





Af in the heat of the latery.

The second Party

PB 151361-2

Eechnical Mote

No. 2-2

Boulder Laboratories

SUPPLEMENTARY WORLD MAPS OF F2 CRITICAL FREQUENCIES AND MAXIMUM USABLE FREQUENCY FACTORS



U. S. DEPARTM INT OF COMMERCE NATIONAL BUREAU OF STANDARDS



THE NATIONAL BUREAU OF STANDARDS.

The structure and A. B. P. Dies.

In the recension of the Nation d Burean of Standards are set forth in the Act of Congress. March 19.1. Concoded by Congress in Public Law 619, 1950. These include the development and contentace of the national standards of measurement and the provision of means and methods for taking measurements consistent with these standards: the determination of physical constants and properties of materials: the development of methods and instruments for testing materials, devices, one steactness: idvisory services to government agencies on scientific and technical problems: inential methods and specific and technical problems: inential and development of devices to serve special needs of the Government; and the development of a udard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various on ultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Burean or when the Burein's anque competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or pubteshed papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers: the Technical News Bulletin presents summary and preliminary reports on work in progress: and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for cadio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellancous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Girealar 160. Publications of the National Bureau of Standards (81.25) and its Supplement (81.50), available from the Superintendent of Documents. Government Printing Office, Washington 25, D.C.

NATIONAL BUREAU OF STANDARDS

Eechnical Mote

2-2

October 1960

SUPPLEMENTARY WORLD MAPS OF F2 CRITICAL FREQUENCIES AND MAXIMUM USABLE FREQUENCY FACTORS

Donald H. Zacharisen

This work was prepared in response to Study Program 60 and Recommendation 176 of the International Radio Consultative Committee (CCIR). This Technical Note supplements Technical Note 2 and together they present F2-layer prediction material for all months of the year.

NBS Technical Notes are designed to supplement the Bureau's regular publications program. They provide a means for making available scientific data that are of transient or limited interest. Technical Notes may be listed or referred to in the open literature. They are for sale by the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

DISTRIBUTED BY

UNITED STATES DEPARTMENT OF COMMERCE

OFFICE OF TECHNICAL SERVICES

WASHINGTON 25, D. C.

Price \$ 3.50

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	l
II.	A DESCRIPTION OF WORLD PREDICTION MAPS, PREDICTION CHARTS AND AIDS	1
III.	INSTRUCTIONS FOR USE OF WORLD PREDICTION MAPS, PREDICTION CHARTS AND AIDS	4
IV.	SAMPLE PREDICTIONS	9
	A. SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH LESS THAN OR EQUAL TO 4000 KM	11
	B. SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH GREATER THAN 4000 KM	12
v.	FIGURES AND TABLES	13
	A. MAP OF THE WORLD	14
	B. GREAT CIRCLE CHART	15
	C. DISTANCE NOMOGRAM	16
	D. SUPPLEMENTAL DISTANCE NOMOGRAM	17
	E. TABLE OF APPROXIMATE VALUE OF ONE-HALF THE GYROFREQUENCY	18
	F. TABLE OF GEOMAGNETIC LATITUDE OF POINTS ON THE EARTH	19
	G. WORK SHEET FOR SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH LESS THAN OR EQUAL TO L	000 KM 21
	H. WORK SHEET FOR SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH GREATER THAN 4000 KM	22
VI.	WORLD PREDICTION MAPS AND PREDICTION CHARTS	23
	A. FEBRUARY	24
	B. APRIL	61
	C. MAY	98
	D. AUGUST	135
	E. OCTOBER	172
	F. NOVEMBER	209

SUPPLEMENTARY WORLD MAPS OF F2 CRITICAL FREQUENCIES AND MAXIMUM USABLE FREQUENCY FACTORS

ЪУ

Donald H. Zacharisen

Summary

This report supplements National Bureau of Standards Technical Note Number 2, April 1959, and completes the basic data required for F2-layer maximum usable frequency predictions. Prediction charts are given for the months of February, April, May, August, October and November. Auxiliary charts are included to aid in predicting F2layer MUFs.

The four parameters used for predicting MUFs are foF2 and the 4000 km MUF factor for a twelve-month running average Zurich sunspot number of 50, and the rates of change of foF2 and 4000 km MUF factor with sunspot number. The first three parameters are presented in map form for each even hour of Greenwich Mean Time. The fourth parameter is presented on a chart of geomagnetic latitude and local time.

1. INTRODUCTION

This report completes the twelve-month set of world prediction maps and charts for use in predicting median maximum usable frequencies (MUFs) for F2-layer transmission. The basic parameters in this report for February, April, May, August, October, and November include most of the data taken during the IGY. National Bureau of Standards Technical Note Number 2¹, which presents the same basic data for January, March, June, July, September, and December, includes only a small amount of IGY data. All of the prediction maps and charts are prepared for average conditions. Each prediction map corresponds to an even hour of Greenwich Mean Time (GMT) which is also known as Universal Time (UT).

The results of a pilot study² cover most of the considerations involved in producing these prediction maps. The history of the preparation of these maps is covered in two sources.^{1,3}

II. A DESCRIPTION OF WORLD PREDICTION MAPS, PREDICTION CHARTS AND AIDS

Figure 3 shows the map projection used in producing the world prediction maps. This map will be used in determining the location of the desired communication path endpoints. Figure 4, a great circle chart, is based on the same projection used in the above map of the world. Figures 3 and 4 are used to determine the great circle communication path between the transmitting and receiving terminals. The world prediction maps are all presented for each even hour of the day. The prediction <u>charts</u> of slope of regression line of M-4000 factor on the twelvemonth running average Zurich sunspot number (RASSN) have time of day rather than longitude as the abscissa. Hence there are fewer charts to represent this parameter than there are maps to represent the other parameters. It was determined, from the results of a pilot study², that it would be of doubtful value to attempt to specify this parameter in more detail.

Figure 5 and Figure 6^* are used to interpolate between the values of F2-zero-MUF and F2-4000-MUF provided by the world prediction maps and prediction charts. Figure 5 is generally used. Figure 6 is to be used during certain daylight hours indicated in the accompanying Table. The nomogram in Figure 6 will, in general, give lower values of MUF than the nomogram in Figure 5. It is felt that the prescribed use of two distance nomograms (Figure 5, Figure 6) will give predictions which are more nearly consistent throughout the year. Both nomograms have F2-zero-MUF along the left vertical axis. F2-zero-MUF is obtained by adding one-half of the gyrofrequency ($f_{\rm H}$) to the foF2. An approximate value of $f_{\rm H}/2$ is obtained from Table 1 as a function of geomagnetic latitude. The geomagnetic latitude, for a given geographic latitude and longitude, may be obtained from Table 2.⁴

The prediction maps for <u>foF2 at RASSN 50</u> and <u>M-4000</u> <u>factor at RASSN 50</u> are used respectively with those for the <u>slope of regression of foF2 on RASSN</u> and the prediction charts of the <u>slope of regression of M-4000 factor</u> <u>on RASSN</u>. The first two parameters above give the value of foF2 or M-4000 factor at a RASSN of 50. The third and fourth parameters give the rates of change of foF2 or M-4000 factor with RASSN. For example, a value from the map of foF2 at RASSN 50 used with a corresponding value from the map of the rate of change of foF2 with RASSN will give, for a given geographical location, the value of foF2 for essentially all values of RASSN.

In addition to the above prediction material a predicted value of RASSN, such as is supplied five months in advance of the month in question by CRPL using the McNish-Lincoln method,⁵ is required to predict F2-layer MUFs.

It should be kept in mind that these maps will provide predictions only for F2-layer propagation. For low sunspot numbers, during local summer at middle latitudes,

^{*}Used by permission of Dr. Kenneth Davies of the National Bureau of Standards, Boulder, Colorado.

the E- and Fl-layers may permit propagation at a somewhat higher frequency than the F2-layer. Also, at anytime, other factors, such as sporadic-E, scatter, layer tilts, etc., may also permit propagation at higher frequencies than predicted from these maps.

A simple set of equations are used to predict MUFs and optimum traffic frequencies (FOTs)^{*} from the prediction maps and charts, the aids, and a predicted RASSN. The following symbols are used in presenting these equations:

- R = predicted RASSN.
- f(R) = median ordinary-wave critical frequency
 (median foF2) at RASSN R (denotes median
 foF2 as a function of R).
- f(50) = median foF2 at RASSN 50.
 - bf = slope of the regression line of median foF2 on RASSN (the rate of change of median foF2 with RASSN).
- M(R) = median maximum usable frequency factor for a transmission distance of 4000 kilometers (median M-4000) at RASSN R.
- M(50) = median M-4000 at RASSN 50.
 - b_M = slope of the regression line of median M-4000 factor on RASSN (rate of change of median M-4000 factor with RASSN).

*The term FOT supersedes OWF which appears in the report[⊥] presenting the first six months of maps.

- F2-zero-MUF(R) = maximum usable frequency for a transmission distance of zero kilometers at RASSN R.
- F2-4000-MUF(R) = maximum usable frequency for a transmission distance of 4000 kilometers at RASSN R.
 - $f_{H} = gyrofrequency.$

$$f(R) = f(50) + (R-50)b_{r}$$

$$M(R) = M(50) + (R-50)b_{M}$$

 $f(R) + f_{H}/2 = median F2-zero-MUF(R).$

[f(R)] [M(R)] = median F2-4000-MUF(R).

f(50), b_f , and M(50) are read from their respective maps at the geographical location of the control points of the great-circle path between the transmitting and receiving terminals. For circuits 4000 km or less, the control point is at the great-circle midpoint. For circuits greater than 4000 km, ionospheric conditions 2000 km from each terminal are assumed to control. b_M is read from a chart at the geomagnetic latitude of the control points. The predicted value of RASSN used with this report should be one that will give the best MUF predictions rather than one that will predict a correct value of RASSN. The above value of RASSN should follow closely the predicted or expected value of RASSN.

The world prediction maps of foF2 at RASSN 50 and

M-4000 factor at RASSN 50 were drawn from median values and the use of the values from these maps in the above equations will result in median values of F2-4000-MUF(R) and F2-zero-MUF(R). The median value is of course the middle value when the observed data are arranged in order of magnitude. Propagation at the MUF calculated from these prediction maps and charts should be possible on approximately 50% of the days of the month.

A frequency that should be propagated via the F2layer approximately 90% of the time (FOT) may be easily obtained from the above median F2-MUF. It might be found by taking 85% of the median F2-4000-MUF(R) and 85% of the median F2-zero-MUF(R), but it is simpler just to take 85% of the median F2-MUF for which the distance interpolation has already been made. Both methods can be seen to yield the same results.

III. INSTRUCTIONS FOR USE OF WORLD PREDICTION MAPS, PREDICTION CHARTS AND AIDS

Much of the material in this section is similar to that in National Bureau of Standards Circular 465^6 which is probably familiar to many users of this report and therefore the use of a similar text should aid in determining F2-layer MUFs from the material included herein. It is suggested that if repeated use is to be made of this report, the staples be removed and the report placed in a looseleaf notebook so that the pages will lie flat.

1. Determination of Great-Circle Distances and Locations of Transmission Control Points

Figure 3 is a map of the world. Figure 4 is a chart to the same scale as Figure 3, on which the solidline curves crossing the equator at two points 180° apart represent great circles. The numbered dot-dash lines crossing the great circles indicate distances along them in thousands of kilometers. In using Figures 3 and 4, proceed as follows:

(a) Place a piece of transparent paper over the map, Figure 3, and draw the equatorial line and the 120°W longitude line. Place dots over the locations of the transmitting and receiving terminals. Also mark the 0° meridian for use in determining GMT from the prediction charts of slope of regression line of M-4000 factor on RASSN.

(b) Place this transparency over Figure 4 and, keeping the equatorial line of the transparency always on the equatorial line of Figure 4, slide the transparency horizontally until the terminal points marked on it either

- 4 -

fall on the same great circle or are the same proportional distance between adjacent great-circle curves. Draw a great-circle path through the terminal points. Paths between Washington, D.C. and Miami, Florida, and Washington, D.C. and Trieste are shown in Figure 4.

(c) For paths shorter than 4000 km, locate the midpoint of the path by keeping the transparency in position on Figure 4 and using the numbered lines as a distance scale. The midpoint of the Washington-Miami path is at M on Figure 4.

