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EVAPORATION DUCT EFFECTS ON MAXIMUM INTERCEPT RANGE FOR 18- AND--ETC(U)
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Technical Report 582

EVAPORATION DUCT EFFECTS ON MAXIMUM INTERCEPT RANGE FOR 18- AND 37.5-GHz EMITTERS

A Theoretical Analysis of Expected Frequency Distributions of Intercept Range for Five Oceanic Areas

HV Hitney

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The effect of the evaporation duct on maximum intercept range of 18- and 37.5-GHz emitters is modeled. Results show that ranges for high-power emitters or high-sensitivity receiver systems are greatly affected, while ranges for low-power emitters are not. Optimum shipboard receiver heights are determined for each frequency. Comparisons of some modeled results to observed data are included.

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OBJECTIVE

Investigate the influence of the evaporation duct on maximum intercept range for 18- and 37.5-GHz emitters. Determine optimum receiver antenna height for shipboard installations.

RESULTS

The study revealed:

1. Maximum intercept range for a low-power emitter is not affected by ducting.

2. Maximum intercept range for a high-power emitter is greatly affected by ducting.

3. Higher sensitivity receiver systems will experience much greater effects from ducting than lower sensitivity systems.

4. Best over-all shipboard receiver antenna height for the 18-GHz systems would be the highest height, independent of system sensitivity.

5. Best over-all shipboard receiver antenna height for the 37.5-GHz systems would be the highest height, except for the highest sensitivity system studied, where the middle antenna height (22 m) would be preferred.

RECOMMENDATIONS

1. Perform an experiment to validate the evaporation duct effects on maximum intercept range predicted by this study.

2. Expand this modeling study to account for variable wind speeds for at least one receiver system for one geometry.

CONTENTS

BACKGROUND

The evaporation duct is a propagation mechanism created by the rapid decrease of moisture in the first few tens of meters above the ocean surface that can result in greatly enhanced propagation at frequencies generally above 3 GHz. References 1 and 2 contain descriptions of this propagation mechanism. Reference 3 describes the results of an extensive experimental program that conclusively shows the evaporation duct to be a dominant mechanism for surface-to-surface over-the-horizon paths at a range of 19 nautical miles. The best measure of the strength of the evaporation duct is the parameter evaporation duct height, which is defined in references 1 and 2. Evaporation duct height can be calculated from the common meteorological measurements of sea temperature, air temperature, relative humidity, and wind speed; and frequency distributions of occurrence of duct heights have been calculated for several geographic ocean areas. Evaporation duct heights normally vary between zero and thirty meters, although higher heights in some areas are not uncommon. Recent advances in modeling of propagation in ducting environments, described in reference 4, allow computer-generated propagation calculations to be made rather easily for a variety of evaporation

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[1]Hitney, H.V. and R. A. Paulus, Integrated Refractive Effects Prediction System (IREPS), Interim User's Manual, NOSC TD 238, March 1979.

[2]Hitney, H.V., Propagation Modeling in the Evaporation Duct, NELC TR 1947, 1 April 1975.

[3]Richter, J.H. and H.V. Hitney, The Effect of the Evaporation Duct on Microwave Propagation, NELC TR 1949, 17 April 1975.

[4]Pappert, R.A. and C.L. Goodhart, Electromagnetic Propagation in Horizontally Stratified Tropospheric Ducting Environments, NOSC TN 510, 1 August 1978.

duct height conditions. These calculations can readily be applied to the receiver intercept problem for most emitters and receivers in a manner similar to that used in preparation of reference 5. The same techniques can readily be expanded to higher frequency emitters at 18 and 37.5 GHz.

OBJECTIVES

The objectives of this project are to investigate the influence of the evaporation duct on receiver intercept range and to determine the height of a shipboard receiver antenna to best utilize the effect of the evaporation duct. The frequencies of concern are 18 and 37.5 GHz and two emitters are assumed, one at high power (100 kW) located 10 m above the ocean surface, and one at low power (10 W) located 50 m above the ocean surface.

APPROACH

The approach used in this study was to modify the NOSC-developed computer code described in reference 4 to account for gaseous absorption and to plot path loss (dB ratio of transmitted-to-received power) versus range for each ducting condition considered in a form such that maximum intercept range could easily be determined for each emitter/receiver configuration considered. Table 1 lists the frequency, height, radiated power, and antenna gains for the four emitters that were assumed for the study. Table 2 details the twelve difference receiver configura-

[5] Available to qualified requesters.

Emitter	Freq (GHz)	Height (m)	Power (kW)	Ant Gain (dBi)
A	18.0	10	100	40
B	18.0	50	.01	38
C	37.5	10	100	40
D	37.5	50	.01	38

Table 1. Emitters assumed in this study showing their frequency, height above sea level, radiated power, and antenna gain.

Receiver Configuration	Ant. Height (m)	Ant. Gain (dBi)	Sensitivity (dBm)
1	15	0	-60
2	22	0	-60
3	30	0	-60
4	15	15	-60
5	22	15	-60
6	30	15	-60
7	15	0	-40
8	22	0	-40
9	30	0	-40
10	15	15	-40
11	22	15	-40
12	30	15	-40

Table 2. Receiver configurations assumed in this study showing their antenna heights above sea level, antenna gains, and sensitivities.

tions assumed in this study which are combinations of three receiver antenna heights of 15, 22, and 30 meters, antenna gains of 0 and 15 dBi, and sensitivities (excluding antenna gains) of -60 and -40 dBm. Since there are 4 emitters and 12 receiver configurations, a total of 48 emitter-receiver combinations have been considered. The path loss threshold for each of the 48 cases can be easily calculated by adding the emitter's radiated power in dBm to the total of the two antenna gains (both emitter and receiver) and subtracting the sensitivity. The resulting thresholds are listed in table 3 for all 48 cases.

Once the path-loss-versus-range plots had been generated for all the evaporation duct heights considered, curves relating maximum intercept range versus duct height were constructed. These curves were then used in conjunction with duct height frequency distributions from the five ocean areas circled in figure 1 to generate accumulated frequency distributions of maximum intercept range for each of the emitter/receiver combinations for each of the five ocean areas. It is this final set of distribution curves from which most of the conclusions of this study are drawn.

The effects on propagation and maximum intercept range by surface-based ducts created by elevated refractive layers in the atmosphere have not been addressed in this study. Generally, when a surface-based duct is present, it will dominate the effects of the evaporation duct and give even higher signal strengths (lower path loss values) and thus greater maximum intercept ranges. Therefore the results of this study should be

Receiver Configuration	Emitters A	B	C	D
1	180	138	180	138
2	180	138	180	138
3	180	138	180	138
4	195	153	195	153
5	195	153	195	153
6	195	153	195	153
7	160	118	160	118
8	160	118	160	118
9	160	118	160	118
10	175	133	175	133
11	175	133	175	133
12	175	133	175	133

Table 3. Path loss threshold in dB for each combination of emitter and receiver configuration.

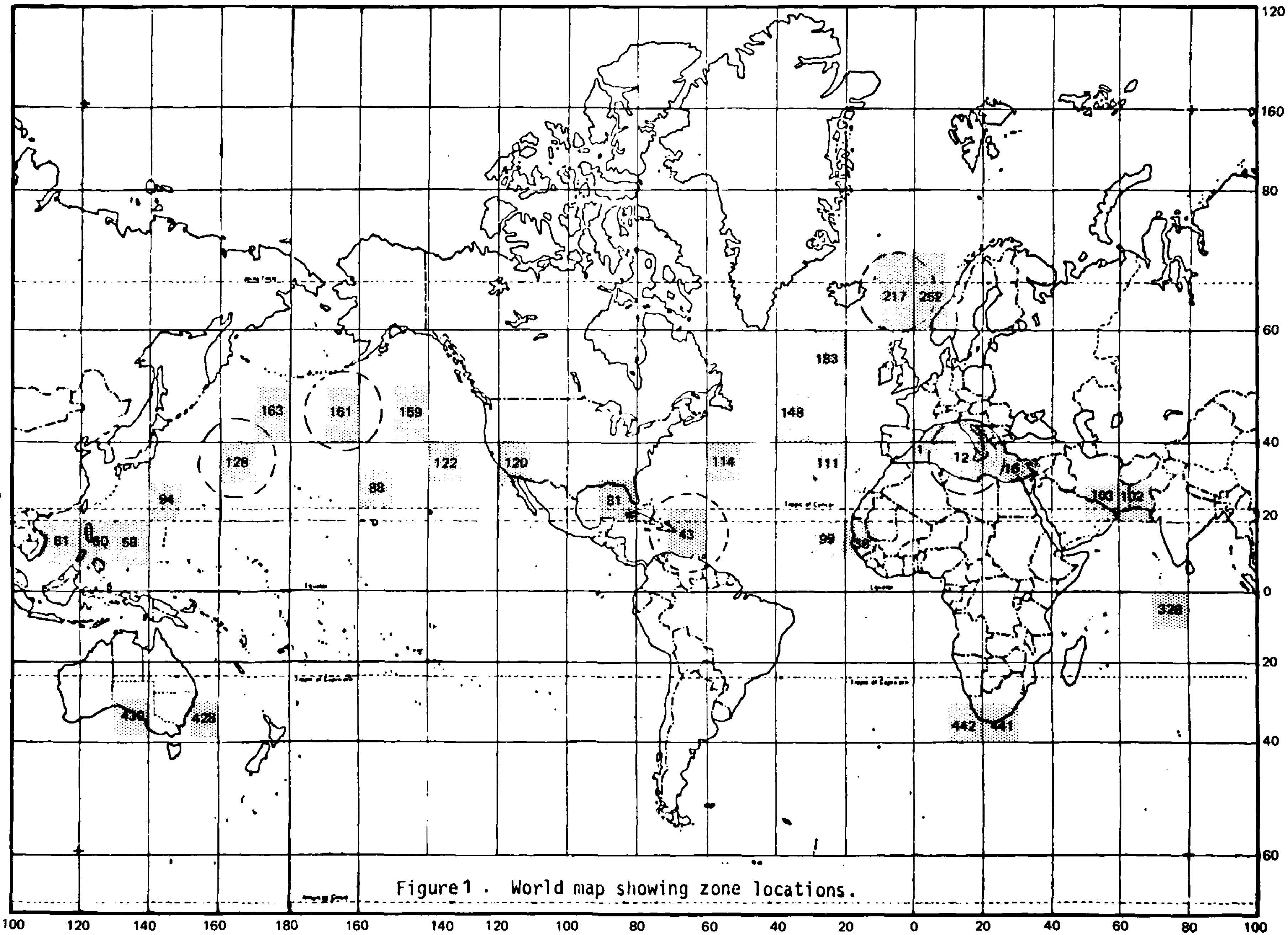

Figure1 . World map showing zone locations.

conservative in that even greater ranges than predicted may occur from surface-based ducts. The occurrence of surface-based ducts will vary from near zero in the poor ducting areas to about 25% of the time in good ducting areas.

PROPAGATION CALCULATIONS

THE WAVEGUIDE PROGRAM

The waveguide program described in reference 4 was modified to include an extra attenuation of 0.13 dB/nmi at 18 GHz and 0.26 dB/nmi at 37.5 GHz to account for average sea level oxygen and water vapor absorption in accordance with reference 6. A wind speed of 12 knots was assumed in all of the calculations, which corresponds to the average wind speed of the five ocean areas used in this study. It is recognized that using a fixed average wind speed, from which the ocean surface roughness is determined, may under- or over-estimate intercept ranges resulting from varying ocean roughness, but the assumption was deemed necessary to keep the number of waveguide computations and results to manageable proportions. The possible errors associated with the average wind speed assumption are discussed in a later section. The plotting portion of the waveguide program was also modified to show the four path loss thresholds indicated by table 3 for each emitter/receiver combination. Including these thresholds on the computer plots facilitated reading off the maximum intercept range using a Gerber variable rule.

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[6] Available to qualified requesters.

Before all of the waveguide path loss computations could be performed, an effort had to be made to ensure that all of the important waveguide modes were to be included in the calculations. A detailed examination of the modes and their interrelationships provided an interesting insight into the evaporation duct as a propagation mechanism at the frequencies studied. Figures 2 and 3 show attenuation of the first four modes versus duct height for 18 and 37.5 GHz respectively. In each case, an individual mode's attenuation rate at first decreases with increasing duct height but then reaches a minimum and increases thereafter. The initial decreasing attenuation rate is expected and is attributable to the increasing trapping effect of the duct as duct height increases. The increasing attenuation rate after reaching a minimum was a surprise, and is conjectured to be a result of surface roughness. In terms of ray theory, stronger ducts will trap rays with higher grazing angles at the surface, but higher grazing angles cause more loss on reflection from the surface. These two counterbalancing mechanisms of increasing trapping effectiveness and increasing surface roughness effects result in the situation that either one or two modes dominate propagation in the cases studied. For example, figure 2 shows mode 1 would dominate up to a duct height of about 11 m, then modes 1 and 2 would dominate since they are about equal up to about 13 m, then mode 2 alone would dominate, followed by modes 2 and 3, and so on.

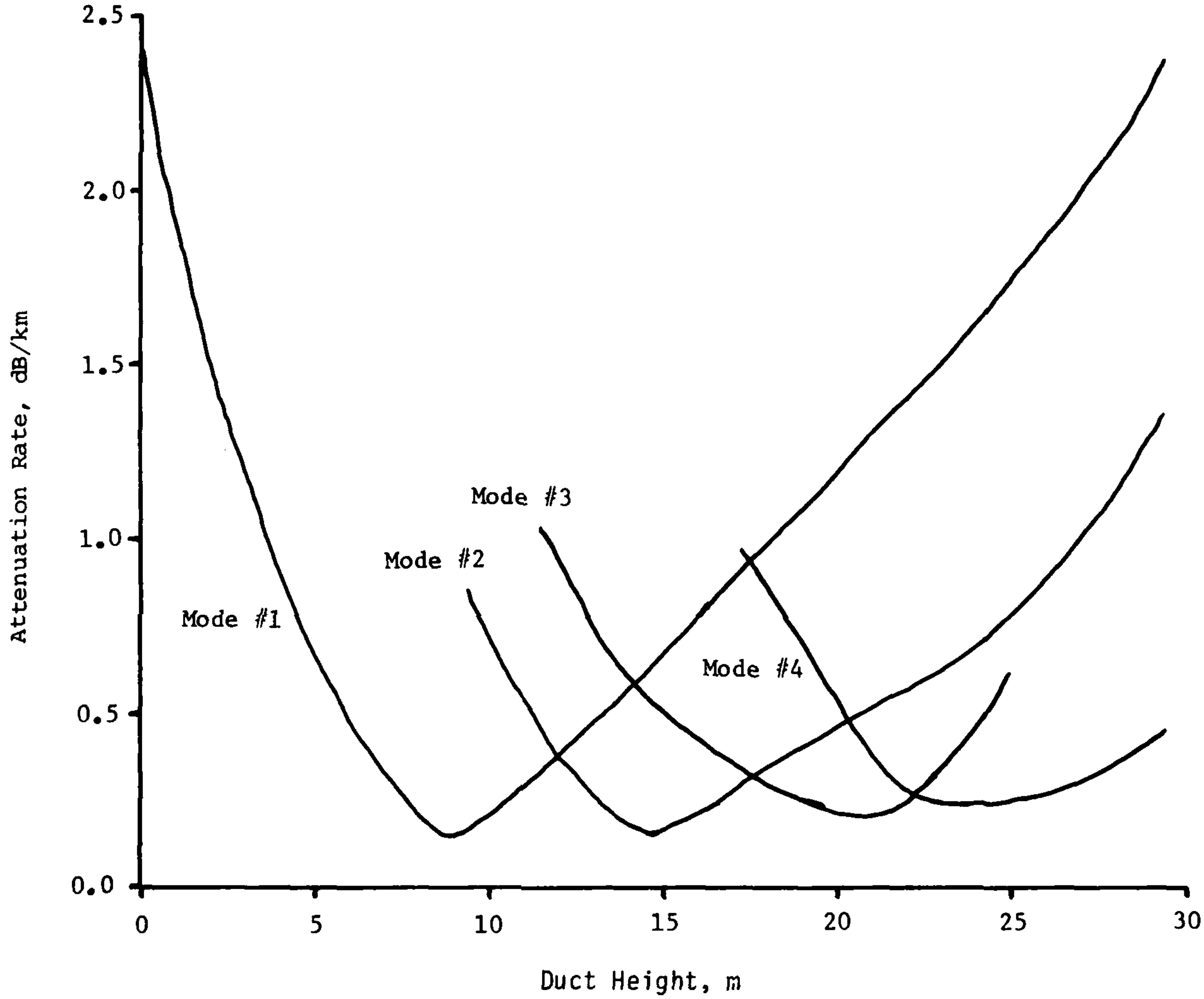


Figure 2. Attenuation rate for the first four individual modes versus duct height for 18 GHz

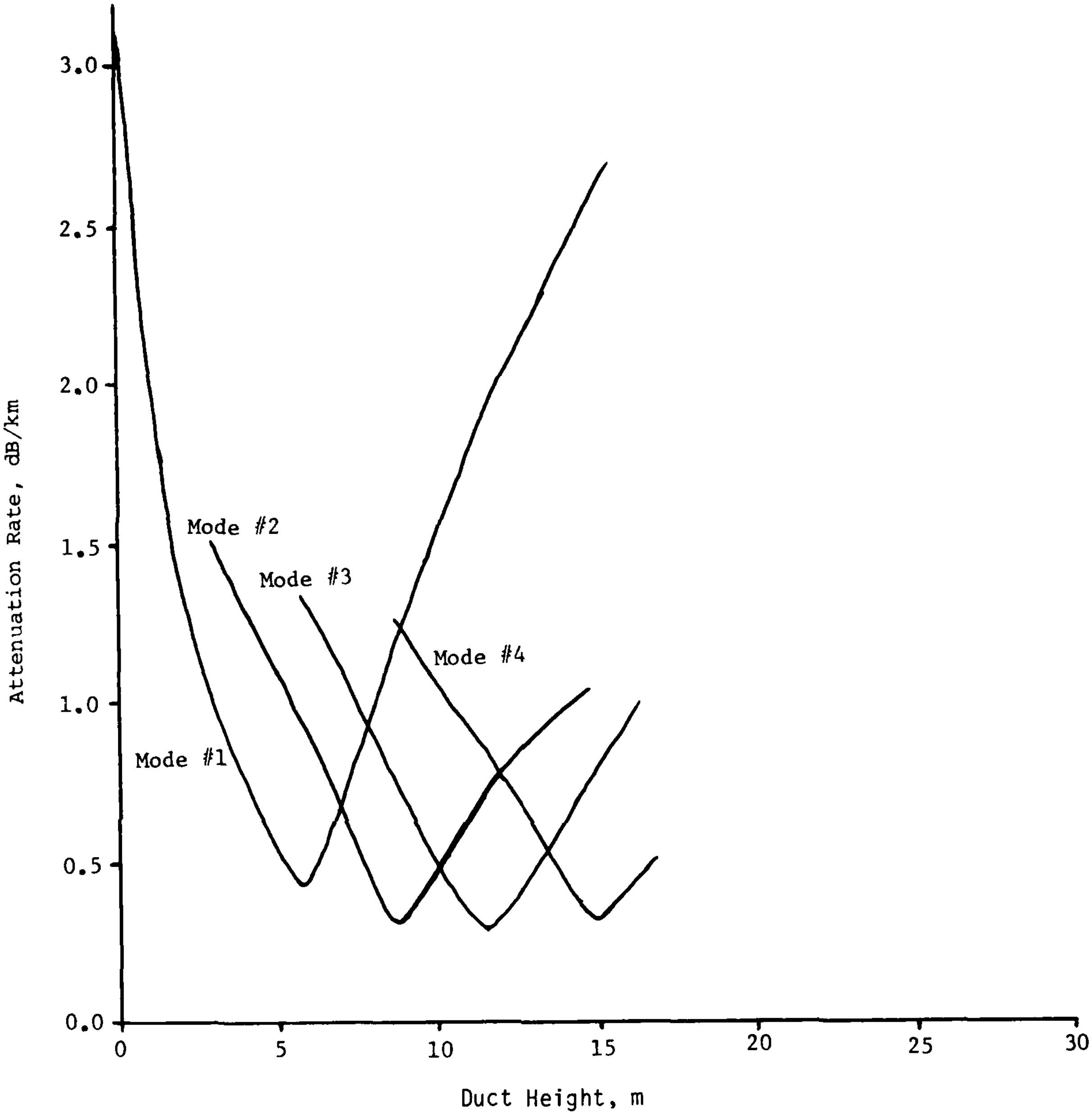


Figure 3. Attenuation rate for the first four individual modes versus duct height for 37.5 GHz

Once it was determined that all the important modes were found for the two frequencies studied, all of the path loss versus range calculations and plots were generated. Nine duct heights of 0, 2.9, 5.8, 8.7, 11.6, 14.5, 17.4, 23.3, and 29.2 m were chosen for the study. Plots for 12 emitter/receiver height combinations (4 emitters times 3 receiver heights), each of which included 4 path loss thresholds (2 receiver sensitivities times 2 receiver antenna gains), were generated for a total of 108 plots. These plots are presented in appendix A. From these plots a maximum intercept range can be determined for any emitter/receiver combination for any of the duct heights studied.

Inspection of the plots in appendix A reveals that the maximum intercept ranges for the low-power emitters are all within the horizon. Since the waveguide model is not generally valid at ranges within the horizon, the maximum intercept ranges for the low-power emitters are assumed to be limited by free space propagation and gaseous absorption and not affected by ducting. No other analysis was performed for the low-power emitters.

MAXIMUM INTERCEPT RANGE VERSUS DUCT HEIGHT CURVES

The path loss versus range curves of appendix A were used to determine maximum intercept range for all the high-power emitters for each duct height considered. These ranges were then plotted versus duct height and a smooth curve was fitted through the nine points by hand for each case. Twenty-four such curves were generated (two emitters times 12 receiver combinations) and are presented in appendix B. To better determine the shape of the hand drawn curves, one case each for 18 and 37.5 GHz was analyzed in more detail by running the waveguide program for several more duct heights. The oscillatory behavior of the curves in appendix B is the result of the one mode - then two mode - then one mode dominance in the waveguide calculations. All of these curves show a strong influence of the evaporation duct on maximum intercept range, with ranges approaching 100 nmi in some cases. Also note the relative increase of the ranges over the nonducting case represented by zero duct height. The improvement in ranges varies from about 100% to 300% or more for optimum duct heights. Although great improvements in range are evident from these curves, the key question is "what values of duct height can be expected in a given area?" This question will be addressed in a later section.

EFFECTS OF ASSUMING A CONSTANT WIND SPEED

Because of the uncertainty in the effects that assuming a constant average wind speed may have on the maximum intercept ranges calculated, one case for a receiver antenna height of 15 m at 37.5 GHz was studied for wind speeds of 0 and 6 knots as well as the 12 knots used in the rest of this study. Figures 4 through 7 are the resulting maximum intercept range versus duct height plots for the four path loss thresholds for this case. The solid curves in these four figures are for 12 knots, the dashed curves are for 6 knots and the dotted curves are for zero wind speed. In all cases, the lower wind speeds do give generally greater, and sometimes much greater, intercept ranges. Note

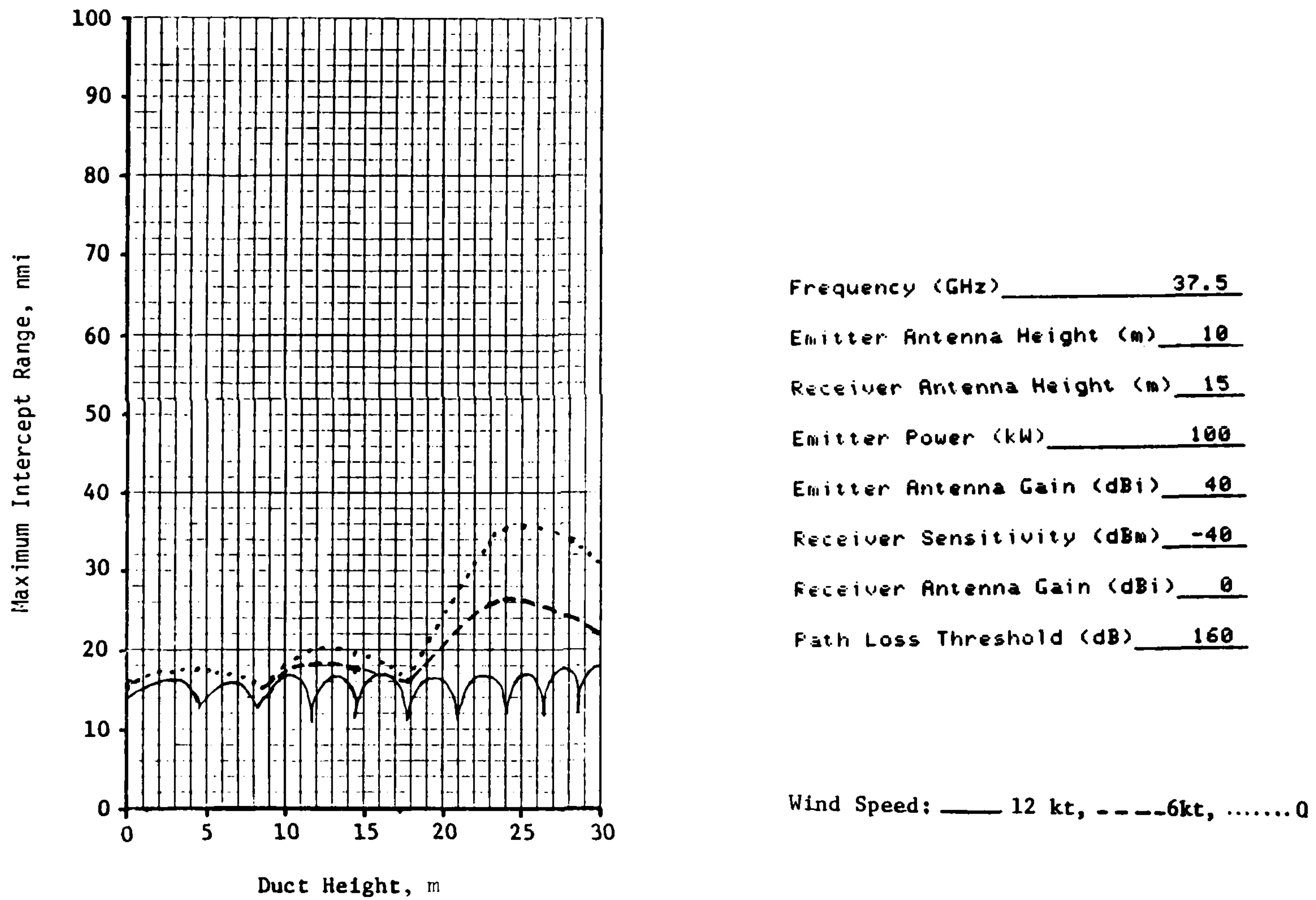


Figure 4. Maximum intercept range versus duct height for three wind speed conditions for the high power 37.5-GHz emitter and the least sensitive receiver system.

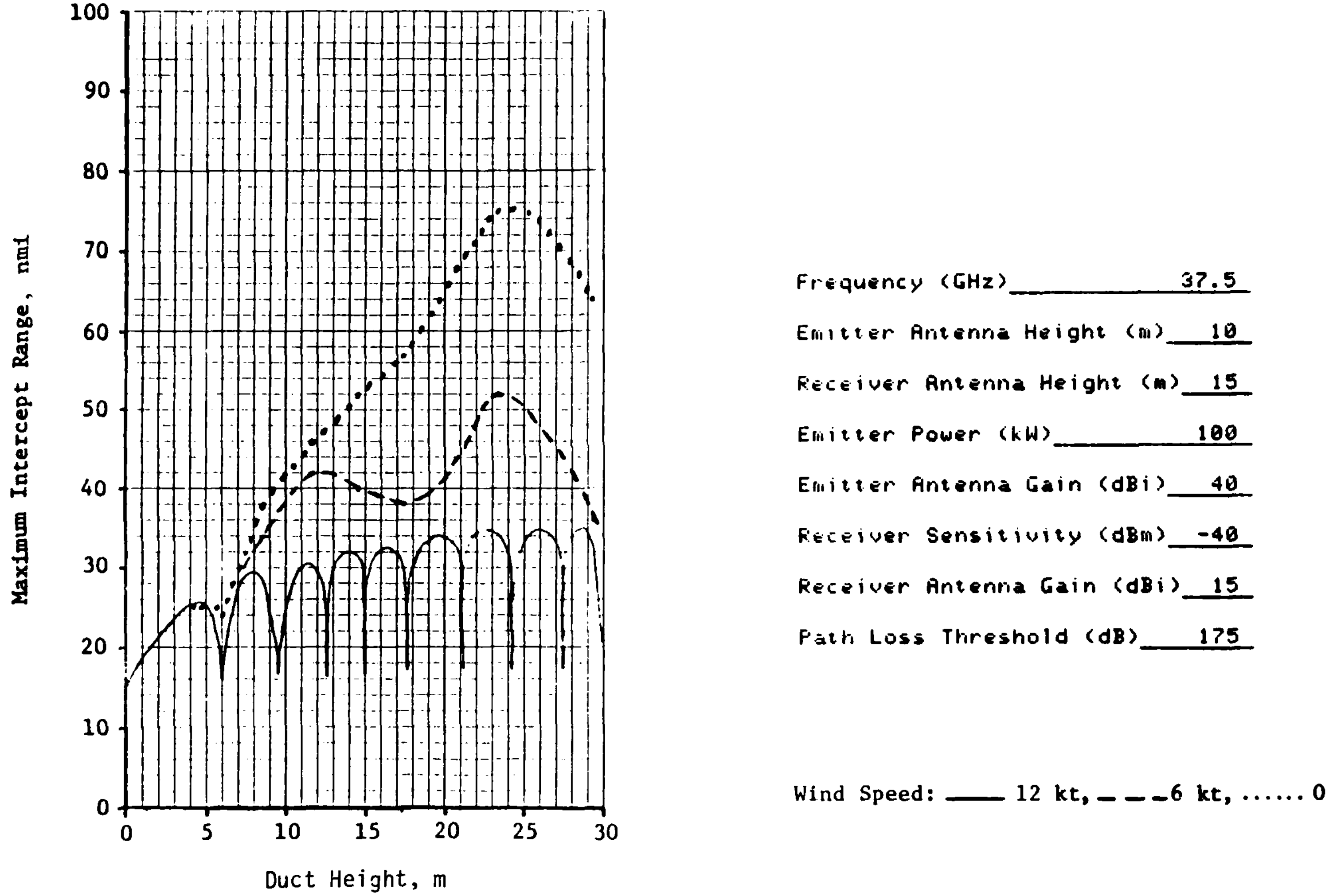


Figure 5. Maximum intercept range versus duct height for three wind speed conditions for the high power 37.5-GHz emitter and the second-least-sensitive receiver system.

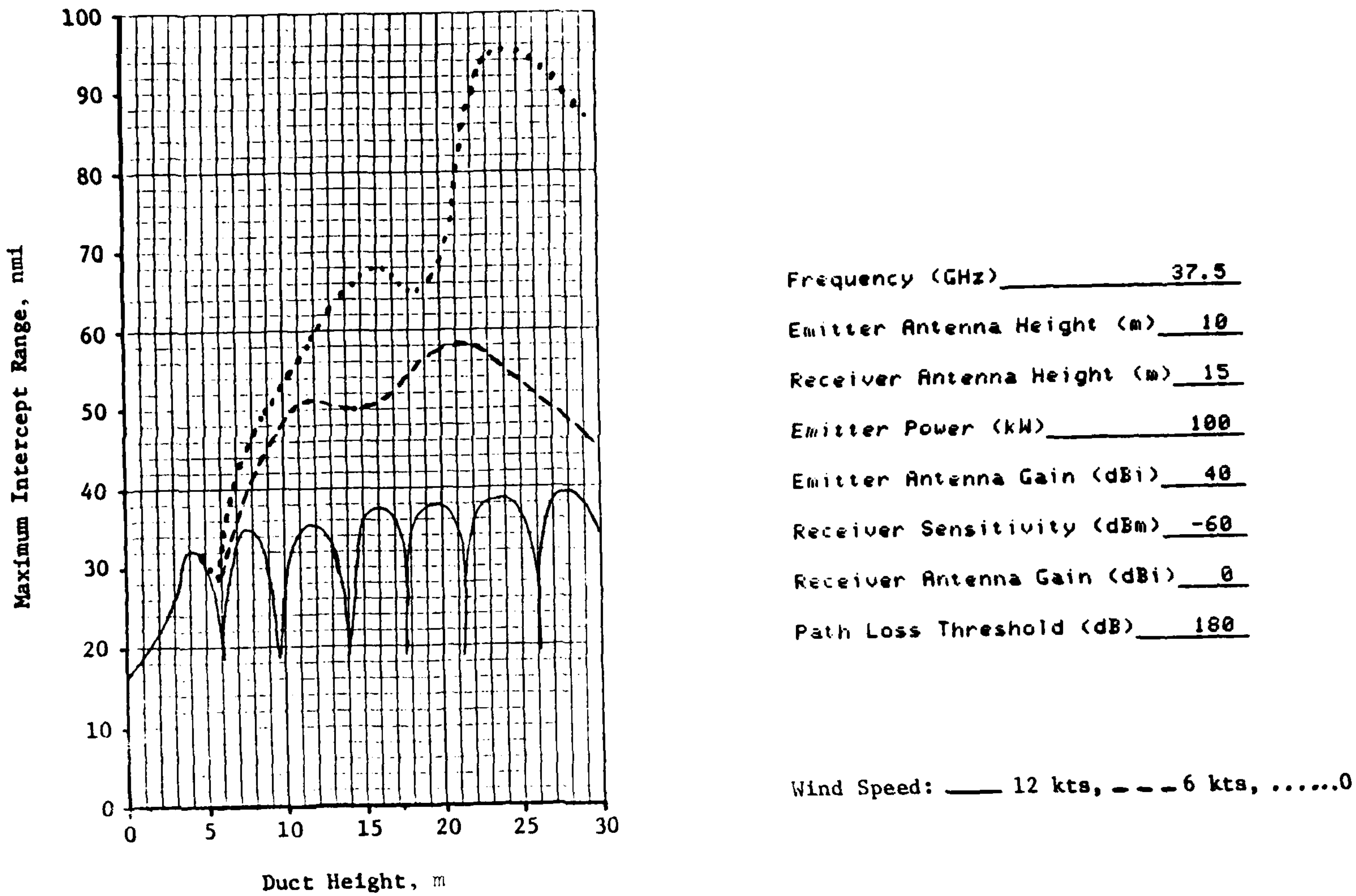


Figure 6. Maximum intercept range versus duct height for three wind speed conditions for the high power 37.5-GHz emitter and the second-most-sensitive receiver system.

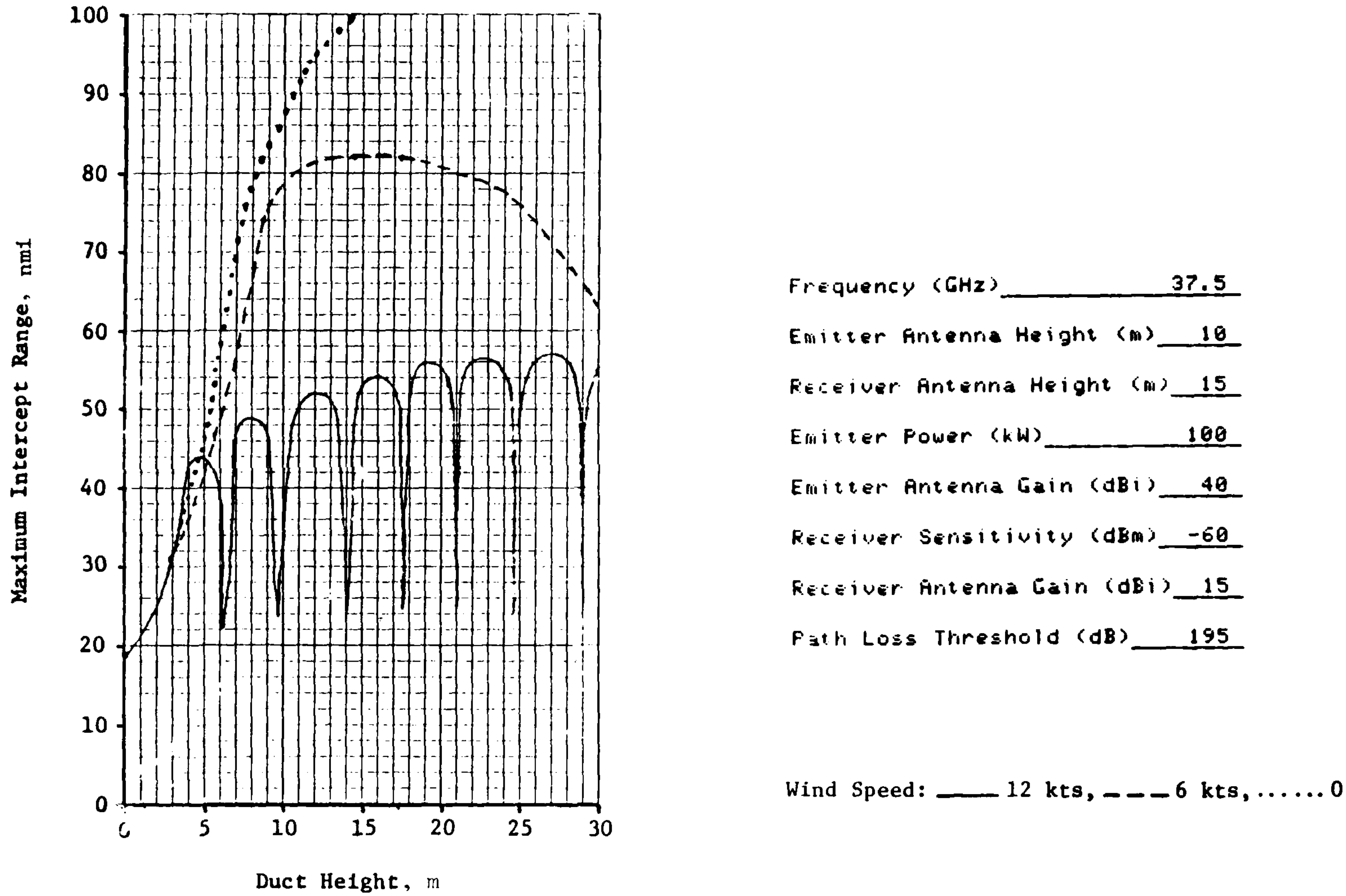


Figure 7. Maximum intercept range versus duct height for three wind speed conditions for the high power 37.5-GHz emitter and the most sensitive receiver system.

that the oscillatory nature of the curves is not as pronounced for the lower wind speeds. The conclusion is that the ranges predicted by this study are most likely very conservative in that they will be less than those actually experienced for wind speeds less than 12 knots. No calculations were made for wind speeds greater than 12 knots, although it is speculated that intercept ranges less than those for 12 knots are likely to result. The exact impact of varying wind speed is very difficult to assess, because duct height is itself a function of wind speed and not independent as implied by figures 4 through 7. An exact assessment of the overall effects would require a case-by-case analysis over a long time history for a given ocean area, which was beyond the scope of the present effort.

FREQUENCY DISTRIBUTIONS OF DUCT HEIGHT

To properly interpret the results of the curves given in appendix B, we must know how often duct heights of various values occur. Surface meteorological observations for a five-year period have been obtained from the National Climatic Center for the five areas circled on the map of figure 1. These observations of wind speed, sea temperature, air temperature, and humidity were processed by computer to calculate duct height as described in reference 2 (as amended) and the resulting duct heights were distributed in 3 m intervals. Figure 8 shows the duct height distributions as histograms for each of the five ocean areas studied for all seasons and day and night hours combined. Inspection of the histograms shows the general order of decreas-

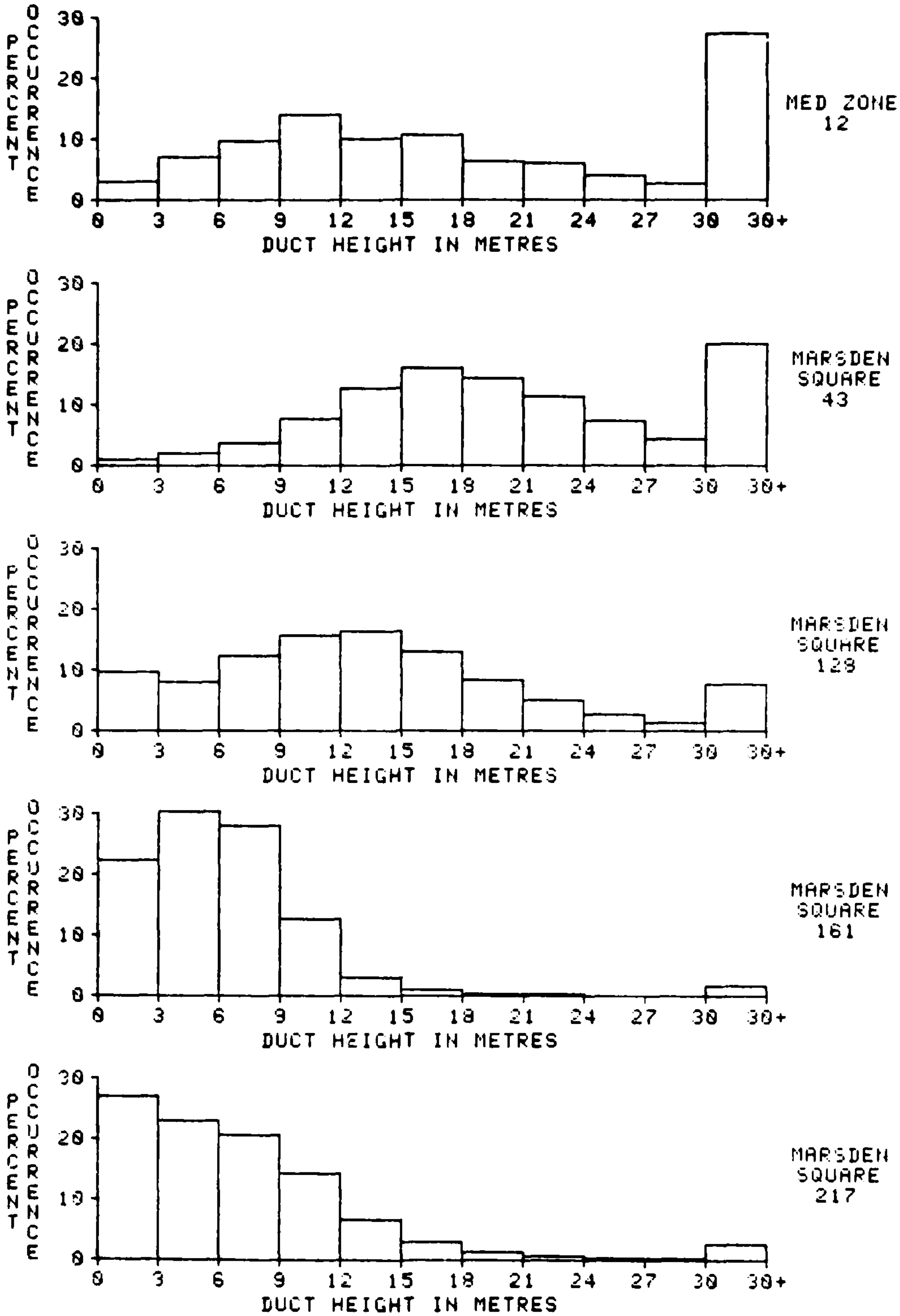


Figure 8. Duct height distributions for the five ocean areas studied.

ing ducting strength by area is Marsden Square 43, Mediterranean Zone 12, Marsden Square 128, Marsden Square 161, and Marsden Square 217.

