EFFECT OF DOPPLER STATION SEPARATION ON STRENGTHENING TERRESTRIAL NETWORKS

By: DR. ENG. AHMED A. SHAKER
SHOUBRA FACULTY OF ENGINEERING
ZAGAZIG UNIVERSITY

ABSTRACT

There is an accepted rule that the 250 - 300 Km separation between two adjacent Doppler stations is an optimum one, if Doppler network is used to strengthen a terrestrial network. The spacing of Doppler stations was specially investigated by Moose [2] . The auther uses The data and the results of the different adjustments given by Mooses paper to verify that the critical separation of the Doppler stations is a function of the inner accuracy of the terrestrial network. As a result of the investigation the critical separation S^* for the Egyptian geodetic network was estimated.

Introduction:

It is well known that strengthening a network can be done either by making additional classical observations like, Laplace azimuths & distances or by introducing some Doppler stations in the net. The use of classical observations is expensive & require a skillful observers and needs much time. On the other hand Doppler observations are not expensive and the intervisibility of stations in the Doppler net is not necessary and over-cast sky is of no concern.

The optimum way to design a Doppler network ,depend on the purpose. For example, if a Doppler network is supposed to provide the transformation parameters from the local into the geocentric system. Then the Doppler station should be arranged very dense. In case of improving an existing terrestrial network, the quality of the Doppler network then depends on how much the Doppler network does affect the standard errors in the terrestrial network.

2. Effective Separation:

One of the accepted rules is that a separation of 250-300km between two adjacent Doppler stations is an optimum one for strengthening a terrestrial work. Moose's work [2] was done on a part of the American triangulation networks ,which includes 838 1st order stations. The spacing of Doppler stations was specially investigated by a series of adjustments C', D, C'', D', D'' & H where no classical base line or azimuth were used.Table 2.1 contains the results of the different adjustments as given by Moose.

adjustment No	Doppler separation	Relative scale error in Doppler A	mean rel. scale error in the net B	P.P.M.
D'	253 km	1: 178 000	1: 179 000	5.5
D	181	1: 128 000	1: 101 000	9.9
C	426	1: 335 000	1: 199 000	5.0
C'	266	1: 209 000	1: 202 000	4.9
D "	350	1: 247 000	1: 200 000	5.0
C "	350	1: 275 000	1: 217 000	4.6
H	578	1: 454 000	1: 248 000	4.0

In order to find out the best contribution from all the seven adjustments, the distance and azimuth standard error of 44 selected lines in the triangulations were calculated. The mean of the relative scale errors of the 44 lines in each adjustment is tabulated in the forth column of table 2.1. The result of the D'adjustment was used as a reference value to which Moose's six results are compared .

The ratio obtained from the comparison is shown in figure 2.1 which is copied from Moose's paper.