(d) For paths longer than 4000 km, locate thefollowing "control points" on the great circle transmission path:

Point "A" 2000 km from the transmitter

Point "B" 2000 km from the receiver

These control points for the Washington-Trieste path are shown in Figure 4.

- 2. Prediction of Maximum Usable Frequencies and Optimum Traffic Frequencies
- 2.1 Prediction of MUF and FOT for distances less than or equal to 4000 km

(a) A work sheet similar to that of Figure 7 is suggested.

(b) To predict the MUF:

(1) Place the great circle transparency over the map of foF2 at RASSN 50 for 0000 hours GMT for the month of interest and keep the equatorial line of the transparency over the equatorial line of the map and the 120°W line of the transparency over the 120°W line of the map.

(2) Read the value of foF2 for the midpoint of the path and record as f(50) in Column a. of Figure 7.

(3) Repeat for the 0200, 0400, 0600, etc. maps.

(4) Repeat steps (1), (2), and (3) for the maps of the slope of the regression line of foF2 on RASSN and again for the maps of M-4000 factor at RASSN 50 and record values as b_f in Column b. and as M(50) in Column e., respectively, of Figure 7.

(5) Compute (R-50), using the predicted value of R for the desired month, and record this value in Column c. of Figure 7.

(6) From Figure 3, determine the geographical coordinates of the path midpoint located in Section

- 5 -

1 (c) above. Table 2 is then used to find the geomagnetic latitude of the midpoint. Geographic latitude is located along the vertical axis of Table 2 and geographic longitude is located along the horizontal axis. 180°E to 360° E longitude on Table 2 corresponds to 180°W to 0° longitude.

(7) If the geomagnetic latitude differs from the geographic latitude, place a dot on the geographic meridian of the great-circle midpoint at a geographic latitude equal to the geomagnetic latitude found in (6) above.

(8) Place the transparency over the chart of the slope of the regression line of M-4000 factor on RASSN and keep the equatorial line of the transparency over the equatorial line of the chart. Slide the transparency horizontally until the Greenwich meridian of the transparency coincides with 0000 hours on the local time (LT) scale.

Note that all points on the great-circle path are in their proper LT relationship to Greenwich.

(9) Read the slope of the regression line of M-4000 factor on RASSN for the location of the dot determined in Instruction (7) above and record as b_M

in Column f. of Figure 7.

Note that on the prediction chart (-) refers to an algebraic increase (e.g.-.0040 to -.0050) of values inside the contour so specified while (+) refers to an algebraic decrease (e.g. -.0040 to -.0030) of values inside of the contour so specified.

(10) Repeat for 0200, 0400, 0600, etc. on the time scale. Frequently it will be necessary to make the Greenwich meridian of the transparency coincide with an imagined 2600, 2800, 3000, etc. on the time scale. A convenient aid is to place marks at two hour intervals on the equatorial line of the transparency.

(11) Compute the values for Columns d., g., and h. of Figure 7 from the equation at the heading of each of these columns. The equation for Column d. is f(R) = Column a. + (Column b.)(Column c.).

(12) Use the geomagnetic latitude of the path midpoint found in Instruction (6) above to obtain one-half of the gyrofrequency (f_H) from Table 1. Add this value of $f_H/2$ to the median foF2 for all even hours to obtain median F2-zero-MUF(R) and record the values in column i. of Figure 7.

- 6 -

(13) For each hour place a straightedge between the values of F2-zero-MUF(R) and F2-4000-MUF(R) at the left-hand and right-hand sides, respectively, of the appropriate grid nomogram, Figure 5 or Figure 6, and read the MUF for the actual path length at the intersection point of the straightedge with the appropriate vertical distance line, interpolating between the oblique lines. Use the nomogram in Figure 6 as indicated by the accompanying Table. Otherwise use the nomogram in Figure 5. Record the values in Column j. of Figure 7.

(14) Calculate the F2-FOT by multiplying each median F2-MUF in Column j. of Figure 7 by the factor
0.85 or by using the conversion scale contained in
Figure 5. Record the values in Column k. of Figure
7.

2.2 Prediction of MUF and FOT for distances greater than 4000 km

(a) General Considerations:

The long distance F2-layer MUF predictions are based on the assumptions:

(1) That there are F2-layer control points A and B.

(2) That the highest frequency that can be

propagated from the A-end to the B-end is the lower of the two frequencies of A and B above.

(3) That the frequency obtained in (2) is the same for propagation from the B-end to the A-end.

(b) A work sheet similar to Figure 8 is suggested. Scaled values and computations for control point A and control point B should be recorded in Columns a. through h. and Columns i. through o., respectively, on Figure 8. In the following instructions, the first designated column letter will apply to control point A and the one in parenthesis to control point B. The lower of A and B is entered in Column p. and the FOT is computed from this and entered in Column q.

(c) Locate the control points A and B as explained in Section 1. For very long paths the "short route" (minor arc of the great-circle path) and the "long route" (major arc) may both need to be considered.

(d) To determine the MUF:

(1) Place the great circle transparency over the map of foF2 at RASSN 50 for 0000 hours GMT for the month of interest and keep the equatorial line of the transparency over the equatorial line of the map and the 120°W line of the transparency over the 120°W line of the map.

- 7 -

(2) Read the value of foF2 for control pointA and record as f(50) in Column a. (1.) of Figure8.

(3) Repeat for the 0200, 0400, 0600, etc. maps.

(4) Repeat steps (1), (2), and (3) for the maps of the slope of the regression line of foF2 on RASSN and again for the maps of M-4000 factor at RASSN 50 and record values as b_f in Column b. (j.) and as M(50) in Column e. (*l*.), respectively, of Figure 8.

(5) Compute (R-50), using the predicted value of R for the desired month, and record this value in Column c. of Figure 8.

(6) From Figure 3, determine the geographical coordinates of the location of control point A which was located in Section 1 (d) above. Table 2 is then used to find the geomagnetic latitude of A. Geographic latitude is located along the vertical axis of Table 2 and geographic longitude is located along the horizontal axis. 180°E to 360°E longitude on this chart corresponds to 180°W to 0° longitude.

(7) If the geomagnetic latitude differs from

the geographic latitude, place a dot on the geographic meridian of control point A at a geographic latitude equal to the geomagnetic latitude found in (6) above.

(8) Place the transparency over the chart of the slope of the regression line of M-4000 factor on RASSN and keep the equatorial line of the transparency over the equatorial line of the chart. Slide the transparency horizontally until the Greenwich meridian of the transparency coincides with 0000 hours on the local time (LT) scale.

Note that all points on the great-circle path are in their proper LT relationship to Greenwich.

(9) Read the value of the slope of the regression line of M-4000 factor on RASSN for the location of the dot determined in Instruction (7) above and record as $b_{\rm M}$ in column f. (m.) of Figure 8.

Note that on the prediction chart (-) refers to an algebraic increase (e.g. -.0040 to -.0050) of values inside of the contour so specified while (+) refers to an algebraic decrease (e.g. -.0040 to -.0030) of values inside of the contour so specified. (10) Repeat for 0200, 0400, 0600, etc. on the time scale. Frequently it will be necessary to make the Greenwich meridian of the transparency coincide with an imagined 2600, 2800, 3000, etc. on the time scale. A convenient aid is to place marks at twohour intervals on the equatorial line of the transparency.

(11) Compute the values for Columns d. (k.),g. (n.), and h. (o.) of Figure 8 from the equationat the heading of each of these columns.

(12) Repeat steps (1) through (11) for control point B using Columns i. through o. on the work sheet as indicated in the parenthesis.

(13) For each of the even hours compare the two values of median F2-4000-MUF(R) in Columns h. and o. of Figure 8 representing control point A and control point B, respectively. The lower of the two values is the MUF for a given even hour for the transmission path. Record this median F2-MUF for the path in Column p.

(14) Calculate the F2-FOT by multiplying each median F2-MUF in Column p. of Figure 8 by the factor 0.85 or by using the conversion scale in Figure 5. The values obtained are recorded in Column q. of Figure 8.

IV. SAMPLE MUF AND FOT PREDICTIONS

1. Short Path

The MUF and FOT for the great-circle communication path between Washington, D.C. (39.0°N, 77.5°W) and Miami, Florida (25.7°N, 80.5°W), have been predicted for average conditions for the month of April using a RASSN of 119. This was the observed RASSN for April of 1956 and the values that have been predicted would be applicable to the propagation conditions encountered during that period. It is possible that a predicted value of RASSN would fit the propagation conditions encountered more precisely than the observed RASSN.

The values that have been calculated are shown in Figure 1. It will be noted here that the values recorded in Columns a., b., e., and f. of Figure 1 will always apply for the above communication path for the month of April. The values in Column c. will vary from year to year with changes in the value of RASSN. The values for Columns a., b., e., and f. could therefore be scaled, for a given month and transmission path, well in advance of the receipt of the predicted value of RASSN. The geographic latitude of the midpoint of the above path is included in the limits indicated in the Table in Figure 6 and therefore the distance nomogram in Figure 6 is used for the period 0700 to 1700 hours local time at the path midpoint. The nomogram in Table 5 is used for all other hours of the day.

2. Long Path

The MUF and FOT for the great-circle communication path between Washington, D.C. (39.0°N, 77.5°W) and Trieste (45.7°N, 13.8°E) have been predicted for average conditions for the month of October using a RASSN of 8. This was the observed RASSN for October of 1954 and the values that have been predicted would be applicable to the propagation conditions encountered during that period. It is again possible that a predicted value of RASSN would fit the propagation conditions encountered more precisely than the observed RASSN.

The values that have been calculated for the control point A are shown in Columns a. through h. of Figure 2 and the values calculated for control point B are shown in Columns i. through o. of Figure 2. Again, it will be noted that the values recorded in Columns a., b., e., and f. and Columns i., j., l., and m. will always apply for the above communication path for the month of October. The values in Column c. will vary from year to year with changes in the value of RASSN. The values for Columns a., b., e., and f. and Columns i., j., l., and m. could therefore be scaled, for a given month and transmission path, well in advance of the receipt of the predicted value of RASSN.

REFERENCES

- Zacharisen, D.H., World maps of F2 critical frequencies and maximum usable frequency factors, Nat. Bur. Stand. Tech. Note 2, 1959.
- Crow, E.L. and D.H. Zacharisen, "The error in prediction of F2 maximum usable frequencies by world maps based on sunspot number", Statistical Methods in Radio Wave Propagation, Pergamon Press, 1960.
- Zacharisen, D.H. and Vaughn Agy, World maps of F2 critical frequencies and maximum usable frequency factors for use in making ionospheric radio predictions, J. Geophys. Research, 65, 593-595, 1960.
- 4. Vestine, E.H., L. Laporte, I. Lange, C. Cooper, W.C. Hendrix, "Description of the earth's main magnetic field and its secular change 1905-1945", Carnegie Institution of Washington Publication 578, Washington, D.C., 1948, pp. 28-33.
- McNish, A.G. and J.V. Lincoln, "Prediction of sunspot numbers", Trans. of the Amer. Geophys. Union, Vol. <u>30</u>, pp. 673-685, 1949.
- NBS Circular 465, "Instructions for the use of basic radio propagation predictions", U.S. Govt. Printing Office, 1947.

SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH LESS THAN OR EQUAL TO 4000 KM

'r	om	Was	hing	ton,	D.C.	