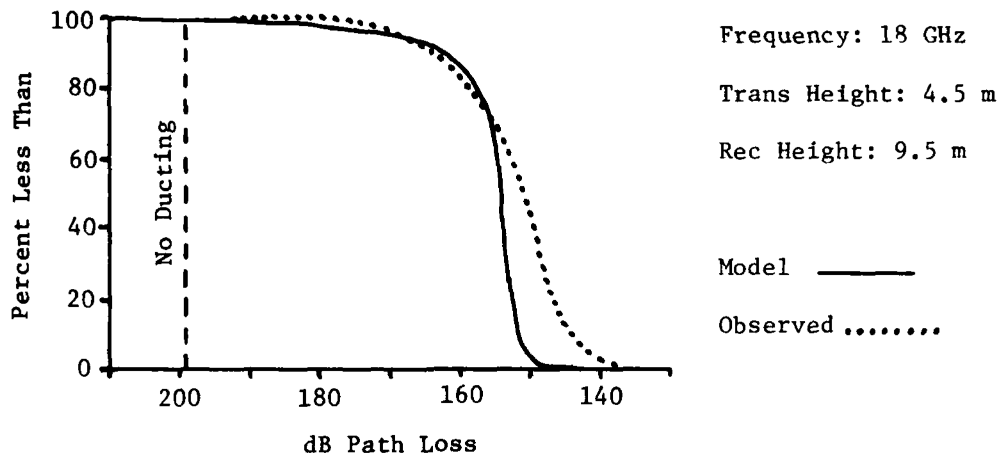
ACCUMULATED FREQUENCY DISTRIBUTIONS OF MAXIMUM INTERCEPT RANGE

The maximum intercept range curves of appendix B have been combined with the frequency distributions of duct height to prepare accumulated frequency distributions of expected maximum intercept range for the five ocean areas for the 24 high-power emitter/receiver combinations considered. These distributions are contained in appendix C. Each graph shows on the ordinate the percent of time that the intercept range on the abscissa is exceeded. Each graph contains separate curves for the five ocean areas and one fixed-range line labeled "no ducting" that shows what the maximum intercept range would be if ducting were not present, and the only propagation mechanisms were diffraction and gaseous absorption. These curves were computer generated using the duct-height frequency distributions and duct-height intervals for which the maximum intercept ranges exceed specified ranges read from the curves in appendix B. The frequency of occurrence of duct heights in the category above 30 meters required special consideration, since the curves in appendix B only went to 30 m. The oscillatory behavior of the curves was assumed to continue indefinitely and an appropriate proportion of the greater than 30 meter duct height category was determined for several intercept ranges spanning the oscillatory region. All of the parameters necessary to define the emitter and receiver plus the path loss threshold corresponding to the plots in appendices A and B are tabulated on each graph in appendix C.

COMPARISONS TO THE GREEK DATA

The reason that the exact frequencies of 18 and 37.5 GHz were chosen was to compare the methods used in this study with propagation measurements made at these same frequencies between the Greek islands of Mykonos and Naxos in 1972 and reported in references 3 and 7. For the Greek measurements, a transmitter at each frequency was placed on Naxos and receivers at Mykonos monitored the path loss across the fixed 19-nmi path. The 3-week period in November 1972 included measurements at both 18 and 37.5 GHz and experienced a variety of meteorological conditions. Frequency distributions of path loss are reported in reference 7 for these cases and are the basis of the comparisons here. The waveguide model was run for the same nine ducting conditions used in the rest of this study for the exact transmitter and receiver heights used in the experiment which were 4.5 and 9.5 m respectively at 18 GHz and 5.1 and 8.6 m respectively at 37.5 GHz. Path loss at 19 nmi from the waveguide calculations was plotted versus duct height in a manner similar to the maximum intercept range versus duct height plots of appendix B. The path loss plots were then combined with the winter duct height distribution for the Mediterranean zone 12 ocean area (which includes Naxos and

[7] Richter, J. H. and H. V. Hitney, Antenna Heights for Optimum Utilization of the Oceanic Surface Evaporation Duct, Part III: Results from the Mediterranean Measurements, NELC TN 2569, 26 November 1973.



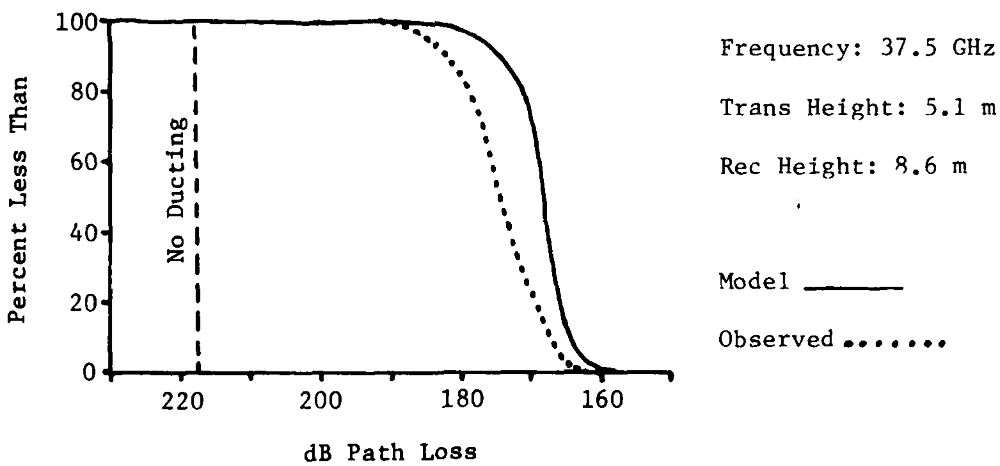


Figure 9. Comparisons of modeled accumulated frequency distributions of path loss to the November 1972 Greek islands observations

Mykonos) to produce accumulated frequency distributions of path loss analogous to the accumulated frequency distributions of maximum intercept range contained in appendix C. Figure 9 shows the results of these calculations along with the observed distributions of path loss for both frequencies. The solid curve in each case is the model, the dotted curve is the observed, and the fixed path loss dashed line represents the path loss expected under nonducting conditions when the only propagation mechanisms would be diffraction and gaseous absorption. These comparisons of the model to observations are considered quite good, especially when referenced to the non-ducting condition. It is interesting to note that in the 18-GHz case the model generally overestimates path loss (underestimates signal strength) while in the 37.5-GHz case, the model consistently underestimates the path loss. The differences are on the order of 6 dB or less, however. Possible explanations for these differences are: the assumption of a constant average wind speed, which should result in greater path loss values from the model; the assumption of horizontal homogeneity, which should result in smaller path loss values from the model; and the assumption of average water vapor absorption, which could result in smaller or greater path loss values from the model depending on exact conditions.

DISCUSSION OF RESULTS

THE EFFECT OF DUCTING ON LOW-POWER EMITTERS VERSUS HIGH-POWER EMITTERS

Inspection of the path loss curves in appendix A shows a strong sensitivity of the maximum intercept range to the path loss threshold values. Larger path loss thresholds allow for much greater variation in maximum intercept ranges than smaller path loss thresholds allow for. Because the path loss threshold is a strong function of the radiated power, the low-power emitter is not affected much at all. In fact, since the indicated maximum intercept ranges are within the horizon where the waveguide model is questionable, it is assumed that the maximum intercept ranges for the low-power emitters will be determined by free-space propagation and gaseous absorption. The high-power emitters, however, show a strong sensitivity to the ducting conditions and can be intercepted at ranges far beyond the horizon where the waveguide model works well.

SENSITIVITY OF MAXIMUM INTERCEPT RANGE TO DUCTING

The curves in appendix B show maximum intercept range to vary considerably depending on duct height and receiver sensitivity and antenna gain. The greater the combination of receiver sensitivity and antenna gain is, the greater is the overall enhancement of maximum intercept range. Also the change in duct height of just a meter or two can cause the range to change by factors of two or more. Thus, in operation, a receiver monitoring these frequency ranges could expect to detect emitters over a broad and changeable region.

EFFECTS OF RECEIVER ANTENNA HEIGHT

One of the main objectives of this study was to assess the effects of receiver antenna height on maximum intercept range and to recommend an optimum antenna height, if appropriate, to maximize ranges. The accumulated frequency distribution plots of appendix C give the best insight into the relative performance of the three antenna heights of 15, 22, and 30 meters that were considered in this study. Perhaps the best measure of performance on these plots is the median range for each area. The median is the range exceeded 50% of the time on these plots. Tables 4 through 11 summarize the median maximum intercept range for each antenna height and each ocean area for each of the eight receiver combinations for the high-power emitters. Tables 4 through 7 are for the 18-GHz cases arranged by increasing receiver system sensitivity (increasing path loss threshold). Tables 8 through 11 are arranged the same way for the 37.5-GHz cases. Inspection of tables 4 through 7 indicates that the best antenna height to give the greatest ranges (at 18 GHz) for all ocean areas would be the 30 m antenna height, independent of receiver system sensitivity. A similar inspection of tables 8 through 11 indicates that the best antenna height to give the greatest ranges at 37.5 GHz for all ocean areas would also be the 30 m antenna height, except for the highest receiver system sensitivity, where the 22 m antenna height would be best.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT 15m	22m	30m
MED ZONE 12	28	25	27
MARSDEN SQUARE 43	29	26	27
MARSDEN SQUARE 128	27	24	26
MARSDEN SQUARE 161	21	22	25
MARSDEN SQUARE 217	21	22	24

Frequency (GHz): 18.0
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -40
Receiver Antenna Gain (dBi): 0
Path Loss Threshold (dB): 160

TABLE 4. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT 15m	22m	30m
MED ZONE 12	51	48	47
MARSDEN SQUARE 43	54	51	48
MARSDEN SQUARE 128	49	47	46
MARSDEN SQUARE 161	34	37	38
MARSDEN SQUARE 217	35	38	39

Frequency (GHz): 18.0
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -40
Receiver Antenna Gain (dBi): 15
Path Loss Threshold (dB): 175

TABLE 5. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT		
	15m	22m	30m
MED ZONE 12	58	56	55
MARSDEN SQUARE 43	62	59	57
MARSDEN SQUARE 128	57	55	54
MARSDEN SQUARE 161	37	41	42
MARSDEN SQUARE 217	38	42	42

Frequency (GHz): 18.0
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -60
Receiver Antenna Gain (dBi): 0
Path Loss Threshold (dB): 180

TABLE 6. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT		
	15m	22m	30m
MED ZONE 12	88	87	86
MARSDEN SQUARE 43	91	89	88
MARSDEN SQUARE 128	85	86	84
MARSDEN SQUARE 161	47	53	60
MARSDEN SQUARE 217	48	56	64

Frequency (GHz): 18.0
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -60
Receiver Antenna Gain (dBi): 15
Path Loss Threshold (dB): 195

TABLE 7. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT 15m	22m	30m
MED ZONE 12	16	17	18
MARSDEN SQUARE 43	16	17	18
MARSDEN SQUARE 128	16	17	18
MARSDEN SQUARE 161	15	17	18
MARSDEN SQUARE 217	15	17	18

Frequency (GHz): 37.5
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -40
Receiver Antenna Gain (dBi): 0
Path Loss Threshold (dB): 160

TABLE 8. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT 15m	22m	30m
MED ZONE 12	32	31	31
MARSDEN SQUARE 43	33	31	31
MARSDEN SQUARE 128	30	31	31
MARSDEN SQUARE 161	25	28	28
MARSDEN SQUARE 217	25	28	28

Frequency (GHz): 37.5
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -40
Receiver Antenna Gain (dBi): 15
Path Loss Threshold (dB): 175

TABLE 9. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT 15m	22m	30m
MED ZONE 12	35	36	36
MARSDEN SQUARE 43	36	36	36
MARSDEN SQUARE 128	33	35	35
MARSDEN SQUARE 161	29	29	31
MARSDEN SQUARE 217	28	29	31

Frequency (GHz): 37.5
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -60
Receiver Antenna Gain (dBi): 0
Path Loss Threshold (dB): 180

TABLE 10. Summary of receiver antenna height effects.

MAXIMUM INTERCEPT RANGES IN nmi
EXCEEDED 50% OF THE TIME

OCEAN AREA	RECEIVER ANTENNA HEIGHT 15m	22m	30m
MED ZONE 12	52	51	51
MARSDEN SQUARE 43	54	52	52
MARSDEN SQUARE 128	50	49	50
MARSDEN SQUARE 161	42	54	43
MARSDEN SQUARE 217	42	54	43

Frequency (GHz): 37.5
Emitter Antenna Height (m): 10
Emitter Power (kW): 100
Emitter Antenna Gain (dBi): 40
Receiver Sensitivity (dBm): -60
Receiver Antenna Gain (dBi): 15
Path Loss Threshold (dB): 195

TABLE 11. Summary of receiver antenna height effects.

CONCLUSIONS

Within the limitations of the models previously discussed, the principal conclusions of this study are the following:

1. Maximum intercept ranges for low-power emitters are not affected by ducting.

2. Maximum intercept ranges for high-power emitters are greatly affected by ducting.

3. The effects from ducting are greater for more sensitive receiver systems.

4. The best over-all shipboard antenna height for 18 GHz is the highest, independent of receiver system sensitivity.

5. The best over-all shipboard antenna height for 37.5 GHz is the highest, except for the most sensitive receiver system studied, where the 22 m middle antenna height would be preferred.

RECOMMENDATIONS

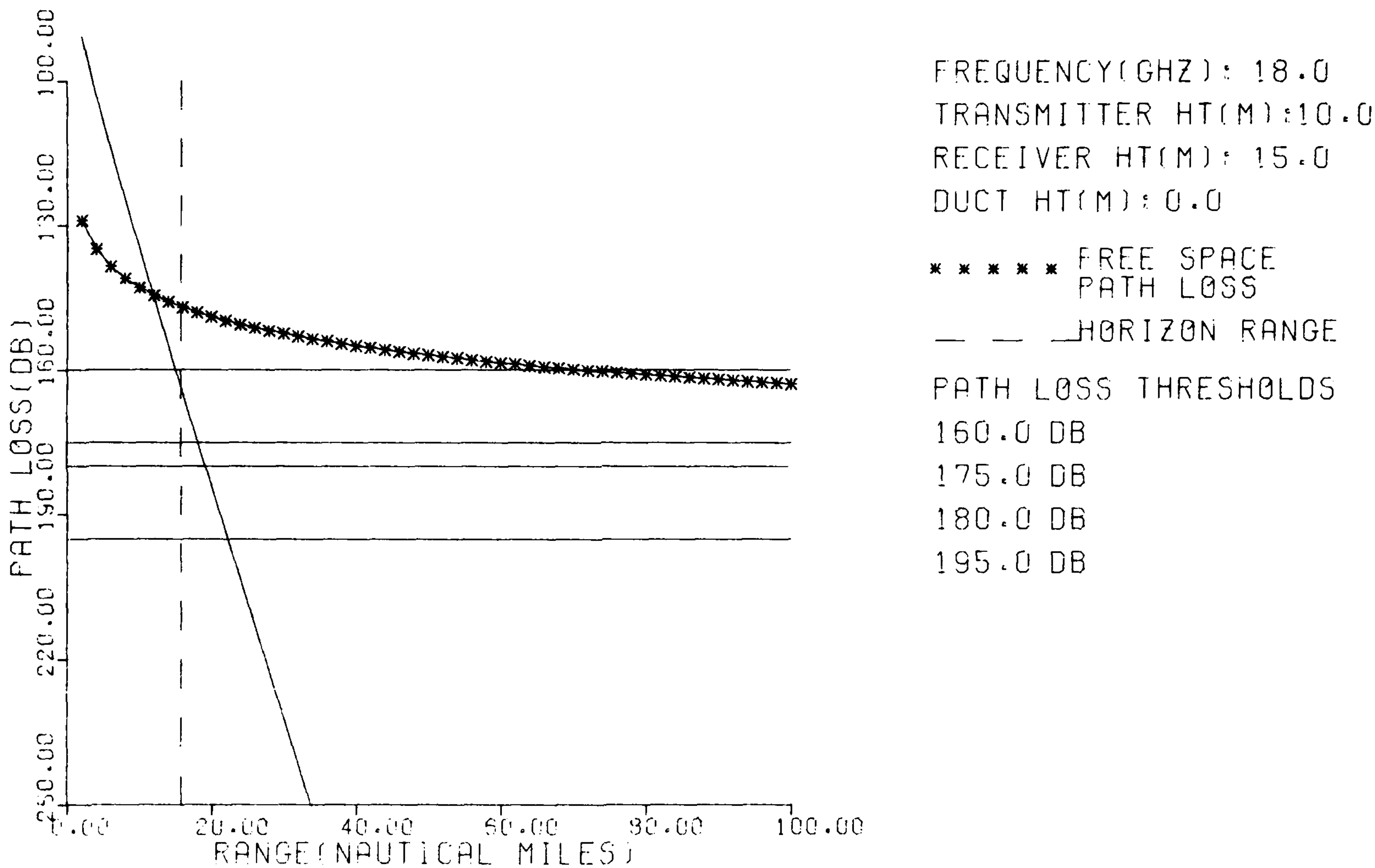
The following two recommendations are submitted to verify and expand the results of this study.

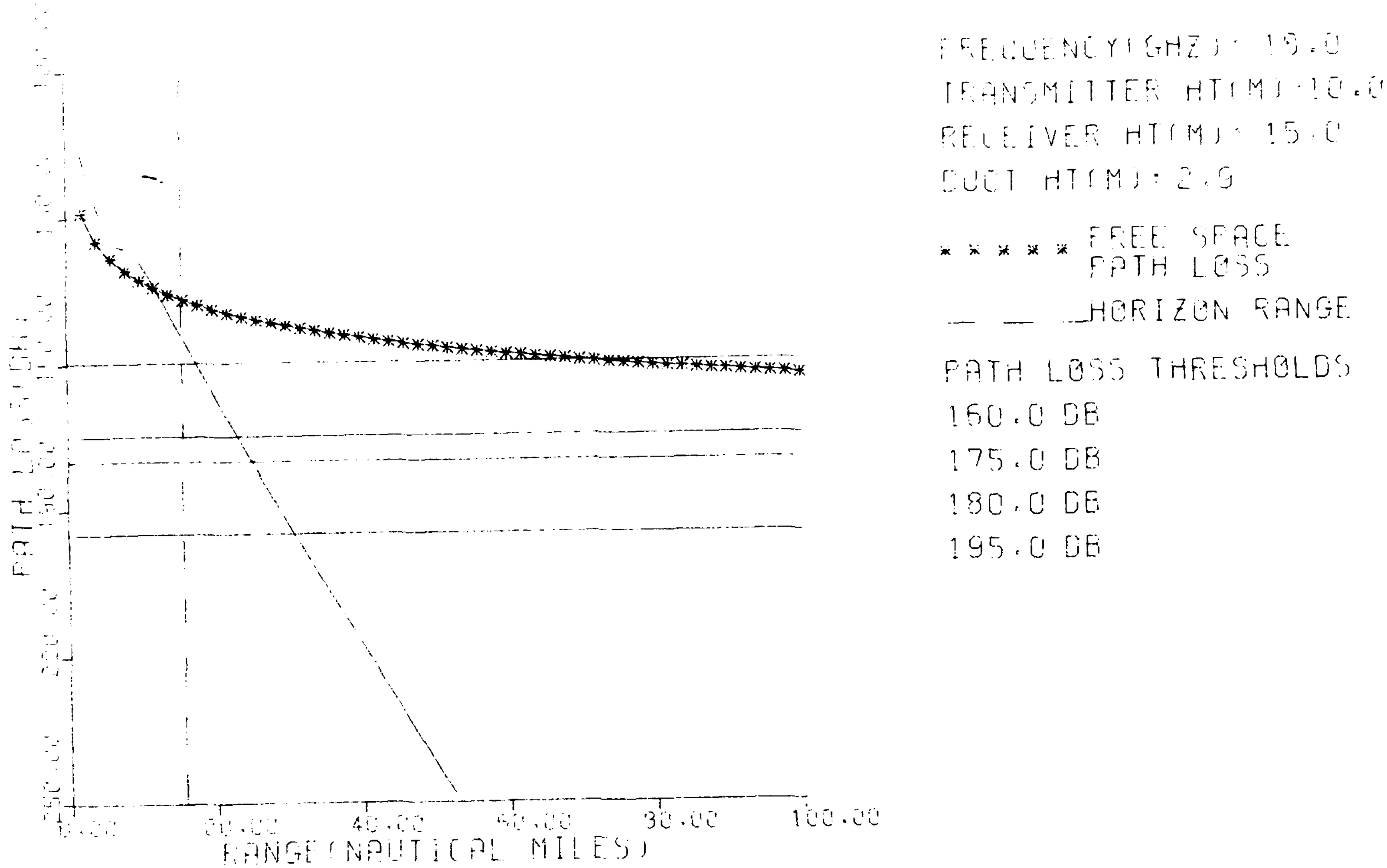
1. An experimental program should be undertaken to validate the modeled accumulated frequency distributions as presented in appendix C. This program would consist of measuring path loss across an over-water path at either 18 or 37.5 GHz (or both) at a range near the median intercept range for the area in question as determined from appendix C. For the San Diego offshore area this range would be approximately from 40 to 50 nmi.

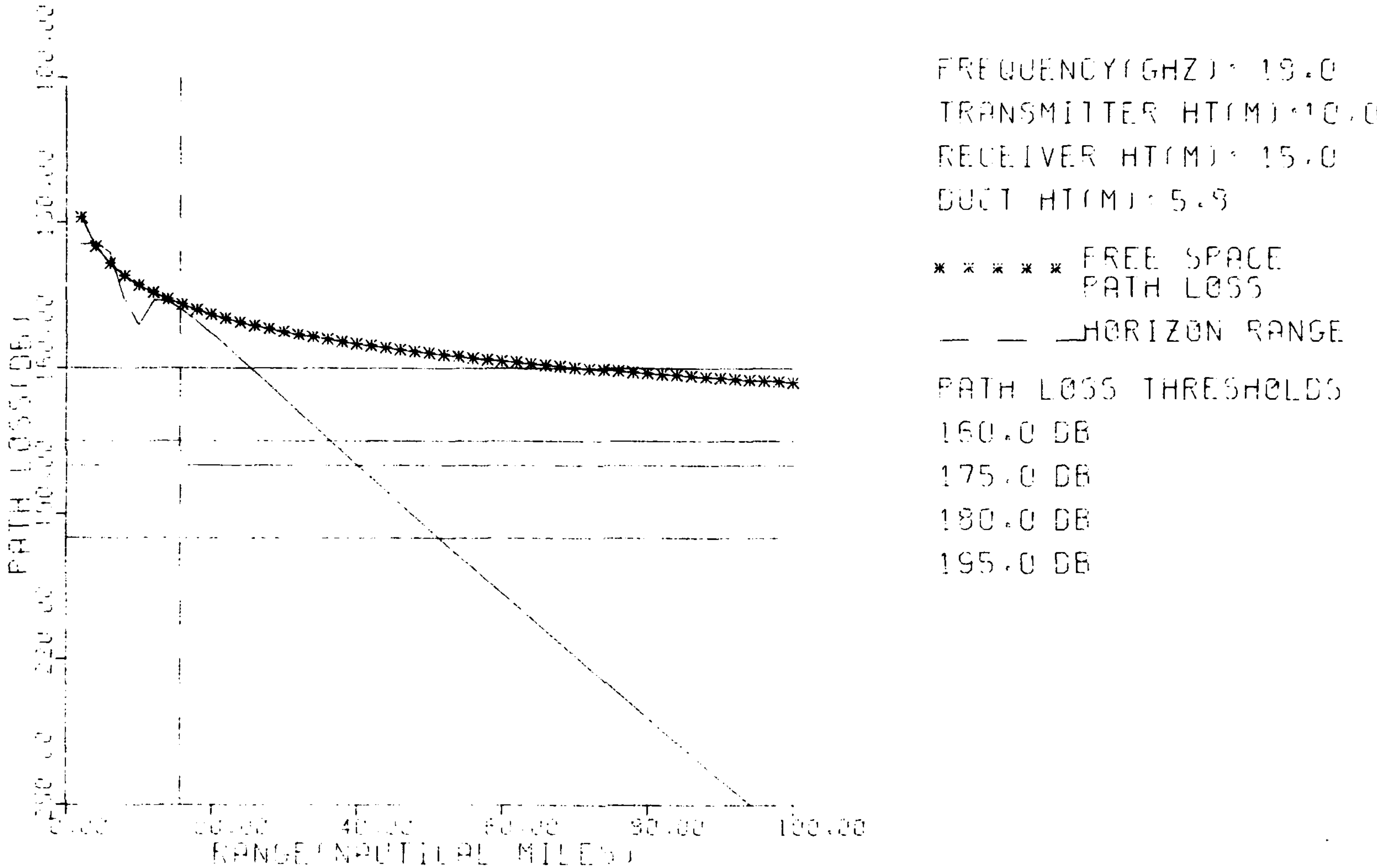
2. An expanded analytical program should be performed that would account for the simultaneous effects that a variable wind speed has on both surface roughness and duct height. This program could be best carried out in conjunction with the experimental program described above.

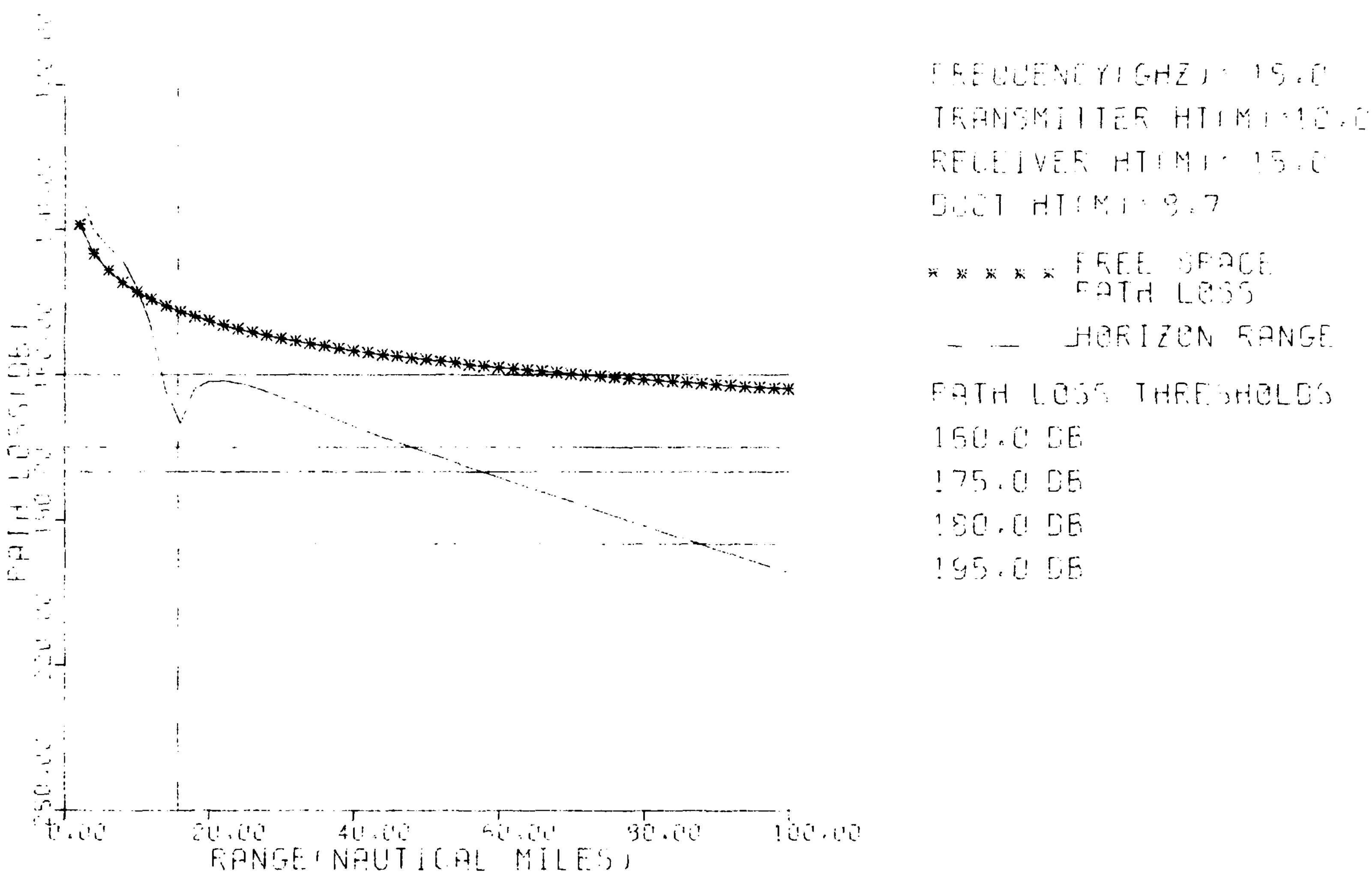
APPENDIX A

Path Loss versus Range Plots from the Waveguide Program

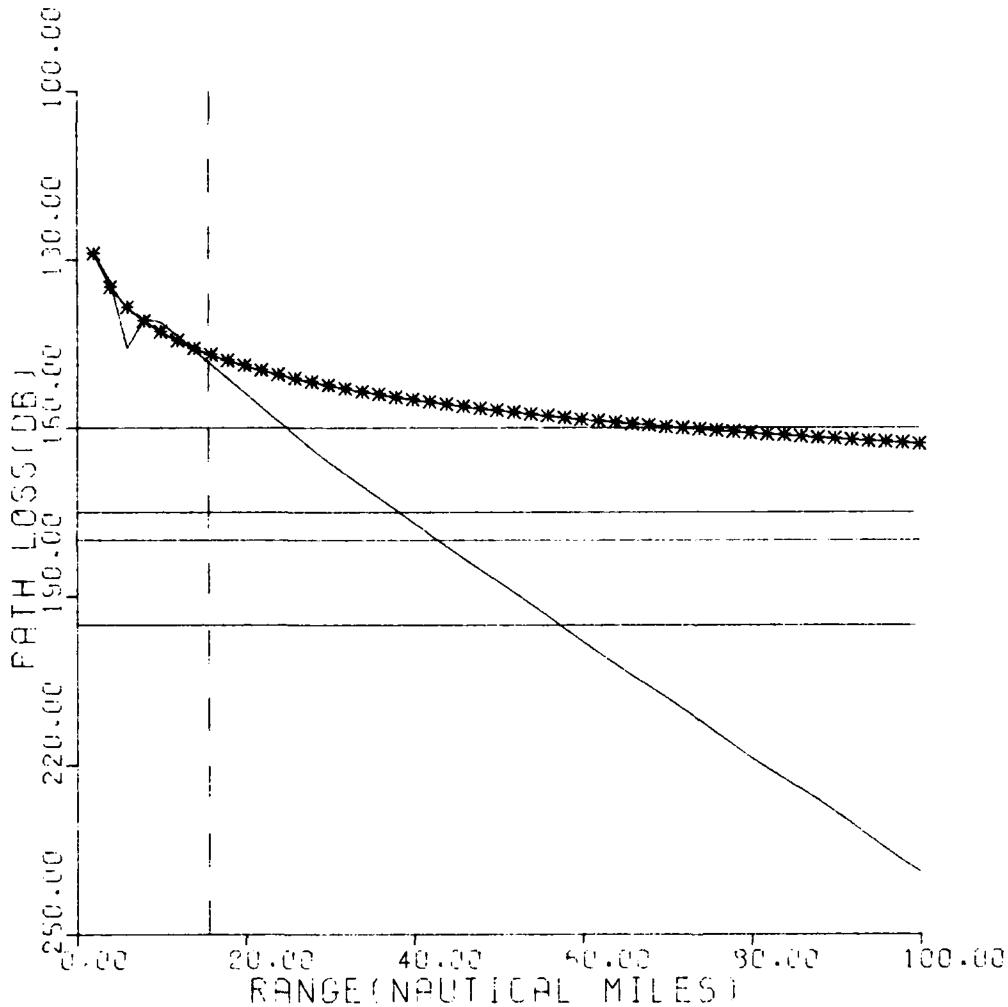

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 0.0
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 10.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 19.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 5.9
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00



PATH LOSS(DB)
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00
FREQUENCY(GHZ): 15.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 9.7
* * * * * FREE SPACE PATH LOSS
_ _ HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB



FREQUENCY(GHZ): 18.0

TRANSMITTER HT(M):10.0

RECEIVER HT(M): 15.0

DUCT HT(M): 11.6

* * * * * FREE SPACE PATH LOSS

— — —HORIZON RANGE

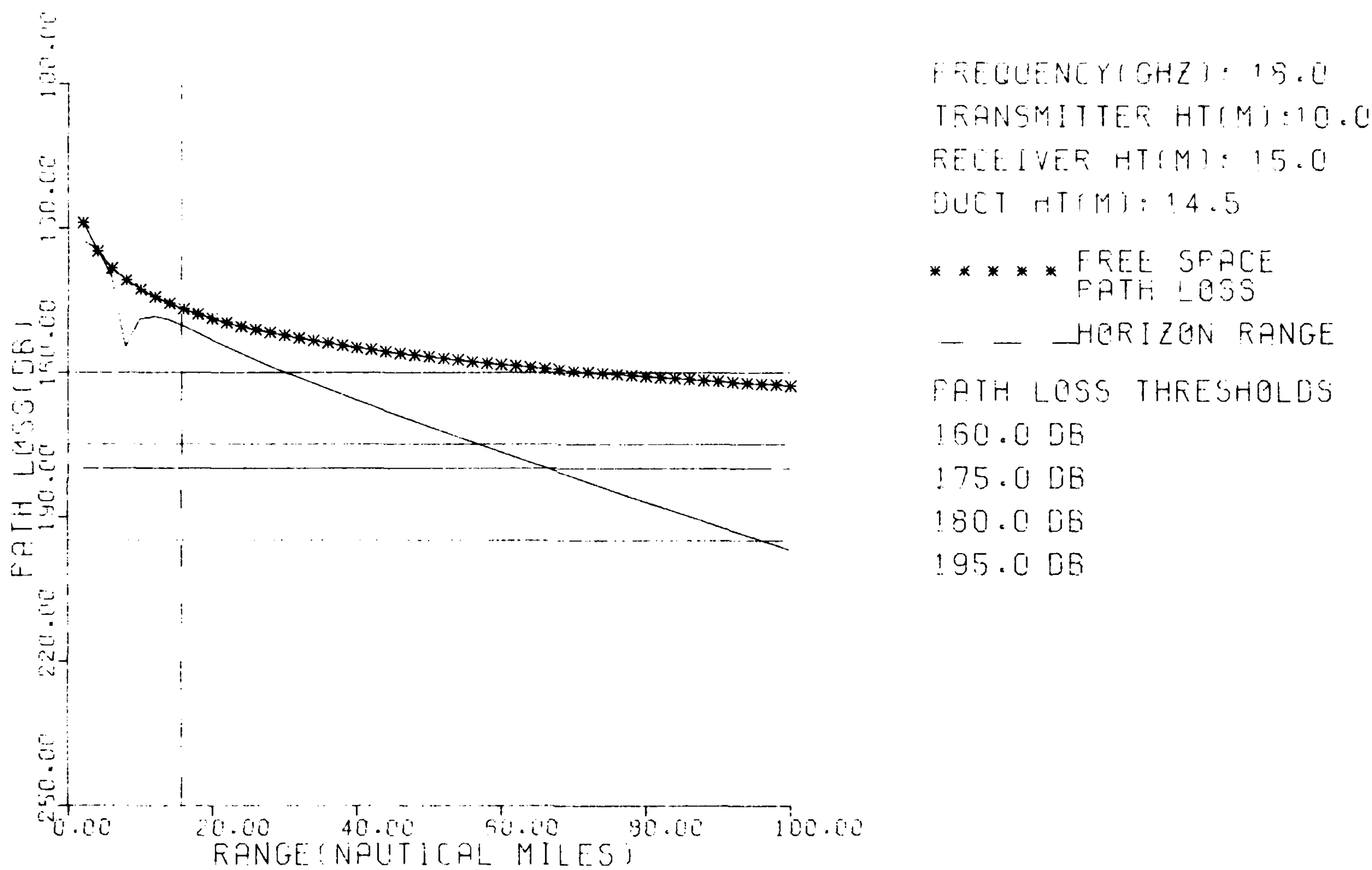
PATH LOSS THRESHOLDS

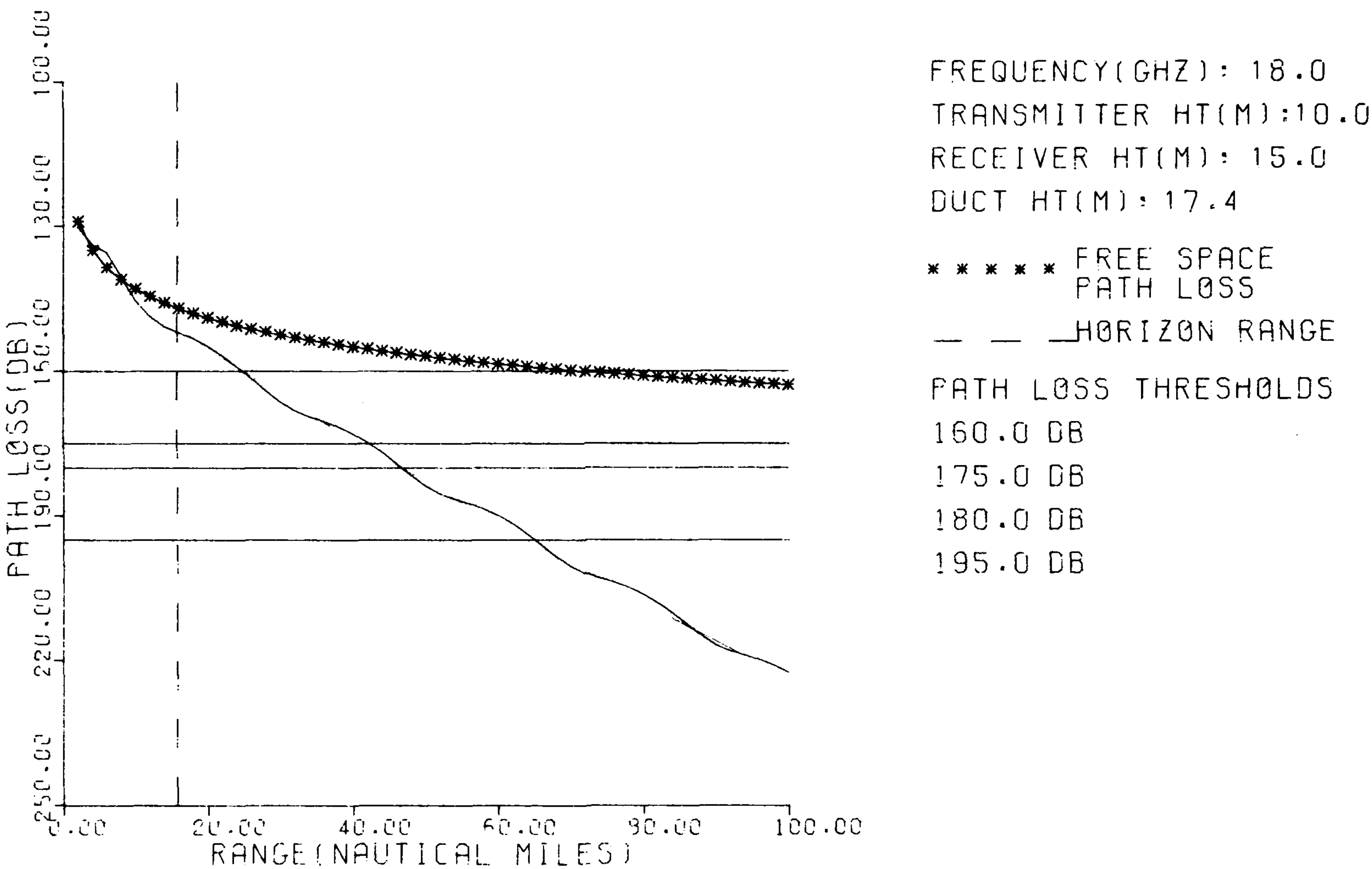
160.0 DB

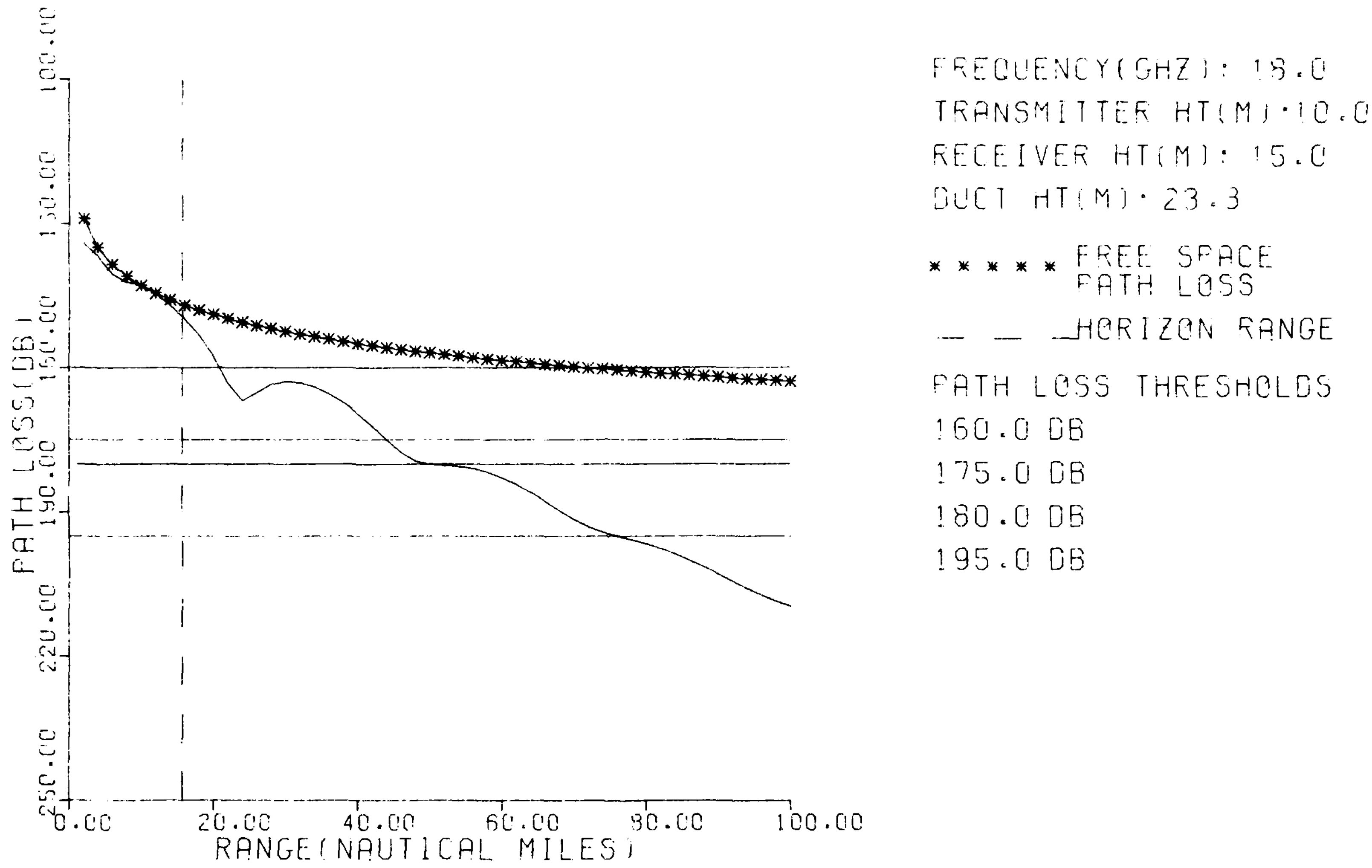
175.0 DB

180.0 DB

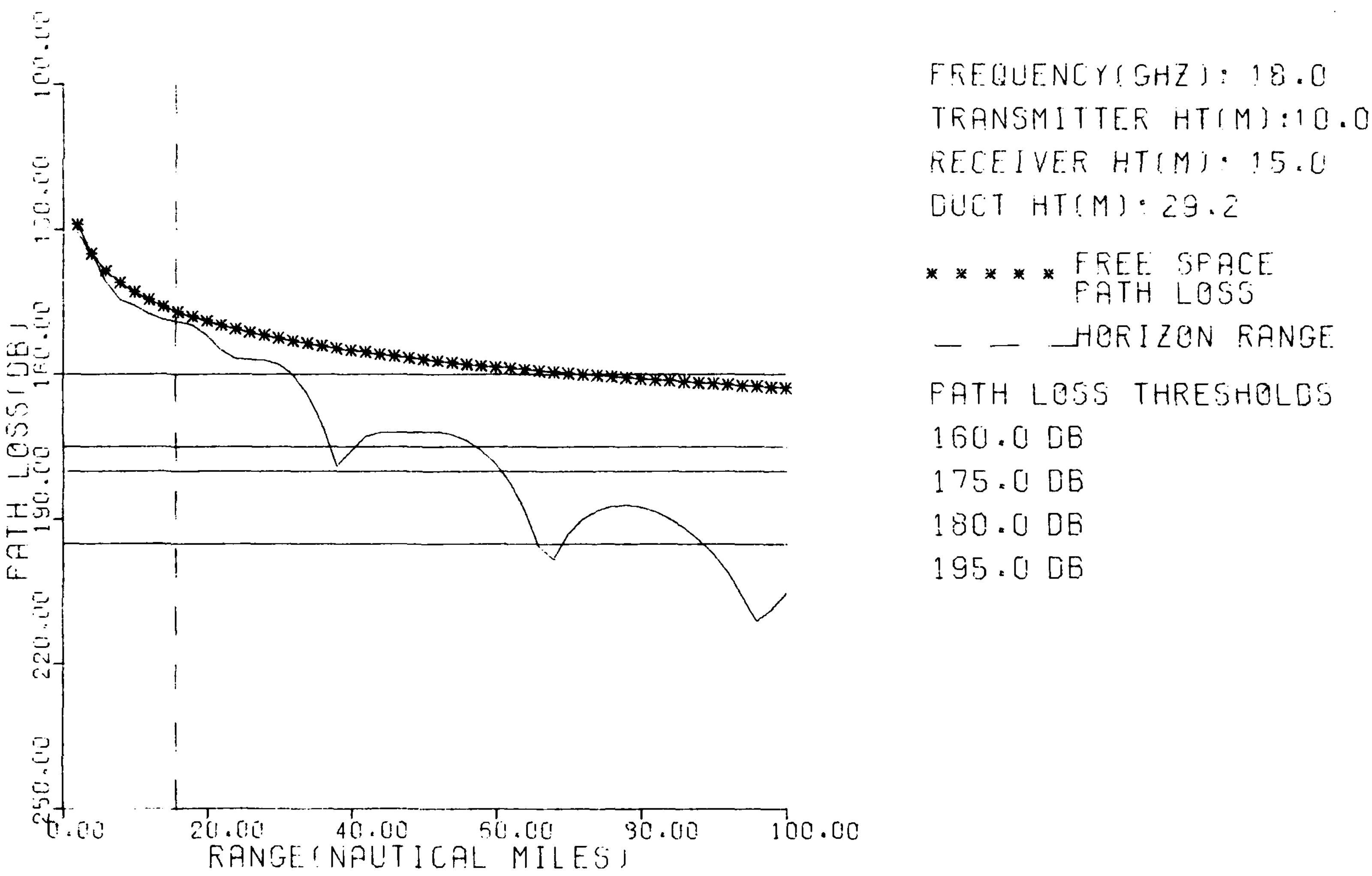
195.0 DB


PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 14.5
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

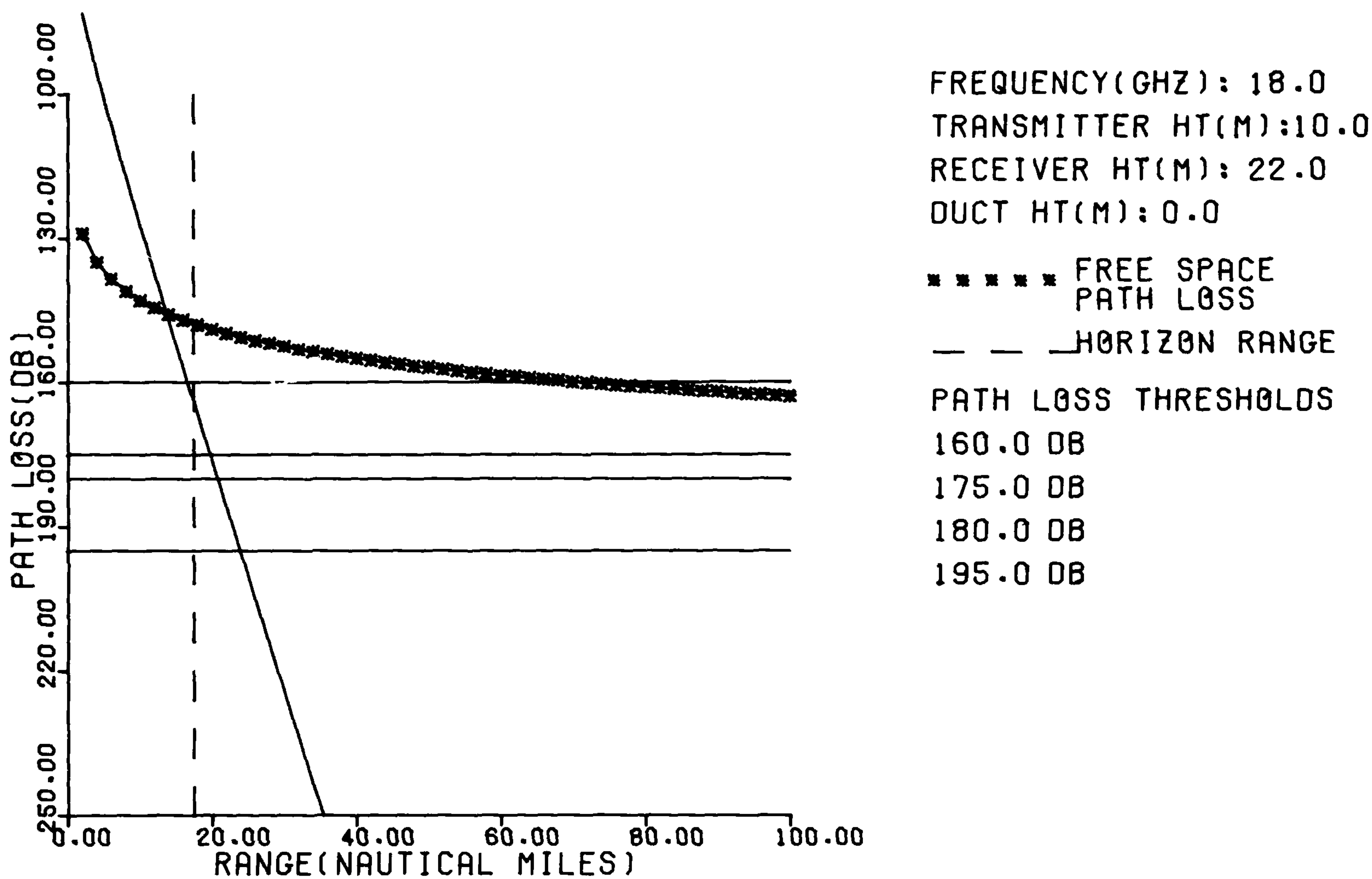

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 17.4
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)



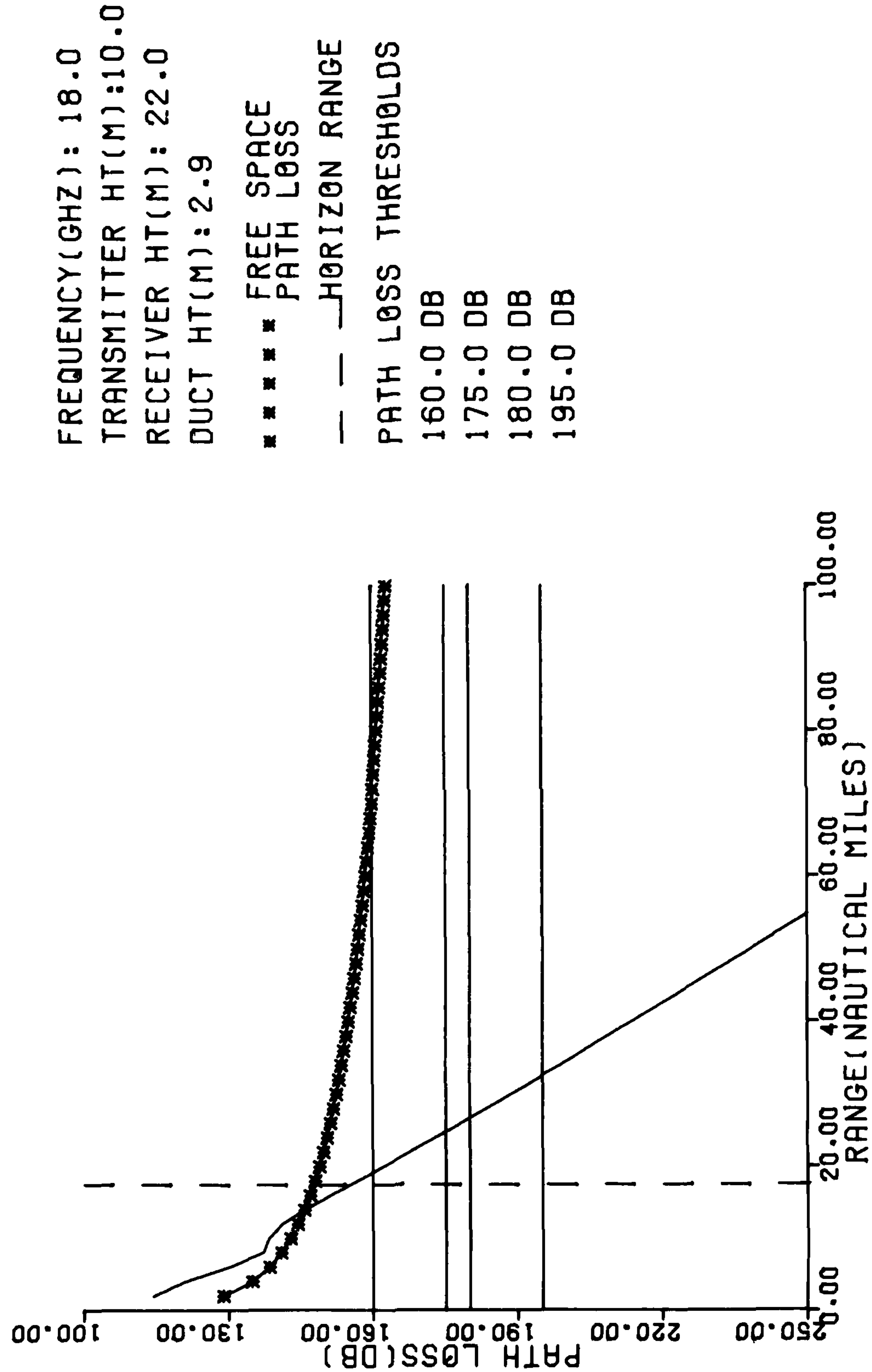
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 23.3
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

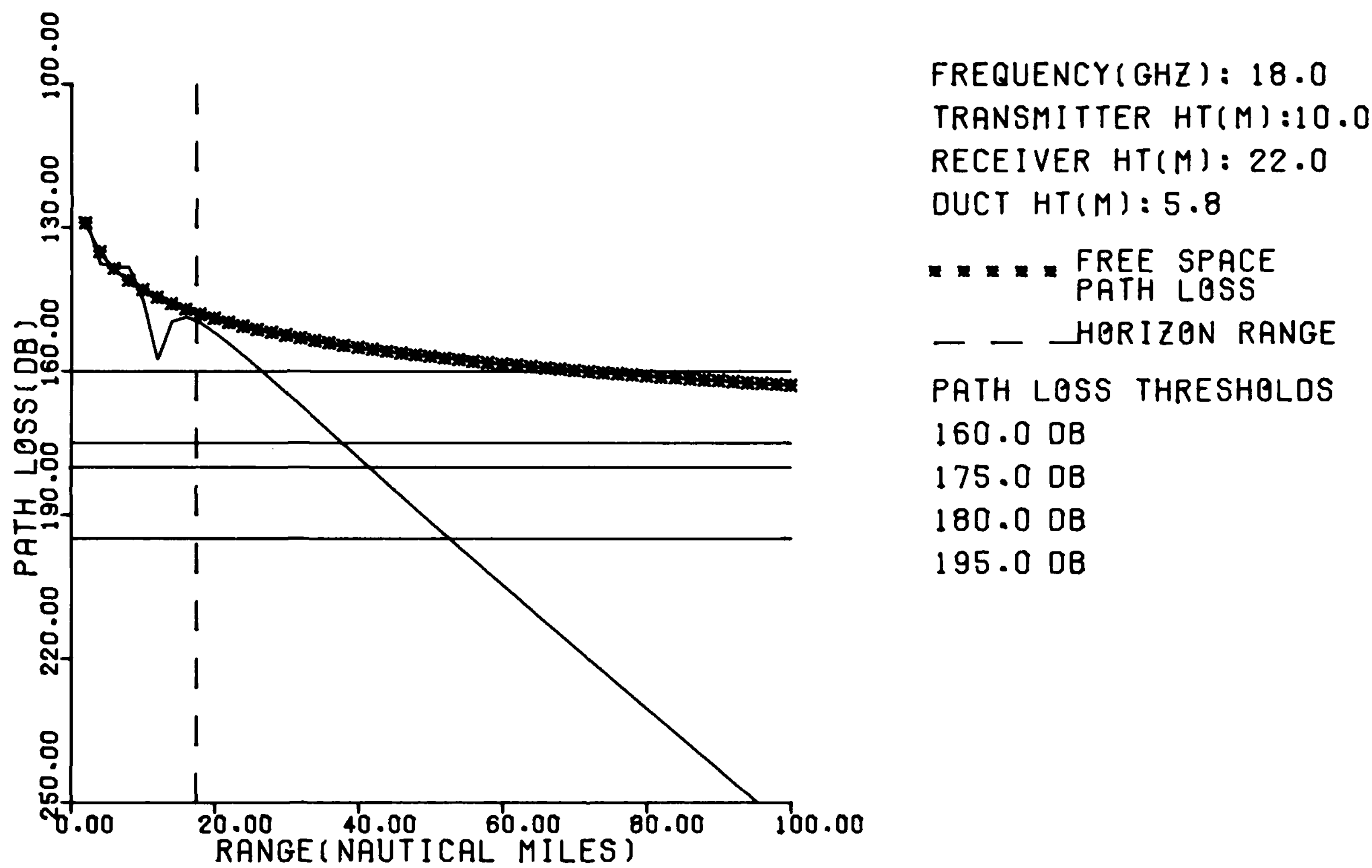


PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 29.2
* * * * * FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

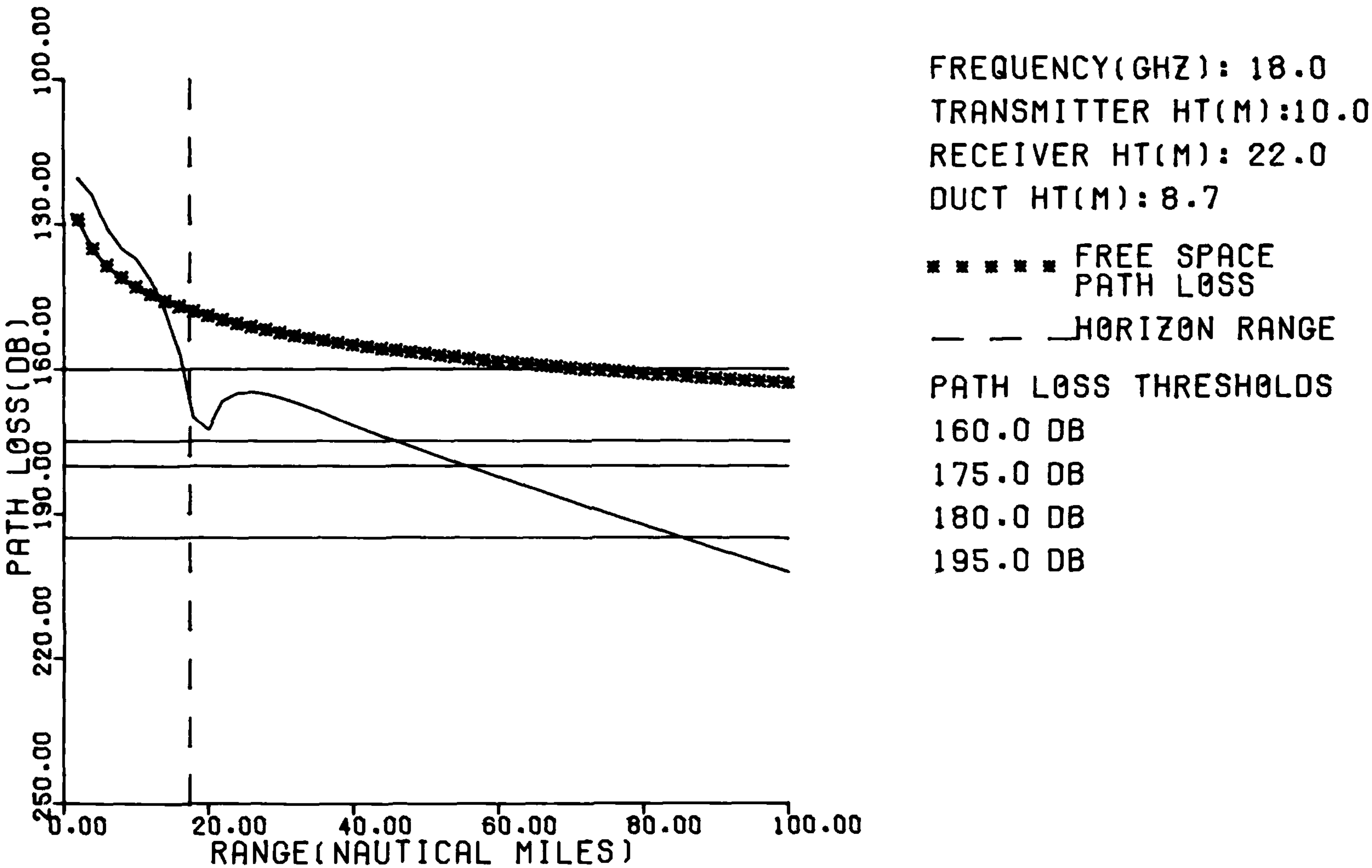


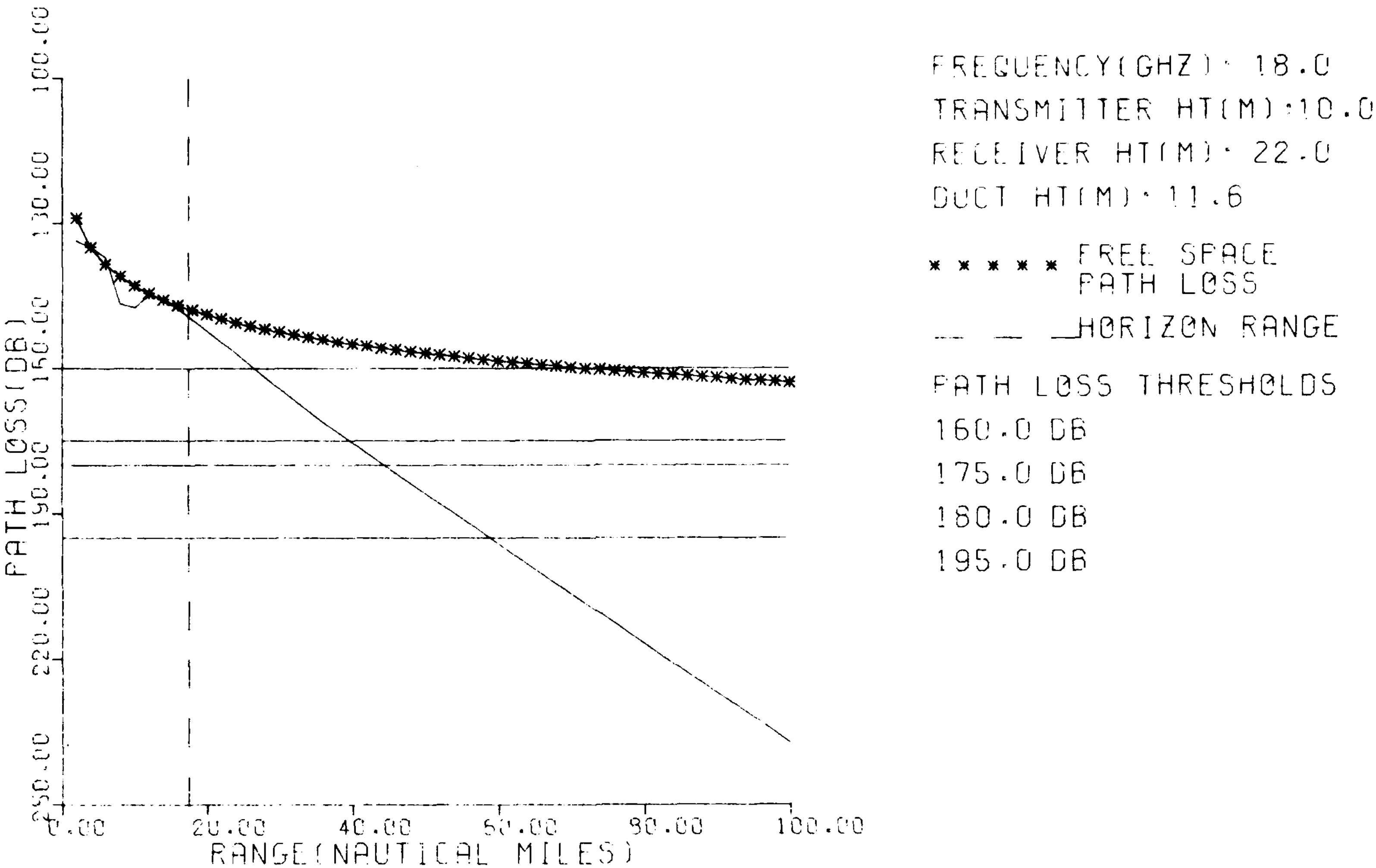
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 0.0
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

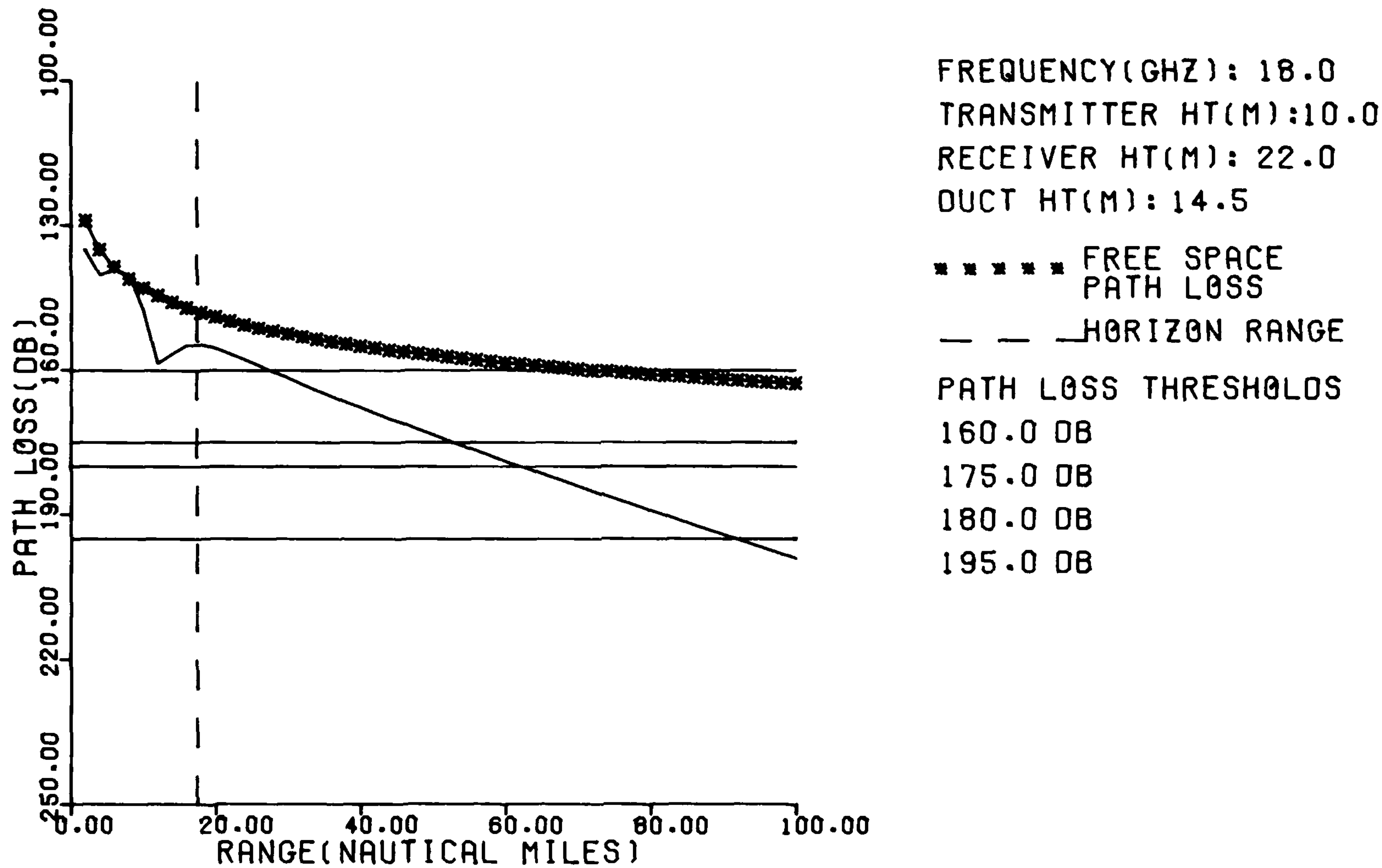

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 2.9
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00

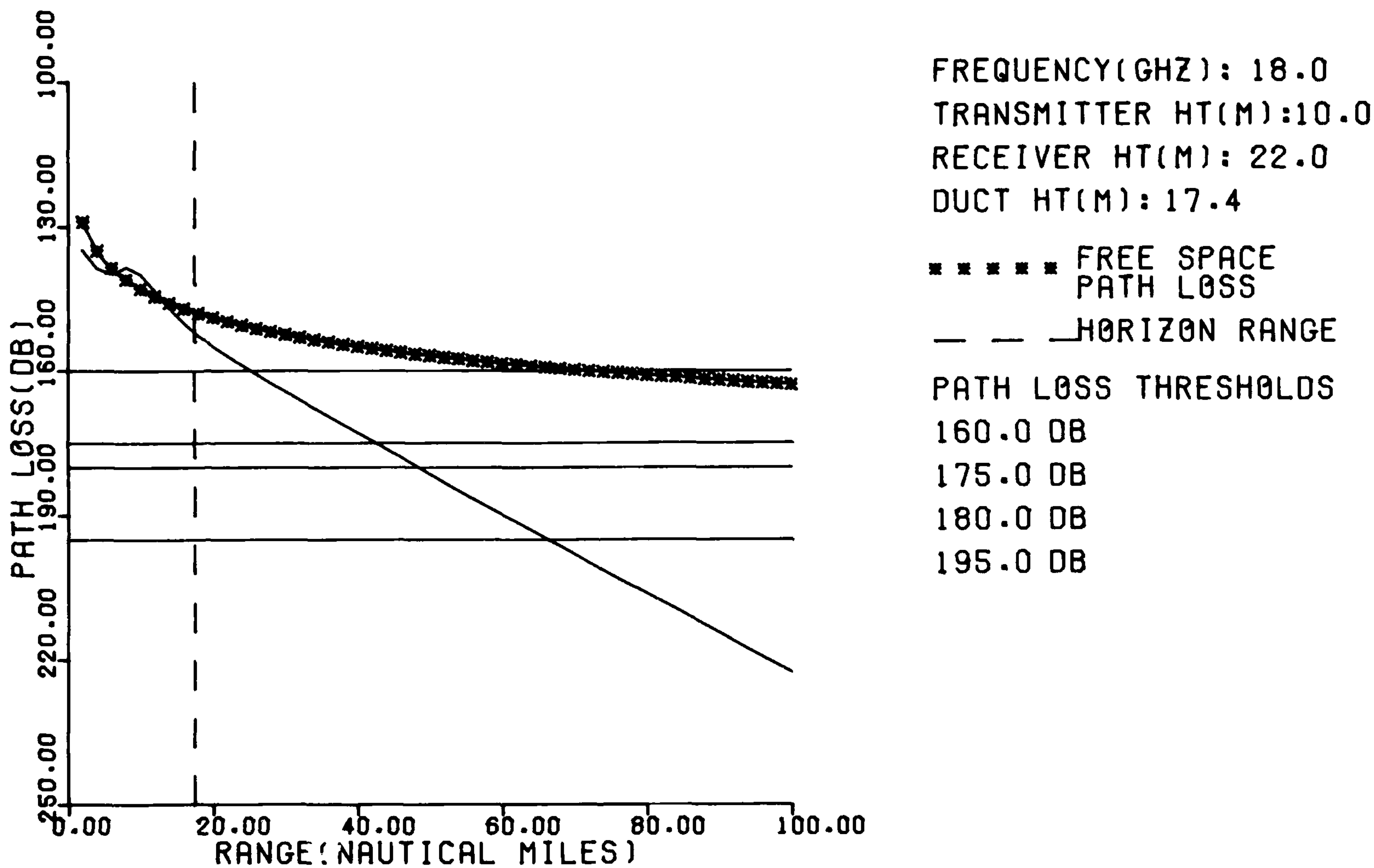


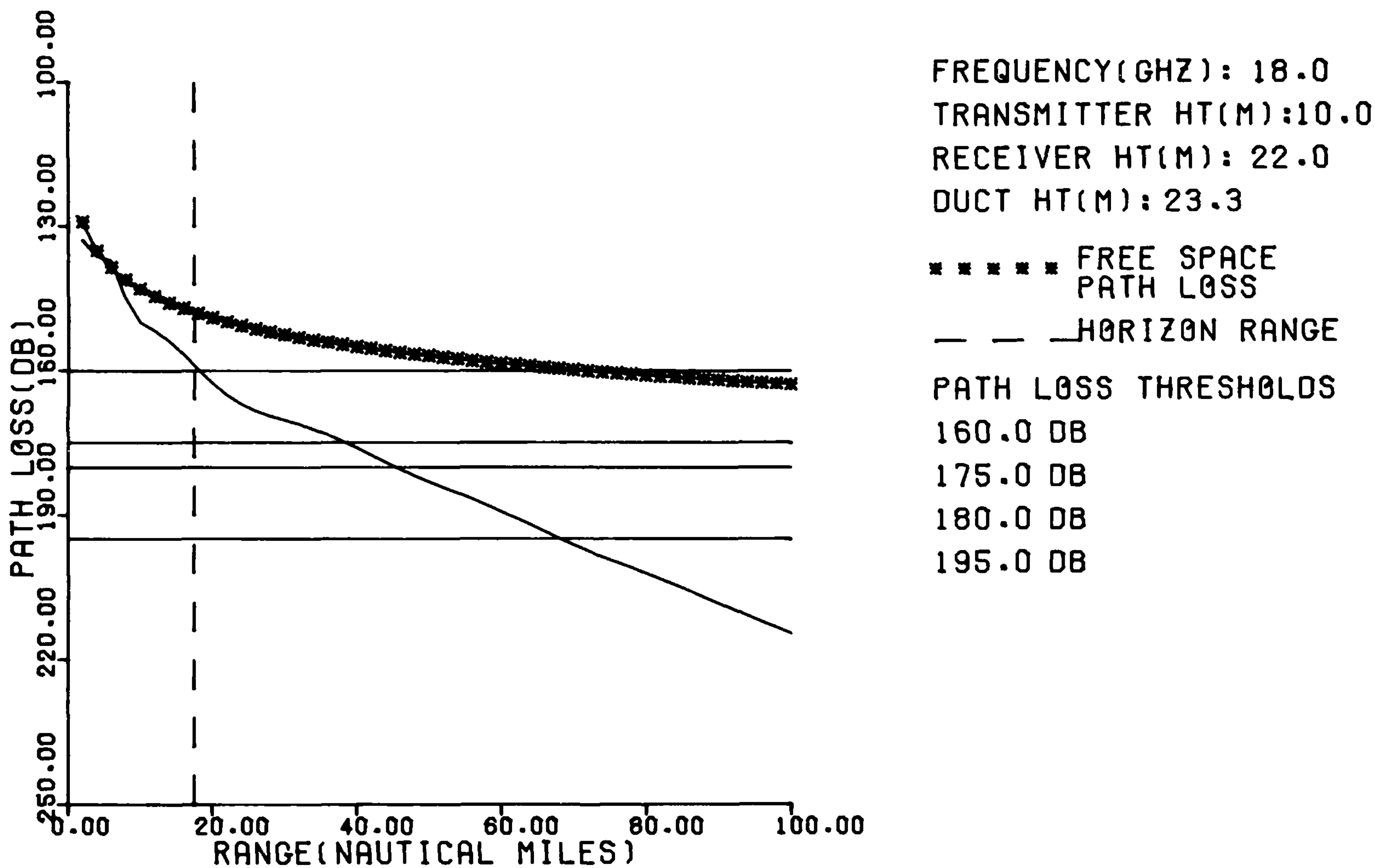
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 5.8
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 8.7
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

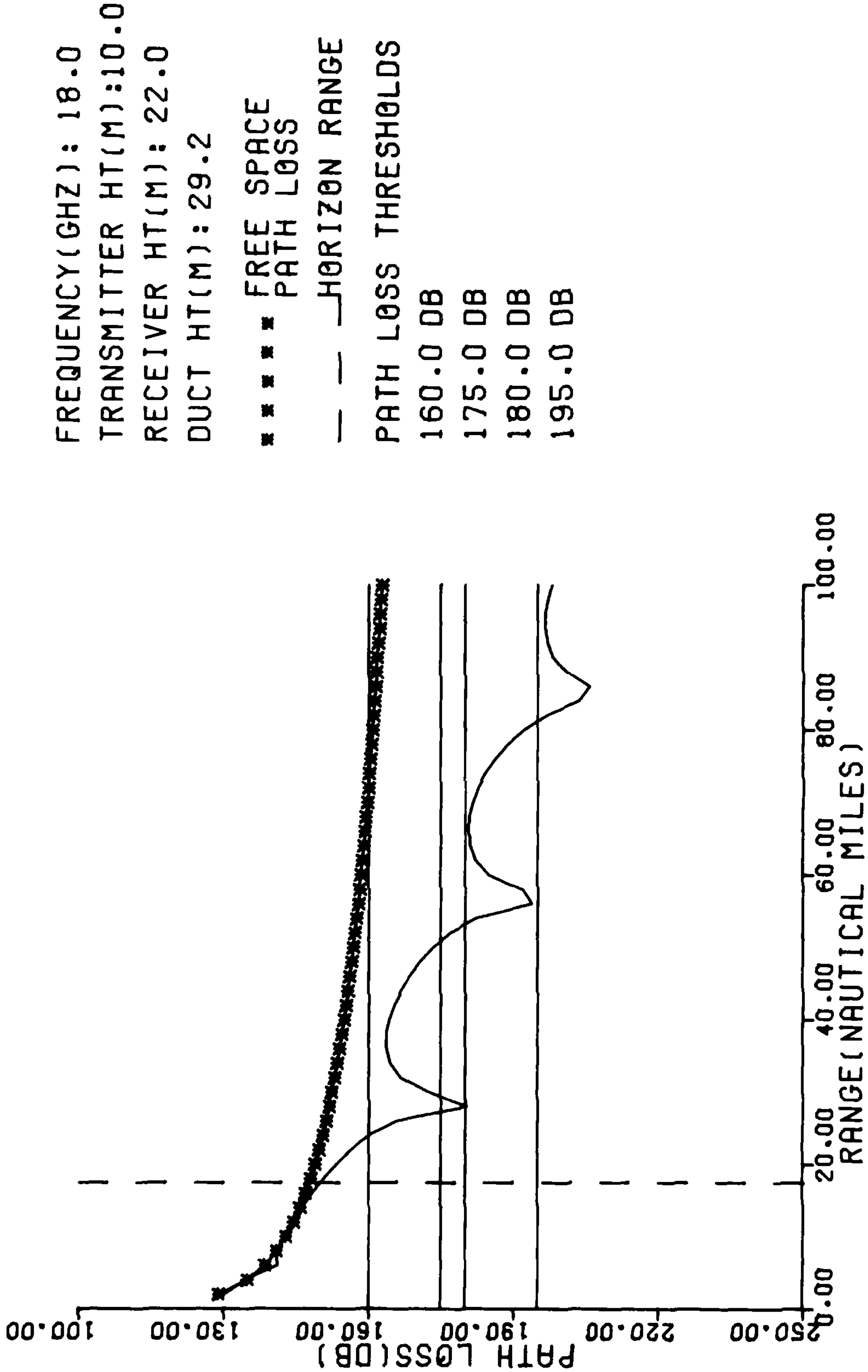

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 11.6
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00

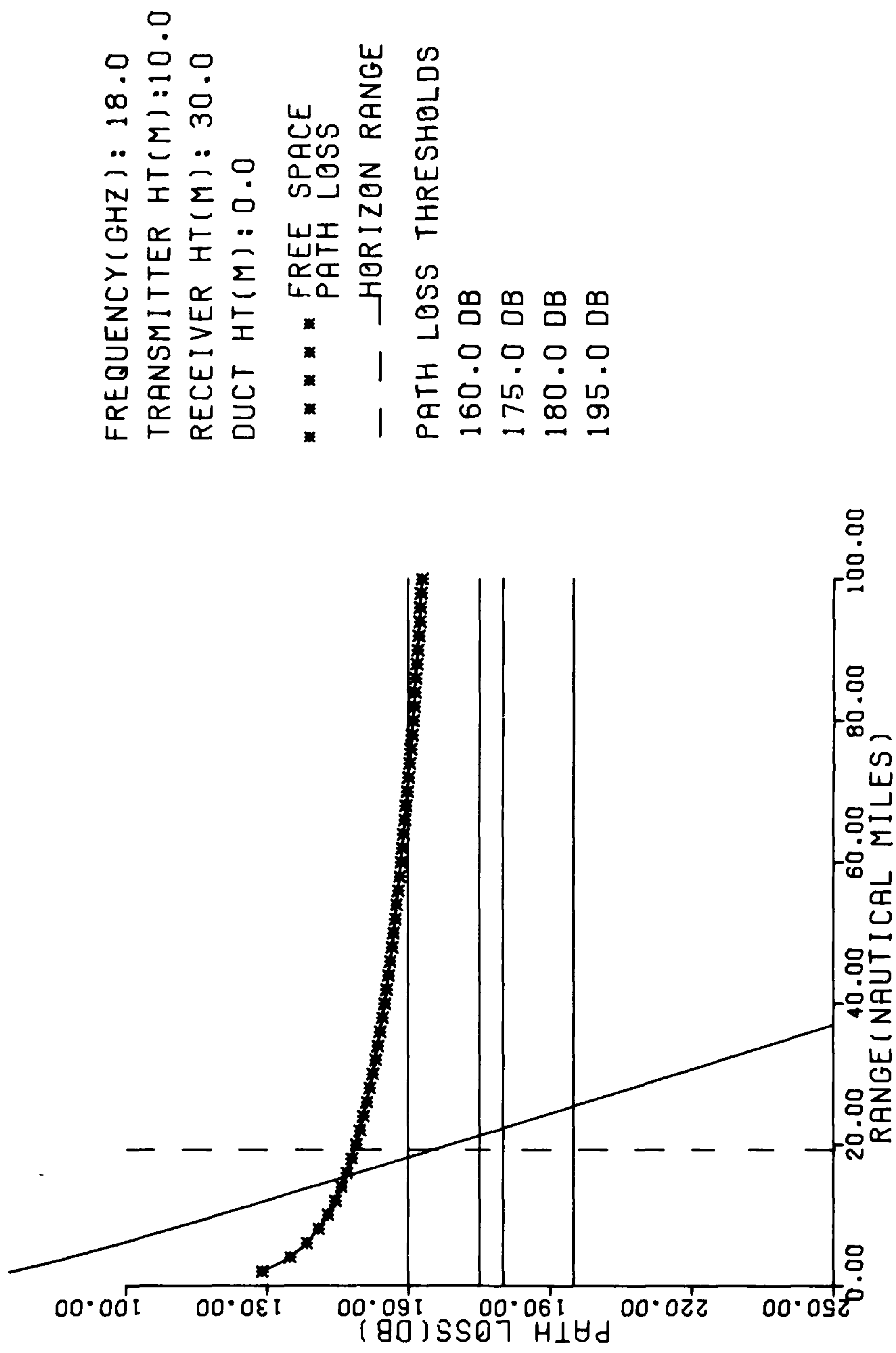

100.00
130.00
160.00
190.00
220.00
250.00
PATH LØSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 14.5
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

