dependent on soil conductivity.

For paths totally over sea water, and for receivers at sea level, a very satisfactory experimental value is available. When such a condition applies, it is recommended[4] that for short distances during daylight the overall error be taken as little greater than the 0.01 mean lane value of instrumental or random error. For paths over land the recommended values of error range from 0.02 to 0.04 mean lanes, depending on the nature of terrain. One experimental operation has been carried out with short land paths and ground based receivers, and the accuracy of the data was disappointing.[5]

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4 Sect. 5, p.5, The Decca Navigator as an Aid to Survey, Issue 3, Jan., 1953.

5 Tests carried out in Germany by an artillery team from the British Army on the Rhine.

Since these position errors are caused by the effect of differences in soil conductivity on the radio signals at a wavelength of 3000 meters, it can be expected that very localized conditions, and anything short of major seasonal climatic or meteorological changes will contribute very little. Thus, over a given area, a single check point of established location could be used to correct for the major portion of the systematic error. The size of the area over which such a correction is valid will vary with the diversity of soil conductivities in the region in question, and the altitude of the receiving system. It should be noted that permafrost is likely to have very low conductivity, so unfortunately the northern portions of Canada, where the provision of check points is so difficult, may be regions in which a close spacing of such points is required. Experiments to date have been insufficient to establish criteria laying down a minimum spacing for check points, either for operations in which the receivers are carried along the ground or at any of the altitudes possible for survey aircraft.

CONCLUSION

It may be stated that the application of Decca to topographic surveying problems in Canada could lead to important economies in time and effort. However, a considerable amount of careful investigation must be made into methods of control of overall accuracy before Decca position-fixing data can be deemed precise enough for use in the production of 1:250,000 maps. It should be noted that the instrumental accuracies discussed relate to Decca equipment with all the features providing maximum precision. In particular, if the receivers are capable of operating in a system with lane identification, then the new circuit which eliminates the serious lag caused by the long time constants of the normal receiver, must be incorporated. Data analyses using a system of photographic recording of the Deccometer dials would be more valuable than Decca Flight Log charts, unless these were at very large scales and had been drawn up with a very high degree of accuracy. However, if a Flight Log were used at a large scale with only a plain paper chart, suitable time correlation being employed, it might well serve to indicate which readings had been taken during a temporary disturbance of the receiver.