To Miami, Florida Distance 1500 km Predicted for April 19

Geomagnetic latitude for path midpoint 43°N One-half gyrofrequency ($f_{\rm H}/2$) for path midpoint 0.6 Mc

Procedure	Scale	Scale	Compute	Compute	Scale	Scale	Compute	Compute	Compute	Scale - use Fig.	Compute
	f(50)	bf	(R-50)	f(R) = a + bc	M(50)	b _M	M(R) = e + cf	median F2-4000- MUF(R) = dg	median F2-zero- MUF(R) = d + fH/2	median F2-MUF for path	F2-FOT for path = 0.85j
GMT	a	Ъ	с	d	е	f	g	h	i	j	k
00	7.3	.034	69	9.6	3.41	0036	3.16	30.3	10.2	18.2*	15.5
02	5.9	.030	69	8.0	3.27	0033	3.04	24.3	8.6	14.8*	12.6
04	4.9	.030	69	7.0	3.09	0029	2.89	20.2	7.6	12.6*	10.7
06	4.6	.031	69	6.7	3.11	0028	2.92	19.6	7.3	12.2*	10.4
08	4.3	.027	69	6.2	3.14	0028	2.95	18.3	6.8	11.4*	9.7
10	3.8	.024	69	5.5	3.20	0032	2.98	16.4	6.1	10.2*	8.7
12	5.7	.029	69	7.7	3.51	0034	3.28	25.3	8.3	15.1*	12.8
14	7.1	.036	69	9.6	3.40	0033	3.17	30.4	10.2	17.0**	14.4
16	7.7	.042	69	10.6	3.15	0029	2.95	31.3	11.2	18.0**	15.3
18	8.3	.043	69	11.3	3.14	0029	2.94	33.2	11.9	19.1**	16.2
20	8.3	.040	69	11.1	3.20	0030	2.99	33.2	11.7	19.0**	16.2
22	8.1	.035	69	10.5	3.30	0034	3.07	32.2	11.1	18.2**	15.5
Done by											
Checked											

Note: All frequencies are in Megacycles

The distance nomogram in Figure 5 was used ×

** The distance nomogram in Figure 6 was used

SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH GREATER THAN 4000 KM

From Washington, D.C. To Trieste Distance 7100 km Predicted for October 19

Geomagnetic latitude for control point A 60°N and control point B 57°N

			(Control	Point A						Cont	rol Poir	nt B				
Procedure	Scale	Scale	Compute	Compute	Scale	Scale	Compute	Compute	Scale	Scale	Compute	Scale	Scale	Compute	Compute	Lower of h and o	Compute
	f(50)	b _f	(R-50)	f(R) = a + bc	м(50)	Ъ _М	M(R) = e + cf	median F2-4000- MUF(R) = dg	f(50)	b _f	f(R) = i + cj	м(50)	Ъ _М	$M(R) = \ell + cm$	median F2-4000- MUF(R) = kn	median F2-MUF for path	F2-FOT for path = 0.85p
GMT	а	b	с	đ	е	f	g	h	i	j	k	l	m	n	0	p	<u>q</u>
00	4.7	.027	-42	3.6	3.19	0035	3.34	12.0	4.0	.022	3.1	3.05	0032	3.18	9.9	9.9	8.4
02	4.1	.024	-42	3.1	3.14	0033	3.28	10.2	3.6	.018	2.8	2.99	0032	3.12	8.7	8.7	7.4
04	3.6	.024	-42	2.6	3.09	0033	3.23	8.4	3.2	.018	2.4	2.99	0032	3.12		7.5	6.4
06	3.1	.021	-42	2.2	3.06	0033	3.20	7.0	2.8	.019	2.0	3.08	0032	3.21	6.4	6.4	5.4
08	2.7	.019	-42	1.9	3.07	0033	3.21	6.1	5.3	.027	4.2	3.52	0034	3.66	15.4	6.1	5.2
10	3.6	.019	-42	2.8	3.33	0033	3.47	9.7	7.1	.038	5.5	3.55	0036	3.70	20.4	9.7	8.2
12	6.4	.032	-42	5.1	3.63	0035	3.78	19.3	8.0	.043	6.2	3.48	0038	3.64	22.6	19.3	16.4
14	7.4	.040	-42	5.7	3.50	0037	3.66	20.9	8.1	.042	6.3	3.46	0038	3.62	22.8	20.9	17.8
16	7.9	.040	-42	6.2	3.40	0038	3.56	22.1	7.9	.044	6.1	3.51	0042	3.69	22.5	22.1	18.8
18	7.8	.042	-42	6.0	3.37	0040	3.54	21.2	7.0	.037	5.4	3.50	0039	3.66	19.8	19.8	16.8
20	7.3	.037	-42	5.7	3.46	0040	3.63	20.7	5.6	.026	4.5	3.35	0036	3.50	15.8	15.8	13.4
22	6.1	.032	-42	4.8	3.35	0037	3.51	16.8	4.2	.024	3.2	3.13	0033	3.27	10.5	10.5	8.9
Done by																	
Checked														_			

Note: All frequencies are in Megacycles

V. FIGURE AND TABLES



.





MAP OF THE WORLD



- 15 -

GREAT CIRCLE CHART CENTERED ON EQUATOR. SOLID LINES REPRESENT GREAT CIRCLES. NUMBERED DOT-DASH LINES INDICATE DISTANCES IN THOUSANDS OF KILOMETERS.



NOMOGRAM FOR TRANSFORMING F2-ZERO-MUF AND F2-4000-MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AT INTERMEDIATE TRANSMISSION DISTANCES; CONVERSION SCALE FOR OBTAINING OPTIMUM TRAFFIC FREQUENCIES (FOT).

FIGURE 5





NOMOGRAM FOR TRANSFORMING F2-ZERO-MUF AND F2-4000-MUF TO EQUIVALENT MUFS AT INTERMEDIATE DISTANCES.

FIGURE 6

Month

January

February

March

April

May

June

July

August

September

October

November

December

An Approximate Value of One-half the Gyrofrequency (f_H) as a Function of Geomagnetic Latitude

$\frac{1}{2}$ Gyrofrequency (f _H)	Geomagnetic Latitude
0.8	81°N - 90°N
0.7	60°N - 80°N
0.6	40°N - 59°N
0.5	21°N - 39°N
0.4	20°N - 20°S
0.5	21°S - 39°S
0.6	40°S - 59°S
0.7	60°S - 80°S
0.8	81°S - 90°S