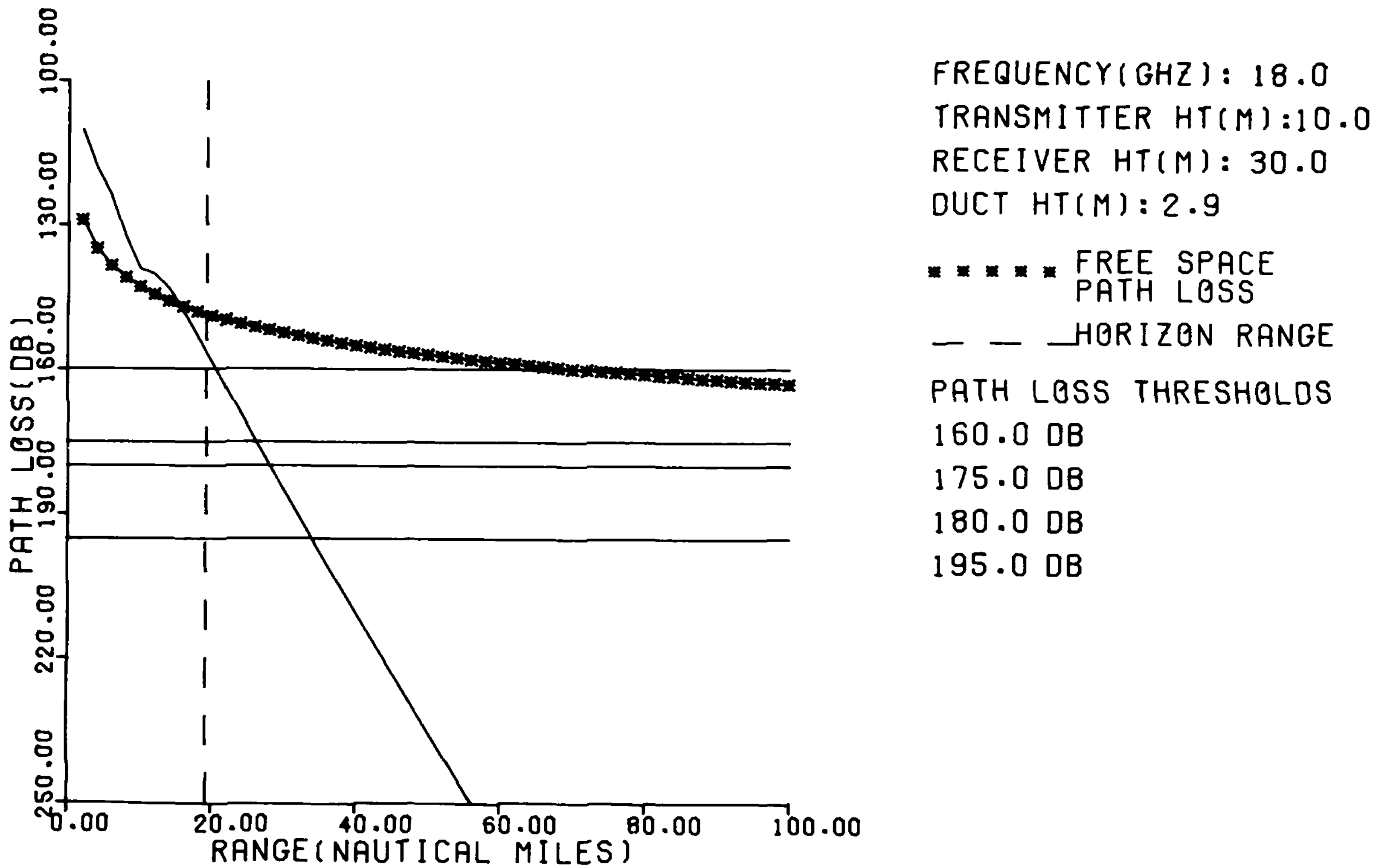

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 17.4
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

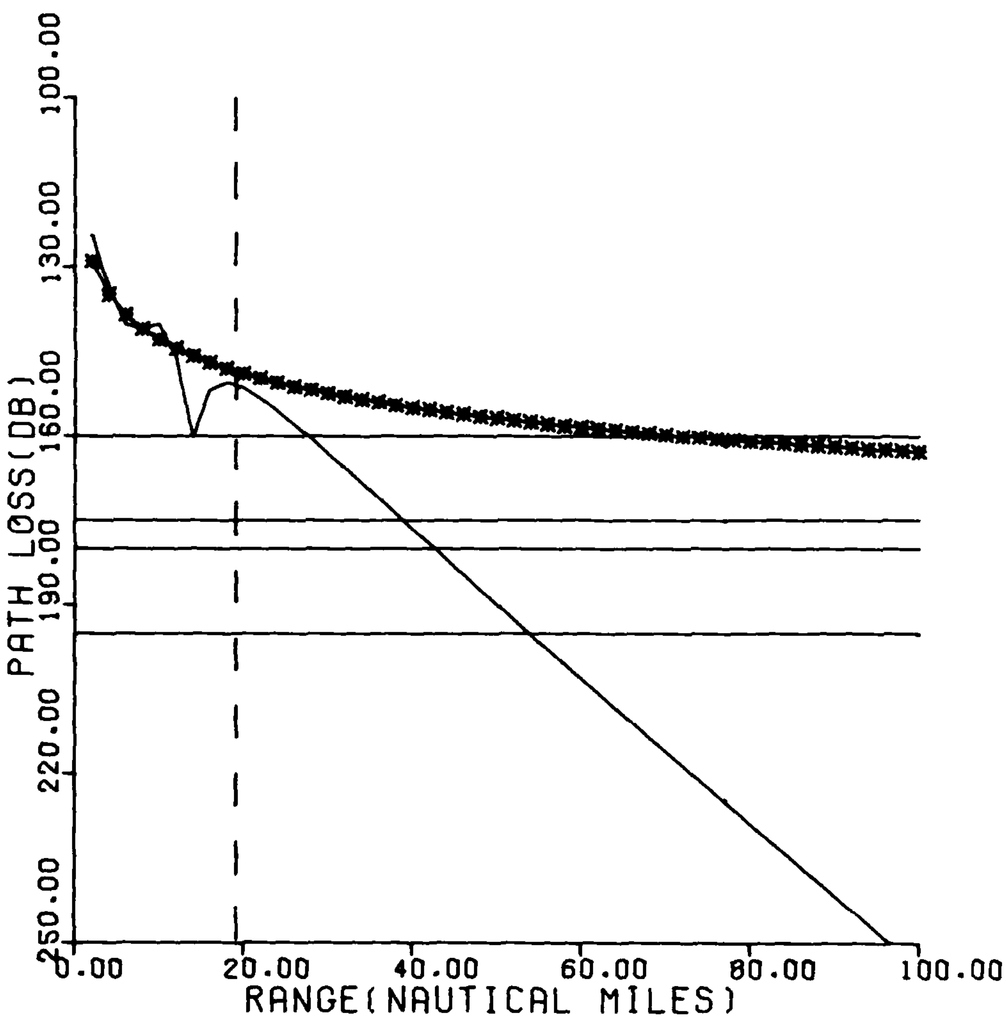


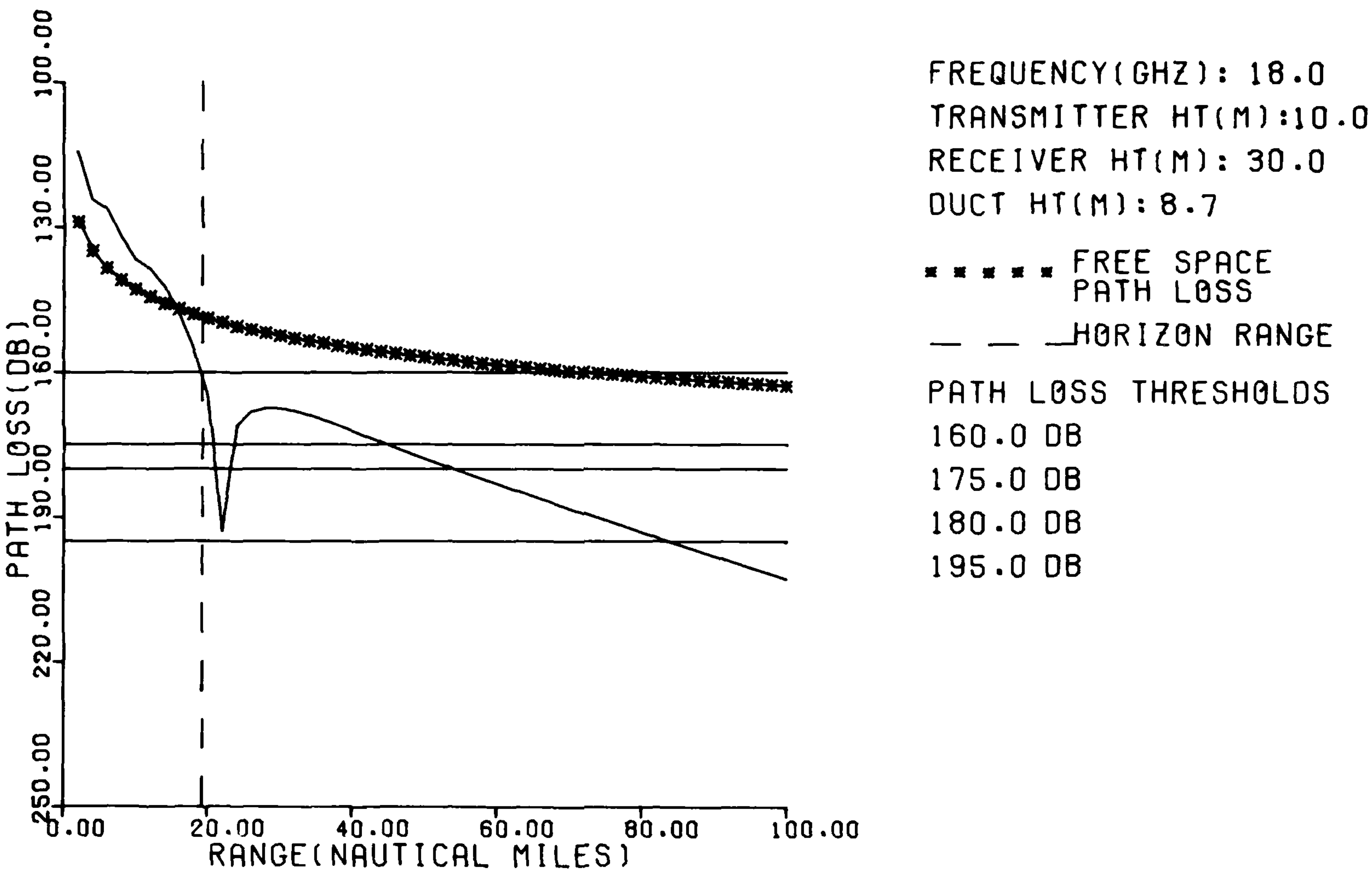
100.00
130.00
160.00
190.00
220.00
250.00
PATH LØSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 23.3
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

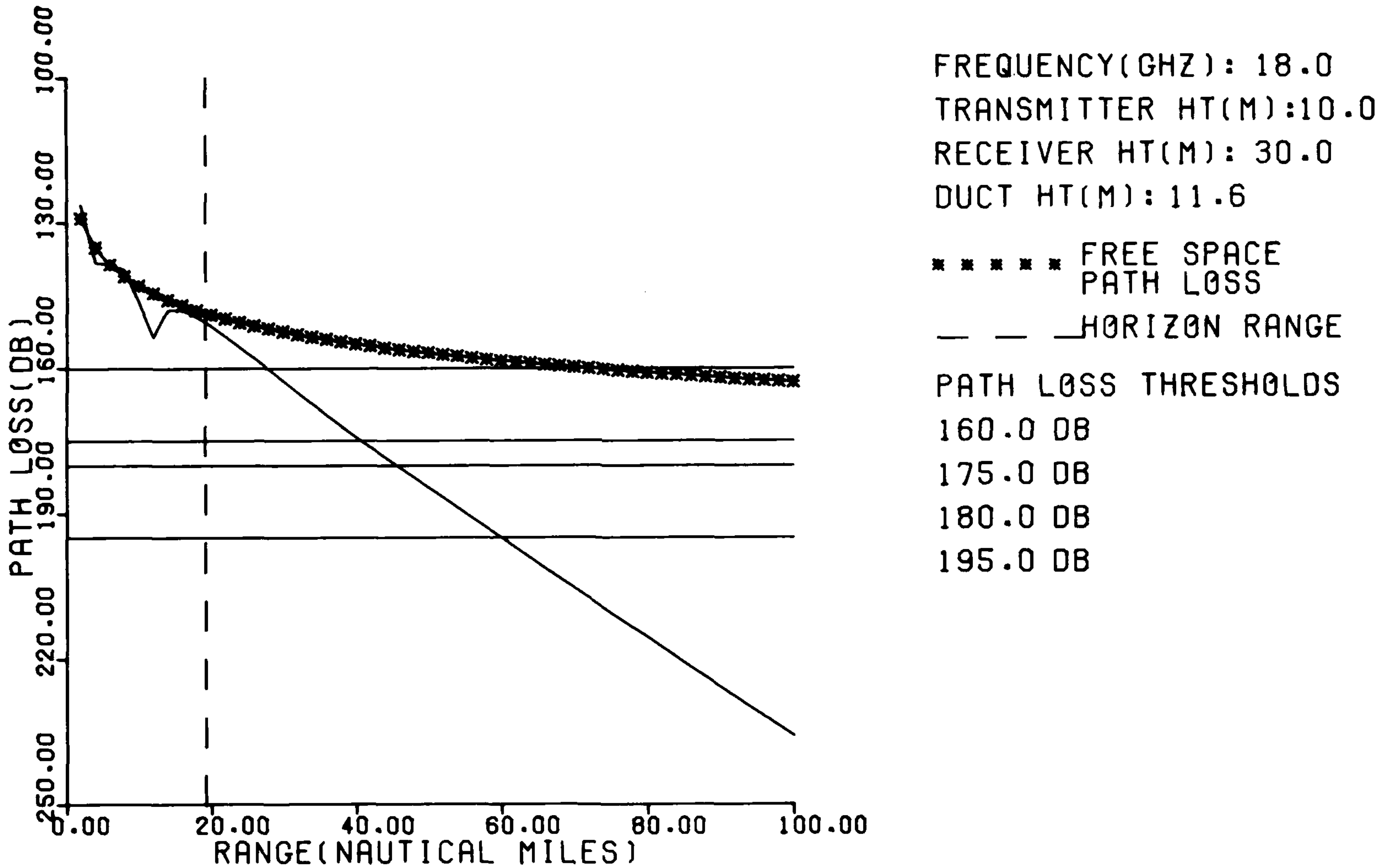

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 29.2
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00

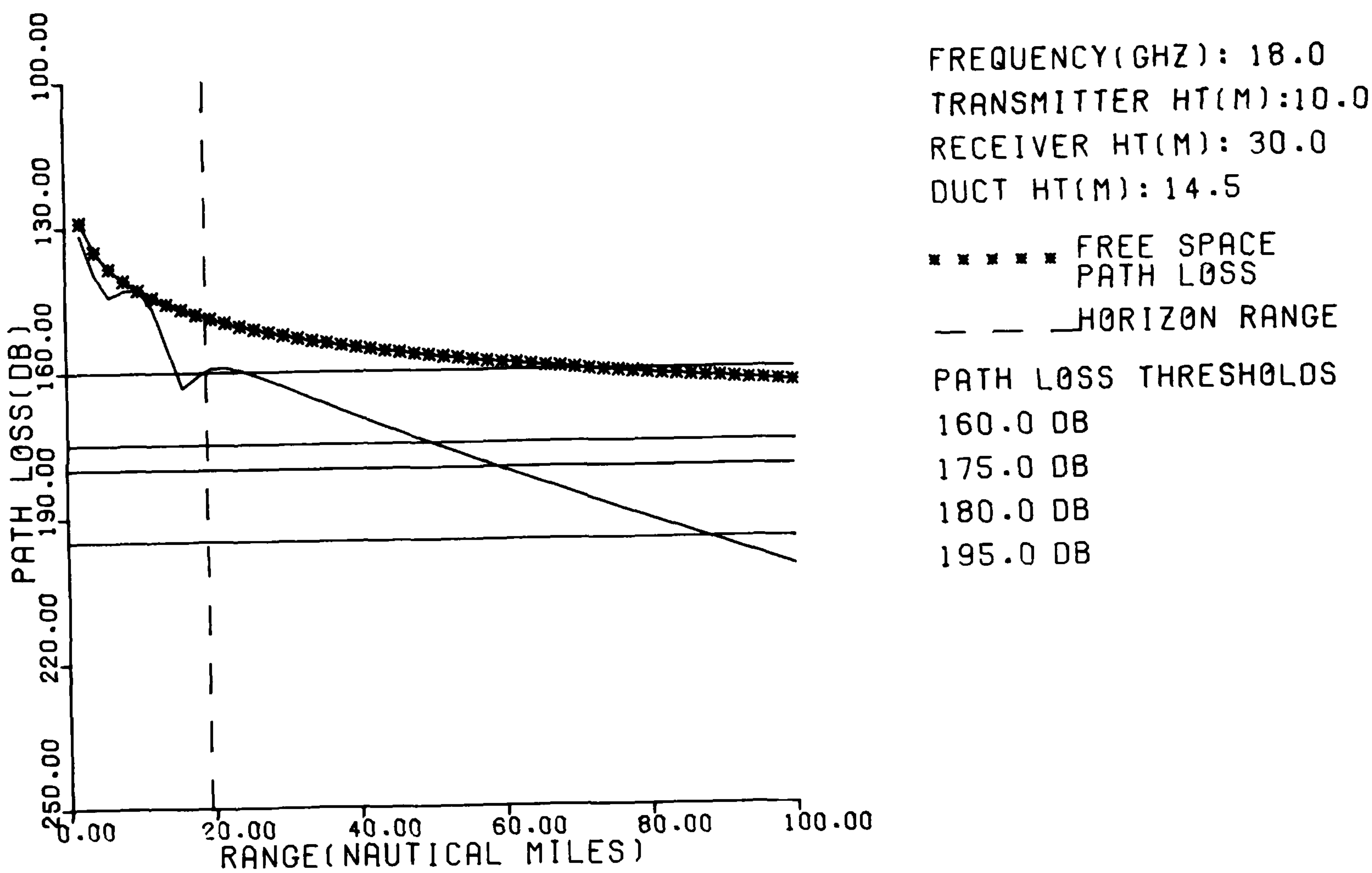

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 0.0
* * * * * FREE SPACE PATH LØSS
— — —HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00

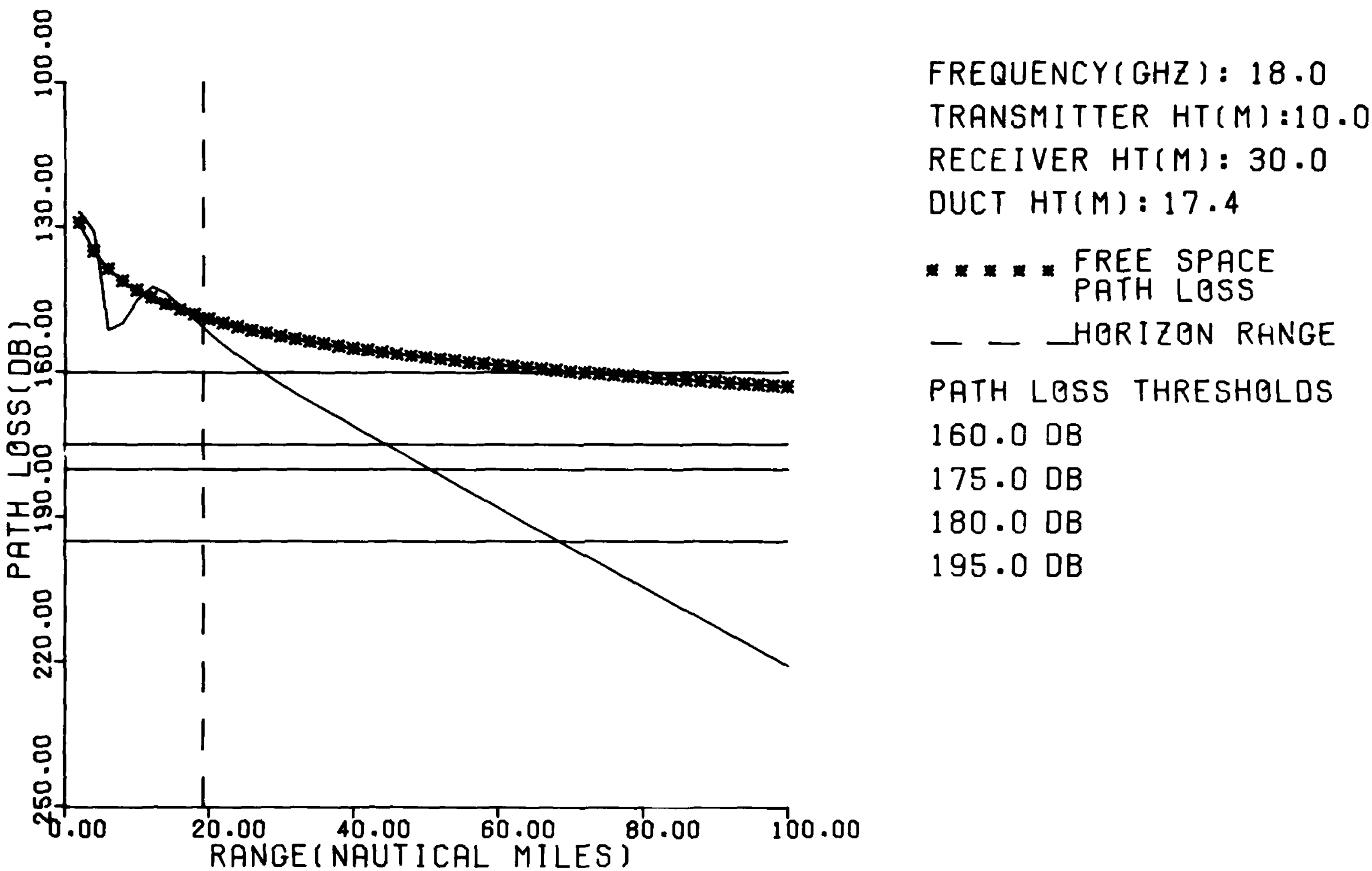

FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 2.9
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

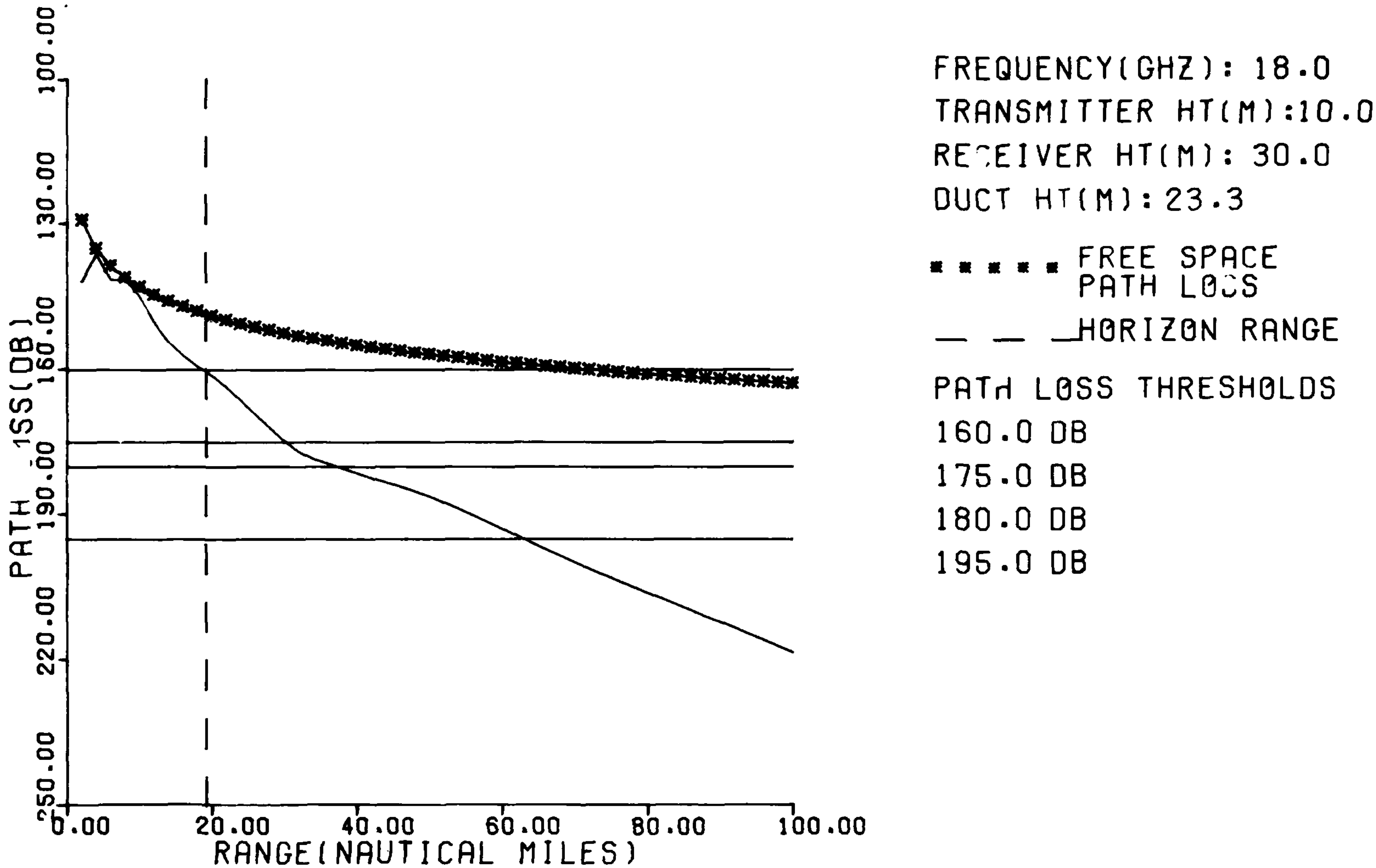

100.00
130.00
160.00
190.00
220.00
250.00
PATH LØSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 5.8
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB


FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 8.7
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 11.6
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 14.5
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


100.00
130.00
160.00
190.00
220.00
250.00
PATH LØSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 17.4
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB


FREQUENCY(GHZ): 18.0
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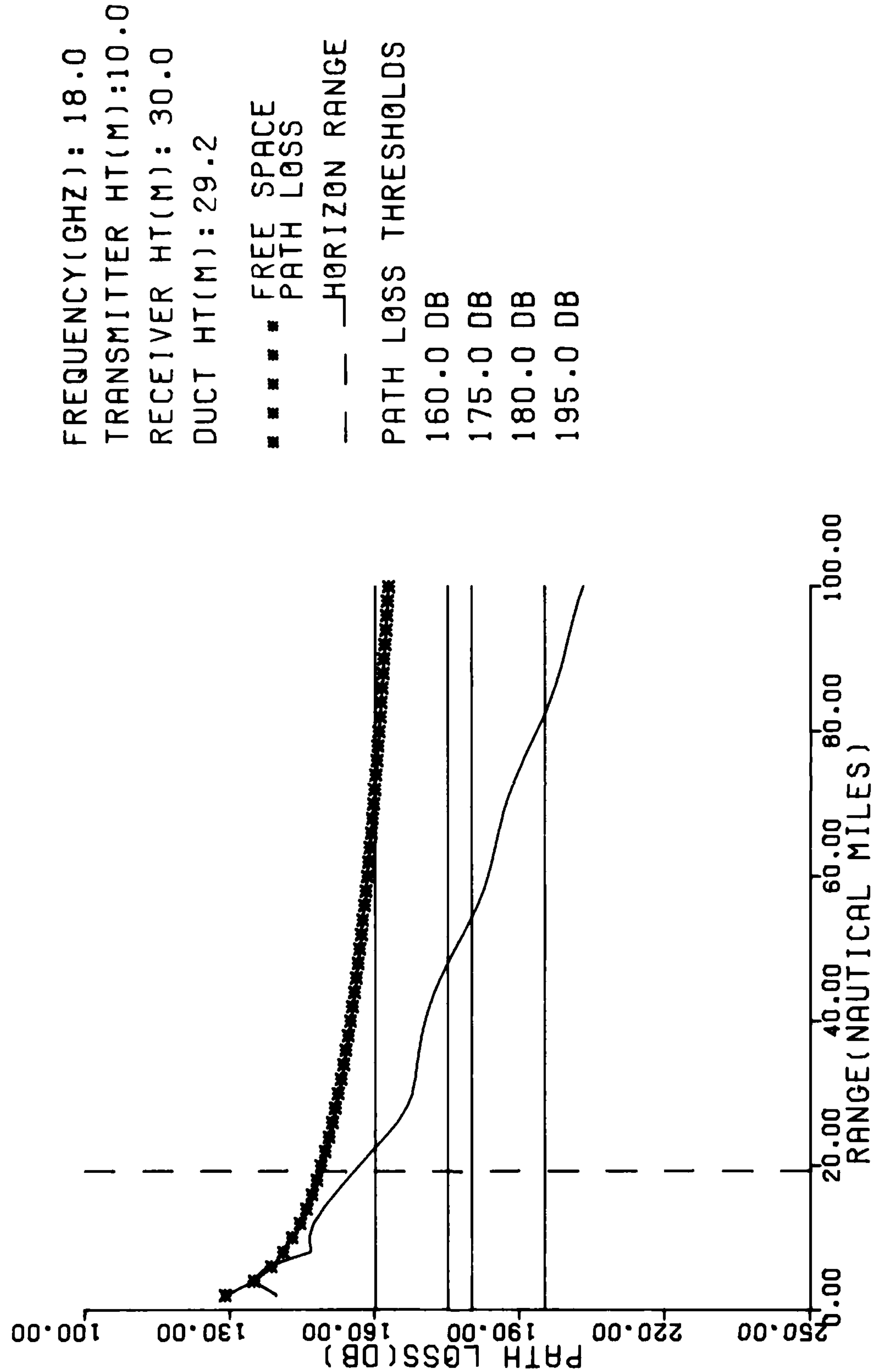
RECEIVER HT(M): 30.0
DUCT HT(M): 23.3
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)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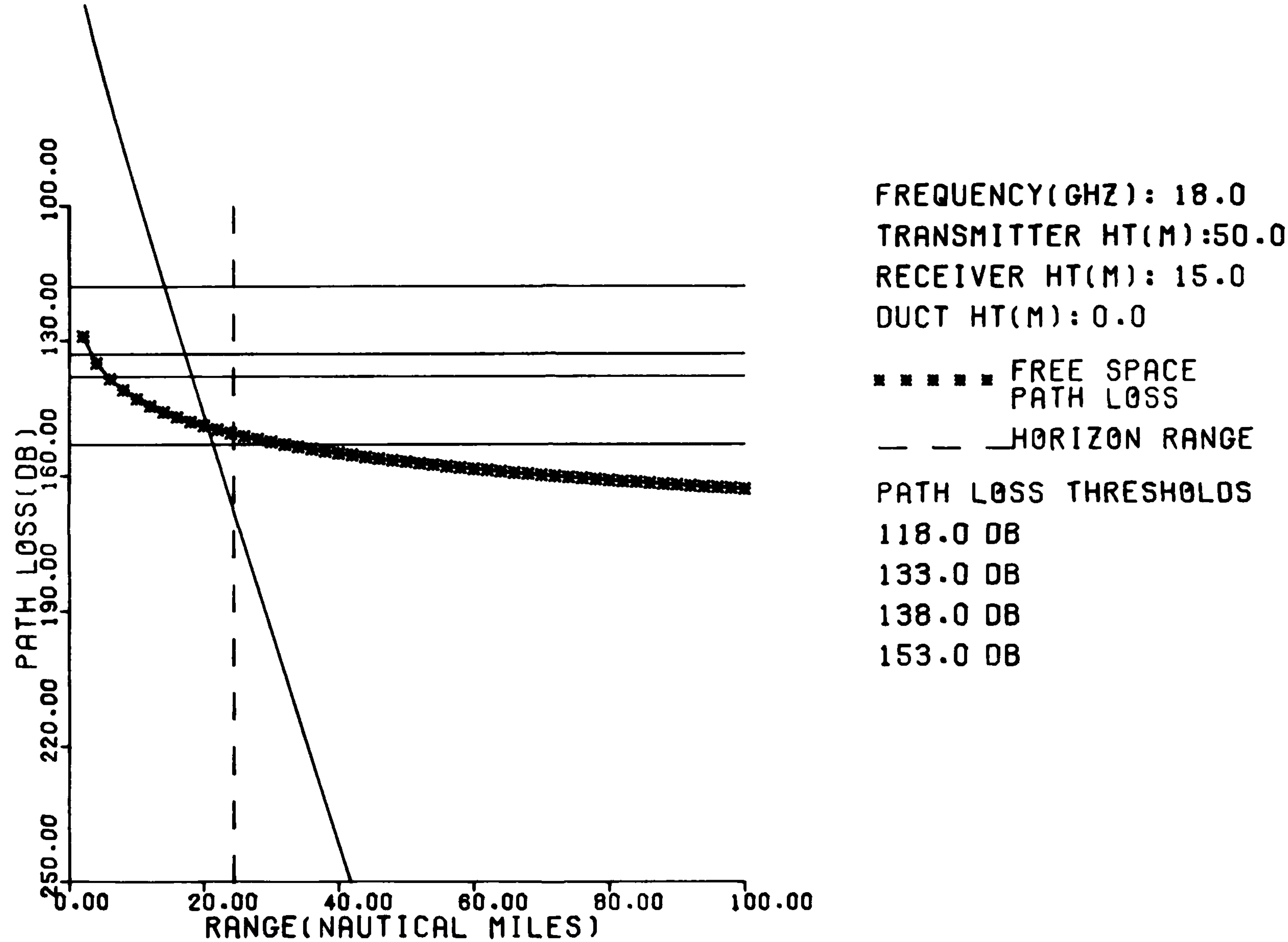
RECEIVER HT(M): 30.0
DUCT HT(M): 29.2
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
100.00
130.00
160.00
190.00
220.00
250.00
PATH LOSS(DB)



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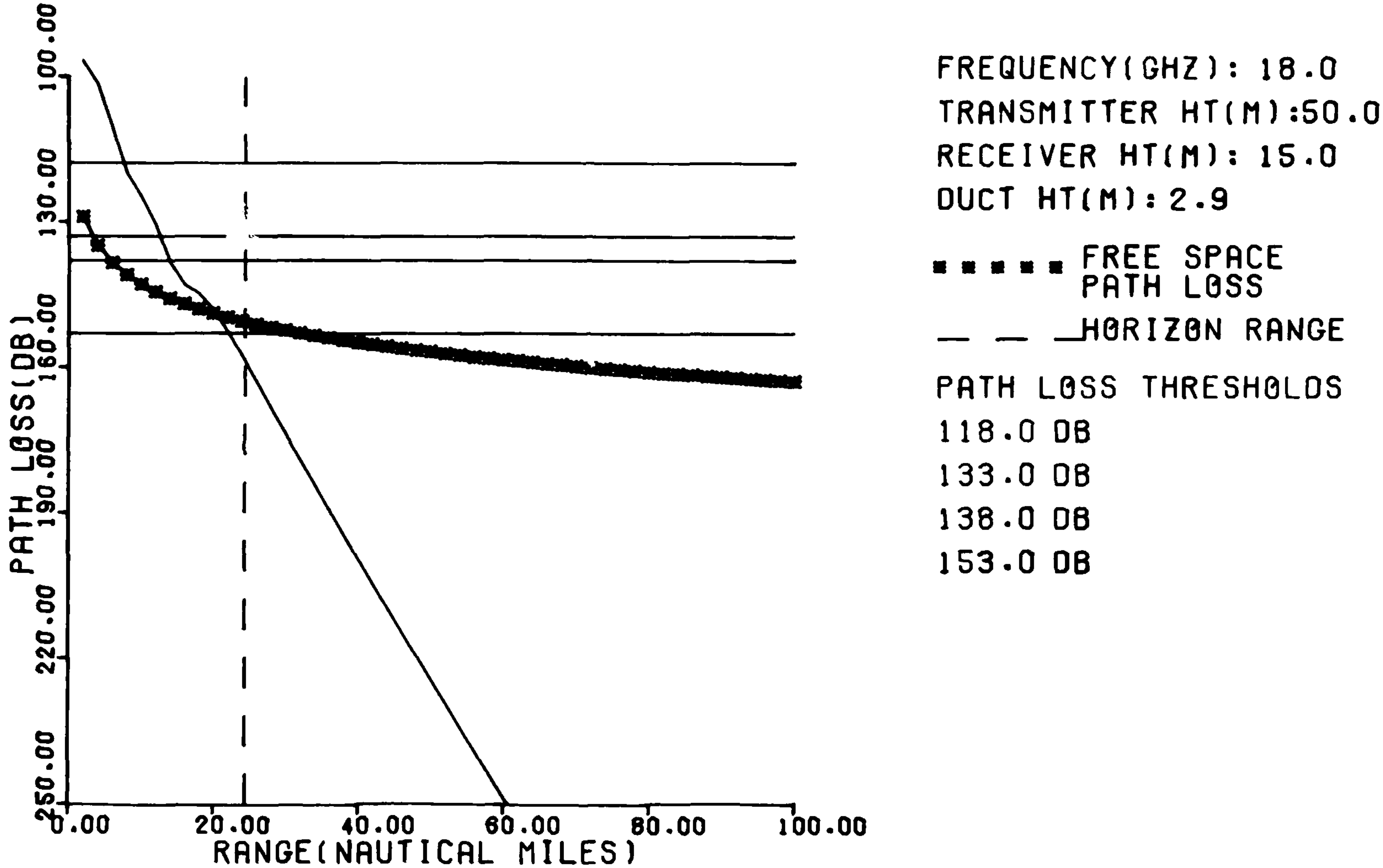
RECEIVER HT(M): 15.0
DUCT HT(M): 0.0
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)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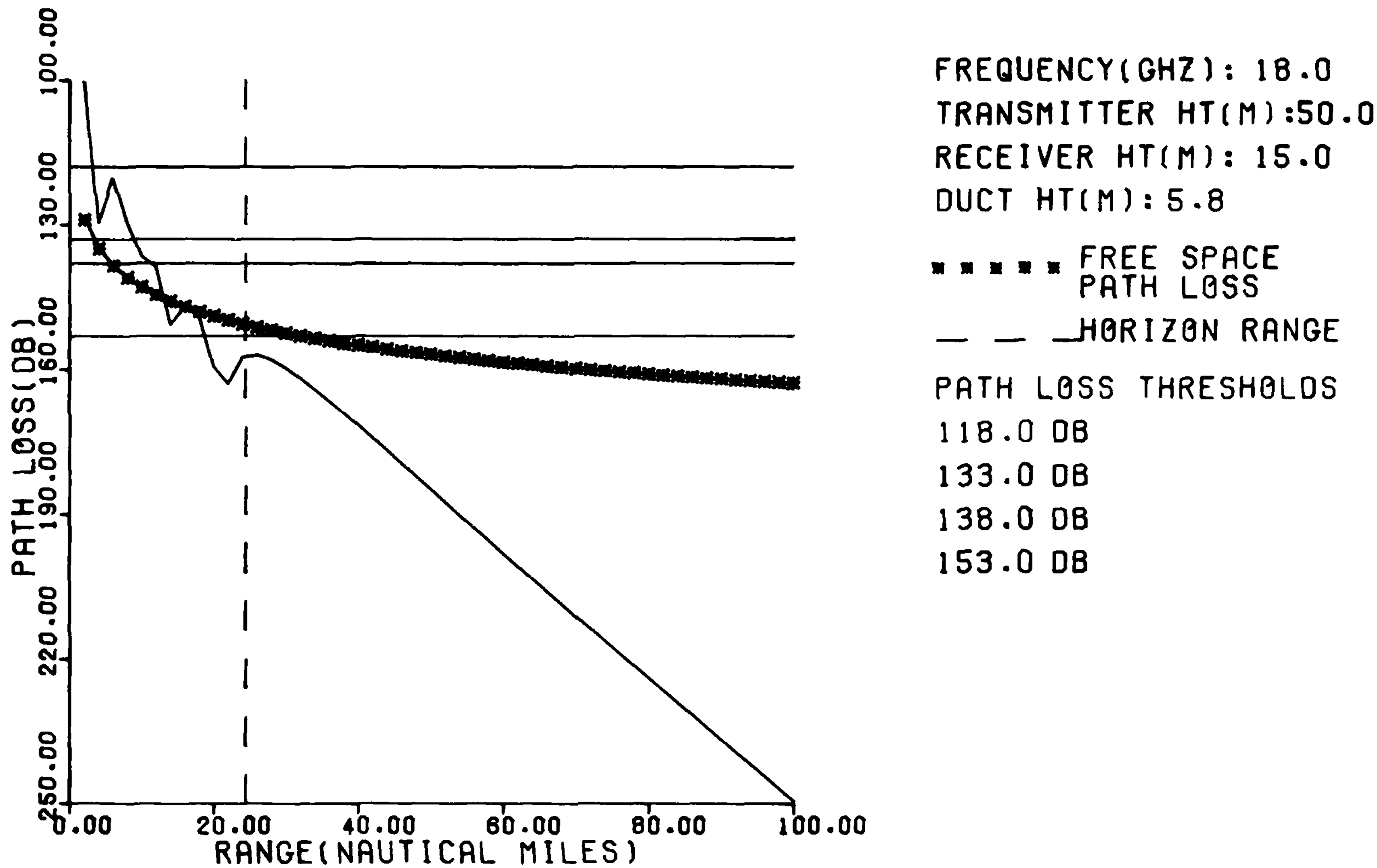
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00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RECEIVER HT(M): 15.0
DUCT HT(M): 5.8
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
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190.00
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0.00
20.00
40.00
60.00
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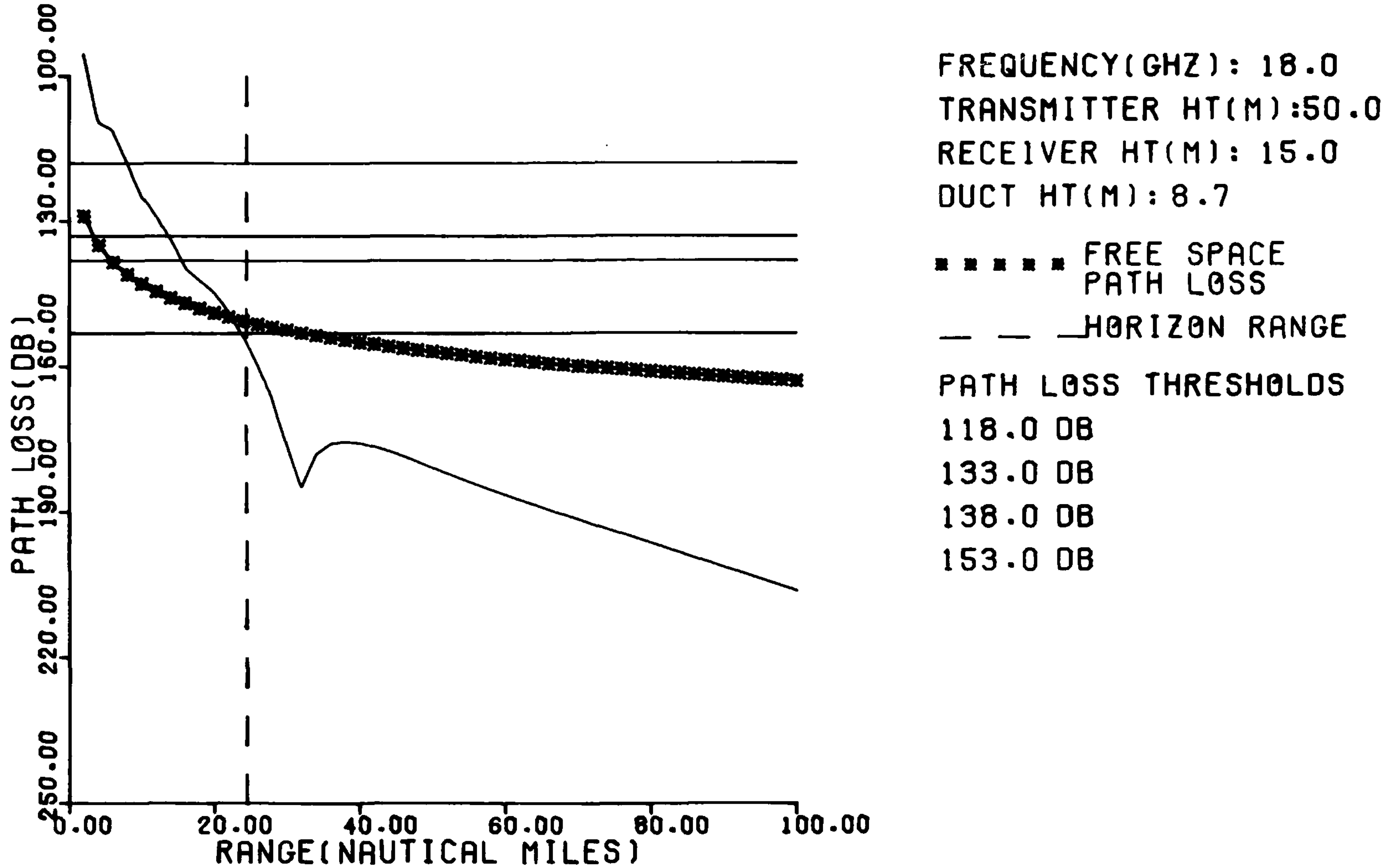
100.00
RANGE(NAUTICAL MILES)