where

R is the relative mean distance standard error

$$R = \frac{B_i}{B_{D'}} \quad i = D, C, C', D'', C'', H$$

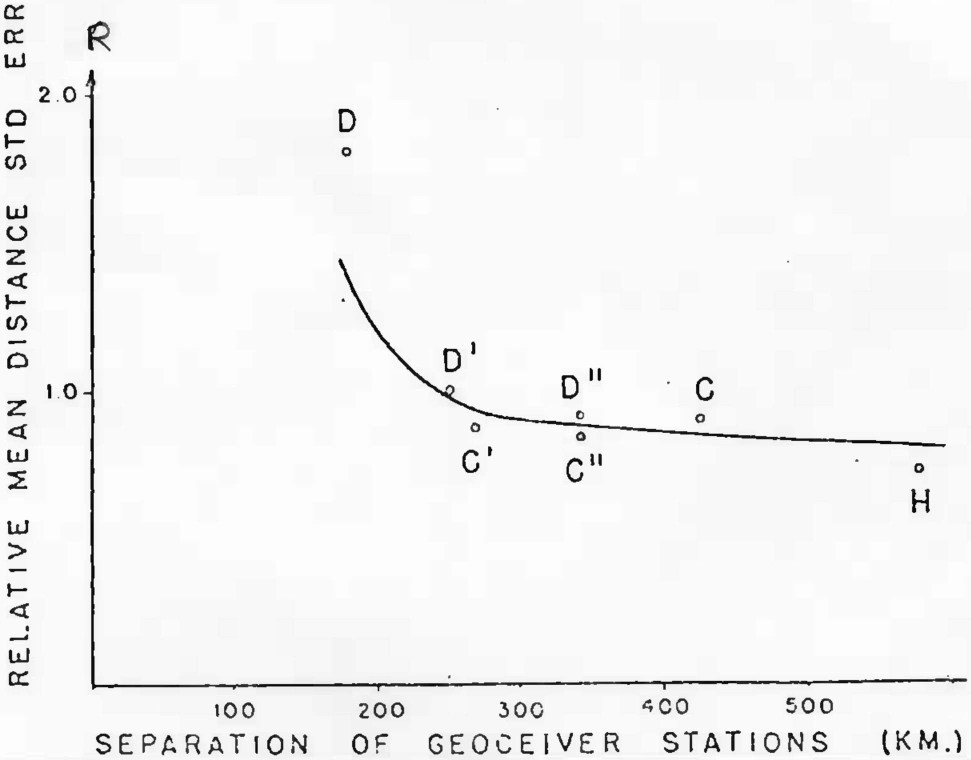

Figure 2.1 : effect of Doppler separation on distance standard error.

From figure 2.1 it can be seen that the s.e. of the distance is decreasing when the distance between the two Doppler stations is increasing, and that at the separation of about 250 km (point D'), there is a remarkable change in the effectiveness of further separation to reduce the s.e. Therefore there is the following important conclusions given by MOOSE [2]," Geoceiver stations need to be separated by at least 250 km to most effectively improve the scale accuracy of a network". This conclusion has been repeated many times by other authors and can be taken as a rule. But there is a question if this conclusion is valid for any terrestrial network or only for the North-American network? To answer this question, the problem will be investigated from another point of view.

Now the mean scale error, B, of the 44 lines after adjustment can be divided into two parts, the first is the relative error in Doppler itself, A, and the second is the inner relative accuracy of distances in the terrestrial network I. This relation will take the form.

$$B^2 = \frac{1}{2}\left(A^2 + I^2\right) \tag{2.1}$$

Figure 2.1 which was given by Moose was drawn according to the following formula.

$$R = \frac{B_i}{B_{D'}} \quad \text{where } i = D, C, C', D'', C'' \;\&\; H \tag{2.2}$$

subestituting formula 2.1 into the above one , we directly obtain the following formula .

$$R = \frac{B_i}{B_{D'}} = \frac{\sqrt{A_i^{\,2} + I}}{B_{D'}} = \frac{I}{B_{D'}} \sqrt{\left(\frac{A_i}{I}\right)^2 + 1} \tag{2.3}$$

in which $B_{D'}$ & I are considered as constants.

& let

A , be the reciprocal of the distance between two Doppler stations.

If we take a coordinate system where the values of R are the ordinate and the values of $\frac{1}{A}$ as absisa we get figure 2.2.