TABLE 1

-

-																			
1	160	78 75 75 75 78	71 69 65 65 64	62 56 56 56	52 51 49 47 45	41 41 33 35 37 35	33 33 29 25 25	23 21 19 18 18	14 12 10 8 6	40004	- 6 - 8 -10 -12 -12	-16 -20 -22 -22	-26 -28 -30 -32 -32	-35 -37 -39 -41 -43	-45 -47 -49 -51 -53	-55 -57 -58 -60 -62	-64 -66 -88 -88 -69 -69	-73 -74 -75 -77 -77 -78	-79 -79 -79
	75	78 775 72 72	70 68 65 65 63	61 559 56 54	52 50 44 44	42 40 36 34	32 30 28 28 28	23 21 19 17 15	13 13 5	8 H H 8 9	- 7 - 11 -13 -15	-17 -19 -21 -23 -25	-27 -29 -31 -32 -32	-36 -38 -40 -42 -42	-46 -46 -48 -50 -52 -52 -52	-56 -58 -59 -61 -61	-65 -57 -69 -69 -70	-74 -75 -76 -76 -78 -79	-79 -80 -80 -79
	7011	77 76 75 71 71	70 68 64 62	60 53 55 53	51 49 45 43	41 39 35 33 33	31 30 26 26 24	22 20 16 14	12 10 6 4	0.000	- 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10	-18 -22 -24 -26	-28 -29 -31 -33	-37 -39 -41	- 47 - 49 - 53 - 53 - 53 - 53 - 53 - 53 - 53 - 5	-53 -59 -60 -62 -62	-66 -70 -73	-75 -75 -77 -77 -79 -79 -79 -79 -79 -79 -79 -79	-80 -80 -79
10	65 1	77 76 74 73 73	69 65 65 64 62	56 56 57 56 57 57 57 57 57 57 57 57 57 57 57 57 57	46 46 42 42	41 33 35 33 33	31 27 25 25 25 25	21 19 15 13	11 9 3 3	B B F	- 11 - 13 - 15	-19 -22 -24 -26 -26	36 - 36 - 36 - 36 - 36 - 36 - 36 - 36 -	- 38 - 40 - 42 - 44		651 - 59 63 - 61 63 - 61	69 - 69 - 71 - 72 - 72	-78 -77 -78 -79 -80	81 - 81 - 80 - 80
DE	60 1	77 78 74 70	69 67 63 61	55 55 54 52	50 46 44 42	40 38 34 32 32	30 26 22 22	20 16 14 12	10 8 8 8 8	00400	- 9 - - 11 - - 13 - 15 - 17 -	-19 -21 -21 -23 -23 -23 -23 -23 -23 -23 -25 -25 -25 -25 -25 -25 -25 -25 -25 -25	33 - 33	- 41 - 43 - 43 - 45 - 45	49 63 55 55	66 64 66 64	68 - 70 - 72 - 73 - 73 - 75 - 75 - 75 - 75 - 75 - 75	76 78 79 80 80	81 81 81 80
E	55 1	77 75 77 72 70	66 66 64 63 81	59 55 53 51	49 47 45 43 41	33 33 33 33	25 25 23 23 23	19 16 14 12	0 8 8 4 8	00400	-10 - -12 - 14 - 16	20 24 26 26		40 - 42 - 44 - 46 - 46 - 46 - 46 - 46 - 46	5.	61 - 63 - 65 - 65 - 67 -	69 - 71 - 72 - 78 - 78	77 79 80 81 82	82 81 81 80
ONG	50 1	77 75 73 72 70	68 64 62 60	56 57 52 50 50	49 47 45 45 41	39 33 33 33	23 23 23 23 23 23 23 23 23 23 23 23 23 2	19 17 13 13	5 C S S I	- 1 N N C O	-11 - -13 - -15 - -17 -	21 23 25 25 25 25 29	- 31 - 33 - 35 - 39 - 39 -	- 41 - 43 - 45 - 45 - 46 - 46	52 - 50 - 564 - 564 - 564 - 564 - 564 - 564 - 565 - 556	60 64 66 66	70 72 73 75	- 78 - 80 - 81 - 81 - 82 - 82	- 83 - 82 - 81 - 81 -
й	2	5 9 9 7 9 7 9	0 0 7 0 0	0 0 4 0 0	09400	8 8 7 8 8	899400	10 10 10 10	00400	0.00.04.03	113	53 52 53 53 53 53 53 53 53 53 53 53 53 53 53	333333 3332333	411	199.2.1 0.0.2.3	61 63 63 63 63	72	79 88 84 84	00000
ANT	0 14	6 10 10 1 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1	22222	C 9 4 8 9	89400	882888	8 9 7 8 0	89420	899400	0.4.000	1102	00 00 00 00 00 00 00 00 00 00 00 00 00	N 4 9 9 0	1 1 1 1 1 0 4 0 0 0	0 4 9 8 9	227 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	11111	888888	1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -
SB	5 14	6 6 6 6 6 6	5 2 2 2 5 6	10 10 10 10 10 10 10 10 10 10 10 10 10 1	31357	622253	53225	0113	~ 5 5 1 1	0.4.0.00	1 1 1 1 1	308.4	2 7 7 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	4 4 4 4 4 0 0 4 0 00 0	0 4 9 8 9 0 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	22 4 5 6 6 	88 8 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
6	0 13	666660	5 5 5 5 6	5355	6 5 6 4 6	622226	5 2 2 2 3 2 3	9113	1 1 3 5 4	1193	21-1-1-2	31	88687	8 4 4 6 8 7 4 6 1 1 1 1 1		55	2 4 8 6 6	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	35 - 1 32 - 1 32 - 1
	5 13	6.6.6.6.0	5 2 2 2 6	10 10 10 10	7 8 8 4 8 7 4 4 7 6	6 22 22 26	688339	9113	11383	1 1 1 1 1	21	33 1 1 1	22582 19991	44 44 11 11 11 11 11 11 11	1111	1 T T T T	5 5 C 6 E	55 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	30 F F F F
LA	0 12	C 2 2 7 0	688348	5 2 2 2 3 2 3	C 2 2 2 2 8	52223 60000 6000	288250	5123 0	- 3 5 -	1	21	22222E	28283		50 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	1 1 1 1 1	5 5 5 5 6 F	200 22 20 20 20 20 20 20 20 20 20 20 20	3 4 5 6 3 7 7 7 7 3 7 7 7
IIC	15	01111			44440							0.00 0 d							9999 0 = 0 0
APE	1118	75 735 735 735 735 735 735 735 735 735 7	55 65 55 65 55 63	4 5 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	44446 194446	588858 598770		SUB33					N N N N T	6 - 4 - 6 - 1 6 - 4 - 6 - 1 6 - 4 - 6 - 1		2000		89 - 6 - 6 19 - 6 - 6 19 - 6 - 6	
OGR		755 755 1	6 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	44446	888888 88888							88884	44440		5 9 9 9 7 9 7 9 9 9 9 9 9 9 9 9 9 9 9 9		66 - 6 - 6 - 6 - 6 - 6 - 6 - 6 - 6	
CEC	100	75 75 73 73 73 73 73 73 73 73 73 73 73 73 73	60 60 60 60 60 60 60 60 60 60 60 60 60 6	4 5 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	4444	688888 6998 6998	58885 5987	Saga.					N N N N N	4 4 4 0		5 -63 - 65 - 65 - 65 - 65 - 65 - 65 - 65 - 65	73		
US 1	100	75 755 73	67 63 63 61 61	57 53 53 53 53 53 53 53 53 53 53 53 54 54 54 54 55 53	444 444 144 145 145 145 145 145 145 145	8 3 3 3 3 A	128883		1		5 -13 -15 -17 -17	-23	- 35 - 35 - 35 - 35 - 35 - 35 - 35 - 35	- 45 - 45 - 45 - 47 - 47 - 47 - 47 - 47 - 47 - 47 - 47	5 - 53 - 55 - 57 - 57 - 57 - 57 - 55 - 55 - 55	-63 -65 -67 -67 -69	-73 -75 -75 -75 -75 -75 -75 -75 -75		
RIO	36	77 75 73 73 71 69	67 65 63 61 61	57 55 53 51 49	45 43 41 39	33333	1988				-13	-231-231-231-231-231-231-231-231-231-231	- 33 - 35 - 35 - 35 - 35 - 35 - 35 - 35	-45 -45 -47 -47 -51	- 53 - 57 - 59 - 61	-63 -67 -69 -69 -71	-73 -77 -79 -79	- 84 - 84 - 87 - 87 - 87	-86 -84 -82 -82
VAF	06	77 75 73 71 71 69	67 65 63 63 63 63	57 55 53 53 49	47 45 43 41 39 39	33 33 31 31 31 29 29	25 23 219 19	11 13 13 13	でで 6 5 4 1	- 1193 - 1193	-13 -15 -17 -19 -19	-23 -25 -27 -29 -29	-33 -35 -35 -37 -37 -39	-43 -45 -45 -45 -47 -49 -49 -51	-63 -57 -58 -58 -58	-62 -66 -66 -68	-72 -74 -75 -75 -75 -78 -78	- 83 - 83 - 85 - 85 - 85	-85 -84 -82 -82
IIN	65	77 75 73 73 71 69	67 65 63 61 59	57 55 53 53 49	47 45 43 43 41 39	37 35 34 32 32 32 32	26 24 22 22 20 20	16 16 14 12 12 10	00400	- 2 - 4 - 6 - 10	-12 -14 -16 -16 -20	-22 -24 -26 -26 -28	-32 -34 -34 -36 -36 -36	-42 -44 -46 -46 -48	-52 -54 -56 -56 -58	-62 -64 -66 -66 -68	-72 -74 -75 -75 -77	-81 -82 -84 -85 -85	-84 -83 -82 -80
	80	77 75 73 73 71 89	67 65 64 62 62 60	56 56 54 52 50	46 44 42 40 40	38 38 38 37 38 37 38 37 38	28 24 28 28 28 20 20 20	18 14 12 12 10	00400	- 2 - 4 - 6 - 10 - 10	-12 -14 -16 -16 -20	-22 -24 -26 -30	-32 -34 -36 -36 -36	-42 -44 -46 -46 -48	-51 -53 -55 -57 -59	-61 -63 -65 -67 -69	-71 -75 -75 -77 -78	-80 -82 -83 -84	- 84 - 83 - 83 - 80 - 80
LAR!	75	77 75 73 73 71 71	66 66 64 82 60	58 56 54 52 50	46 44 42 40 40	38 36 37 38 38 38 38 38 38 38 38 38 38 38 38 38	28 24 23 23 23 23	19 17 15 13 13	で 3 5 4 6	1 1 1 1 1	-11 -13 -15 -17 -17	-23 -25 -25 -25 -25	-31 -35 -35 -35 -35 -33	-41 -43 -45 -47 -49	-53 -55 -57 -59	-61 -63 -64 -66 -68	-70 -72 -74 -76 -75	-79 -81 -82 -83	-83 -82 -81 -81
E E	20	77 75 74 74 72 70	66 66 64 62 62 60	58 57 55 53 53	49 45 45 43 41	39 35 33 33 33	29 25 23 23 23	19 17 15 13 13	P 3 5 3 6		-11 -13 -15 -17 -19	-21 -23 -24 -25 -26	-30 -32 -34 -36 -36	-40 -42 -44 -46 -46	- 560 - 54 - 56 - 56 - 56 - 56 - 56	-80 -54 -68 -68	-69 -71 -75 -75 -76	-78 -80 -81 -82	-82 -81 -81
E	65	77 75 74 72 72 72	68 67 65 63 63 61	59 55 53 53 53	49 45 45 43 41	39 36 35 35	30 26 24 22 22	20 16 14 12	10 10 10 10	00400	-10 -12 -14 -16 -16	-20 -22 -24 -26 -26	-30 -32 -34 -36 -36	-40 -42 -45 -45	-49 -51 -53 -55 -57	-59 -51 -63 -65 -67	-68 -70 -72 -74 -76	-77 -79 -80 -81 -81	-82 -81 -81
NO	60	77 76 74 72 72 72	69 67 65 63 63	60 58 54 52 52	50 48 44 42	40 38 38 34 32 32	30 28 24 22	20 17 15 13	11 9 3 3		- 9 -11 -13 -15	-19 -21 -23 -25 -25	-29 -31 -33 -35 -35	-39 -41 -43 -45 -45	-48 -50 -52 -54 -56	-58 -60 -64 -64	-68 -69 -71 -73 -73	-75 -78 -79 -80 -81	-81 -81 -80 -80
TS	55	77 76 74 74 73 73	69 66 64 62	60 55 56 54 50 54 50 50 50 50 50 50 50 50 50 50 50 50 50	51 49 45 45 43	41 33 35 33 33 33	31 29 25 25 23	21 19 17 15 13	11 3 3 3	~0049	8 10 12 14	100000	38 32 38	38 40 46 46	48 53 53 53 53	65 63 65 65	67 68 70 72 74	75 77 79 80 80	79 80 79 79
A	50	77 76 75 73 73	70 68 64 63	61 59 55 53	51 49 45 44	42 40 36 35 34	32 30 28 28 28	22 20 16 16	10 6 6 4	00040		13 - 13 - 13 - 13 - 13 - 13 - 13 - 13 -	27 - 231 - 35 -	37 - 41 - 45 -	447	1 1 1 1 1 1	66 - 67 - 69 - 71 - 73 -	74 - 77 77 77 78 77 79	- 980 980 79
Ĥ	45	78 75 74 72	70 69 65 63	61 60 58 58 54	52 50 46 44	42 40 33 35 35	33 31 29 25	23 21 17 15	113 9 5	8 H H 8	- 9 - 11 - 13 - 41	16 - 118 - 20 - 22 - 22 - 24 -	26	36 - 38 - 40 - 42 - 44 -	46	55	659 - 668 - 720 - 7	73 - 73 - 75 - 77 - 77 - 77 - 778 - 7	- 62 - 62 - 62
IO	40	718 77 75 75 74 73	71 69 66 66 64	62 60 53 55 55	53 51 49 45	43 41 39 35 35	32 32 26 26	24 22 20 16	114 112 10 10 10	40004	- 6 - 10 - 12 - 14 -	- 113 - 113	33	35 37 41 - 43	45 - 45 - 49 - 50 - 52 -	6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	65	72 - 778 - 775 - 776 - 77	- 85 - 79 - 79 - 79
DES	35	718 775 75 73	72 70 66 86 85	63 63 59 56 56	552 552 46 46	44 42 38 38	34 32 33 29 29	25 23 23 19	15 13 9 7	3 5 5 3 2	- 2	115 - 116 - 22 - 228 -	230 28	34 36 40 42 42	51 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	53 - 553 - 59 61	664	71 - 773 - 773 - 779 - 7	78 - 778 - 779 - 7
	30	78 77 76 75 75	72 71 69 66	64 60 58 58 58	55 53 51 49 47	45 43 43 39 39	33 33 33 33 33 33 33 33 33 33 33 33 33	26 22 22 20 20 18	16 12 10 10	64000	- 10 10 10	-14 - -16 - -17 - -19 -	23 - 23 - 23 - 23 - 23 - 23 - 23 - 23 -		43 - 43 - 45 - 45 - 100	2 4 9 9 9 9 9 9 9 9 9 9 9 9 9 9	60 60 60 60 60 60 60 60 60 60 60 60 60 6	70 - 72 - 73 - 73 - 75 - 75 - 75 - 75 - 75 - 75	77 - 78 - 97 - 79
AT	52	82 29 4	88 273 88 273	883 833 833 833	10 00 0 00 0 00 0 0 0 0 0 0 0 0 0 0 0 0	38 0 0 4 4 0 38 0 0 4 4 0	9 4 8 8 6	19133557	9 13 13	-	5 0 0 0 0	<u></u>	01 4 9 9 9 9 	0, 7 0 0 0 	N 4 0 0 0	1 1 1 1 1	11111	0 4 8 4 9	9 2 8 9
н U	50	78	22	S 4 8 8 8	10 10 10 10 10 10 10 10 10 10 10 10 10 1	39133 5 5	222222	89580	89420	009400	0 8 9 9 9 0 0 9 9 9 7 1	8,4,8,6,6,	28860	1 12 12 12 12 12 12 12 12 12 12 12 12 12	4 4 4 4 4	00400 111111	000000	000000	0 6 8 8
IL	15	0.00.00.00	71 22	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	C 99 4 8 0	8 8 4 8 0	88283	5 5 5 5 5	9 <u></u> 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	- 00 C - 00 - 1	9 - 1 - 1 9 - 1 - 1 9 - 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 4 9 0	00400	00400	0 1 10 0 C	0 1 0 4 9	8 0 1 0 4	1 - 2 - 7 - 7 - 7 - 7 - 7 - 7 - 7 - 7 - 7 - 7
CM	10	0 0 0 1 0	5 4 8 7 8	29420	133093	00000	868888	000040	0,0,0,4,0	0,00,04 0	004400	0.034.05	22222		00 11 10 10 10 1 1 1 1 1 1 2 2 2 2 2 4 4	00040 1111 40000	000000 111111	0000	5 -7 5 -7 8 -7
OMA	5	55582	735	52 6 6 6 53 6 6 6	0 0 0 4 0	08940	0.8.8.8.6	100000	397.98	10000	4 6 8 5 5	6 6 6 1 F 6 1 1 1 1 1	0.4 0.0 0	0.0000 1	80040 1111 04444	001100 1 1 1 1 1 1 1 1 1 00170	4 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	310000	4 - 7 - 7
U E E	H	00000	6 5 2 6 7	00040	0.00 - 0.00	10000	10000	00004	4 9 9 9 9 9	4 0 00 0 1	0.00.40	6 - 1 6 - 1 6 - 1 6 - 1	0 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5	1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1	0 - 0 - 0 0 - 1 - 0 0 - 4 - 1 - 0 0 - 1 - 0 0 - 1 - 0 0 - 0 0 0 - 0 0 0 - 0 0 0 0 - 0 0 0 0		00000 1111 • 0000		5 - 7 5 - 7 - 7 - 7 - 7 - 7
		to to to to to	to to to to to		ວທິທິທິທິ	10 4 4 4 4	4 0 10 10 10	000000	P P P 0 0				60000	000000	00444	44000	က်က်တွင်တွင်	1 1 0 8 8	2000