PATH LØSS(DB)
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220.00
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20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 8.7
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HØRIZØN RANGE
PATH LØSS THRESHØLDS
118.0 DB
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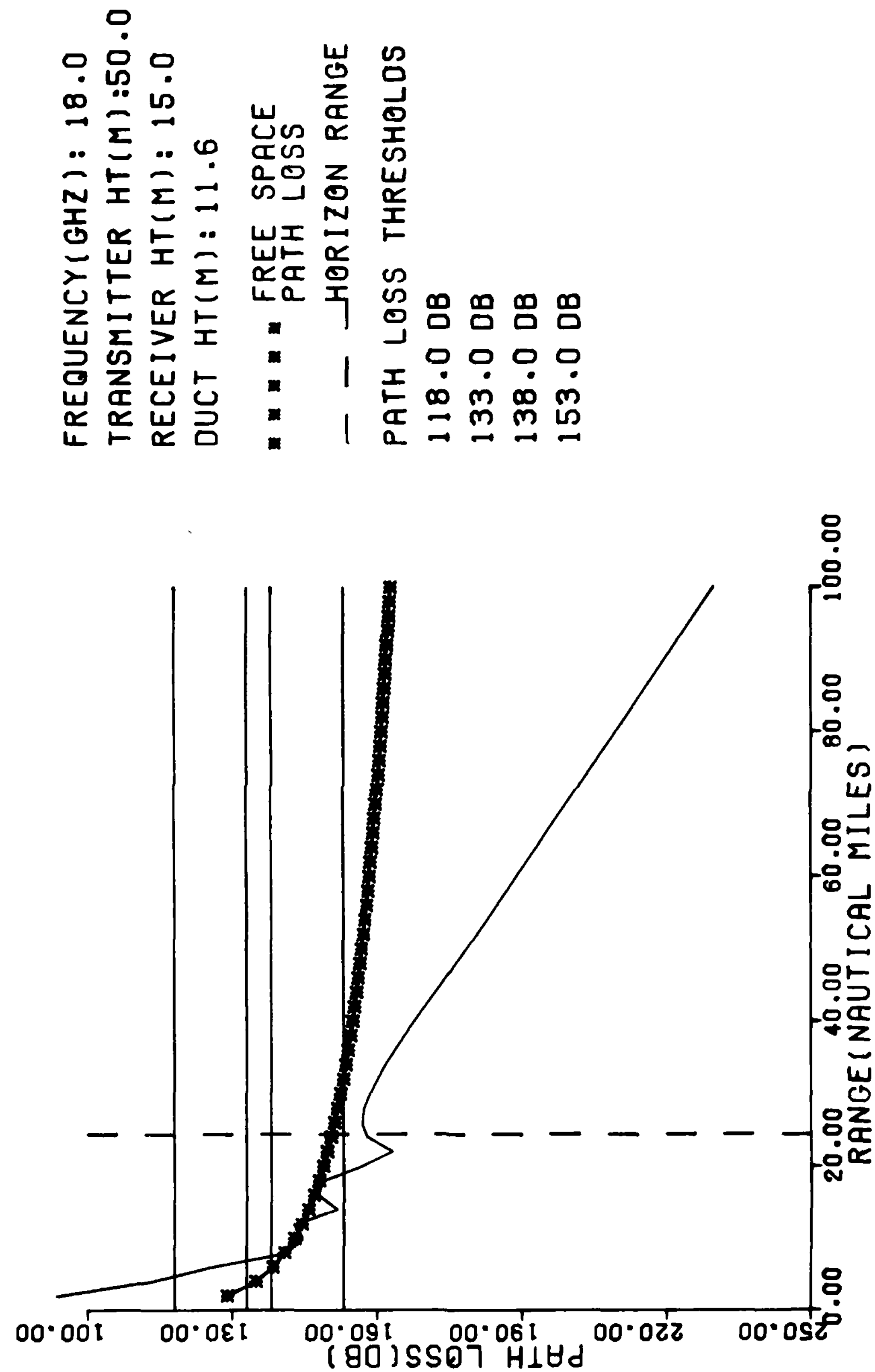
138.0 DB
153.0 DB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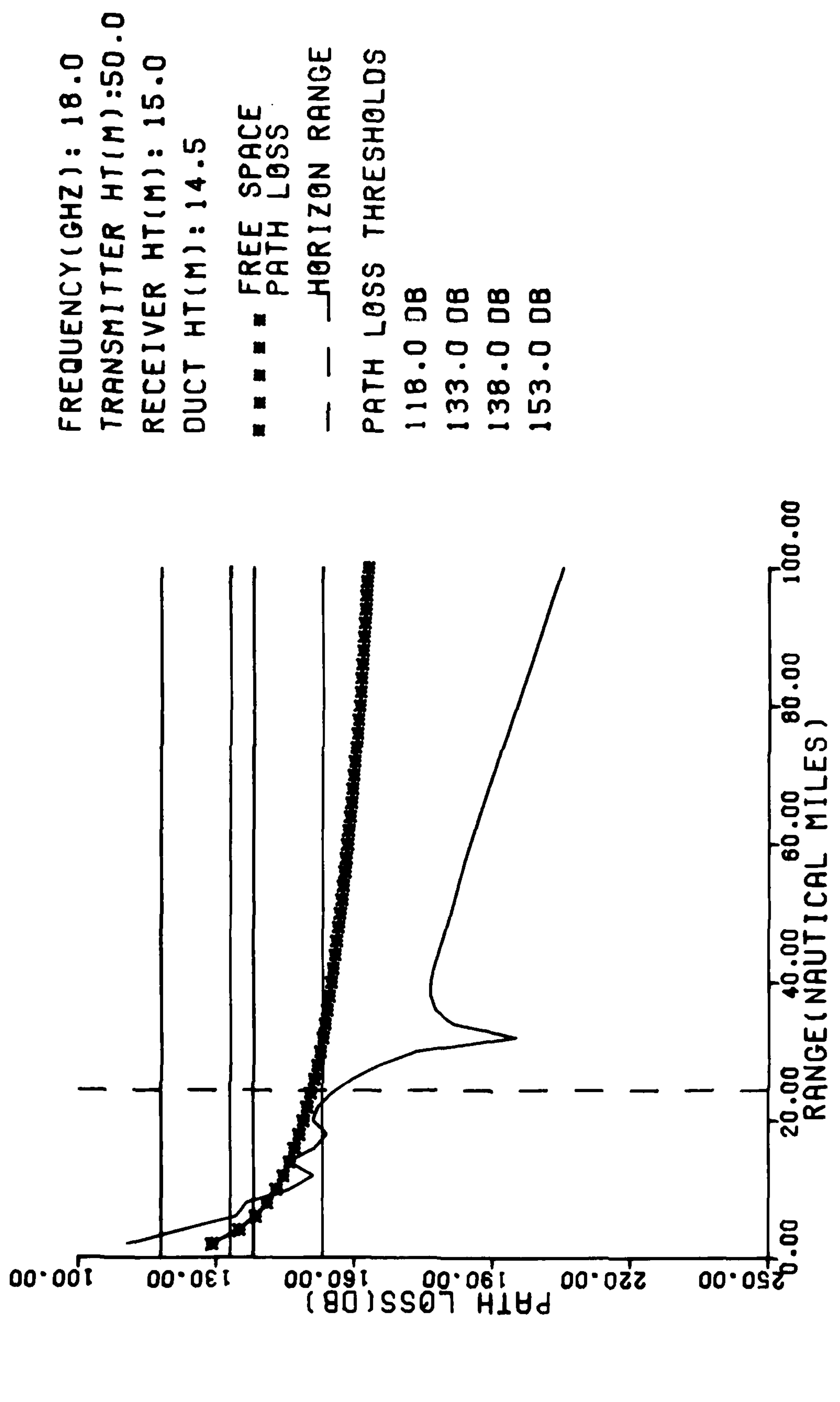
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00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RECEIVER HT(M): 15.0
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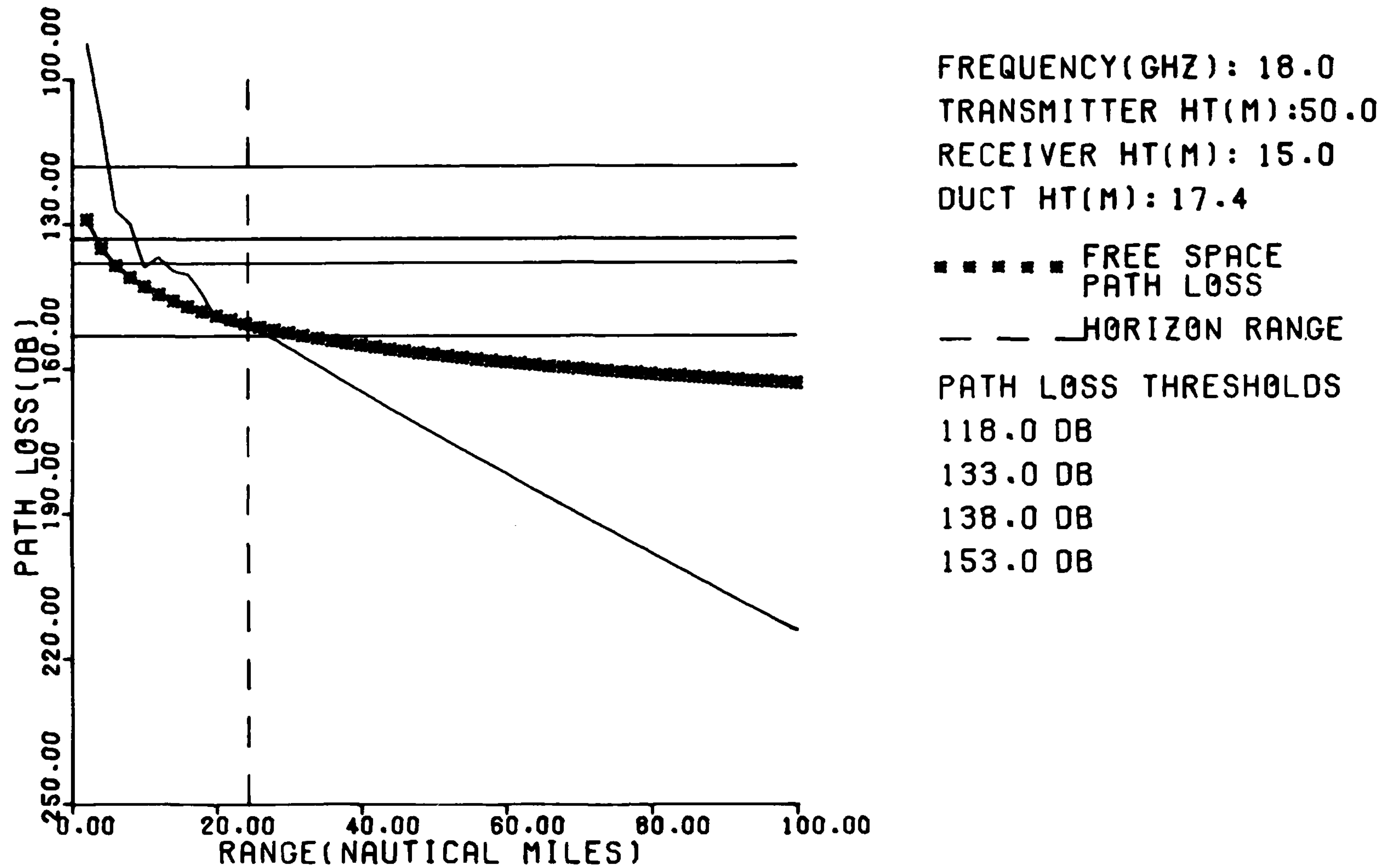
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00



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FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
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133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
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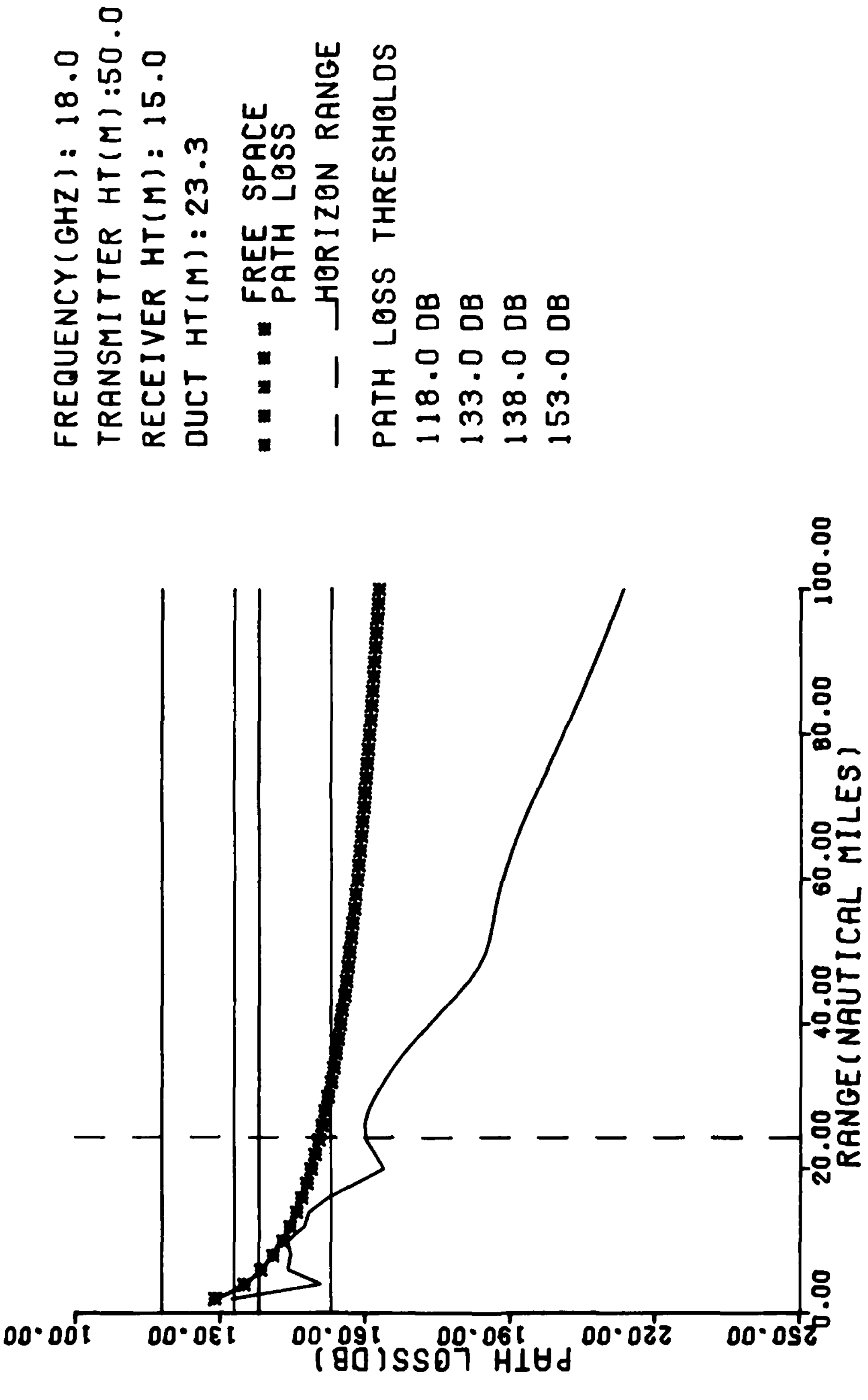
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)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DUCT HT(M): 23.3
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
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250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
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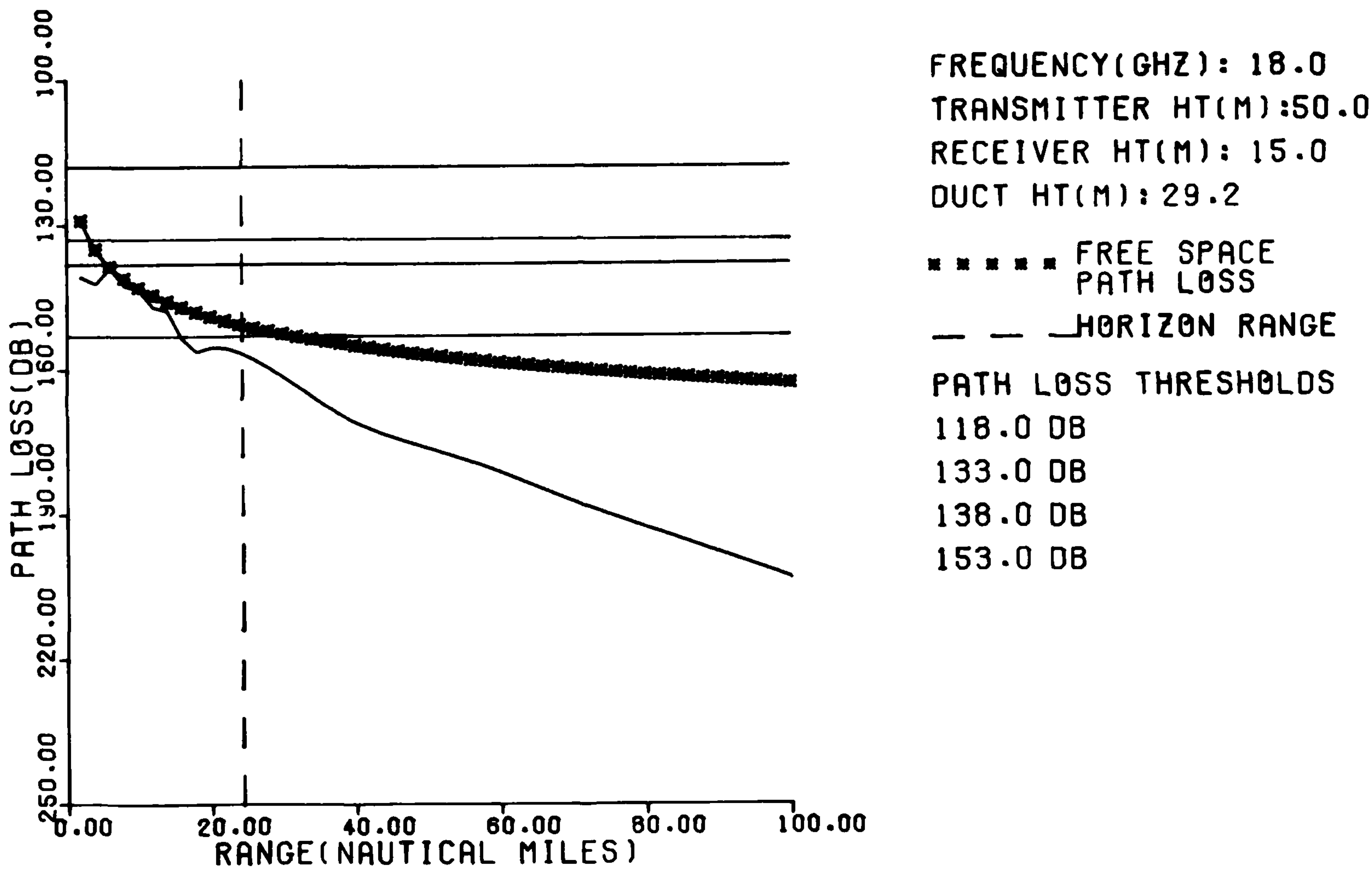
100.00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HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
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130.00
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20.00
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60.00
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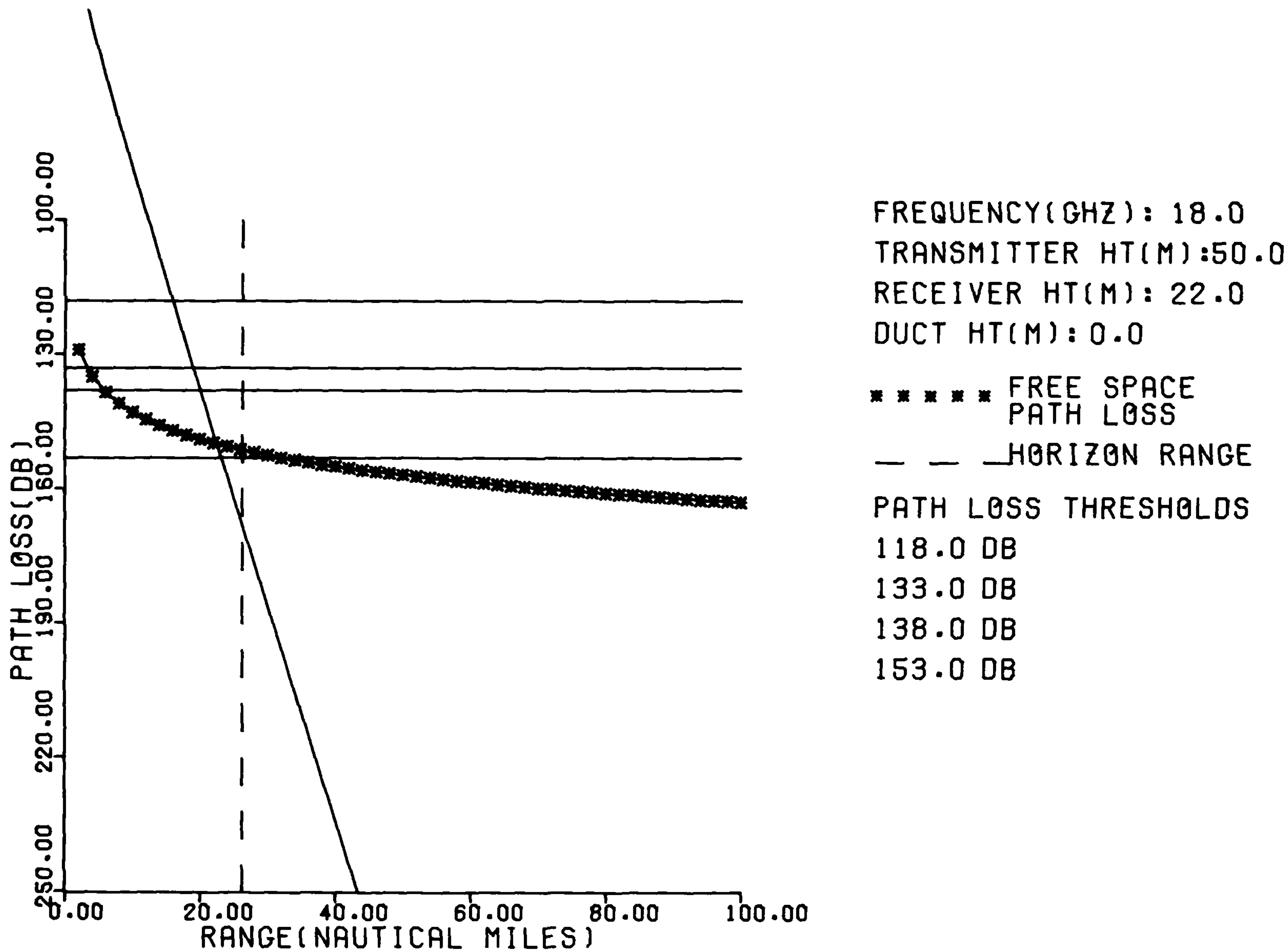
100.00
RANGE(NAUTICAL MILES)



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HORIZON RANGE
PATH LOSS THRESHOLDS
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133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
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250.00
RANGE(NAUTICAL MILES)
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60.00
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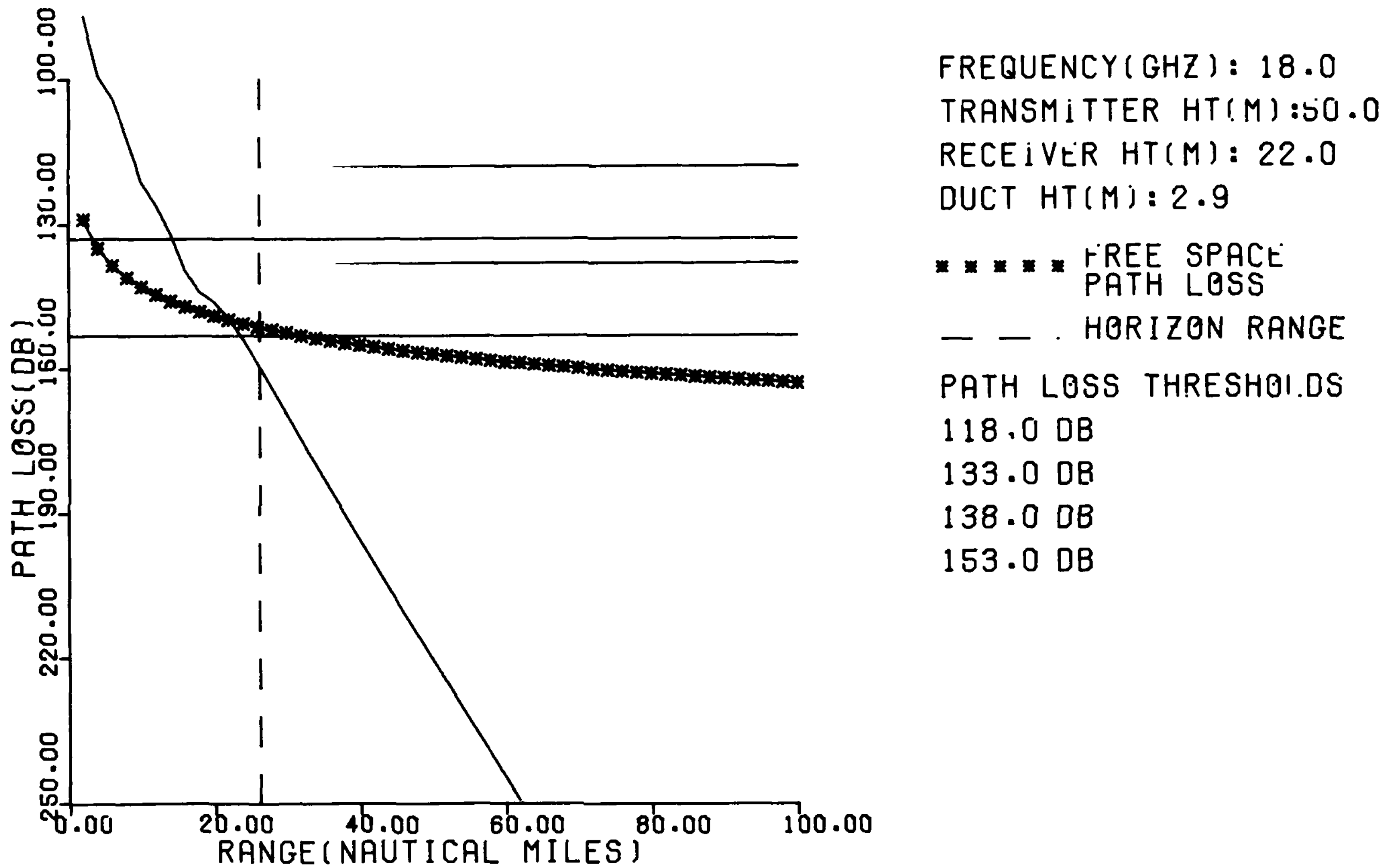
100.00


PATH LØSS(DB)
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100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 2.9
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HØRIZØN RANGE
PATH LØSS THRESHØLDS
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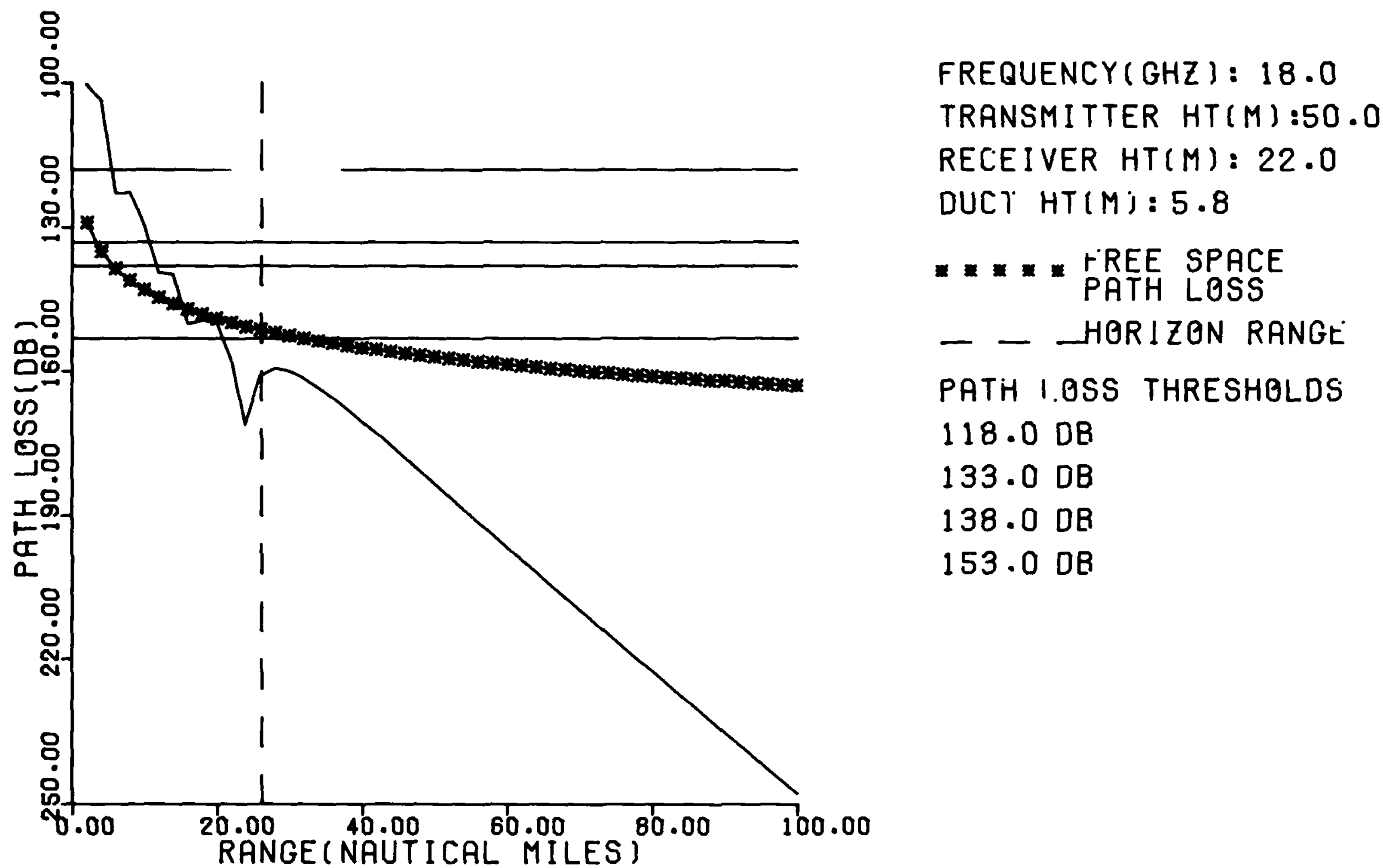
PATH LØSS(DB)
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40.00
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100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 5.8
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HØRIZØN RANGE
PATH LØSS THRESHØLDS
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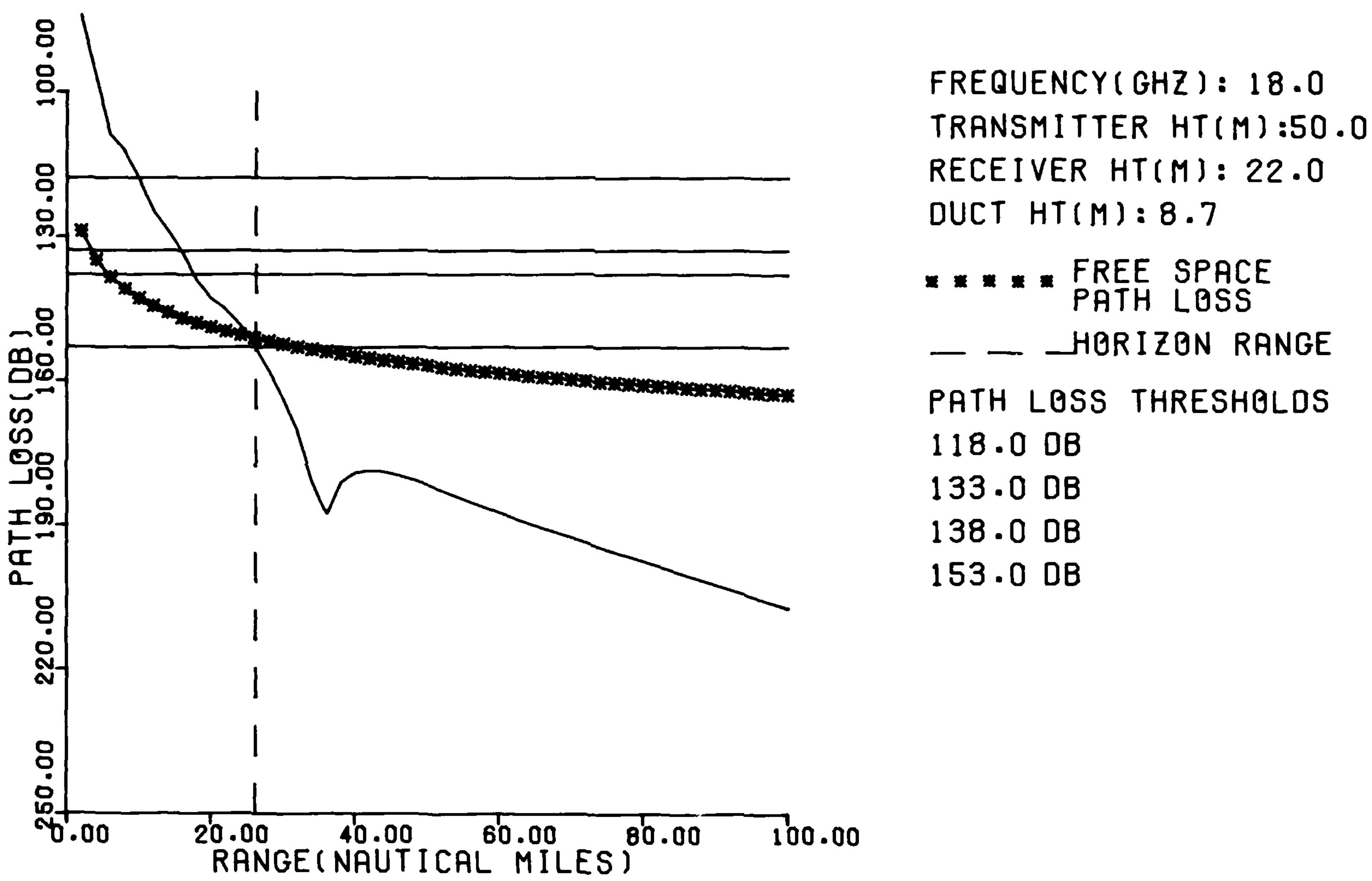
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40.00
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100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
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FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
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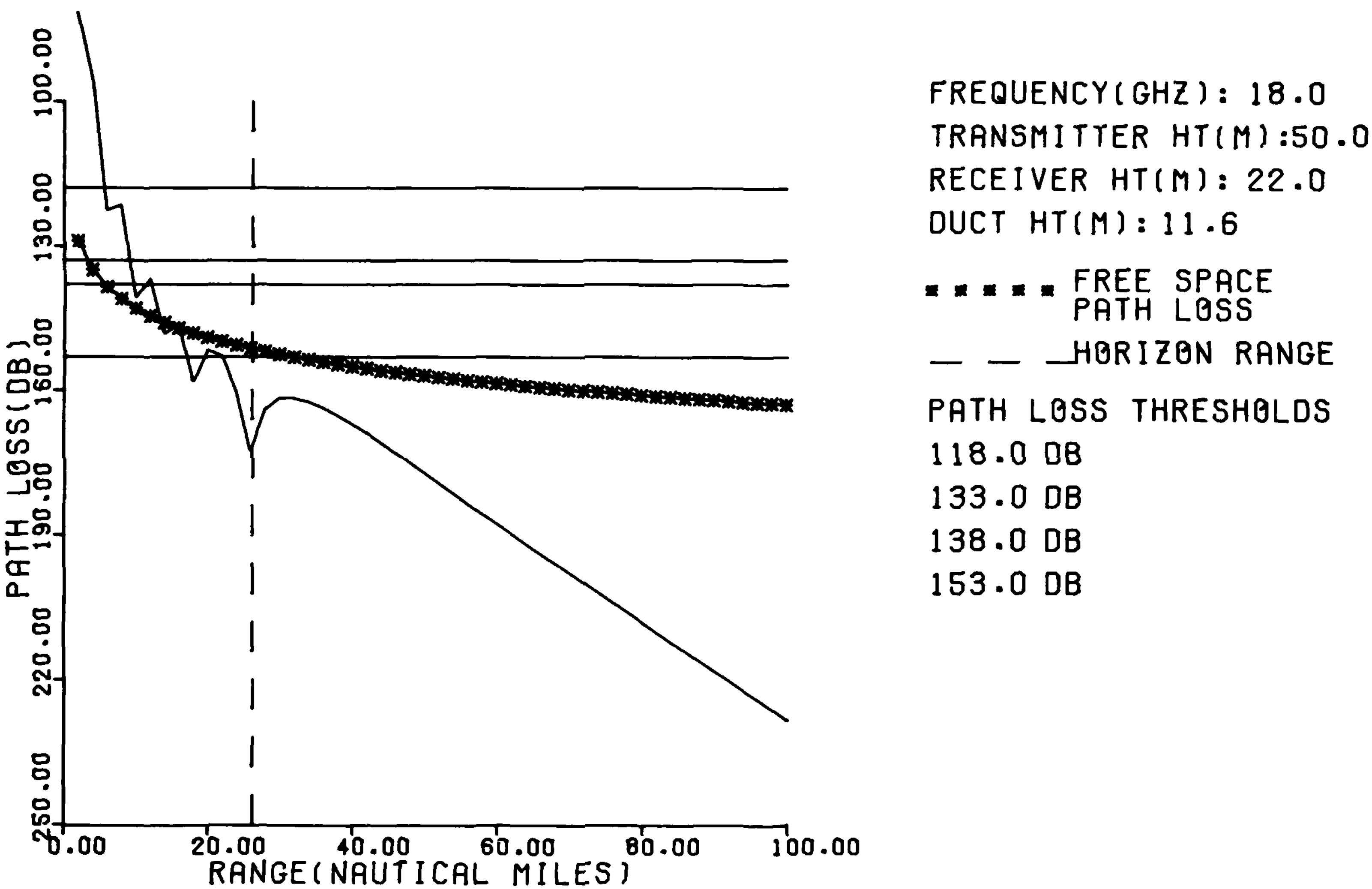

