INTERSERVICE RADIO PROPAGATION LABORATORY
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C.
Organized under Joint U.S. Communications Board

THE PREDICTION OF USABLE FREQUENCIES OVER A PATH OF SHORT OR MEDIUM LENGTH, INCLUDING THE EFFECTS OF Es.

The long-recognized need for the inclusion of the effects of sporadic E in the prediction of radio propagation conditions over paths of all lengths has resulted in the development of the techniques outlined under IV, 3, on pp.7-8 of the report IRPL-D2, issued October 1944. Since this report, which is one of the supplements of the IRPL Radio Propagation Handbook, Part 1, will be referred to frequently in this report, it is necessary to have a copy of it on hand for reference.

The path chosen as an example was the one from Halifax, N.S., to Goosebay, Labrador, since the path is of practical interest, and although the midpoint is south of the auroral zone, it suffers from frequent auroral-zone blackouts. The calculation was made for January 1945.

In VI, 1, of the above-mentioned report, on pp.8-9, is given an example of the prediction of propagation conditions for January 1945, over a relatively short path, i.e., that from Washington, D.C. to Miami, Fla., taking into consideration the effects of all the layers in the ionosphere including Es. A tabulation of the results of these calculations is given as Table 1, and the resulting graphs in Fig. 17. Both optimum working frequency (owf) and maximum usable frequency (muf) were calculated and plotted. In the case considered here, however, only the owf has been calculated. This method of path analysis affords an adequate means of frequency planning for short-path communication, taking all the ionosphere layers into consideration, and yet is not too lengthy for practical use.

Table I is a step-by-step tabulation of the predictions, with reference to the material in the IRPL-D2 report which was used in the analysis. The owf values for propagation by all the layers are plotted in Fig. 1, for study purposes, together with a graph representing the overall combined owf drawn through the highest values.

The combination of the F2-layer owf and the normal E-layer (and F1-layer) owf represents the prediction made without the inclusion of Es. Exclusive of Es, the optimum frequency is governed by the E and F1 layers from about 12 to 20 GCT. From 12 to 22 GCT an operating frequency of 5 Mc could probably be used, but in the event of high daytime absorption a frequency of 7 or 8 Mc would be better for most of the period. In the early morning hours the owf drops to 2.5 Mc so that if Es were not considered, the conclusion would be that it would not be advisable to try a frequency above about 2.5 Mc between 03 and 08 GCT.

Actually, however, if the operating frequency were chosen on this basis, there would be many nights when propagation would fail because of the "auroral absorption" or "blackouts".

The graph for the Es owf, which for the method of calculation outlined in IRPL-D2 represents the frequency which will be propagated over the path 80% of the days, indicates a possibility of transmission during the night hours 80% of the time on frequencies as high as 11 or 12 Mc. In fact, according to the graph a frequency of 11 Mc could be used successfully from 00 to 16 GCT.

In using short-path predictions, including the effects of Es, it should be remembered that Es predictions are as yet only approximate and that only rough qualitative check measurements have thus far been made on Es propagation. Such long- and short-path checks as have been made of the probability of Es propagation have shown that performance calculated by inclusion of Es is still on the conservative side.

At times of intense Es ionization, continuous automatic field-intensity records indicate that reliable Es-propagation may take place continuously over periods of hours. In fact Es propagation is often relied upon for short-distance communication in Alaska and other places in the auroral zone.

For the present some caution should be observed in using predictions involving Es propagation, because of uncertainties in predicting this type of propagation. For instance, referring to the graph, it is probably unwise to plan a frequency schedule for this path during this month using a night frequency of 10 or 11 Mc. However, it is reasonably certain that a night frequency of 4 or 5 Mc would give fairly reliable communication, except during severe ionospheric disturbances, since the path is a short one. In the event of an auroral type of blackout which would prevent contact on 4 or 5 Mc, it is of course futile to try a lower frequency. On the other hand, Es ionization is likely to be more intense in the auroral zone during an ionosphere storm, so that much higher frequencies may be tried with some chance of success. Often, however, auroral blackouts occur of such intensity that no high frequency can be used even over moderately short paths.

As regards direction finding, there is not yet sufficient correlated data on bearings taken above the predicted F2-layer owf during periods of Es occurrence to permit any conclusions as to the reliability of bearings.

Table 1.

Usable Frequencies, Halifax, N.S. to Goosebay, Labrador;
Predicted for January 1945 from Material in IRPL-U2.