16	to be to to be		000,000						I I	I I I I I	- I I T T T					1111	11111	1.1.1.1.	
75	78 78 75 73 73	70 68 67 65 65	61 59 56 56 56	52 50 46 44	42 36 36 35	32 30 26 26 24	23 21 19 17 17	11 19 5 7	001-100 111	- 7 - 9 -11 -13 -15	-17 -19 -21 -23 -23	-27 -29 -31 -32 -32	-36 -38 -40 -42 -42	-46 -48 -50 -52 -52	-56 -58 -59 -61 -61	-65 -57 -69 -70 -72	-74 -75 -76 -76 -78 -79	-79 -80 -80 -79	
102	77 75 75 71	70 66 64 62	60 53 55 53 53	51 49 45 43	41 39 35 35 35	31 30 26 26 28	22 20 16 16 14	12 10 6 4	00 77 10 0 10	- 8 -10 -12 -14 -14	-16 -20 -22 -24 -26	-28 -31 -33 -35	-37 -39 -41 -43 -43	-47 -51 -53 -53	-57 -59 -60 -62	-66 -68 -70 -71 -73	-75 -76 -77 -78 -78	-80 -80 -79	
65]]	77 76 74 73 73	69 67 65 64 62	60 56 54 52 52	50 46 42 42	41 33 35 33 33	31 29 25 23 23	21 19 15 13	11 9 5 3		- 9 -11 -13 -15 -17	-19 -21 -22 -24	-30 -32 -36 -36	-38 -40 -42 -44	- 50 - 50 - 52 - 54 - 56	-58 -59 -61 -63 -65	-67 -69 -72 -72 -72	-78 -77 -78 -79 -79	-81 -80 -80	
60 1	77 78 74 72 70	69 65 63 61	59 55 54 52	50 46 46 42	40 38 37 37 37 37	30 26 28 28 28	20 16 14 12	01 8 8 4 8	00400	- 9 -11 -13 -15	-19 -23 -25	33 33 33	-41 -43 -45 -45	-49 -51 -55 -55	60.000	68 72 73 75	76 79 79 80 81	-81 -81 -81 -81	
55 1	77 75 72 72 70	66 64 63 81	59 55 53 51	49 45 43 41	33 33 33	25 25 23 23 23	19 16 14 12	0 8 8 4 8	0 0 4 6 6	-10 -12 -16	26-26-26-26	88 38 38 38 38 38	40 42 46 46 46 46	52.50	61 63 65 65	69 71 72 78 78	77 79 80 81 82	83 83	
50]1	77 75 73 72 72	66 66 62 62 60	56 54 52 52	49 45 45 41	33 33 33 33 33	522222	19 15 13 13	9 r 9 8 1	1 10 10 10 10	-11 -13 -15 -17	23 -25	- 31 - 35 - 39 - 39 -	41 - 45 - 46 - 46 - 46 - 46 - 46 - 46 - 46	58	664 664 664 664	70 72 73 75	- 78 - 80 - 81 - 81 - 83 - 83	82 82 81 80	
5 1	0 T 3 2 4	00400	00400	00400	88288	89480	0 5 4 6 0	0 0 4 0 0	0.4.6.000	11	<u></u>		1311	1 2 2 2 2 3	1		0 T 2 D 7	0 5 3 3	
0 14	6 7 7 7	0 - 3 0 0 0 0 - 3 0 0 0 0 0 0 0 0 0	6 0 4 0 0 0 0 0 0 0	44444	0,0,4,0,0	00400	6 9 4 N G	60 4 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2 4 9 6 2	0.4.0.00	22 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	5 4 9 9 9 9 1 4 1 4 1 9 9 9 9 9 9 9 9 9 9	0 4 9 8 0	5 4 5 C 5	10000	0 0 0 2 4 4 C 0 0 0 0 0	4 2 2 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	
5 14	01323	0 1 3 2 9 0 1 3 2 9	0 - 3 2 2 3 0 - 3 2 2 2	44444	60000 00000	00000	6.00.00	~ 5811	0 4 0 0 0 1 1 1 1 1	0.4.0.00 0.1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	048800	8 2 8 6 6	9 4 9 0 0 4 4 9 0 0	04000	8 4 9 9 0 1 1 1 1	0 4 0 0 0 1 1 1 1 1		0 0 0 0	
0 13	61111	0 1 3 0 2	0 - 0 0 - 0 0 - 0 0 0 0	4 4 4 4 M	0 - 0 0 - 0 0 - 0 0 0	1 10 10 10	6 0 0 1 0 1 1 1 1	1 1 3 5 4	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		89683	5969-	1 1 1 0 0 1 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	04000	0 4 0 0 0 1 1 1 1 1 0 0 0 0 0	5 - 8 - 9 - 9 - 9 - 9 - 9 - 9 - 9 - 9 - 9 - 9	
130	0 7 7 7 7	ດັບບໍ່ມີຜູ້	ទសសសល ៣	44440	N N N N N N	- 10 10 10 10		1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		0 0 0 0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		1 - 6 6	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 0 0 0 0 0 0 0 0 0 0 0	0 4 0 0	
125	52223		÷ សេសសំលី	44440	000000	88888 888						8000	8 0 0 0 J			0 3 3 3 3 3			
120	77 75 73 73 73 73 73 75 73 73 73 73 73 75 73 75 75 77 77 75 75 75 75 75 75 75 75 75		40 0 0 0 0	14 4 4 4 8 8 4 4 8 8 6 8 6	68888X	នេះ ដែល ជា		1	11111	17778 8	ងដុំសុំសុំសុំ		44440	ហ៊ី ហ៊ី ហ៊ី ហ៊ី ហ៊ី		6 7 7 7 7	8 8 8 8 8		
115	76 75 73 73 71 69	67 65 63 61 61 59	57 55 53 53 51 49	47 45 43 43 41 39	37 35 33 31 31 29	27 25 23 23 21 19	17 15 13 13 13 13	- 1 1 3 5 4	- 3 - 5 - 7 - 11	-13 -15 -17 -19 -21	-23 -25 -27 -29 -29	-33 -35 -37 -37 -39 -41	-43 -45 -47 -49 -49	-63 -55 -55 -59 -59	-63 -65 -67 -69 -69	-73 -75 -79 -79 -81	-83 -85 -85 -87 -89 -89 -88	-86 -84 -82 -82	
110	76 73 73 71	67 65 63 61 59 59	57 55 53 53 51 49	47 45 43 43 41 39	37 33 33 33 33	27 25 23 23 21 19	17 15 13 13 11 9	1 1 2 3 3 4	- 13 - 13 - 11	-13 -15 -17 -19 -21	-23 -25 -27 -27 -29 -23	-33 -35 -37 -39 -39	-43 -45 -49 -61	-53 -65 -59 -61	-63 -65 -67 -69 -69	-73 -75 -79 -79 -81	-83 -85 -87 -89 -89 -89	-86 -84 -83 -83	
legre 105	77 75 73 73 69	67 65 63 81 59	57 55 53 53 49	47 45 43 43 41 39	37 35 33 31 29	25 25 23 23 23 21 21	17 15 13 13 13	- 3 2 4	- 3 - 11	-13 -15 -17 -19 -21	-23 -25 -25 -29 -31	-33 -35 -37 -37 -41	-43 -45 -47 -49 -61	-53 -55 -57 -59	-63 -65 -67 -69 -71	-73 -75 -77 -79 -79	-83 -85 -87 -88 -88 -88	86 84 82 80 82	
1n 0	77 75 73 73 69	67 65 61 59	57 55 53 51 49	47 45 43 43 41 39	37 35 33 33 33 33 33 29	27 25 23 21 21	17 15 13 11 11	11384	- 13 - 19 - 11	-13 -15 -17 -19 -21	-23 -25 -25 -29 -31	33 33 33	-43 -45 -47 -49 -51	-53 -53 -57 -59 -59	-63 -65 -67 -69 -71	-73 -75 -79 -81	83 83 83 83 83	86 84 82 80 80 80	
ude 95	77 75 73 71 69	67 65 63 61 59 59	57 55 53 53 49	47 45 43 43 41 39	37 35 31 31 29	27 25 23 23 21 21	17 13 13 11		3 11 11	13	31 23 23	33 35 35 35 35 35 35 35 41	45 45 45 49 49 51	53 55 55 59 61	63 67 69 71	73 77 79 80	82 84 84 87 87	86 84 82 82 80	
ng1t 90	77 75 73 73 69	67 65 63 81 59	57 55 53 51 49	47 45 43 41 39	37 35 33 31 29	25 25 23 23 23	17 15 13 11		3 9 11	-13 - -15 - -17 - -19 - 21 -	- 23 - 27 - 25 - 29 - 31 -	- 33 - 35 - 37 - 39 - 41 -	43 - 45 - 47 - 49 - 51 -	63 - 57 - 58 - 58 - 60 -	- 62 - 84 - 66 - 66 - 66 - 70 - 70 - 70 - 70 - 70	- 72 - - 74 - - 75 - - 78 - - 80 -			
st lo 65	77 75 73 73 73 73	37 55 59 59	55 55 51 49	47 443 39	32 35 37 32 32 32 32 32 32 32 32 32 32 32 32 32	2 2 2 4 0 B	100420	00400	0.4 9 8 0	20 20 20 20	30862	40 3 4 3 3 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5	144 146 148 160	S 4 9 8 9	2004	75	832	88 83 80 80 80 80 80 80 80 80 80 80 80 80 80	
60 ea:	75 273 273 273 273 273 273 273 273 273 273	5855	20 4 4 0 0 20 4 4 0 20 5 4 6 0	4 4 4 4 4 8 9 4 5 0 4 0 4 0	338	0 0 4 0 0 0 0 4 0 0	18 116 112 10	00400	0.4 0.00	20112 2011 2011 2011	308675	2 8 8 8 8 9 9 7 1 1 1 1	0,4,0,00,0 1,1,1,1,1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1.1.1.1	, , , , , , , , , , , , , , , , , , ,	08 1 1 2 1 1 1 4 1 1 1 1 1 1 1 1 1	887 - 1 803 - 1 80 - 1	
55	72 25	862466	899400	0 0 7 0 0	8888888	8 8 8 8 8 8	113	- 3 C - 3 O	 ດ⊲ດທ⊨	1221	122555	222255 11111	11111	1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0.04.06		1 1 1	
ogra	1 2 4 8 0	8 8 7 8 8	8 6 2 2 2 1	55557	853855	85885 	1122	o < S S I	9 3 C 3 1	1 6 9 6 6	1 10 4 10 00	0 0 4 0 0	00400	0 0 4 0 0	0 0 4 0 5	0 1 0 0 0	8 2 7 9 9 7 9 9 9 9		
55 Ge	60400	86985	00000	0 C 0 0 4	0.00.40	009540	0.00.00.4.00	0.00.04 0	00400	0,0,4,0,0	00400	00400	00000	0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		00040	5 1 0 0 7 1 1 1 1 1	0 1 2 2 6	
0	C 10 4 00 -	00000 00000	0 0 0 0 4 0 0 0 0 0 0 0	00040	00040	000040	000000	1 0 C S S			0 1 10 10 1 1 1 1 10 1 1 1 1 10		9 - 1 D D C - 4 - 4 - 1 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2	6 0 0 4 9 1 1 1 1 1 4 0 0 0 0 0	0 0 0 4 0 1 1 1 1 1 0 0 0 0	8 - 0 - 0 3 - 1 - 1 - 1 - 0 5 - 1 - 1 - 1 - 1 - 0 5 - 1 - 1 - 1 - 1 - 0 5 - 1 - 1 - 1 - 1 - 0 5 - 1 - 1 - 1 - 1 - 0 5 - 1 - 1 - 1 - 1 - 0 5 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	1 - 8 - 7 - 7 - 8 - 7 - 7 - 8 - 9 - 9 - 7 - 7	9 9 9 9	
		 	ູ້	04444	4 0 0 0 0	00000		,	1 1 1 1	<u> </u>	00.00 m	0,00,000	04444	4 0 0 0 0		9966	C C C 0 0	60 60 60 1 1 1 1	
55	76 76 74 73 73 73 73 73 73 73 73 73 73 73 73 73	69 66 64 62	60 56 56 56 56 56 56 56 56 56 56 56 56 56	51 49 45 43	41 33 33 33 33	31 25 23 23	21 13 13 13	11 32 7 9 3	 0 0 4 0	- 8 -10 -12 -14 -14	-18 -20 -22 -24 -24	-28 -30 -32 -34 -34	-38 -40 -42 -42 -44	-50 -51 -51 -53 -53	-57 -59 -61 -63 -63	-67 -68 -70 -72 -72	-75 -77 -78 -78 -79 -79	-80 -80 -80 -79	
50	71 76 75 73 73	70 68 64 63	61 59 55 53	51 45 45	42 36 36 36 36	32 30 28 28 28	22 20 16 16	10004	00040	- 8 - 9 -11 -13	-17 -19 -21 -25	-27 -29 -31 -35	-37 -39 -41 -43 -45	-47 -49 -51 -52 -52	-56 -56 -50 -62 -64	-66 -67 -69 -71 -71	-74 -76 -77 -78 -78 -79	-80 -80 -80 -79	ev.
45	78 75 75 74 72	70 69 65 65 63	61 58 58 58 58	52 50 46 46	42 40 33 35 35	33 31 29 25 25	23 19 17	13 9 5	1 1 0 1 1 1 0 0	- 7 - 9 -11 -13 -14	-16 -18 -20 -22 -24	-26 -30 -32 -32	-36 -38 -40 -42 -44	-46 -48 -50 -51 -53	-55 -57 -59 -61	-65 -68 -68 -70	-73 -75 -77 -77 -78	-79 -79 -79	gati
40	78 77 75 75 75 75 75	71 69 68 66 66	62 60 58 57 55	53 51 49 47 45	43 41 39 35 35	32 32 38 28 28 28	24 22 20 20 16 16	14 12 10 10 8	40004	- 6 - 8 -10 -12 -12	-15 -17 -19 -21 -23	-25 -27 -31 -33	-35 -37 -39 -41	-45 -47 -49 -50 -52	-54 -56 -58 -60	-64 -65 -67 -69 -69	-72 -74 -75 -76 -77	-79 -79 -79	s ne
32	78 76 75 73	72 70 68 86 65	63 61 59 56 56	54 52 50 48 46	44 42 38 38 36	32 31 29 29	25 23 23 21 21 19	15 13 9 7	3 1 1 3 2 2 1 1	- 5 - 9 -13	-15 -16 -16 -20 -22	-24 -26 -30 -32	-34 -36 -38 -40	-44 -46 -48 -50 -51	-53 -55 -59 -59	-63 -64 -66 -68 -70	-71 -73 -74 -78	-78 -79 -79	tude
30	78 77 75 75 75	72 72 69 67 66	64 60 58 58 58	55 53 51 49 47	45 43 43 39 37 37	35 33 30 30 28	26 22 20 20 20 20 20 20 20 20 20 20 20 20	16 12 10 10 8	1 0 4 0 0 0	- 1 5 - 1 6 - 1 0 - 1 2	-14 -16 -17 -19 -19	-23 -23 -23 -23 -23 -23 -23 -23 -23 -23	-33 -35 -35 -37 -37	-43 -45 -47 -49 -49	80 80 80 80 80 80 80 80 80 80 80 80 80 8	-63 -65 -65	-70 -72 -73 -75 -75	-77 -78 -78	lati
52	78 78 76 75 76	73 70 68 66	65 63 61 59 57	555 57 50 50 50 50	46 446 420 38 38	33 33	27 25 23 23 21 19	17 135 113 11	FF302	3 9 11	13 16 16 20	3088	36 34 40 40	4 4 4 4 4 4 4 6 6 4 7 4 6 6 6 6	5925	666 666 666 666 666 666 666 666 666 66	69 773 75 75	76 77 78 78	uth.
50	78 77 75 75	74 712 712 69 67	65 64 62 60 58	55 53 51 49	47 45 41 39	37 33 31 30	226 224 228 228	10 11 10 10 10	004000 I	0 4 9 9 0 0 1 1 1 1	1 1 1 1 1 1 1	222 222 232 232	333	11111	0 0 4 9 6	1 T T T T 2 2 2 2 2 2	23.20	282	Soi
15	778 778 778	74 73 70 68	66 65 61 59 59	57 56 52 52	4 4 6 4 4 6 4 4 6 4 0 4 4 0 4 10 4 1	38 37 31 31 31 31 31 31 31 31 31 31 31 31 31	25 23 23 23	11 11 11	5 5 3 3	6 - 2 C F - 1	113	000490	88288		52 23 2 7		8 8 4 8 4	75 - 75	t1ve
10	979 979 76	75 74 712 89	666 52 52 52 52 52 52	133.56.69	130.440	868888	0 8 9 7 7 8	20 16 16 12 12	00040	0.014.000	1 1 1 1	01000	6 T E S S C	00 1 10 00	8 0 0 4 9	808889	20000	12 - 25 - 26 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	031
5	00000	85550	52 22 23 23 23 23 24 24 24 24 24 24 24 24 24 24 24 24 24	0 2 0 9 0 0	0 8 9 4 0	0.00.000	10000	10000	10000	4 6 8 7 7	6 1 1 1 1 1 1 1 1 1 1 1	0 0 0 4 0	00040	00040 1111 04444	001+00 000104	6 0 - 1 0 4 0 - 1 0 - 4 0 - 1 - 1 0 - 4	317796	4000	59
	50.00	1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	00040	0.00 - 0.00	10000	10000	00004	90004 1	10804	0.0014.00	6 + 1 - 1	0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 1 1 0 J	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		00000 1111 00000	91976 1176	5 - 7 5 - 7 9 - 7	I tud
				<u></u>	W 4 4 4	4 0 0 0 0	666666			1.1.1	1111	1995	8 8 8 8 8 8 1 1 1 1	00444	44000	0,0,0,0,0	9 9 9 7 7	2-2-	lat.
aph1	88 88 84 84 82 80	78 76 72 72	666 666 624 666 666 666 666 666 666 666	56 54 52 50 50 50 50 50 50 50 50 50 50 50 50 50	448 446 442 442	82 92 75 05 82 92 75 05	20 5 5 6 8 8 5 5 6 8 8 5 5 5 5 5 5 5 5 5 5	118 116 12 12	0.0400	004400	2 7 9 8 0	2 7 9 9 9	03 X 0 00 0	0,40,000	0.4980	N 7 9 9 0	04000	2 7 9 0	lorth
Geogr	* * * * *	+ + + + +	+++++	+ + + + +	+ + + + +	+++++	+ + + + +	+ + + + +	+ + + +					1 1 1 1					•