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HØRIZØN RANGE
PATH LØSS THRESHØLDS
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133.0 DB
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153.0 DB
PATH LØSS(DB)
100.00
130.00
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20.00
40.00
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80.00
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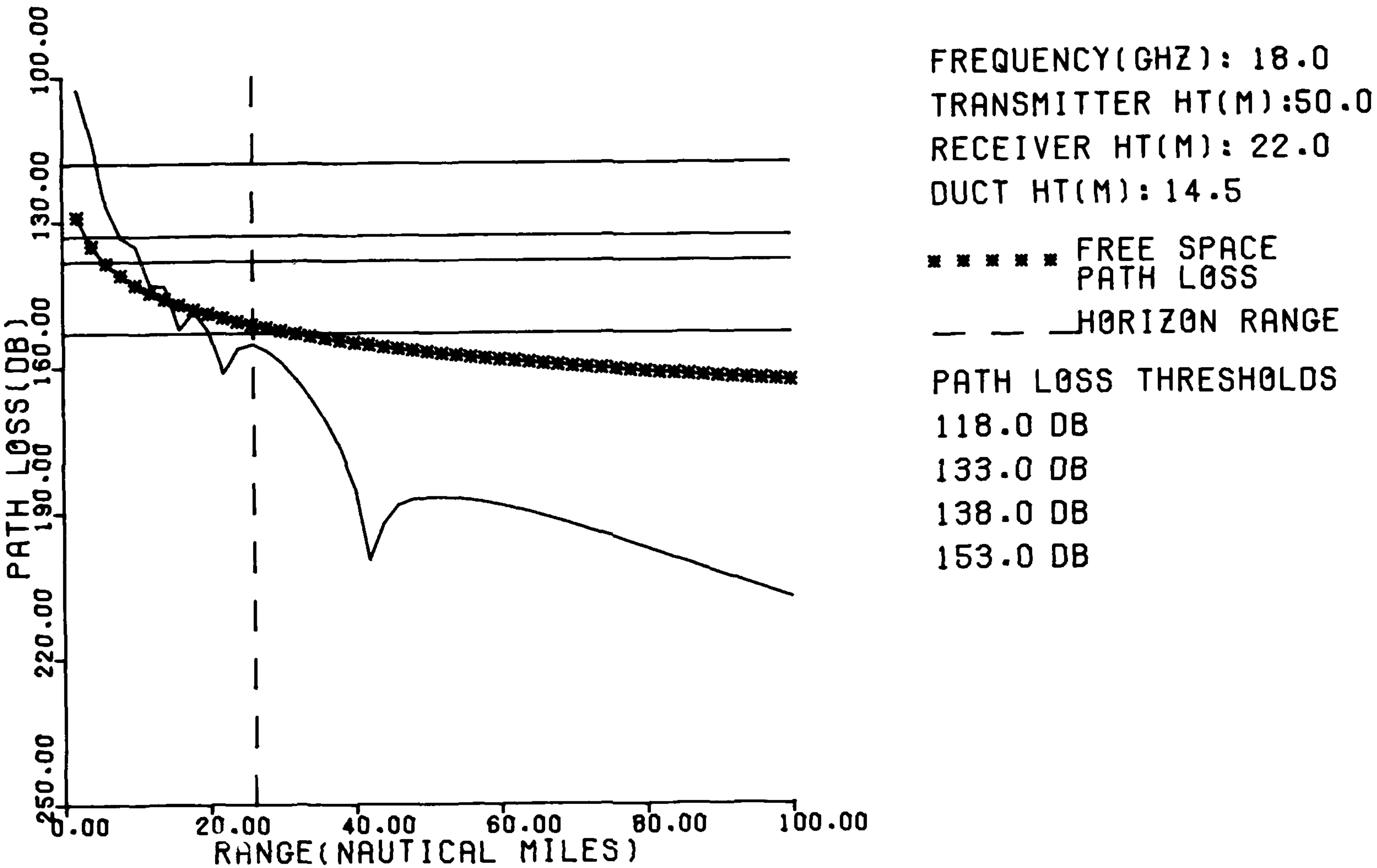
RANGE(NAUTICAL MILES)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PATH LØSS(DB)
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100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 14.5
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PATH LØSS THRESHØLDS
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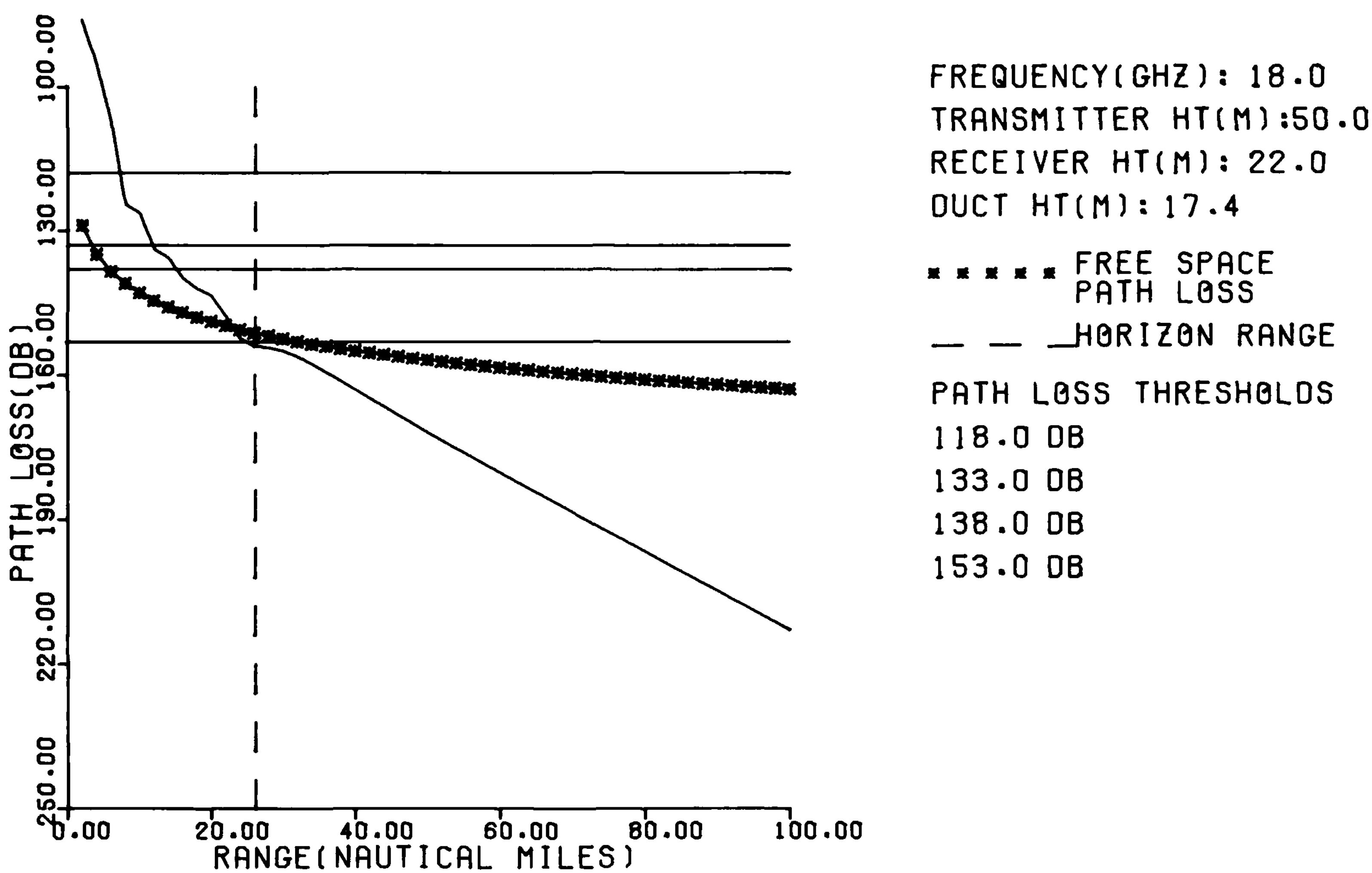

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PATH LØSS(DB)
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RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 17.4
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PATH LØSS THRESHØLDS
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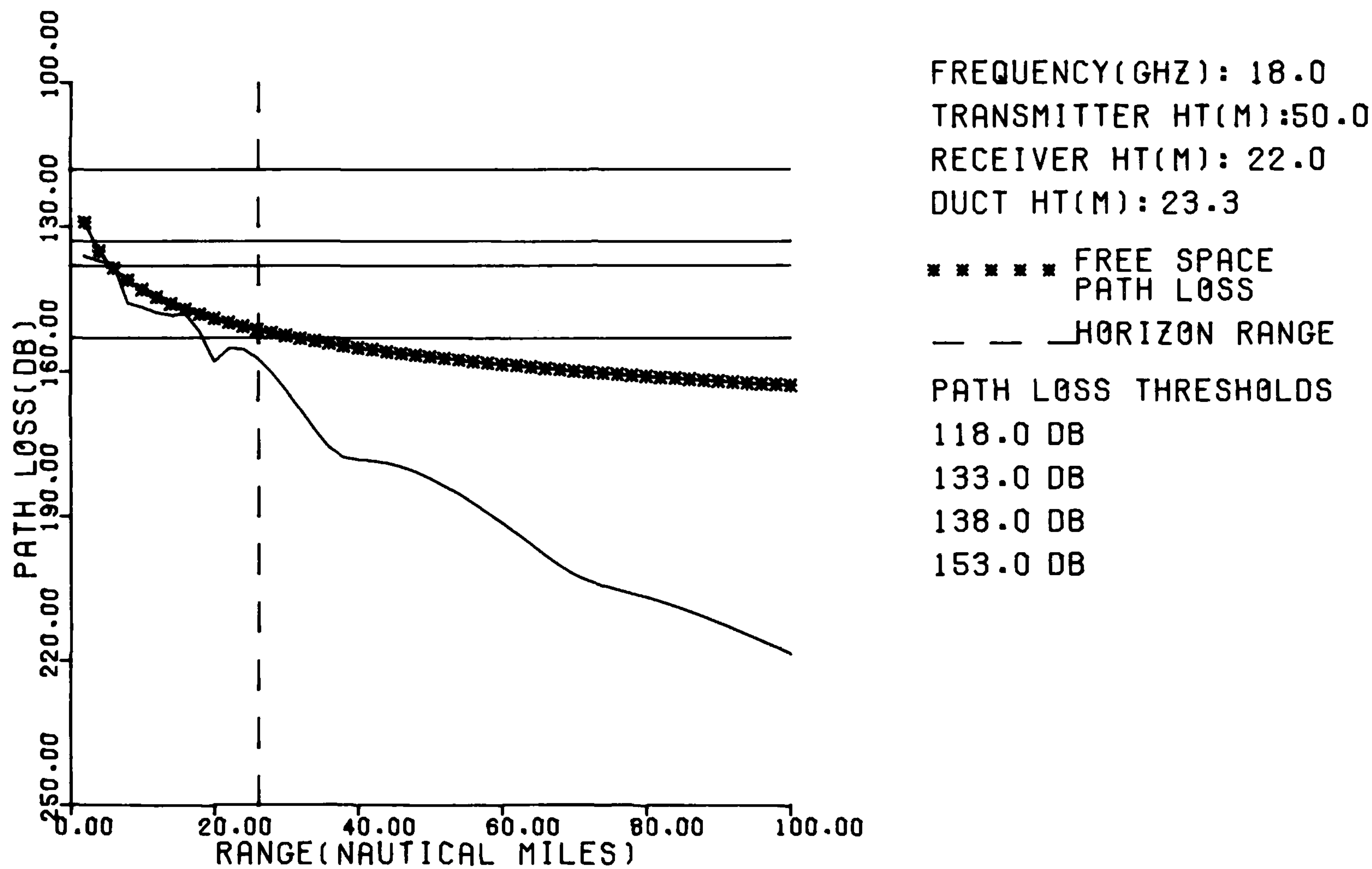

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PATH LØSS(DB)
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20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
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RECEIVER HT(M): 22.0
DUCT HT(M): 23.3
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HØRIZØN RANGE
PATH LØSS THRESHØLDS
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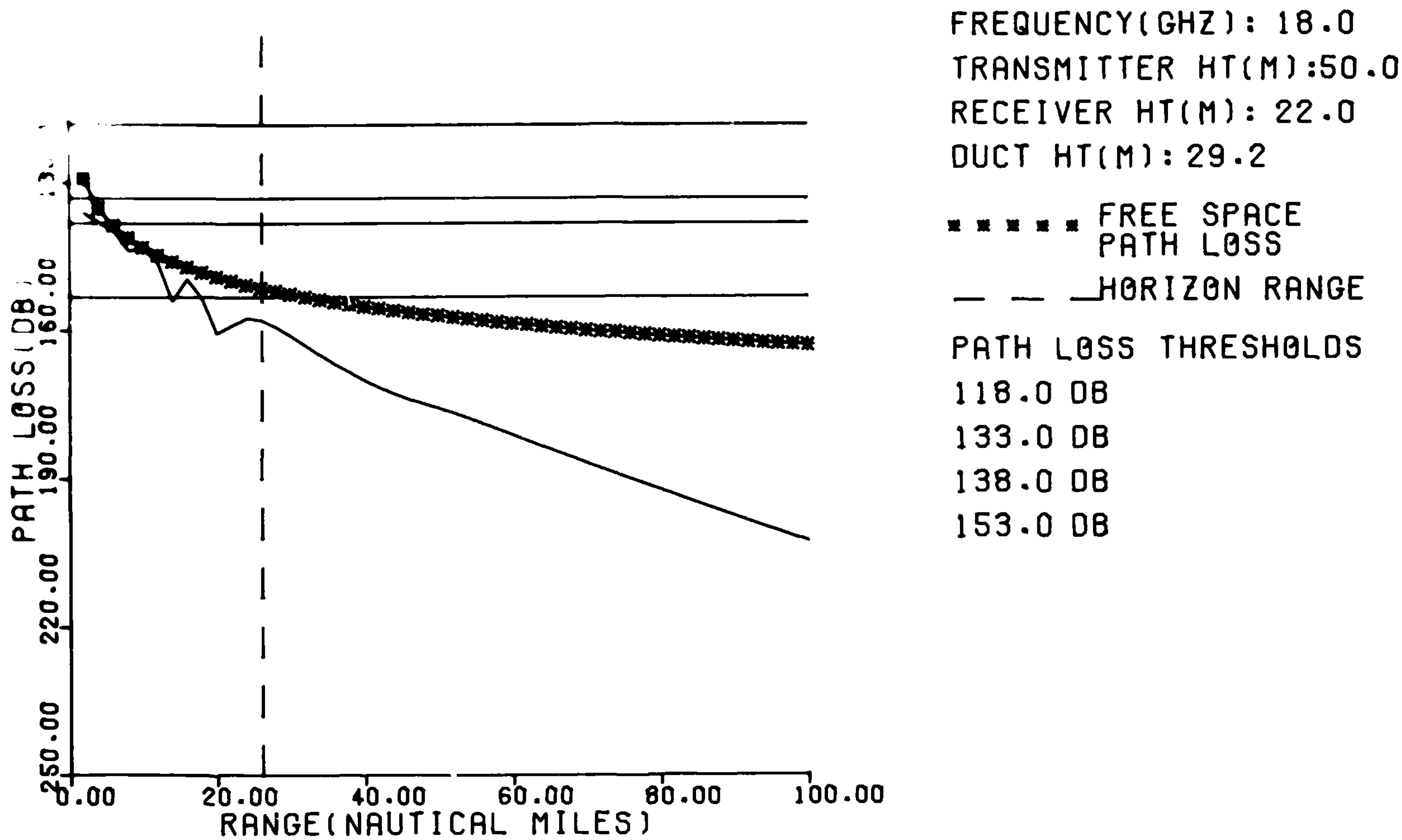
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HORIZON RANGE
PATH LOSS THRESHOLDS
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133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
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20.00
40.00
60.00
80.00
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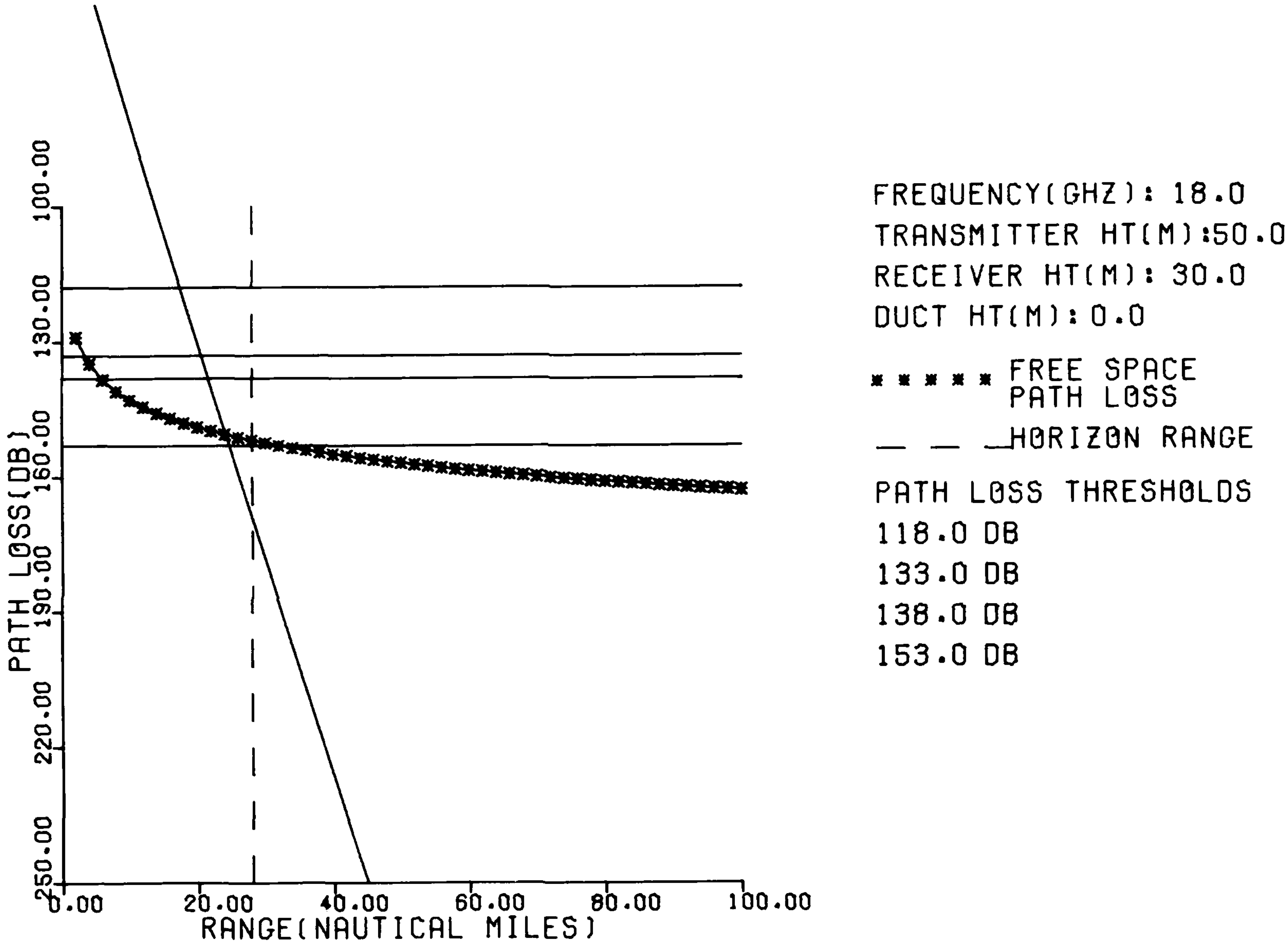
RANGE(NAUTICAL MILES)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RECEIVER HT(M): 30.0
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* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
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20.00
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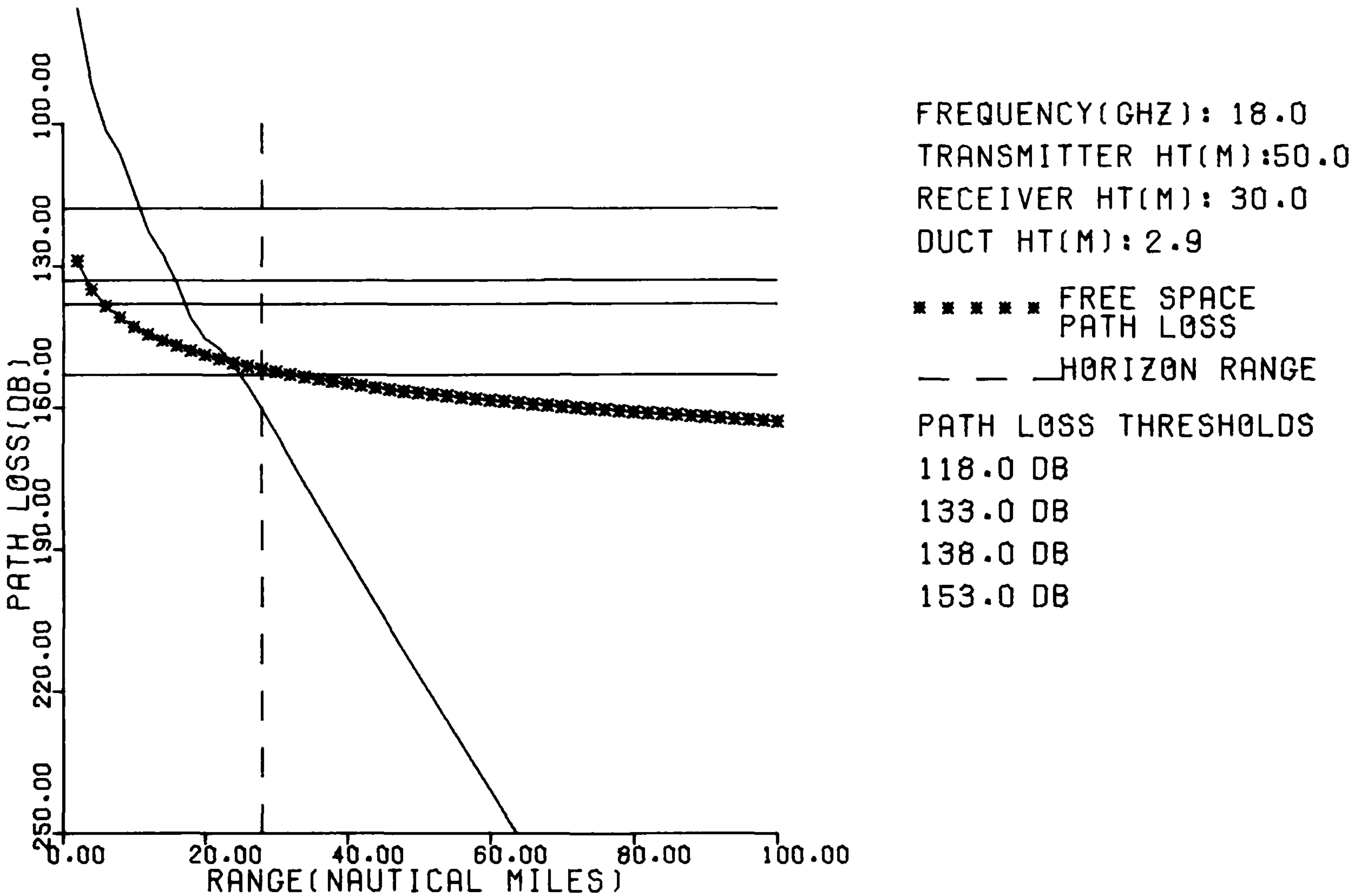
RANGE(NAUTICAL MILES)



PATH LØSS(DB)
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40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 2.9
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
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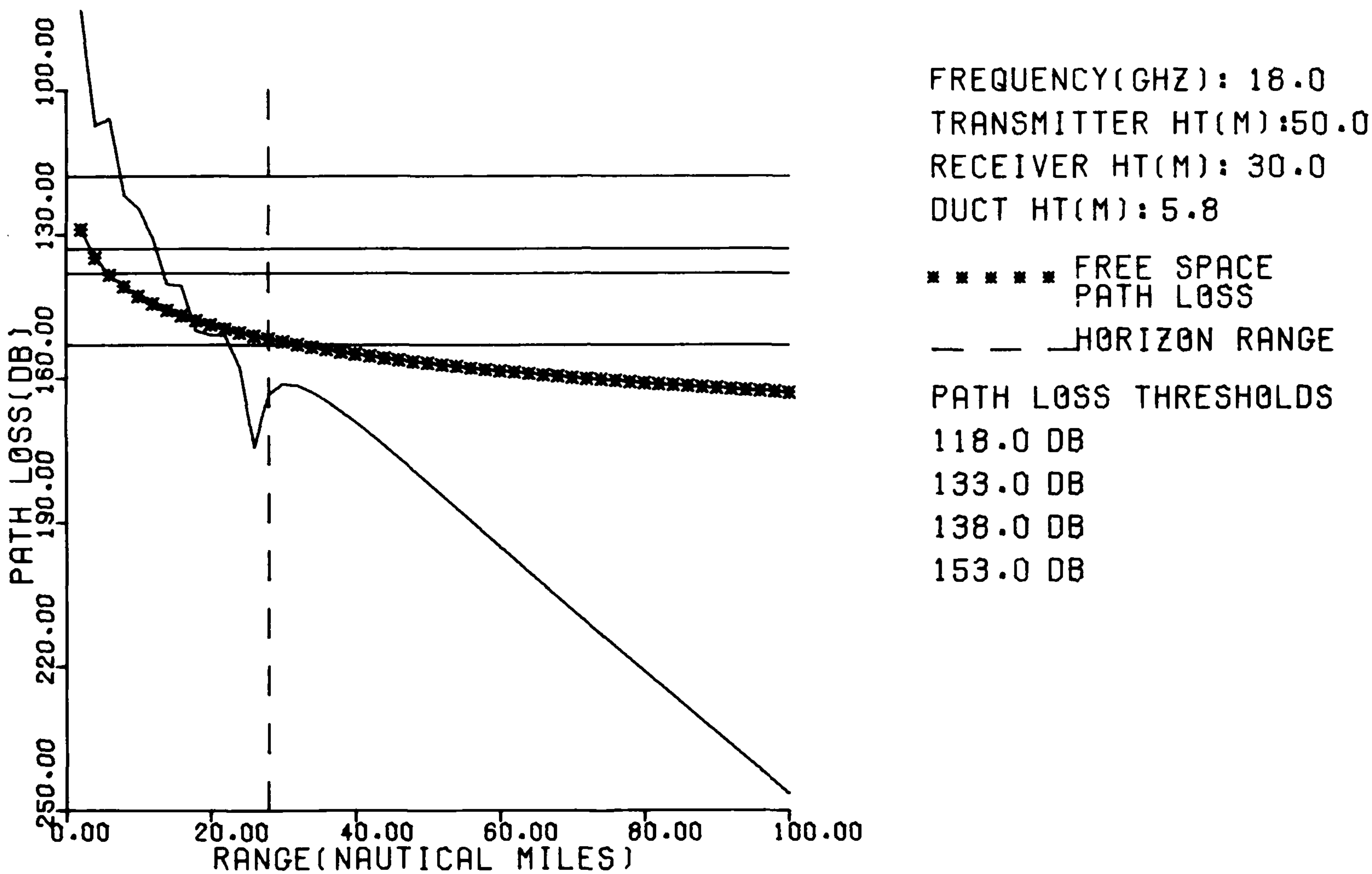
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PATH LOSS(DB)
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40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 5.8
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
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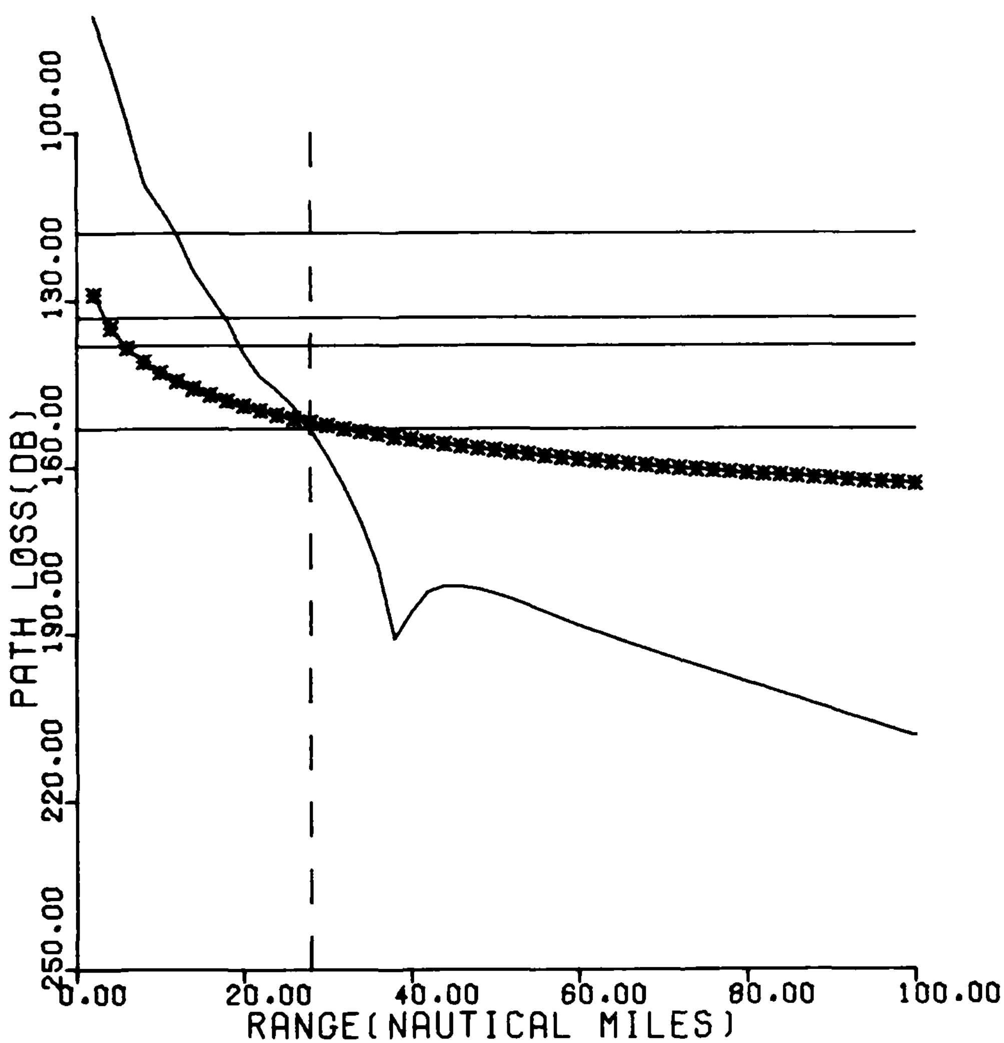

FREQUENCY(GHZ): 18.0
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RECEIVER HT(M): 30.0
DUCT HT(M): 8.7
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
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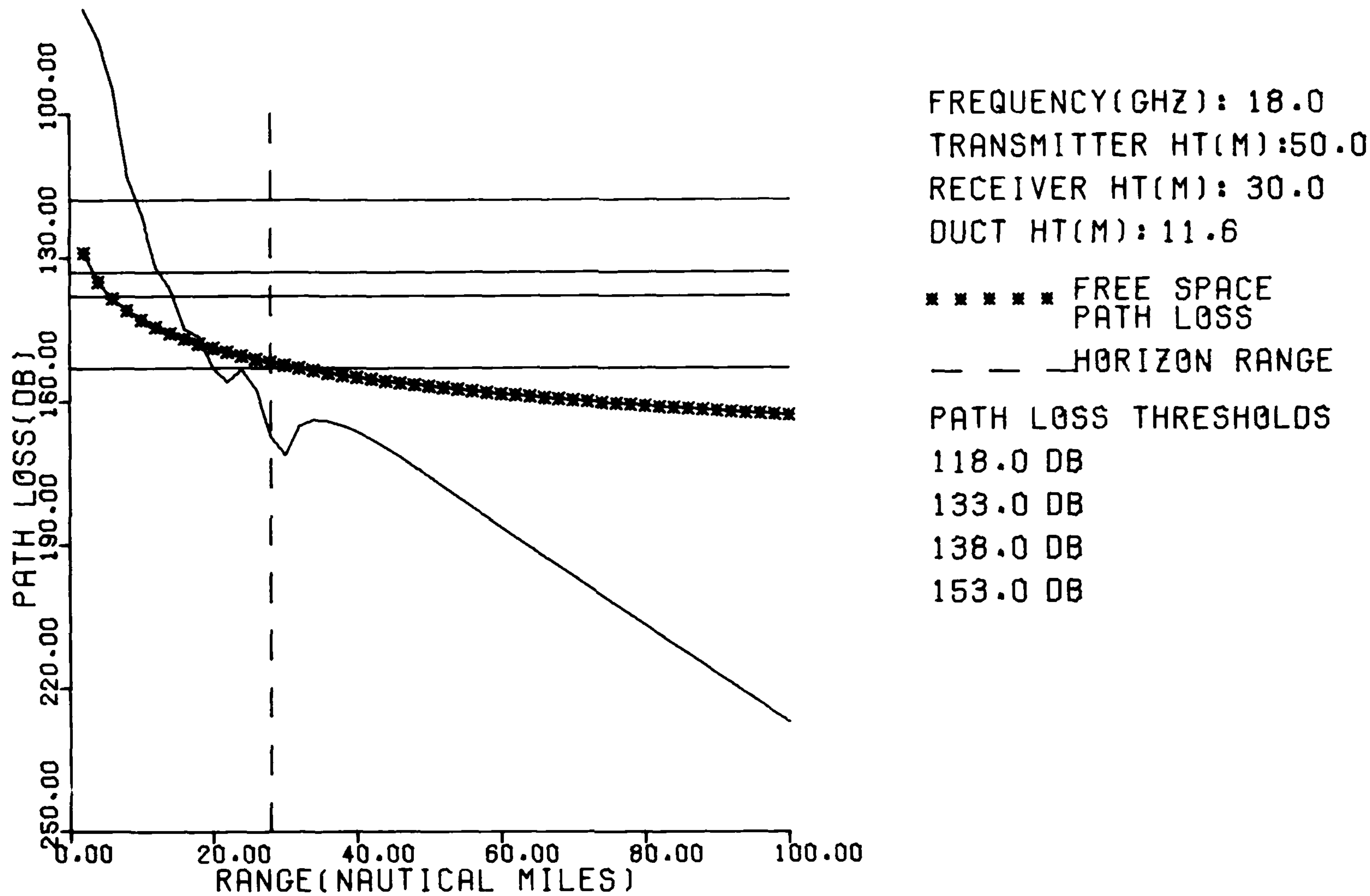
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TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 11.6
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
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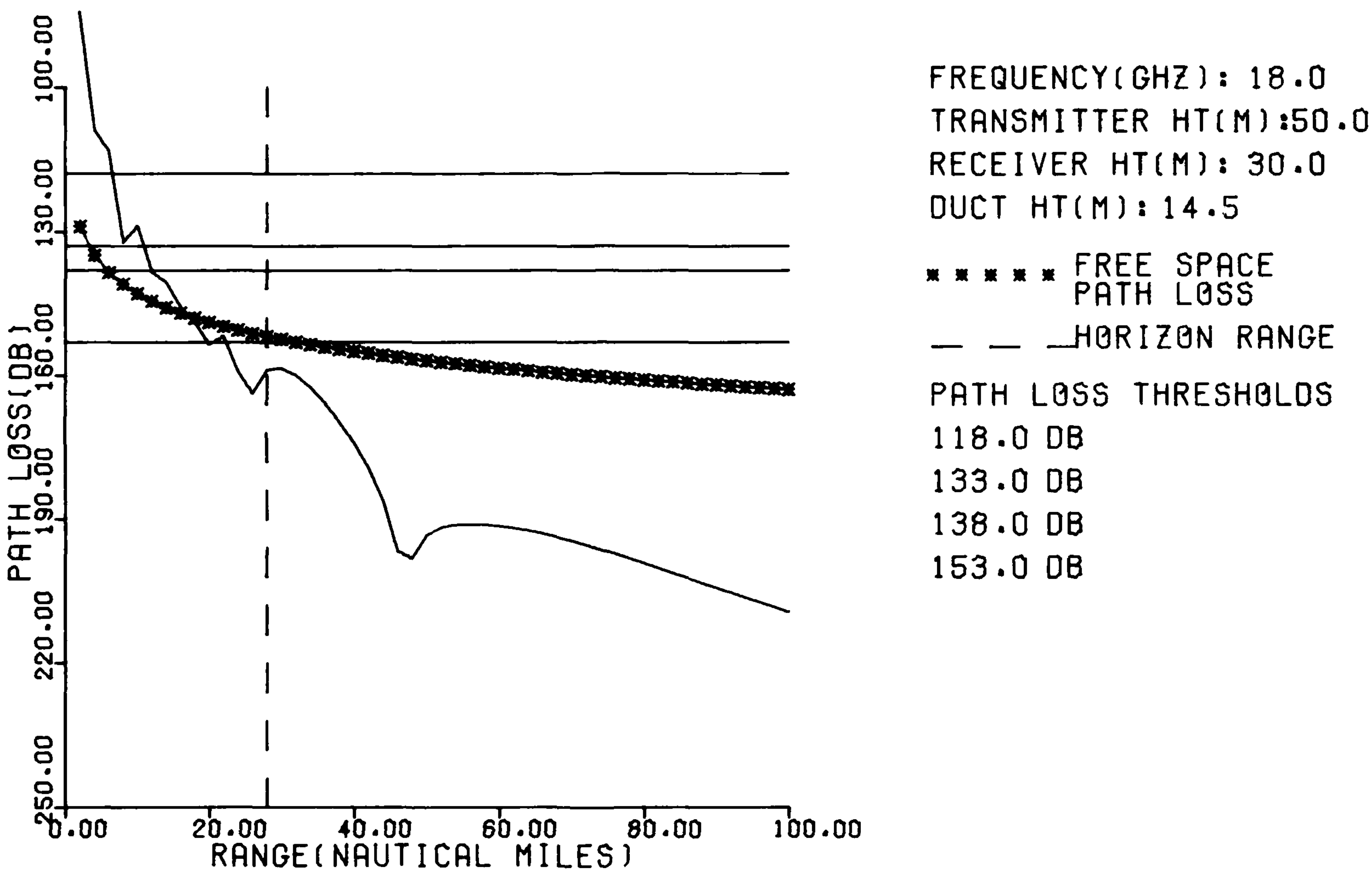
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)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RECEIVER HT(M): 30.0
DUCT HT(M): 14.5
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
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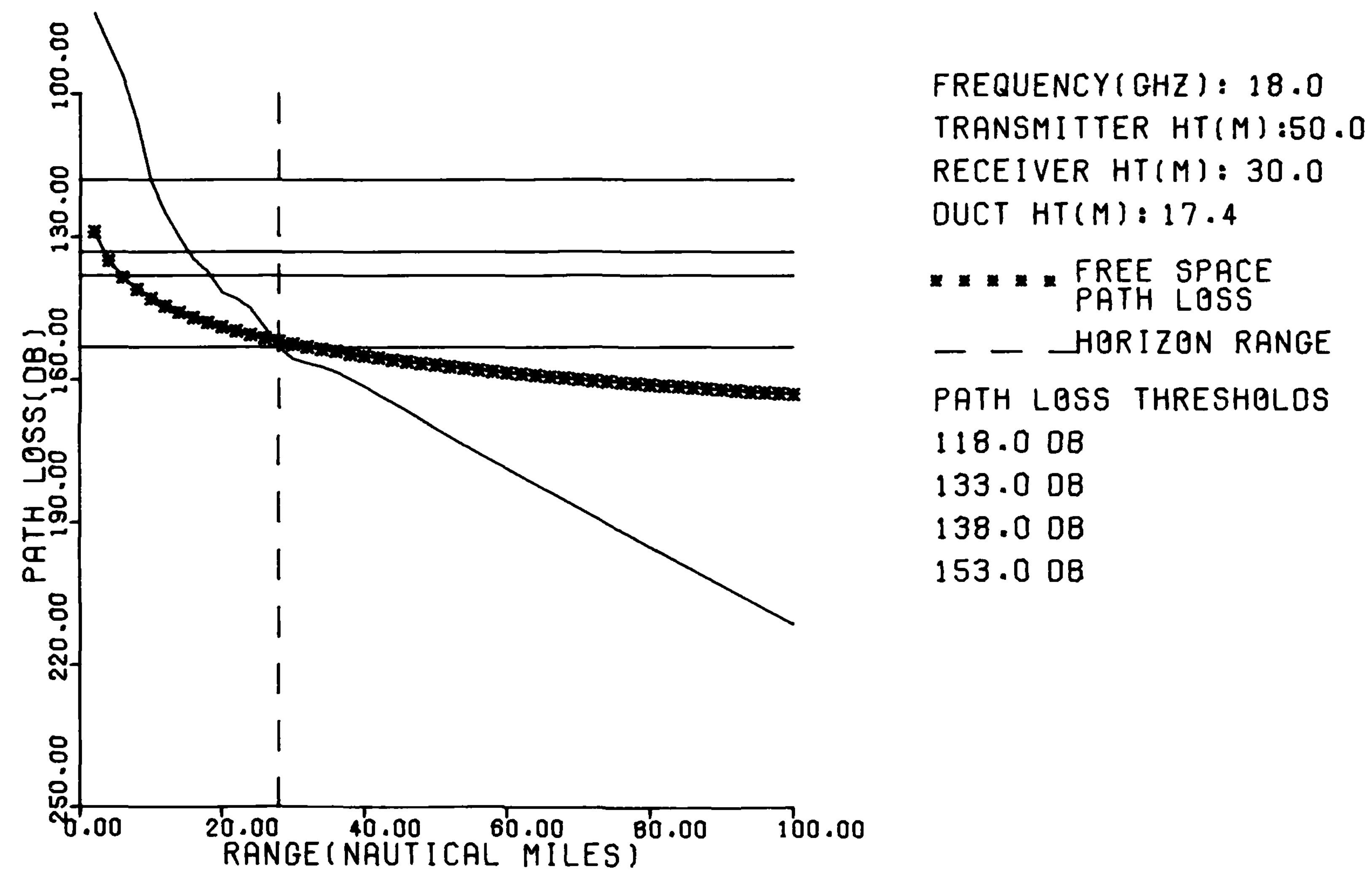
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)