(1) Local time	(2) F2 Zero-muf W-zone Fig. 5	(3) F2 4000-muf W-zone Fig. 6	(4) 1200-km F2 muf Fig.13	(5) 1200-km F2 owf Fig.13	(6) 2000-km normal-E (and F1) muf Fig. 11	(7) 1200-km normal-E (and F1) owf Fig. 14	(8) Median fEs Fig.12	(9) 2000-km Es owf (5fEs-4)	(10) 1200-km Es owf Fig.14 (using muf scale)	(11) Combined owf, highest of (5),(7) and (10)
00	3.2	7.7	4.4	3.7			3.0	11.0	9.1	9.1
02	2.5	5.2	3.1	2.7			4.0	16.0	13.0	13.0
04	2.4	4.8	2.9	2.5			3.9	15.5	12.5	12.5
06	2.4	4.9	3.0	2.5			3.8	15.0	12.2	12.2
08	2.4	5.5	3.1	2.6			3.7	14.5	11.4	11.4
10	2.4	5.8	3.2	2.6			3.8	15.0	12.2	12.2
12	3.5	10.0	5.1	4.3	6.1	4.9	4.1	16.5	13.5	13.5
14	5.5	17.0	5.4	7.1	11.0	8.7	4.2	17.0	13.9	13.9
16	6.1	20.1	9.5	8.1	11.9	9.4	4.0	16.0	13.0	13.0
18	6.2	20.0	9.6	8.2	11.2	9.1	2.6	9.0	7.4	9.1
20	5.8	17.5	8.7	7.4	7.1	5.6	2.1	6.5	5.4	7.4
22	4.5	12.5	6.5	5.5			2.0	6.0	4.9	5.5

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RESTRICTED

Usable Frequencies
Halifax, N.S.
To
Goosebay, Labrador

Predicted
for
January 1945

—o—o—F_2 layer OWF
—x—x—Normal E-layer
(and F_1 layer) OWF
- - - E_s OWF
combined OWF

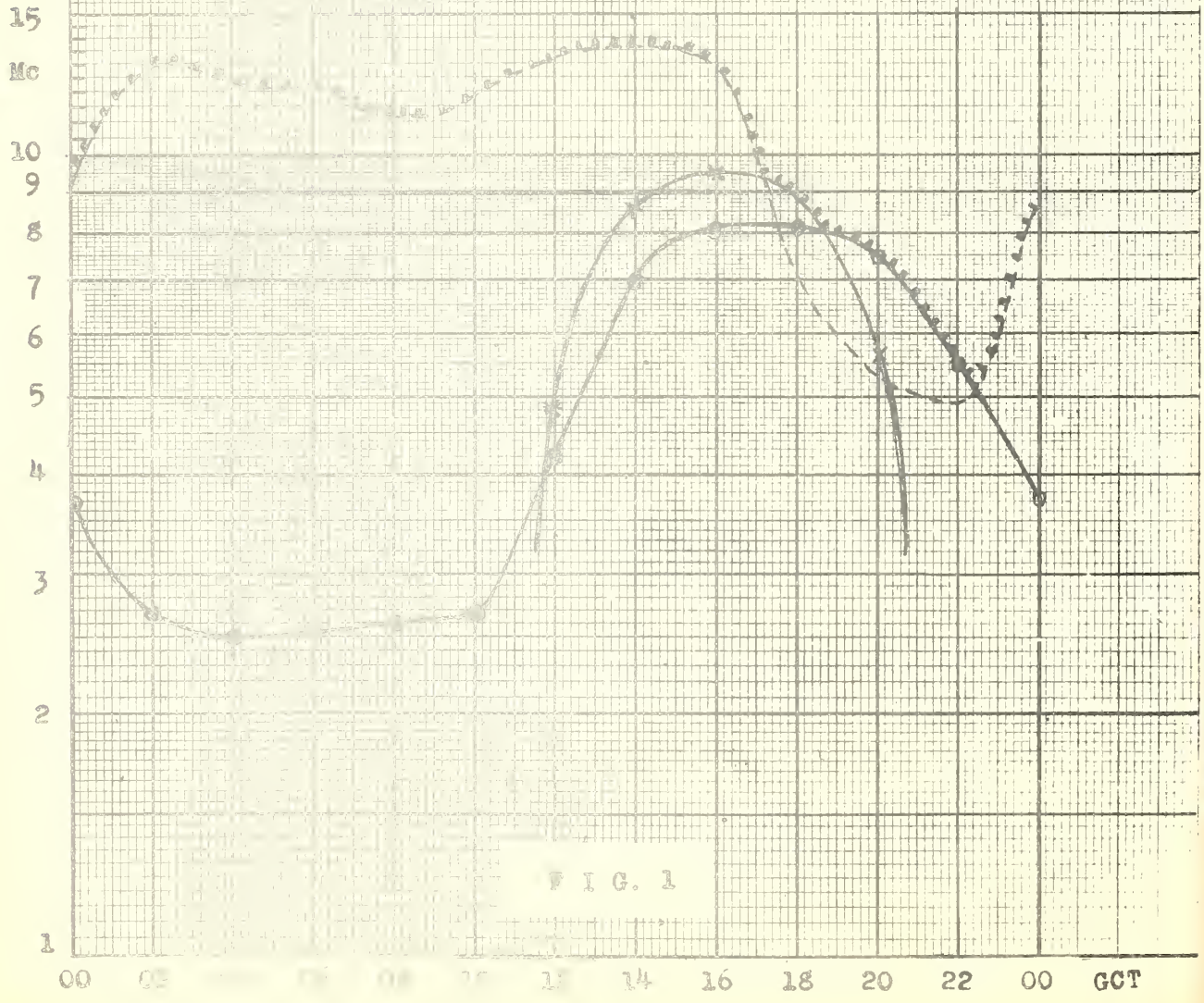

FIG. 1