Ī	100	79 27 27 27 8	77 75 75 73 73 73	6 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	60 58 55 53	51 49 45 43	41 33 35 33	32 30 26 26 26	22 20 18 16	12 10 8 6 4	00040	- 8 -10 -12 -14 -16	-18 -19 -21 -23	+27 -29 -33 -35	-37 -39 -41 -43 -45
	55	0 0 0 0 0	78 75 74 72	70 69 63 63	61 55 56 56 56 56 56 56 56 56 56 56 56 56	4 4 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	42 40 38 38 34	32 33 25 25 25	23 23 19 17 15	13 11 11 7 7 7	00100	- 7 - 11 -13 -13	-17 -19 -23	-26 -30 -32	-36 -36 -40 -40 -44
	503	208 208 208 208 208 208 208	76 778	71 70 68 68 64	62 59 55 55	53 51 49 45	41 33 35 35 35	33 33 29 28 28 28	24 22 20 18 16	14 12 8 6	4 20 00 4	- 10 - 12 - 14	-16 -16 -20 -22	-26 -30 -31 -33	-35 -37 -39 -41 -43
	45 3	80 80 80 80 80	719 778 776	72 69 65	63 66 58 58 58	55 57 48 48	44 42 40 38 38 38	34 32 30 28 28	22 22 23 19 17	15 13 9 7	ດ ເກ ເຕ ເ	-13 -13	-15 -17 -19 -21 -23	-25 -27 -27 -27 -31 -33	-35 -37 -39 -41 -42
	10	81 81 81 81 81 81	80 79 76 75	73 72 68 68	64 62 58 58 57	55 53 51 49 47	45 43 41 39 37 37	33 33 33	25 23 23 19 17	15 13 11 8	1 0 4 0 0 0	- 4 - 6 - 8 -10 -12	-14 -16 -18 -20	-24 -26 -30 -32	-34 -36 -36 -38 -40
	8	83 82 82 82 82 82 82 82 82 82 82 82 82 82	81 80 77 76	74 72 71 69 67	65 63 61 59 53	55 54 52 50 48	46 42 48 38	38 34 30 30 28	26 24 28 28 28 18	16 14 10 10 10 8	0 4 0 O 0	- 4 - 6 - 10 -12	-14 -16 -18 -19 -21	-23 -27 -29 -29	-33 -35 -35 -37 -39 -39
	330 3	80 82 83 83 83	82 81 77 77	75 73 72 68	66 64 62 58 58	56 54 52 50 50 48	46 45 43 41 39	37 33 33 33 33 33 33 33 33 33 33 33 33 3	25 25 23 23 23 23	17 15 13 11 9	- 133		-13 -15 -17 -19 -19	-23 -25 -27 -29 -29	-33 -35 -37 -39 -41
	52	885 885 87 87 87 87 87 87 87 87 87 87 87 87 87	83 88 88 88 73 98 73 98	76 74 72 72 71	67 65 63 63 63	55 55 53 49	47 45 45 43 43 41 39	233333	27 25 23 23 23 23	17 15 13 11 10	00400	- 2 - 4 - 6 - 10	-12 -14 -16 -16 -18	-22 -24 -26 -28 -30	-32 -34 -36 -36 -36 -36
	203	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	*****	77 73 73 89	67 65 64 60 60	50 50 50 50 50 50	48 44 46 40 40 40 40 40 40 40 40 40 40 40 40 40	36 38 38	28 57 58 58 58 58 58 58	16 16 12 10	89400	0.4080	-12 -14 -16 -16 -18	-28-26-28	-32 -34 -36 -36 -38
	15 3	8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	85 84 83 83 79	78 76 74 72 70	68 66 62 60 62	50 50 50 50	48 46 42 422 40	33 32 32 32 32 32 32 32 32 32 32 32 32 3	28 28 28 28	18 16 14 12 10	809457	- 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	-11 -13 -15 -17 -19	-23	-31 -35 -35 -35 -37 -37
	310	80 84 85 85	88 83 28 88 88	78 76 77 72 71	69 67 65 63 63	59 55 53 53	4 9 47 45 43 43	33 33 33	25 25 23 23 23	19 17 15 13 13	9 C 9 B I	- 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	-11 -13 -13 -17 -19	-2] -23 -25 -25 -23	-31 -33 -35 -37 -39
	205	80 86 86 87	67 86 83 81	79 77 73 71	63 63 63 63	59 56 53 51	49 45 45 43 41	33 33 33 33	25 25 23 23 23	19 17 15 13 13	9 C S 8 L		-11 -13 -17 -19	-21 -23 -25 -27 -29	-31 -35 -37 -37
	300	80 84 88 88 88 88	88 83 83 83 83 83 83 83 83 83 83 83 83 8	79 77 75 73 73	69 65 65 81	59 55 53 53	49 45 45 45 41	39 35 33 33	29 25 23 23 23	19 17 13 13	5 5 5 5 7 10		-11 -13 -15 -17 -19	-21 -23 -25 -27 -29	-31 -33 -35 -37 -37
	35	80 84 88 88 88 88	83 83 81	779 776 776 773 773	63 69	59 57 53 63 51	\$ 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5 4 4 5	58833	23 23 23 23 23	19 17 15 15 113	5000	~ ~ ~ ~ ~	-11 -13 -15 -17 -17	53 53 53	33 33
	90 2	0 8 8 8 8 8 8 8 8 8 8 8 8 8 8	83 83 81	79 77 75 73 73	65 65 61	55 56 53 61	4 9 47 45 43 43	33 35 31 31	25 25 23 23 23	19 15 13 11	1 3 2 J	~ ~ ~ ~ ~ ~ ~	-11 -13 -15	83 52 53 53 52 53 53 53 53	3 4 3 3 3
legte	85 2	80 84 88 88 88	88 87 83 81	77 77 75 71 71	69 67 63 63 63	59 55 53 53	49 45 43 41	8 F 8 8 E	25 25 23 23 28	19 15 13 11	50001	- n n r o	-113 - -13 - -19 -	52 52 53 53 53 53 53 53 53 53 53 53	3 9 9 9 9
	28012	0 0 0 0	8.998	6 F 9 E E	61 25	65 8 8	45 43 41	****	22 23 23 23 53 53 25 53 53	19 17 13 13	ちちらら	6-10 GF	13	23 23 29 29 29	33.33
tude	275	80 84 85 85 85 85 85 85 85 85 85 85 85 85 85	68288	78 75 73 73	69 65 63 61	59 55 53 53	49 47 45 45 45 41	33 33 33 33 33 33	23 25 25 23 25 23 23 23 23	19 17 15 13 13	90004		-11 -15 -15	21 -23 -25 -25 -29 -29	33 -33
ong 1	012	80 84 85 85 85	86 85 82 80 80	78 76 74 72 72 72	68 68 68 68 68 68 68 68 68 68 68 68 68 6	58 55 53 53	49 47 45 45 43 43	39 35 35 33 33	29 25 25 23 23	19 17 15 13 13	9 2 9 9 1	10000	-13	-23 -23 -23 -23 -23 -23	-33
ist.	593	6 6 8 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	388858	728	6 6 6 6 6 6 7 4 6 6 8	566 566 50 50	844404	38.23.28	22 28	16 14 12 10	000400	108648	12 14 16 16 18	308854	***
5	560 2	80 83 83 83	64 83 82 80 78	77 75 73 73 89	67 65 63 61 59	57 55 63 51 50	46 46 46 40 40 40 40 40	38 34 38	28 28	18 16 14 12 10	00400	10 20 4 10	12 14 16 16 18	22 24 26 30 30	334 - 338 - 349 - 3
doar	255	80 81 82 83 83	83 81 79 77	76 74 72 88	66 64 63 61 59	57 55 53 51 49	45 45 41 39 39	33 33 29 29	23 23 23 23 23	17 15 13 13	63 63	5	-13 -17 -19 -21	23 28 28 28 28 28 28 28 28	32 34 36 36 40 40
Geog	250	80 81 82 82 82 82	82 81 78 76	75 73 69 67	66 64 50 58 58 58 58	56 58 58 48 60 48	46 42 40 38 38	38 34 38 38 38 38 38 38 38	26 23 23 23 23 23 23	17 15 13 11	1 1 2 2 2 2		-13 -15 -17 -19 -21	23 25 27 29 29 31	33 33 33 33 33 33 33 33 33 33 33 33 33
	245	80 82 82 82 82 82 82 82	81 80 79 76 76	72 72 70 68 67	65 63 69 69 57	55 53 51 49 47	45 43 42 40 38 38	38 32 38 28 28	26 22 22 22 20 20 20	12 12 13 13 13 14 15 15 15 15 15 15 15 15 15 15 15 15 15	64000	4 	-14 -16 -18 -22	24 26 30 30 30	34 - 36 - 38 - 38 - 38 - 38 - 38 - 38 - 38
	240	8999	36 37 36 35 35	22 66 66 66	2 8 8 8 8 8 2 8 8 8 8 8	52 52 47 47	84 14 55 FE	****	22225	11 13 13 13 13	010111101 11	-111	-13	26.28	34 334 34
-	83	79 80 80 80	79 778 778 778 775 775	72 70 69 65 65	63 63 55 55	53 53 50 46 46	445 46 36 36 36	****	24 22 22 22 20 20 20 20 20 16	14 12 10 10 10 8 8	40010	5 9 11 13	23 23	33 33 33 33	86848
	230	20 20 20 20 20 20 20 20 20 20 20 20 20 2	78 77 76 76 74	71 69 68 68	58 56 54 54	52 51 49 45	43 39 35 35	52 53	23 21 19 15	13 9 8 8	40004	6 10 14	116 - 116 - 22 - 120 - 1	32 32 8 34 1 1 1	36 - 36 - 36 - 40 - 42 - 42 - 440 - 4
	225	79 79 79 79	77 76 75 73 72	20 88 83 83 83 83	61 55 55 53	51 50 46 44	3 8 8 8 8	28 28 28	22 20 16 16	13 9 5 5	∾⊣~₽°		- 13 - 13 - 13 - 13 - 13 - 13 - 13 - 13	233	37 - 38 - 42 - 42 -
	220	79 79 78	78 75 74 72 72 72	65 65 62 65	58 58 58 58	50 49 45 43	33 33 34	31 29 25 23	21 19 15 15	12 10 8 8 4	00000	8 10 12 16	18 22 24 26	- 58 - 32 - 32 - 35 - 35	37 - 39 - 41 - 43 - 45 - 45 - 45 - 45 - 45 - 45 - 45
	215	79 79 78 77	76 74 73 73 71 71	68 64 63 61	59 55 53 53 53	50 50 50 50 50 50 50 50 50 50 50 50 50 5	36 36 37 37 37 37 37 37 37 37 37 37 37 37 37	28 28 28	20 16 15 13	10 C O E	30322	11 13 13	-19 23 25 25 25	29 31 32 36	- 40 - 42 - 44 - 44
1	210	79 77 77 76	75 73 72 70 69	65 63 62 63	5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	40 40 40 40 40 40 40 40 40 40 40 40 40 4	33 33 33	22 23 23 23	119 119 119	0 8 8 4 8	00400	-10 -12 -14 -16	-26 -26 -26 -26 -26 -26	33 33	-39 -41 -45 -45
	205	78 78 78	74 73 73 68 68	66 62 63 59 59	57 65 53 53 49	46 46 42 42 42 40	36 37 38	20 24 26 28	16 15 13 13	0000 m	~ 5 5 6 6	113	38858	38 4 33	0 0 4 9 9 4
	200	78 77 76 75	73 72 69 67	60 60 58 60 58 58 58 58 58 58 58 58 58 58 58 58 58	56 52 52 50 50	47 45 43 43 41 39	37 35 33 33 29	25 23 21 21	15 15 12 10	89400	10 8 4 8	1 4 6 6 0 3 7 4 6 6 6 0 3 1 1 1 1 1 1 1 1	222 230 30	33 33 33 33 33 33 33 1	447 447 454 454 454 454 454 454 454 454
	Set	78 77 76 75 75	73 71 69 68 66	84 62 59 67	56 51 49 48	44 44 38 38	33 34 38 38 38	26 22 22 28 18	16 14 13 13	- 5 B L L	11 4 2 6 4	113 - 115 - 117 - 21 - 21 -	23 - 25 - 27 - 31 -	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	444444 01440000
	190	78 76 76 75 75	72 70 69 65	63 60 58 58 58	534 52 50 47	46 41 33 37 37	33 33 33	25 23 23 23	15 14 12 10 8	0 4 N O N		14 - 16 - 20 - 22 -	1	333 - 355 - 379 - 41 -	442
	185	78 77 76 78 78 73	71 70 68 66 64	63 61 59 57 56	53 50 46 46	44 46 36 38 38 38	32 33 34 30 33 26 28	24 22 16 16	11 11 11 29	00100		- 115 - 117 - 21 - 22 - 221 - 23	25 - 23 - 23 - 23 23 - 23	34 - 36 - 42 - 42 -	44 - 46 - 50
	180	78 78	2 6 6 9 2 8	60 56 56 56 56 56 56 56 56 56 56 56 56 56	52 51 49 45 45	43 39 35 35	33 33 23	23 21 19 18 18	110 100 00 00	40004	6 10 14	16 -16 -22 -22 -22	33 33 38	335 37 41 43	45 47 49 51 51
	10												11111	11111	
	Latitud	+ 86 + 86 + 84 + 84 + 82 + 80	+78 +74 +72 +72	+68 +66 +64 +64 +62	+68 +56 +64 +52 +52	+46 +46 +44 +42	+36 +36 +36 +32	+28 +28 +24 +22 +22	+18 +16 +14 +12 +12	++++ 00040		-12 -14 -16 -18	-22 -24 -26 -30	-32 -34 -36 -36 -40	
	100														