100.00
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190.00
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PATH LOSS(DB)
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20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 17.4
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
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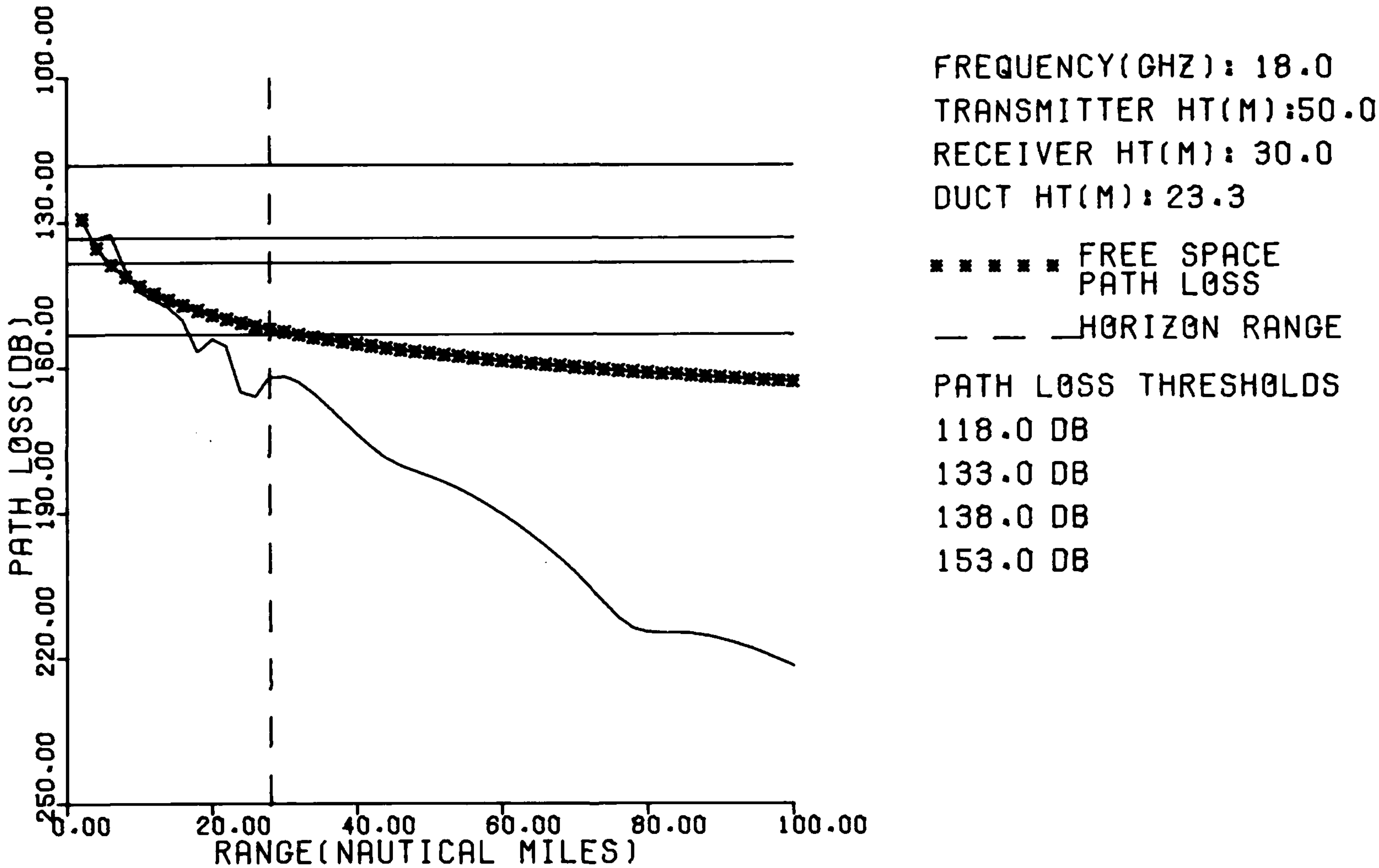
153.0 DB



FREQUENCY(GHZ): 18.0
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RECEIVER HT(M): 30.0
DUCT HT(M): 23.3
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LØSS(DB)
100.00
130.00
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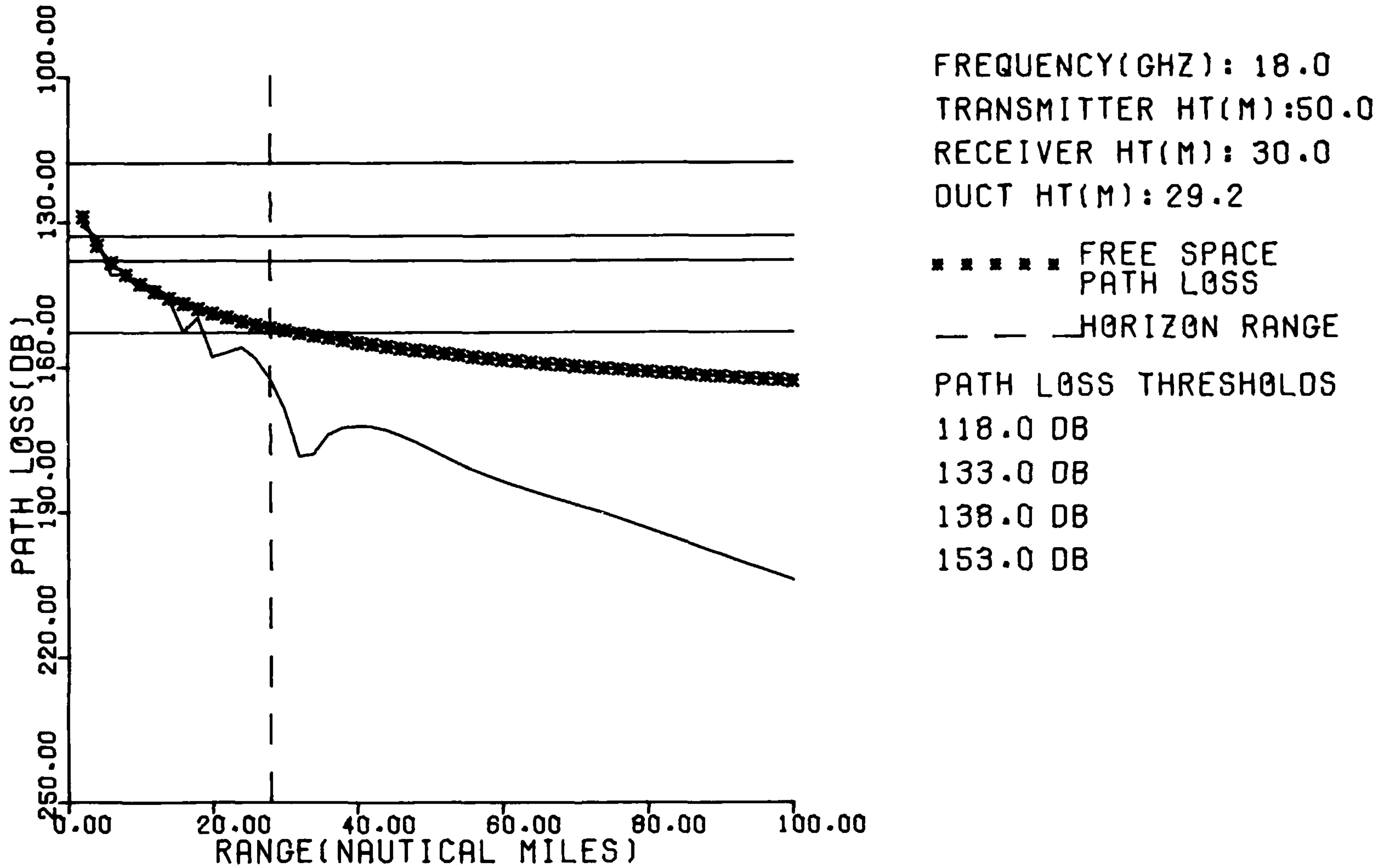
RANGE(NAUTICAL MILES)



PATH LØSS(DB)
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250.00
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60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 18.0
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 29.2
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
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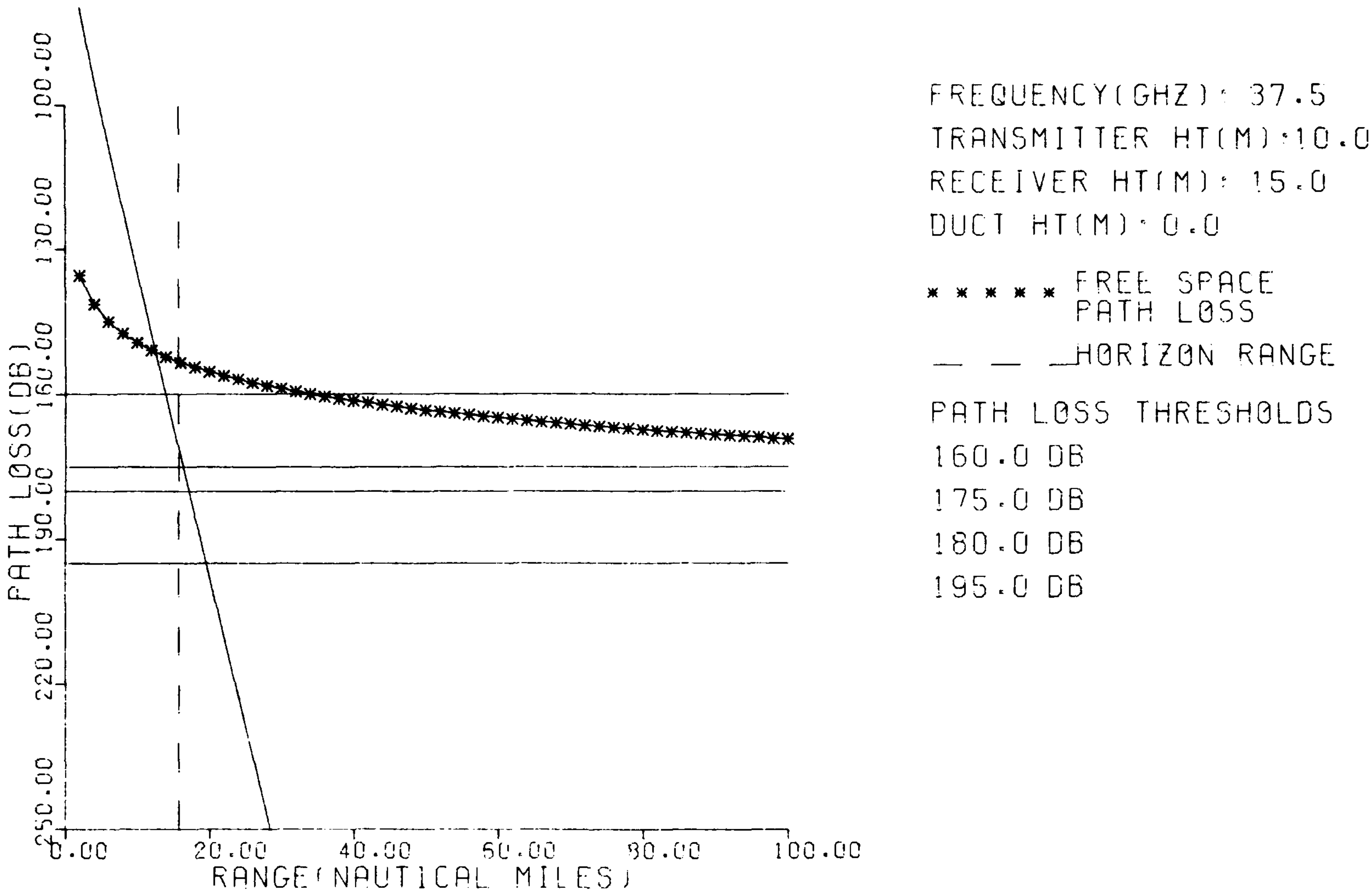
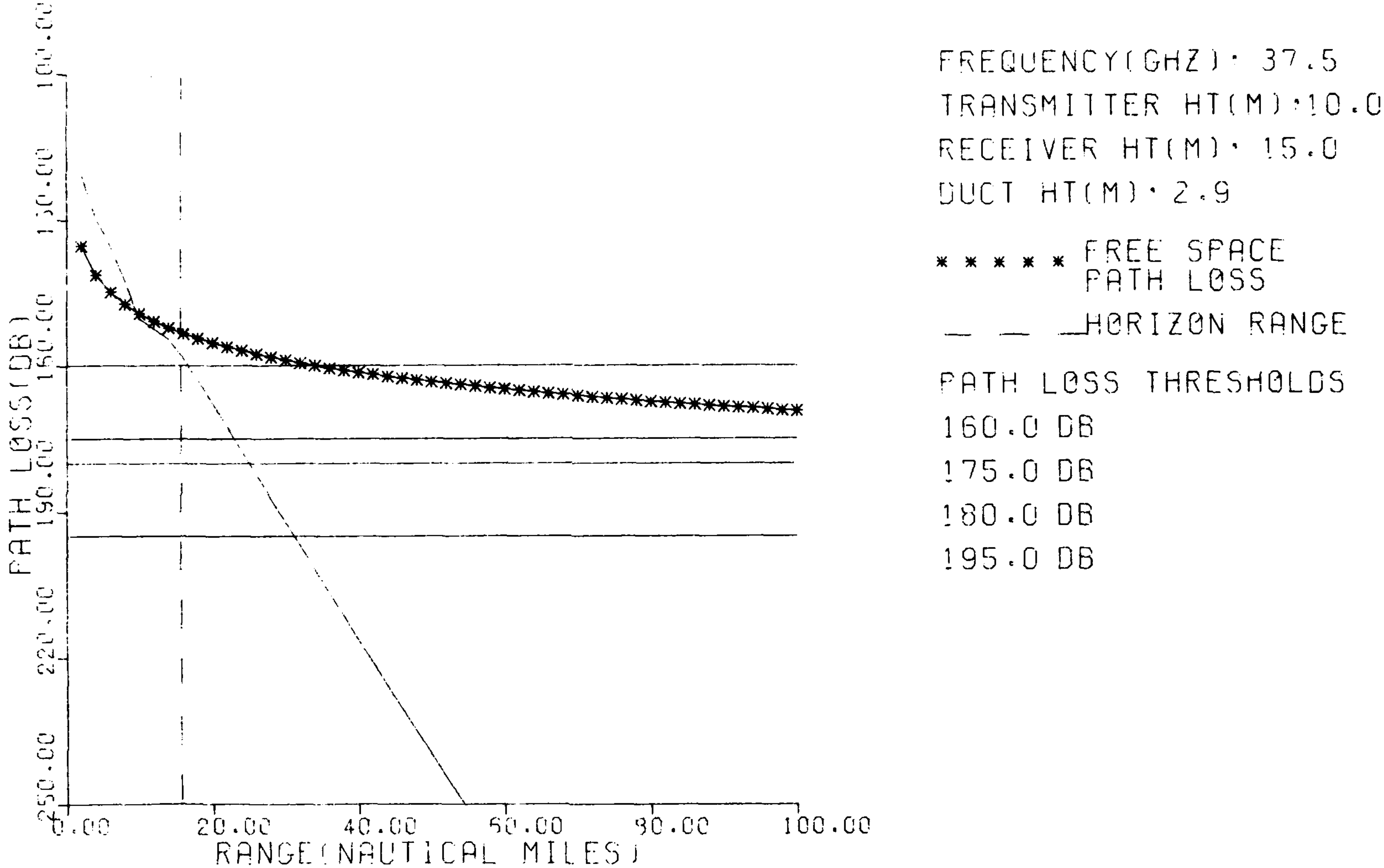
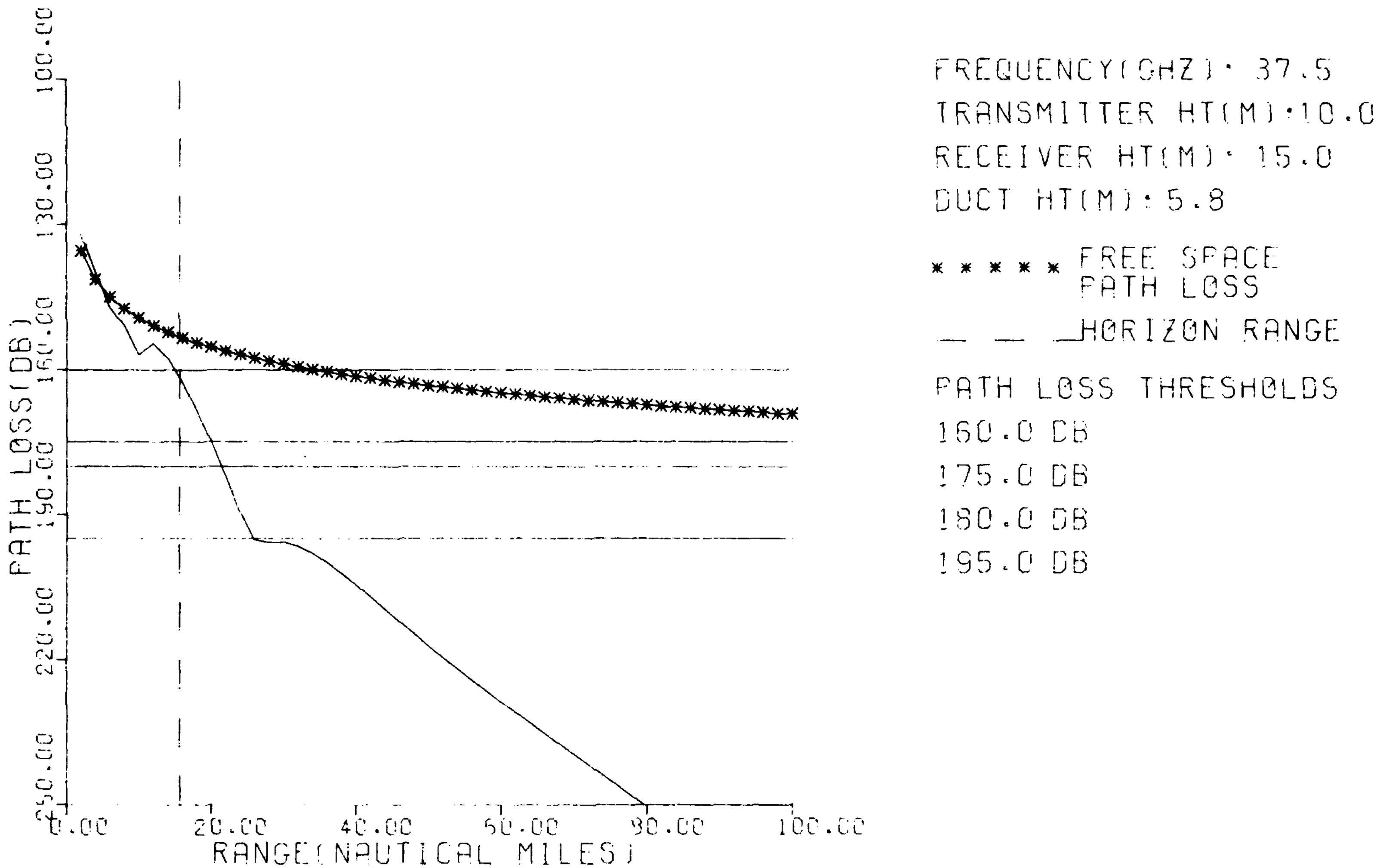
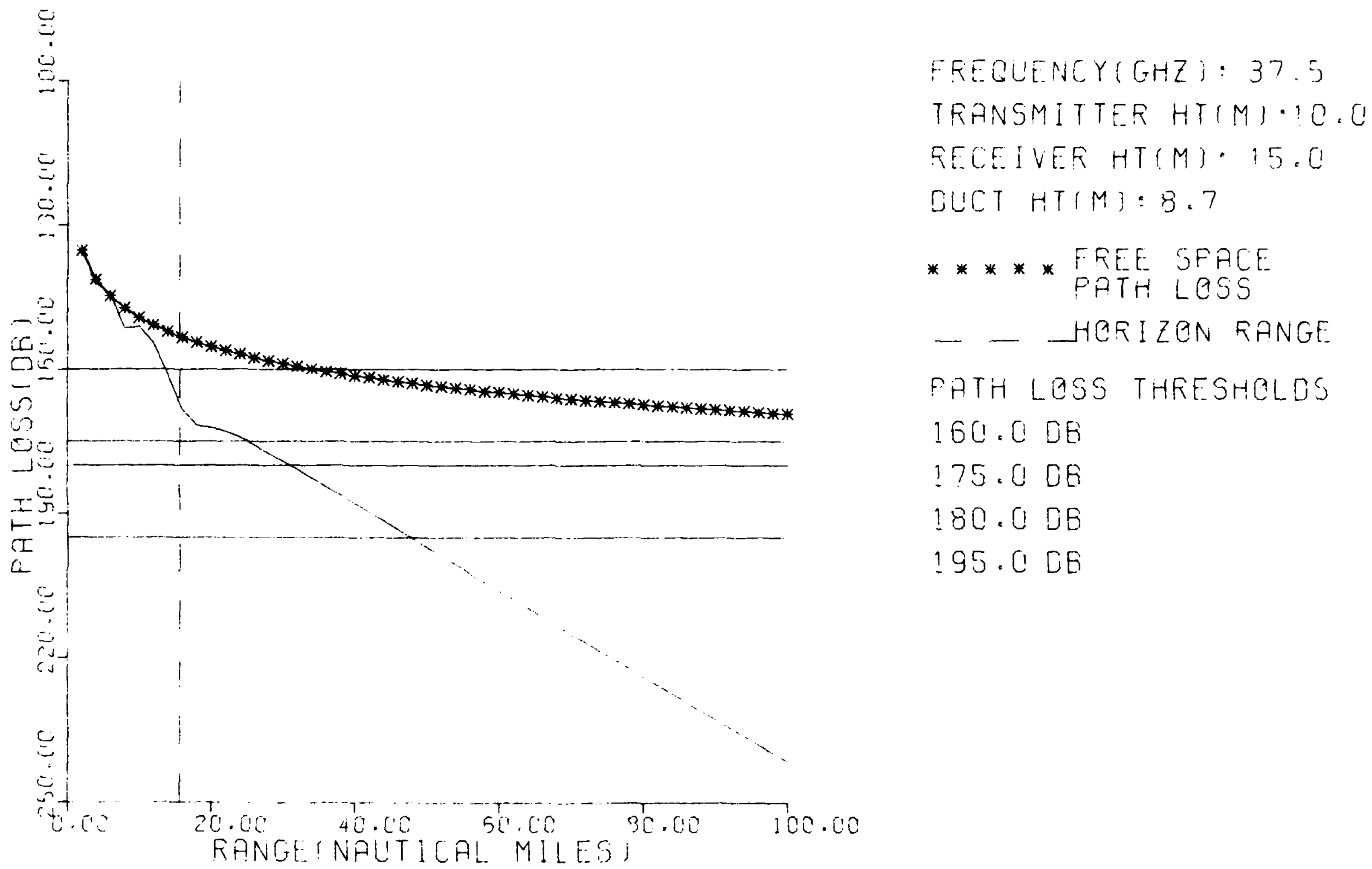
133.0 DB
138.0 DB
153.0 DB


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 0.0
* * * * * FREE SPACE PATH LØSS
— — —HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

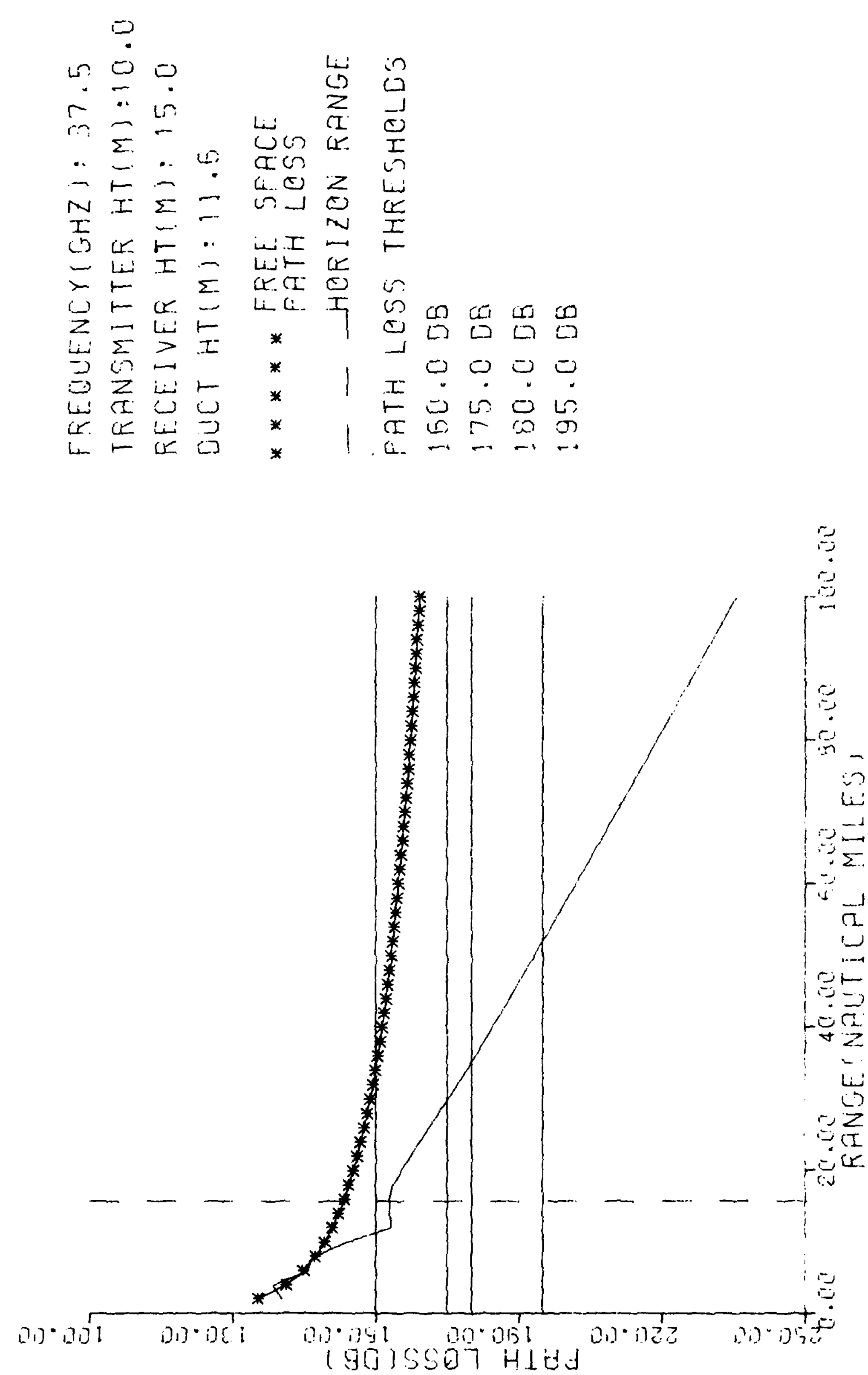

PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 5.8
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB



PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 8.7
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

AD-A091 724 NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA F/G 20/14
EVAPORATION DUCT EFFECTS ON MAXIMUM INTERCEPT RANGE FOR 18- AND--ETC(U)
SEP 80 H V HITNEY
UNCLASSIFIED NOSC/TR-582 NL

2 OF 3
AD
A091724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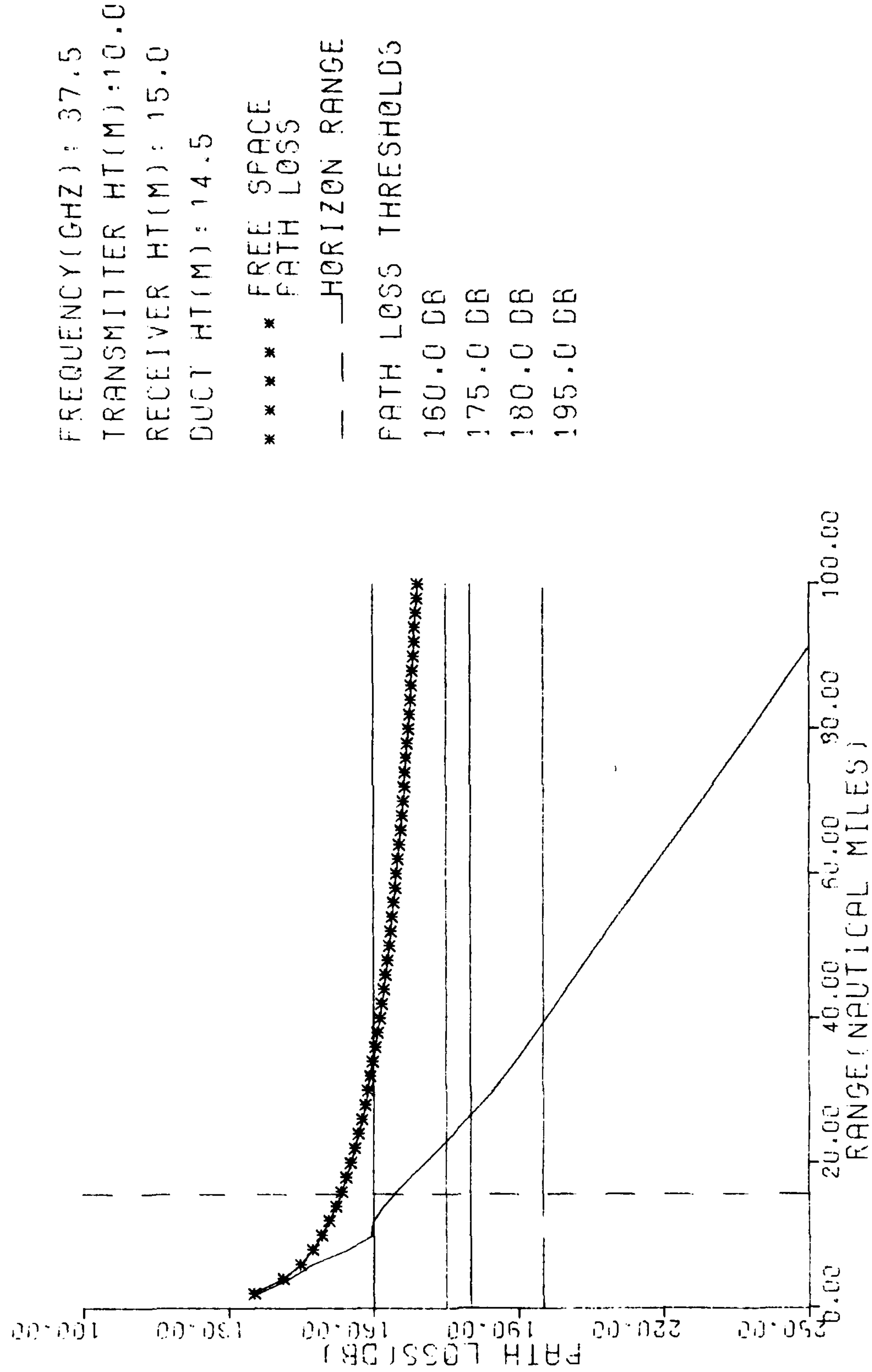
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 11.5
* * * * * FREE SPACE PATH LOSS
— — HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
100.00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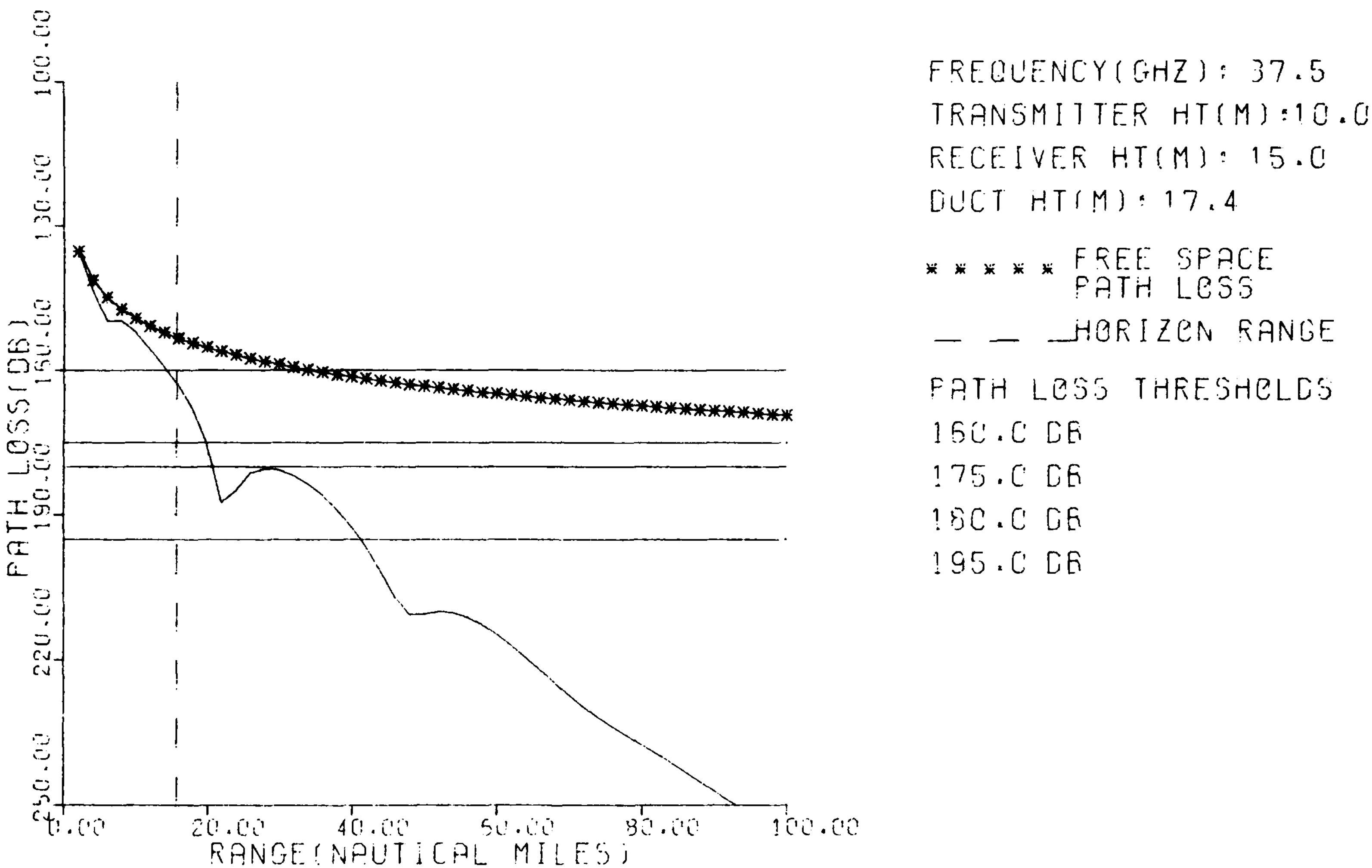
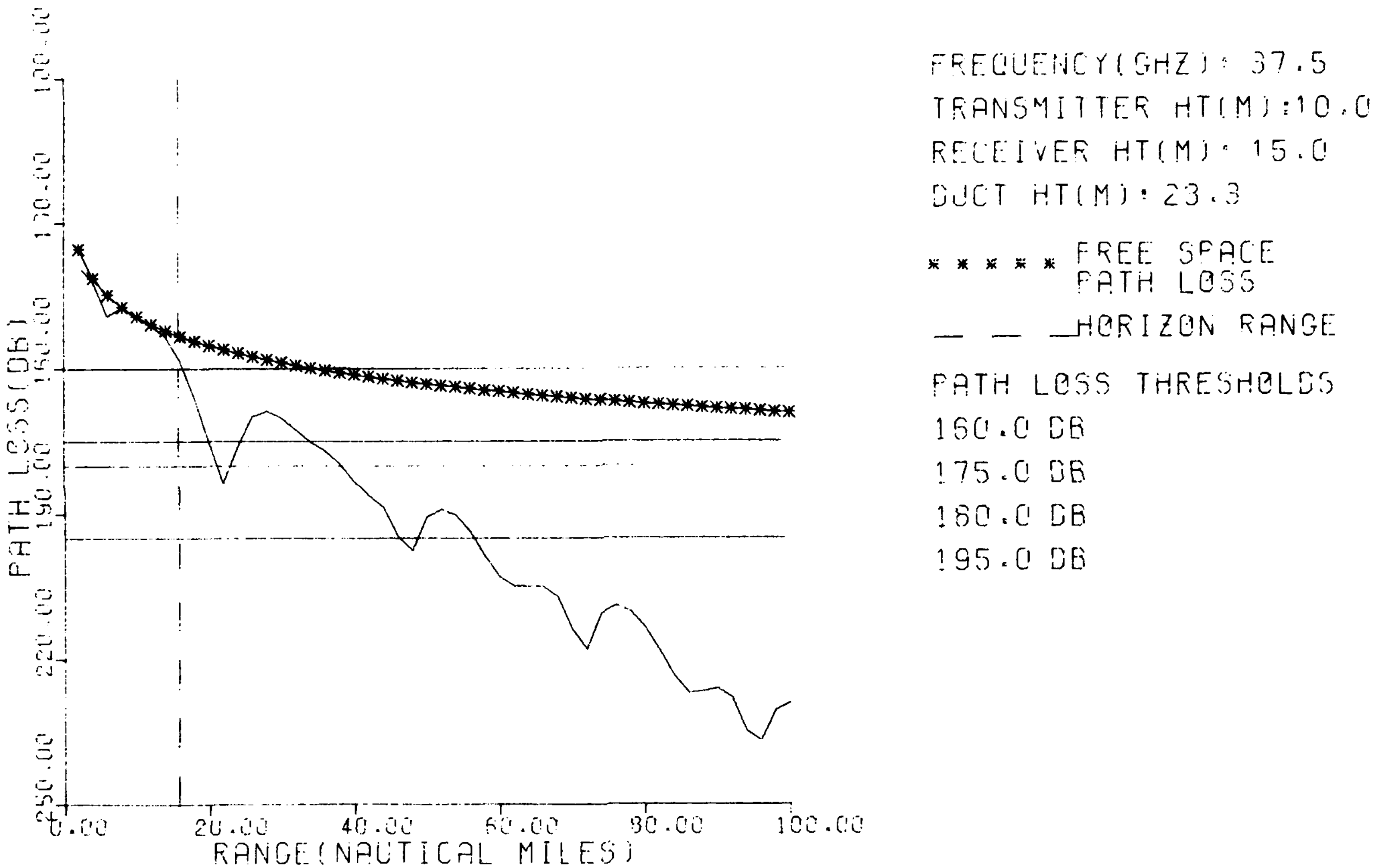
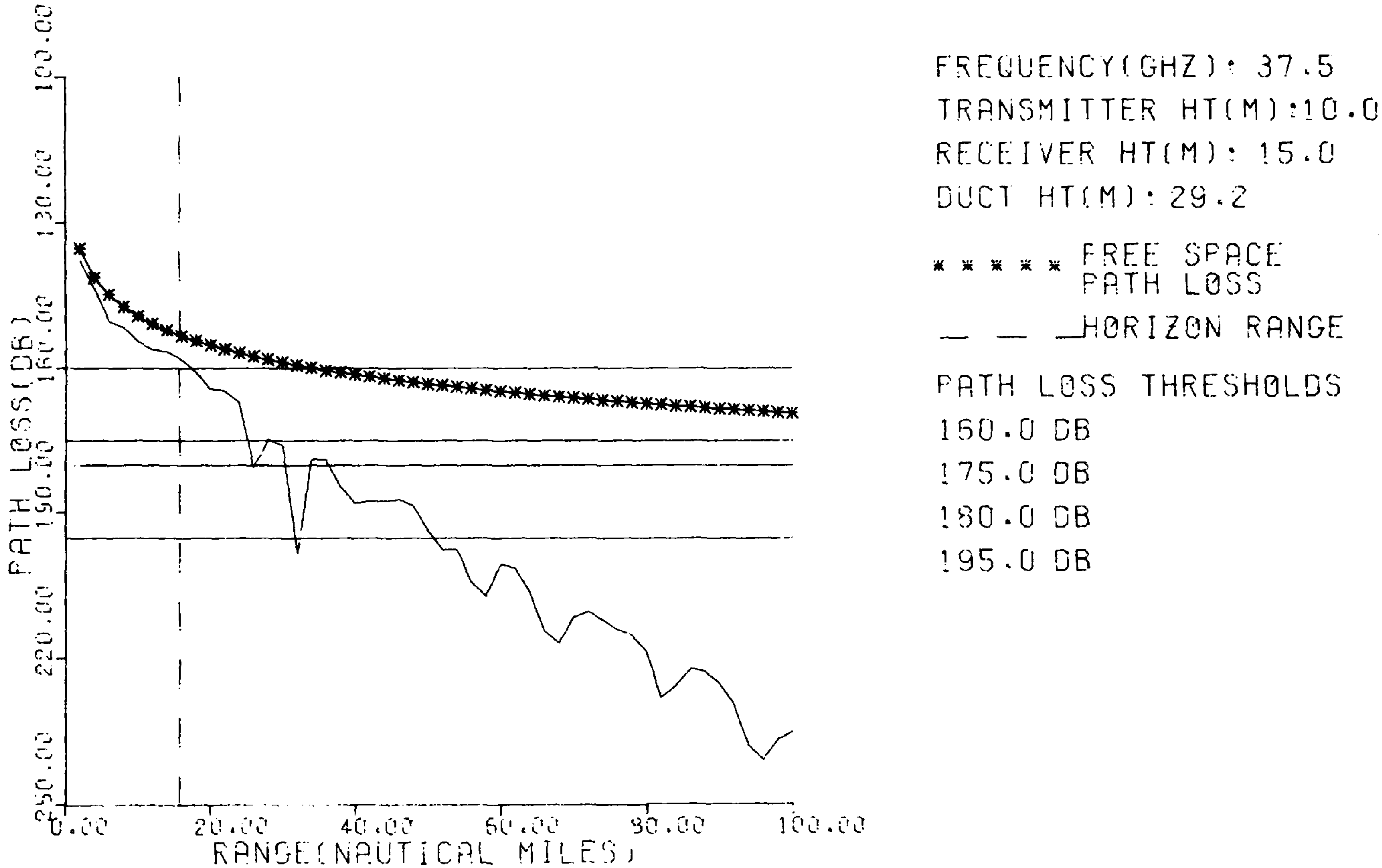
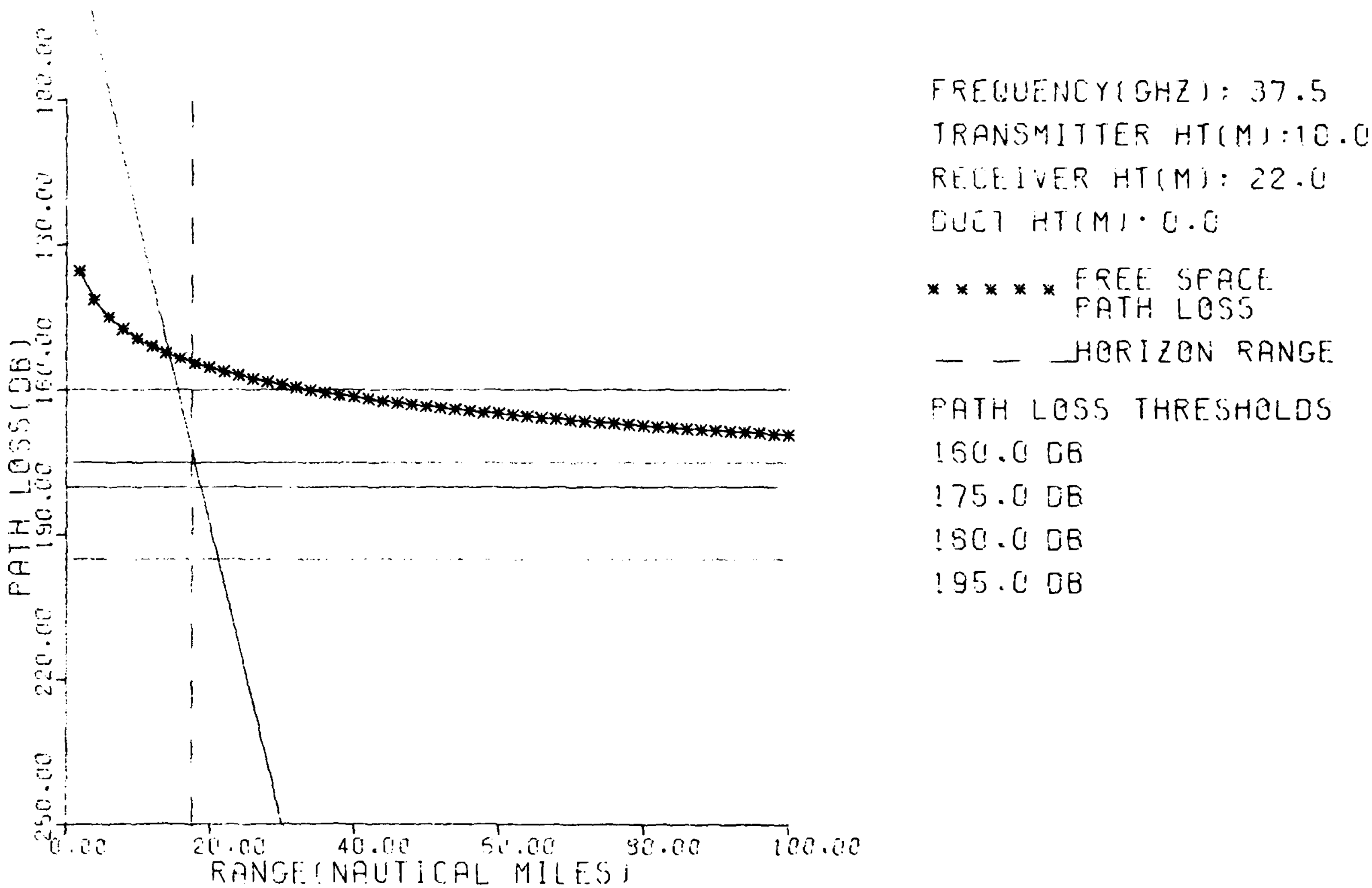
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 14.5
* * * * * FREE SPACE PATH LOSS
— — HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00