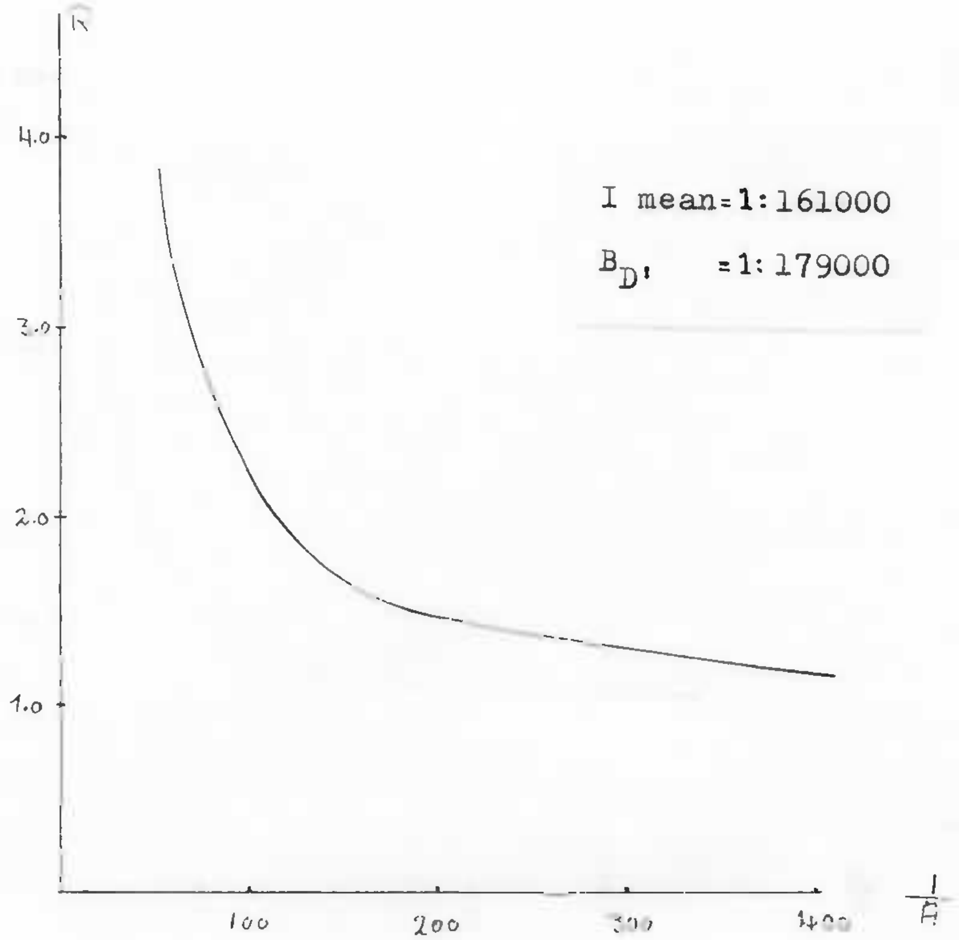

fig 2-2

An important phenomena in figure 2.2 is a change of the curve direction where A equals nearly to I. based on this fact, the change of the curve direction in Moose's paper manifests nothing special but that at this changing point the inner accuracy of Moose's test network is equal to the accuracy of the Doppler net. The separation distance corresponding to this point is the shortest and most effective one to reduce the standard errors of the combined net. Therefore the separation which possesses the above feature is defined as the critical separation of Doppler stations in a given terrestrial network.

3. Critical separation for the Egyptian terrestrial network:

From the results of adjusting the Egyptian geodetic network which were done by the auther [3] , by applying the technique of free adjustment, the mean inner relative accuracies of the lines in the net can be taken as 4 P.P.M. The critical separation of Doppler stations is determined not only by the above accuracy of the terrestrial network but also by the accuracy of Doppler positioning itself. The values of the critical separations which fit the Egyptian terrestrial network are presented in table 3.1 as follows:

Doppler accuracy	0.5	1	2	3
separation in km ..	175	350	700	1060

table 3.1

The Doppler accuracy in table 3.1 is the positional accuracy of Doppler positioning in one component.

4. Conclusion:

From the above results it can be said that if a Doppler network should be combined with a terrestrial network, the separation of the Doppler stations must be chosen so that the terrestrial network will not be distorted by the errors of the Doppler positions. The critical separation of Doppler stations, S*, for a given terrestrial network can be determined from the requirement that the accuracy of S* between Doppler stations is nearly equal to that in the terrestrial network .

S* is the ideal separation of Doppler stations. The errors in terrestrial network which we discussed above are all the random errors. As a matter of fact the dominant error in a large scale network is often a systematic error rather than the random error, [1] . In this case the definition of the critical separation mentioned above is also valid. It is to say, that the accuracy of S* between Doppler stations should be nearly equal to the systematic error of the corresponding distance in the terrestrial network. Otherwise, the combination of terrestrial network with Doppler network is meaningless. Those stations with longer separation than S* can be used in the combination adjustment. However stations, whose separations are shorter than S* , can not improve the accuracy of terrestrial network, though they are useful for the determination of transformation parameters of geodetic systems. Therefore the 250 km critical separation is obviously valid for R. MOOSE's test network and not certainly valid for any geodetic networks.

References:

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3. Shaker. A.A.(1982): Three Dimensional Adjustment and Simulation of The Egyptian Geodetic Network . Ph. D. Thesis, Tech.Univ. Graz.