negativ lati south pos1 ×No

-49 -51 -52 -54

-46 -50 -52 -52

-45 -47 -49 -51 -51

-44 -46 -48 -50 -50 -52

-44 -46 -46 -78 -50 -50

-43 -45 -47 -49 -49

-43 -45 -47 -49 -49

-42 -44 -48 -48 -48

-42 -44 -46 -48 -48

-41 -43 -45 -45 -47 -49

-41 -43 -45 -47 -49

-41 -43 -45 -47 -49

-43 -43 -45 -47 -47

-41 -43 -45 -47 -49

-41 -43 -45 -45 -47 -49

-41 -43 -45 -47 -49

-41 -45 -45 -47

-41 -45 -45 -45 -49

-43 -45 -45 -49

-46-46-50

-42 -46 -46 -48 -50

-43 -45 -47 -49 -51

-45 -45 -47 -47 -47 -47 -51

-44 -46 -46 -50 -52

-45 -47 -49 -51 -51

-45 -47 -49 -51 -51

-46 -48 -50 -52 -52

-47 -49 -51 -53 -53

-51 -53 -55 -56

-52 -54 -55 -55

-51 -53 -55 -56 -56

-52 -54 -55 -57 -57

-53 -55 -56 -58 -58

54 55 57 57 59 59

-55 -57 -58 -60 -62

-50

-51

52

-50

-56 -58 -60 -62 -62

-56 -59 -59 -61 -61

-55 -57 -59 -60 -60

-54 -56 -58 -58 -58

-54 -55 -57 -69 -69

-53 -65 -57 -59 -61

-52 -54 -56 -56 -58 -58

-52 -54 -56 -57 -57

-51 -53 -56 -57 -69

-51 -55 -57 -69

-51 -53 -55 -57 -59

-51 -53 -55 -57 -69

-51 -53 -55 -57 -57

-51 -53 -55 -57 -57

-51 -53 -55 -55

-51 -53 -55 -55

-51 -53 -55 -57

-51 -53 -55 -55

-53-55

-52 -54 -66 -58 -58

-52 -54 -66 -58 -58

-53 -55 -57 -58 -58

-53 -55 -57 -59 -61

-54 -56 -58 -58 -60

-54 -56 -58 -58 -58 -60 -60

-55 -57 -59 -61 -61

-56 -58 -60 -61

-57 -58 -60 -62

-58 -60 -62 -64

-59 -63 -66

-80 -62 -64 -65 -65

-81 -63 -65 -66 -68

-62 -64 -65 -67 -67

-63 65 68 68 -70

-64 -68 -68 -69 -71

-52 -54 -56 -56 -56 -60 -60 -60 -60 -72 -72 -72 -72 -73 -73 -78 -60 -88 -70 -88 -88 -88 -88

48 55 54 55 56 56 61 65 65 65

-65 -67 -67 -69 -71 -72 -72 -75 -75 -75

-65 -67 -68 -70 -72 -64 -66 -68 -70 -70

-84 -65 -67 -69 -69

-63 -65 -67 -69 -69

-63 -64 -66 -68 -70

-68 -68 -66 -66 -66

-64 -64 -68 -68 -68

-61 -65 -65 -65

-61 -65 -65 -67 -69

-61 -63 -65 -67 -69

-61 -63 -65 -67 -69

-61 -63 -65 -67 -69

-81 -63 -65 -67 -67

-61 -63 -65 -65 -69

-61 -65 -65 -67 -69

-61 -65 -65 -67 -69

-61 -63 -65 -65 -65

-61 -63 -65 -67 -69

-61 -65 -65 -67 -67

-62 -64 -65 -67 -67

-62 -64 -66 -68 -70

-63 -67 -68 -68 -68

-63 -67 -67 -69 -71

-64 -66 -68 -68 -69 -71

-64 -66 -66 -70 -71

-65 -67 -69 -70 -72

-66 -69 -71 -73

66 68 72 72 72

-67 -69 -71 -71 -72

-68 -70 -71 -73

-69 -71 -72 -74 -75 -70 -71 -73 -74 -74

-71 -72 -74 -75 -75

72 73 75

-73 -74 -75 -75 -75

-62 -64 -66 -68 -70 -72 -75 -75

-73 -75 -76 -76

-73 -75 -76 -77

73 -73

-72 -74 -76 -77

-72 -74 -75

-73 -73 -75

-71 -73 -75

-71 -73 -75

-71 -73 -75 -77

73

-73

-73 -73

-71 -73 -75 -75

-71 -73 -75 -76

73 -73

73 73

-73 -73

-71 -73 -75

-71 -73 -75

-72 -74 -75

-72 -74 -76

-73 -74 -76

-73

-74 -75 -76 -76 -74 -75 -77 -78

-75 76 77 78

-75 -76 -77 -78

-76 -77 -78 -78

-76 -77 -78 -78

-79 -79 -79

62-67-67-

- 20 -

SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH LESS THAN OR EQUAL TO 4000 KM

 From
 To
 Distance
 km
 Predicted for
 19

Geomagnetic latitude for path midpoint

One-half gyrofrequency ($f_{\rm H}/2$) for path midpoint _____

Note:	All	frequencies	are	in	Megacycles
-------	-----	-------------	-----	----	------------

Procedure	Scale	Scale	Compute	Compute	Scale	Scale	Compute	Compute	Compute	Scale - use Fig.	Compute
	f(50)	b _f	(R-50)	f(R) = a + bc	M(50)	Ъ _М	M(R) = e + cf	median F2-4000- MUF(R) = dg	median F2-zero- MUF(R) = d + f _H /2	median F2-MUF for path	F2-FOT for path = 0.85j
GMT	a	Ъ	с	d	е	f	g	h	i	j	k
00											·
02		0									
04											
06											
08											
10											
12	1										
14											
16											
18											
20											
22											
Done by											
Checked											

FIGURE 7

- 22 -

SOLUTION OF F2-LAYER TRANSMISSION PROBLEM FOR A PATH GREATER THAN 4000 KM

 From
 To
 Distance
 km
 Predicted for
 19

Geomagnetic latitude for control point A _____ and control point B _____

				Control	Point A				Control Point B								
Procedure	Scale	Scale	Compute	Compute	Scale	Scale	Compute	Compute	Scale	Scale	Compute	Scale	Scale	Compute	Compute	Lower of h and o	Compute
	f(50)	b _f	(R-50)	f(R) = a + bc	M(50)	Ъ _М	M(R) = e + cf	median F2-4000- MUF(R) = dg	f(50)	b _f	f(R) = 1 + cj	M(50)	ъ _М	$M(R) = \ell + cm$	median F2-4000- MUF(R) = kn	median F2-MUF for path	F2-FOT for path = 0.85p
GMT	a	b	с	d	е	f	g	h	i	j	k	l	m	n	0	P	q
00																	
02																	
04																	
06																	
08																	
10																	
12																	
14												<u> </u>					
16																	
18												<u> </u>					
20																	
22																	
Done by																	
checked																	

Note: All frequencies are in Megacycles

VI. WORLD PREDICTION MAPS AND PREDICTION CHARTS





P. 24





P. 26



P. 27



f₀F2 AT RASSN 50 FEBRUARY 1000 HOURS GMT



90°
























LONGITUDE

-

















LONGITUDE























LOCAL TIME














UVE

























SLOPE OF REGRESSION LINE OF foF2 ON RASSN





































LOCAL TIME











LONGITUDE
















SLOPE OF REGRESSION LINE OF foF2 ON RASSN





SLOPE OF REGRESSION LINE OF foF2 ON RASSN

















SLOPE OF REGRESSION LINE OF foF2 ON RASSN



























SLOPE OF REGRESSION LINE OF M-4000 FACTOR ON RASSN



LOCAL TIME


























































LONGITUDE



M-4000 FACTOR AT RASSN 50 AUGUST 1200 HOURS GMT 90° -32 - 3.2 ____3.2 60° NOR TH 3.3 3.3 3.4 3.4 3.5 30° 3.6 -3.2 3.0 32 3.3 --- 3.1 . -2.8 3.0 2,9 LATITUDE 3.4 2.6. 2.7 0° 3.4 3.0 3.5 -3.2 3.6 - 3.4 3.0 3.3 3.5 3.5 ☐ 30° 3.5 3.6 SOUTH 3.6 3.4 3.2 3.7 3.6 3.3 -3.1 3.8 60° _____90° 180° EAST į WEST 0° 120° 120° 60° 60[•] WEST | EAST LONGITUDE











P 170

SLOPE OF REGRESSION LINE OF M-4000 FACTOR ON RASSN



LOCAL TIME



foF2 AT RASSN 50 October 0200 hours GMT



foF2 AT RASSN 50 OCTOBER 0400 HOURS GMT


foF2 AT RASSN 50 October 0600 Hours GMT







foF2 AT RASSN 50 OCTOBER 1000 HOURS GMT foF2 AT RASSN 50 OCTOBER 1200 HOURS GNT



foF2 AT RASSN 50 OCTOBER 1400 HOURS GNT



foF2 AT RASSN 50 OCTOBER 1600 HOURS GMT









foF2 AT RASSN 50 OCTOBER 2200 HOURS GMT



SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 0000 HOURS GNT



SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 0200 HOURS GMT



SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 0400 HOURS GNT

OCTOBER 0600 HOURS GMT 90° .030 .040 ____ 60° .020 N OR TH -.020 .040 .020 .030 .040 -. 030 -30° .030 .040___ -.050_ .060 .050-LATITUDE -.040 .030 0° -.020 -.020 .030 -.030 __ -.030 --.040-.040 .050 30° .030 SOUTH .030_ 60° .020 .020 _____90° 60[•] 120° 60° 180° 120° 0° EAST | WEST WEST | EAST

SLOPE OF REGRESSION LINE OF foF2 ON RASSN

P. 187

LONGITUDE



SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 1000 HOURS GMT





SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 1200 HOURS GMT

SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 1400 HOURS GNT





SLOPE OF REGRESSION LINE OF foF2 ON RASSN OCTOBER 1600 HOURS GMT

SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 1800 HOURS GMT





SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 2000 HOURS GMT

SLOPE OF REGRESSION LINE OF fof2 ON RASSN OCTOBER 2200 HOURS GMT





M - 4000 FACTOR AT RASSN 50 October 0200 Hours GNT





M - 4000 FACTOR AT RASSN 50 October 0600 Hours GMT





M - 4000 FACTOR AT RASSN 50 OCTOBER 1000 HOURS GMT





M - 4000 FACTOR AT RASSN 50 OCTOBER 1400 HOURS GMT







M - 4000 FACTOR AT RASSN 50 OCTOBER 1800 HOURS GMT







OCTOBER 90° T I -60° --.0030 ---.0040--.0030 -.0040 -. 00 50 -(-) - -.0020 30° -.0020 -.0030 -(+) -.0040 **(+)** -.0050 -0030 GEOMAGNETIC LATITUDE -.0060 -.0030 . -0070--.0050 -0030 0° - -.0020 (+) -.0030 .0050 (-) -.0040 -.0020-(+) -.0030 -.0020 -0030 (+) -.0020 <u>-.</u> 30° - -.0030 -(-) -0040 -.0030 --.0040 -.0030 (+) 60° 00 02 04 06 80

SLOPE OF REGRESSION LINE OF M-4000 FACTOR ON RASSN

LOCAL TIME

12

14

16

18

20

22

1 90°

00

10

foF2 AT RASSN 50 NOVEMBER 0000 HOURS GMT




foF2 AT RASSN 50 NOVEMBER 0400 HOURS GMT





foF2 AT RASSN 50 NOVEMBER 0600 HOURS GMT foF2 AT RASSN 50 NOVEMBER 0800 HOURS GMT





foF2 AT RASSN 50 NOVEMBER 1200 HOURS GMT



.



foF2 AT RASSN 50

90° 4.0 5.0 60° 6.0 3.0 7.0 NORTH 3.5 8.0 ____9.0_ -4.0_ 3.5 30° 5.0 9.0 6.0 10.0 -9.0 -10.0 7.0 8.0 5.0/ LATITUDE 4.0 6.0 / -11.0 -12.0 11.0 9.0~ -10.0-0° 40.0 6.11 11.0 -10.0-9.0 - 8.0 --7.0 --6.0 30° 12.0 5.0 -10.0 SOUTH 4.0 9.0 4.5 - 8.0 5.0 70 60° 5.0_ 60°90° 180° EAST į WEST 120° 120° 60° 60° 0° WEST | EAST LONGITUDE

foF2 AT RASSN 50 NOVEMBER 1600 HOURS GMT

foF2 AT RASSN 50 NOVEMBER 1800 HOURS GMT



foF2 AT RASSN 50 NOVEMBER 2000 HOURS GMT



P. 220 NOVEMBER 2200 HOURS GMT 90° 4.0 3.0 4.0 60° 3.5/ 5.0 4.0 NORTH -3.5-C4.0 3.5 6.0 5.0 3.0 30° 7.0 -11.0 --8.0 4.0~ 12.0 9.0 -8.0 9.0 10.0 -10.0 -LATITUDE 13.0 8.0 . 7.0 0° - 12.0 6.0 5.0 9.0 <10.0 -12.0--11.0 10.0 9.0 10.0. 30° 9.0 4.0 8.0 4.0 SOUTH 8.0. 7.0 7.0~) _3.0 6.0 3.0 60° 5.0 6.0 4.5 5.5 4.5 5.0 90° 180° EAST i WEST 60 ° 60° 120° 120° 0° WEST | EAST LONGITUDE

foF2 AT RASSN 50

I



SLOPE OF REGRESSION LINE OF fof2 ON RASSN



SLOPE OF REGRESSION LINE OF foF2 ON RASSN NOVEMBER 0200 HOURS GNT



SLOPE OF REGRESSION LINE OF foF2 ON RASSN 0600 HOURS GMT NOVEMBER 90° -.020 ' 030 .015 -.020_ 60° .030 .015 050 .020 N OR TH 010. .020 .040 -.040 -.010 30° -050 -.060 .010 .020-.040 .030 LATITUDE -.025 .030 .025 0° .020. .025 .030 .030 .040 30° .025 SOUTH .020 60° .015 .020 .015 _____90° 60° 120° 180° EAST į WEST 120° 60° 0° WEST | EAST LONGITUDE

SLOPE OF REGRESSION LINE OF fof2 ON RASSN NOVEMBER 0800 HOURS GMT











SLOPE OF REGRESSION LINE OF fof2 ON RASSN NOVEMBER 1600 HOURS GMT







SLOPE OF REGRESSION LINE OF foF2 ON RASSN



M-4000 FACTOR AT RASSN 50





.



M - 4000 Factor at rassn 50



M-4000 FACTOR AT RASSN 50





M — 4000 FACTOR AT RASSN 50 NOVEMBER 1200 HOURS GMT



M = 4000 Factor at rassn 50



LONGITUDE

90° 33 3.2 3. 2 3.2 3.3 3.3~ 3.4 3.1 3.1 60° 3.5 3.0 NORTH 3.4 3.6 3.7) (3.1) 3.5 30° 3.2 3.3 3.5 -3.3 3.4 3.5 3.1 3.3 3.2 2.8 0° 3.1 3.2 2.9 2.8 2.7-3.0 -2.6, 2.9 -- 3.2 3.1--3.2 3.4 3.1 30° 3.3 3.1 3.0 3.3 3.1 SOUTH 3.1 ,3.2 3.1 60° _____90° 60° 120° 180° East i West 120° 60° 0° WEST | EAST LONGITUDE

LATITUDE

M - 4000 FACTOR AT RASSN 50 NOVEMBER 1800 HOURS GMT

.P. 242



M - 4000 FACTOR AT RASSN 50 NOVEMBER 2000 HOURS GMT



LONGITUDE

•



LOCAL TIME
F derick H. Mueller, Secretary

NATIONAL BUREAU OF STANDARDS A. V. A tin, Director



THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and s ctions engage1 in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colormetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetic . Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS, N-Ray, Radioactivity, Radiation Theory, High Energy Radiation, Radiological Equipment, Nucleonic Instrumentation, Neutron Physics.

CHEMISTRY, Surface Chemistry, Organic Chemistry, Analytical Chemistry, Inorganic Chemistry, Electrodeposition, Molecular Structure and Properties of Gases. Physical Chemistry, Thermochemistry, Spectrochemistry, Pure Substances.

MECHANICS, Sound, Pre-nre and Vacuum, Fluid Mechanics, Engineering Mechanics, Combustion Controls, ORGANIC AND FIBROUS MATERIALS, Rubber, Textiles, Paper, Leather, Testing and Specifications, Polymer Structure, Plastics, Dental Research,

MF.TALLURGY. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion, Metal Physics. MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metall. Constitution and Micro tructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical System. Organic Building Materials. Code. and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physic .

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. C-yogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Iononhere Renanch. Prediction Sonvent. Sum-Earth Relation hips. Field Engineering. Rendo Warning Services. RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Meaunic ment., Tropospheric Analysis. Proprigation-Terrain Elects. Radio-Meteonolity. Lower Atmospheric Physics. RADIO STANDARDS. High frequency Electrical Stanlard. Radio Broadcast Service. Radio and Microwave Meterial. Atomic Frequency and Time Standard., Electronic Calibration Center. Millingter-Wave Research. Ministrumentation.

RADIO SYSTEMS. High Liquincy and Very High Frequency Research. Modulation Research. Antenna Research. Nav. ation System. Space Telecommunications.

CPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Ex., c.c. Scatt r. Ai rlow and Aurora. Dno pheric Radio Astronomy.