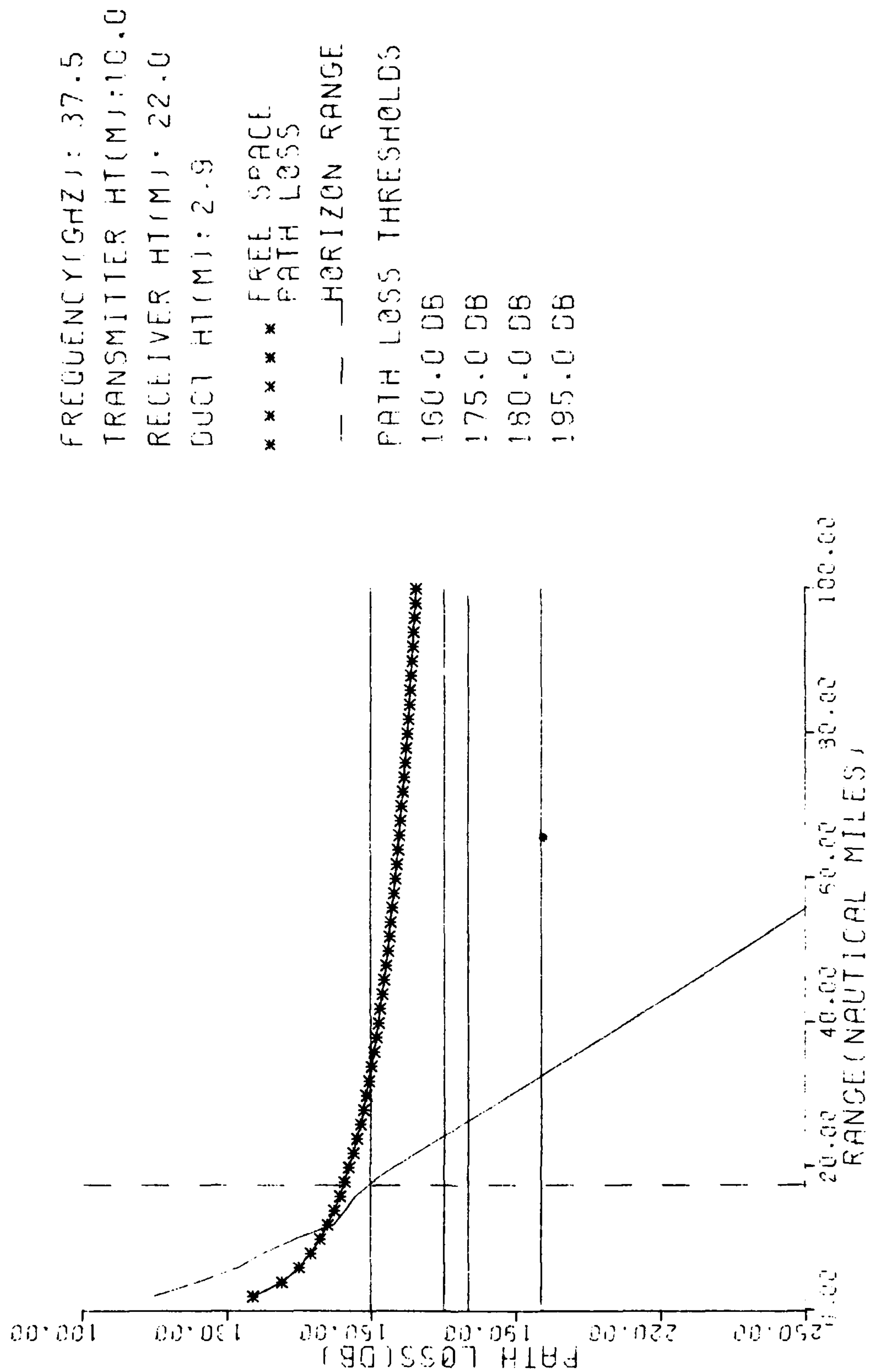

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 17.4
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

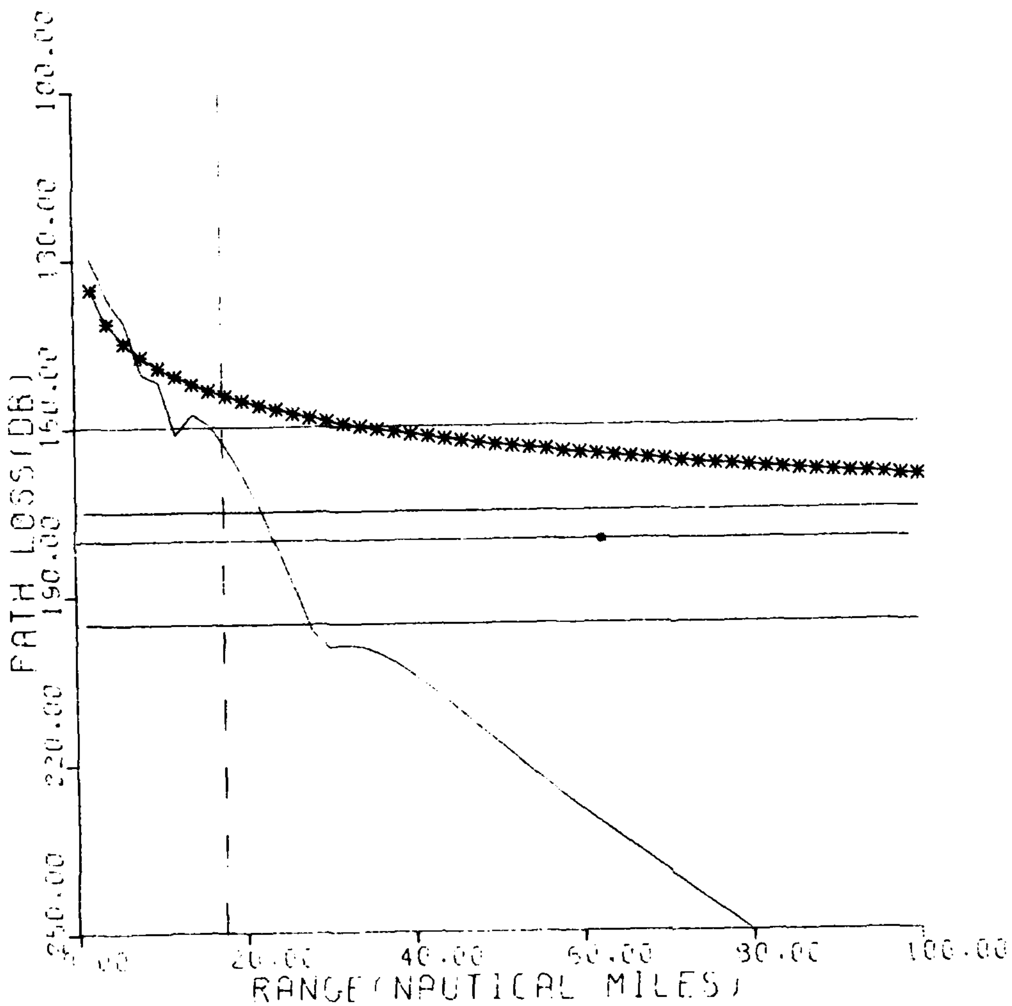

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 23.3
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 15.0
DUCT HT(M): 29.2
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)



FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M)· 0.0
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
— — — HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00



FREQUENCY(GHZ): 37.5

TRANSMITTER HT(M):10.0

RECEIVER HT(M): 22.0

DUCT HT(M): 5.8

* * * * * FREE SPACE PATH LOSS

_ _ _HORIZON RANGE

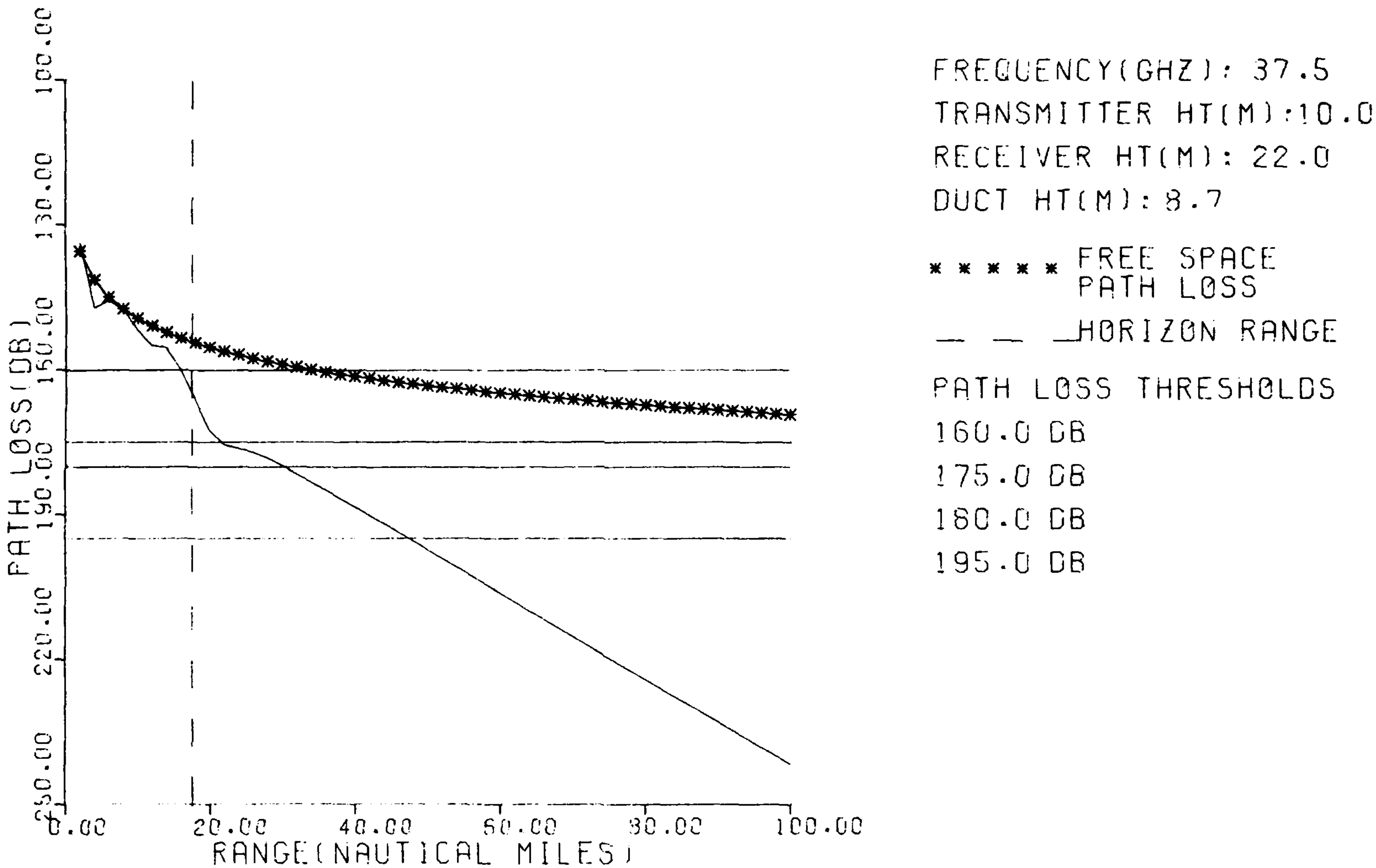
PATH LOSS THRESHOLDS

160.0 DB

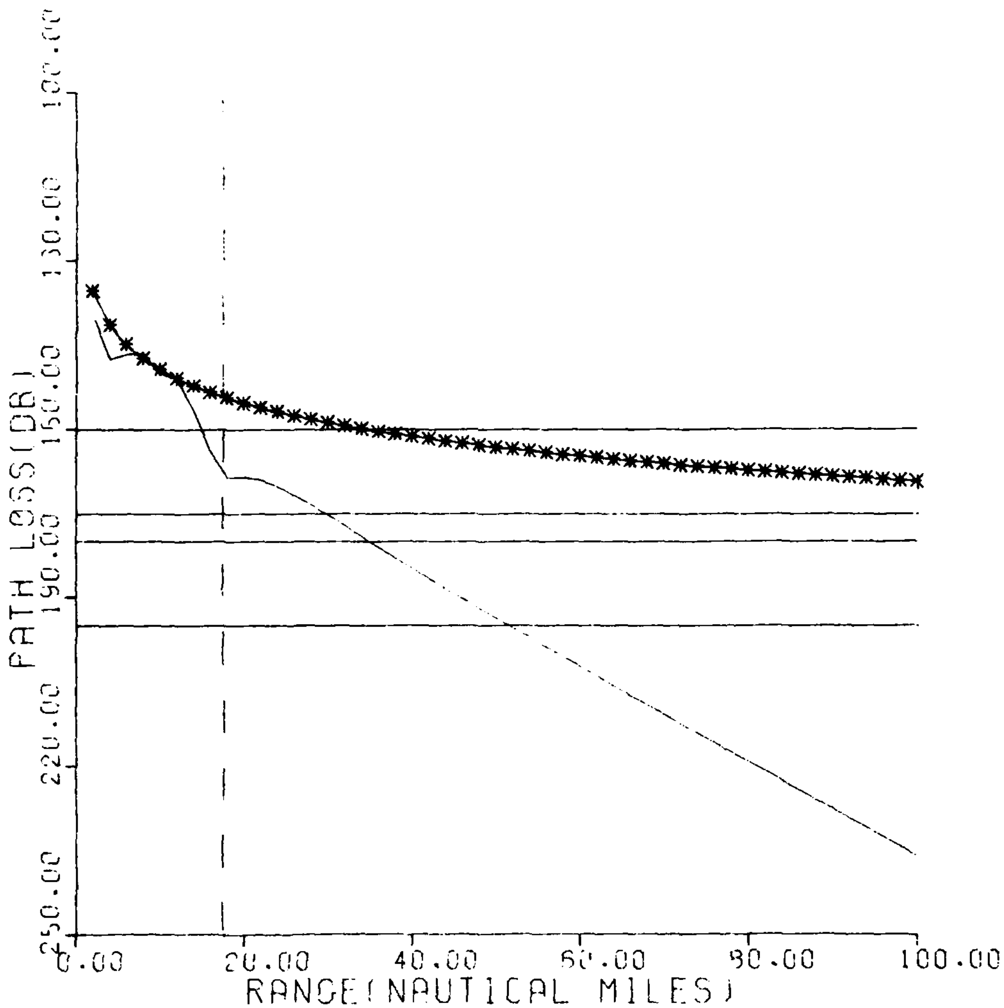
175.0 DB

180.0 DB

195.0 DB



FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 8.7
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)



FREQUENCY(GHZ): 37.5

TRANSMITTER HT(M):10.0

RECEIVER HT(M): 22.0

DUCT HT(M): 11.6

* * * * * FREE SPACE PATH LOSS

— — —HORIZON RANGE

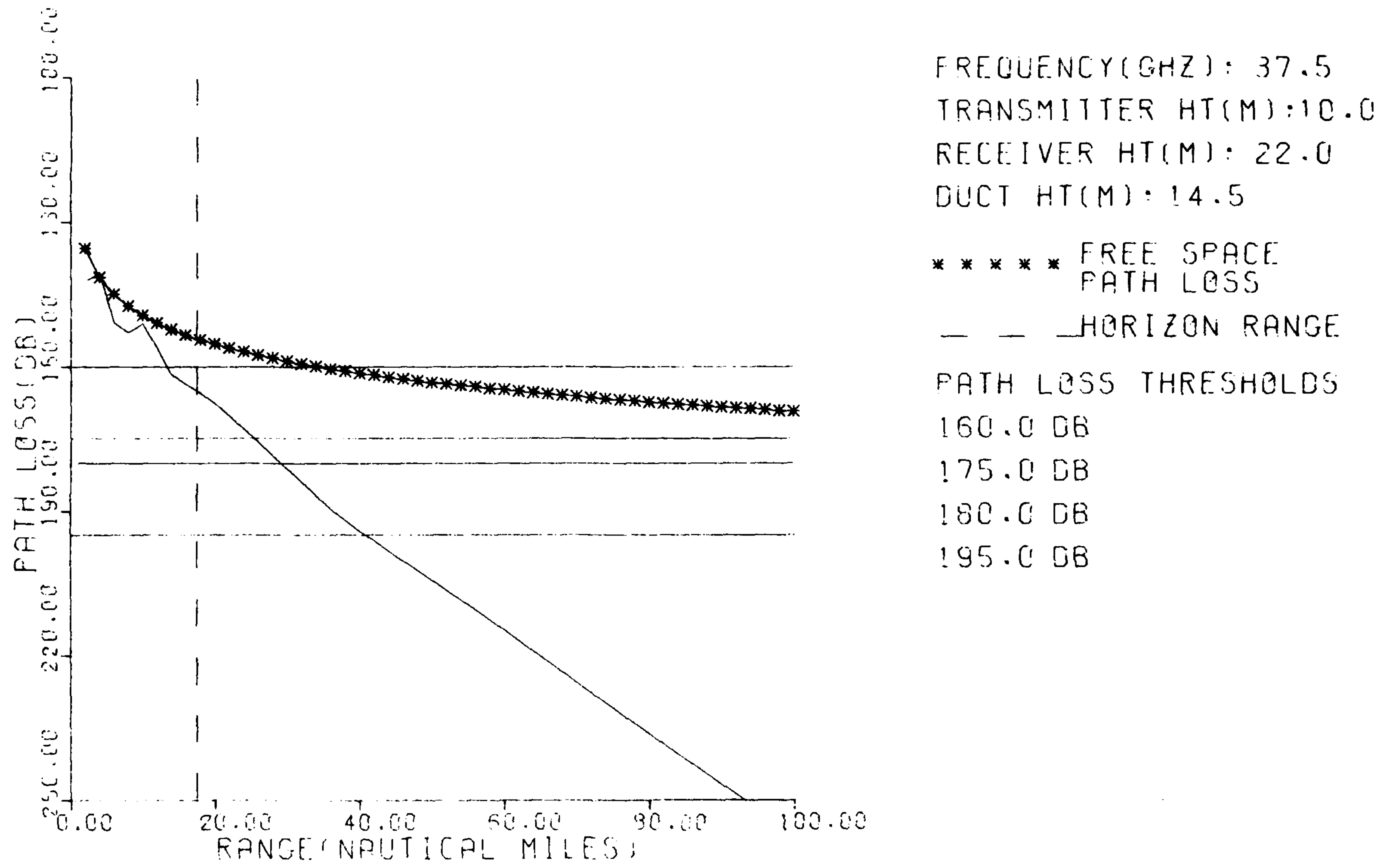
PATH LOSS THRESHOLDS

160.0 DB

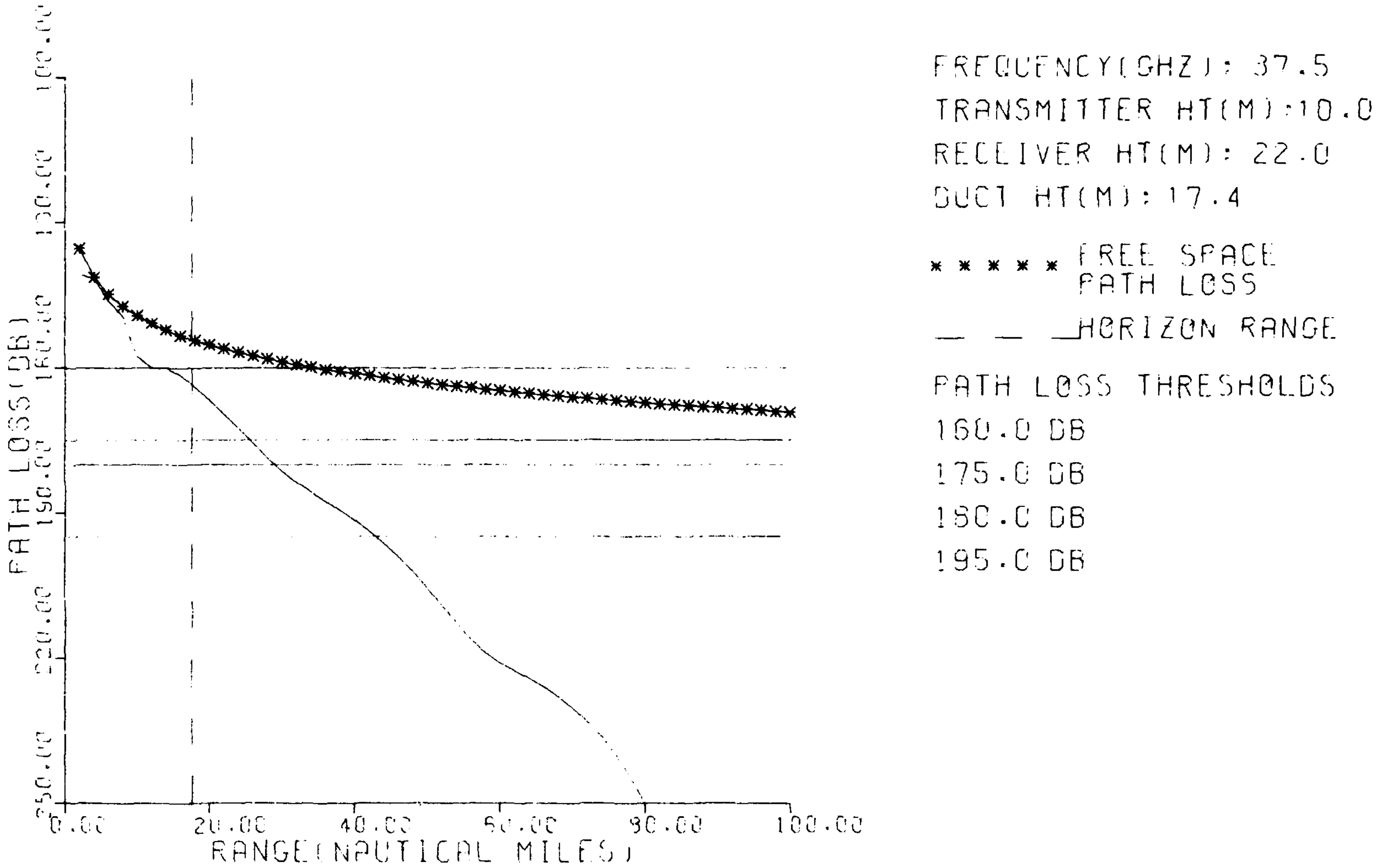
175.0 DB

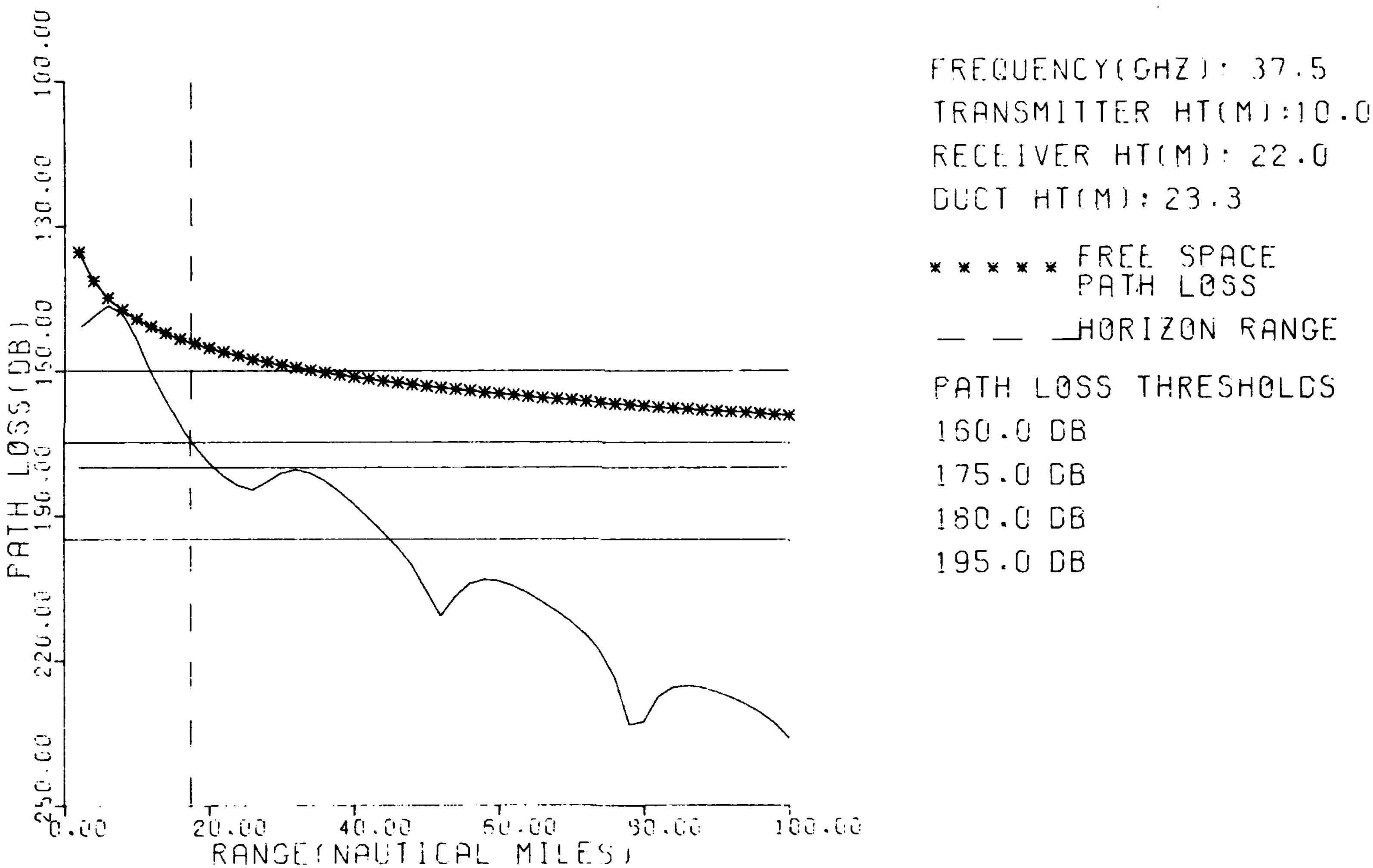
180.0 DB

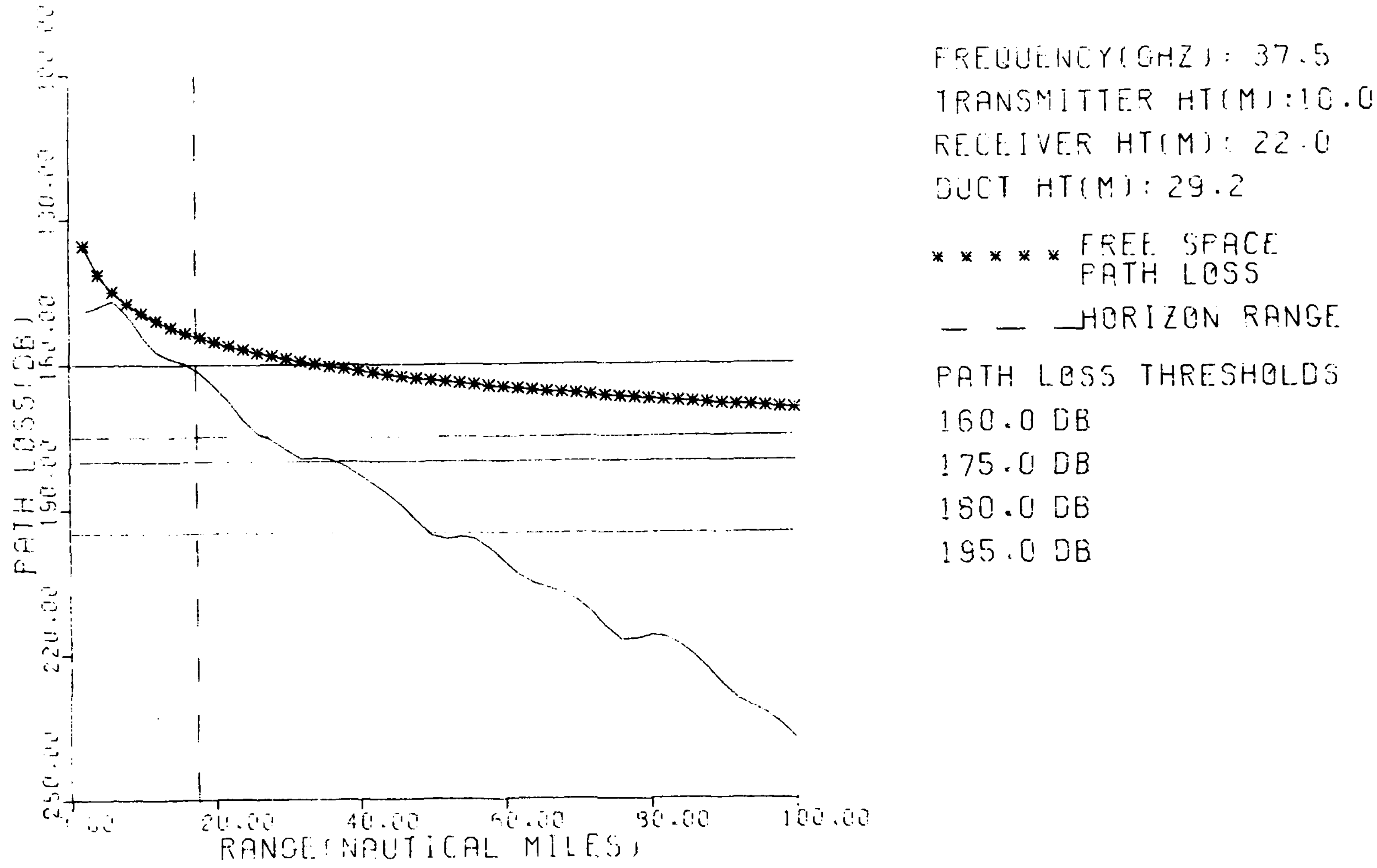
195.0 DB

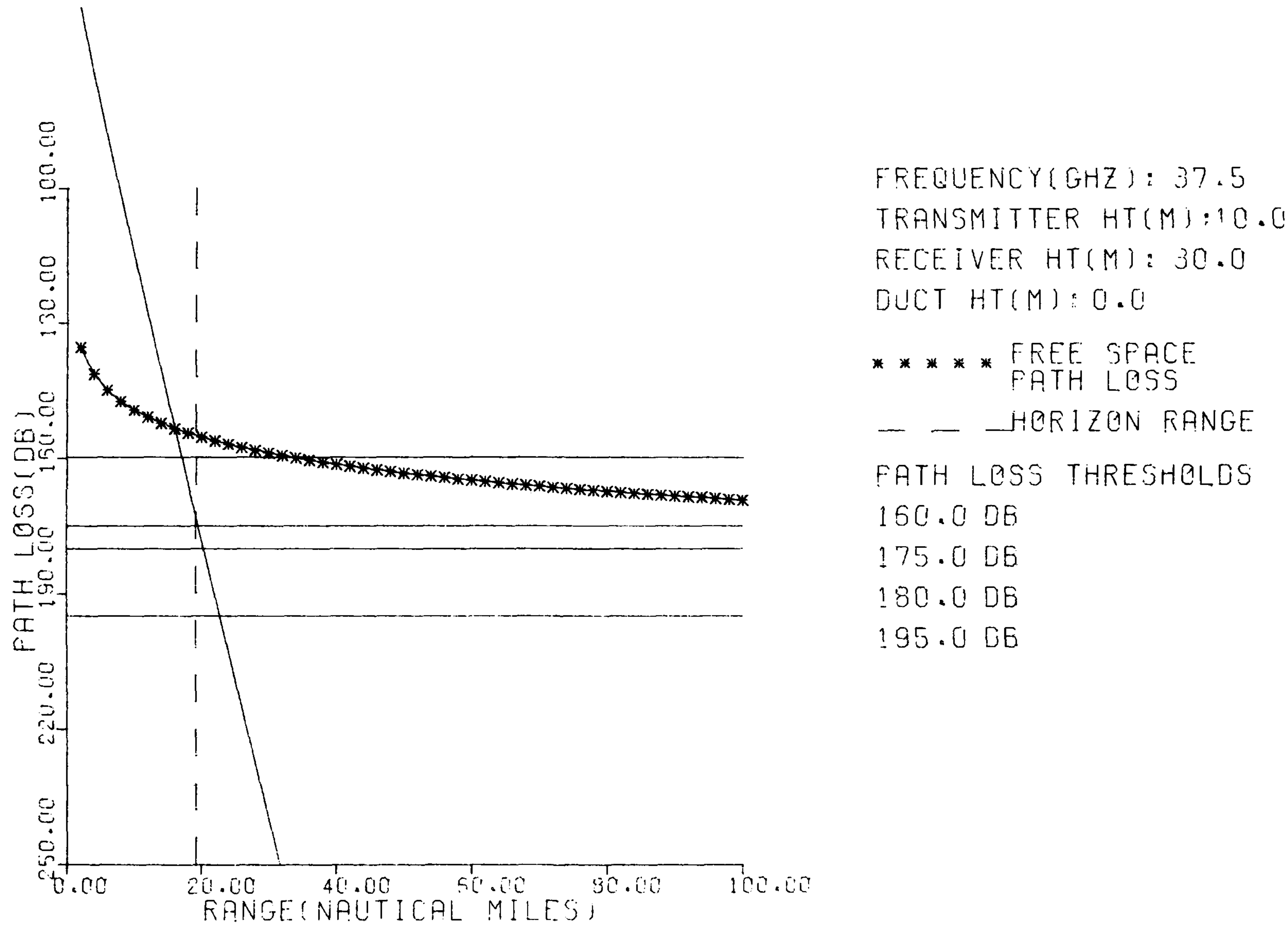


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 14.5
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

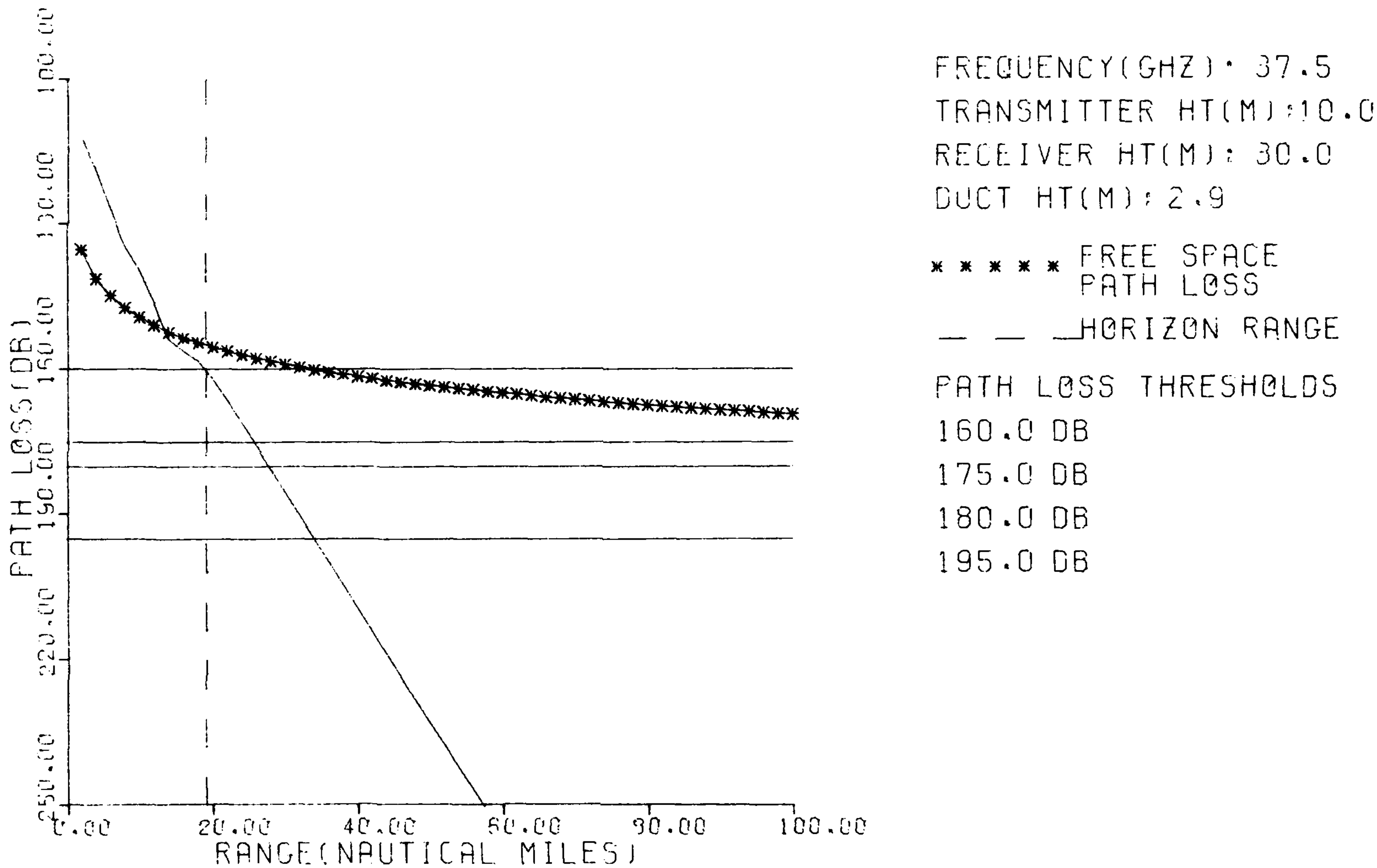

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 17.4
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 23.3
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

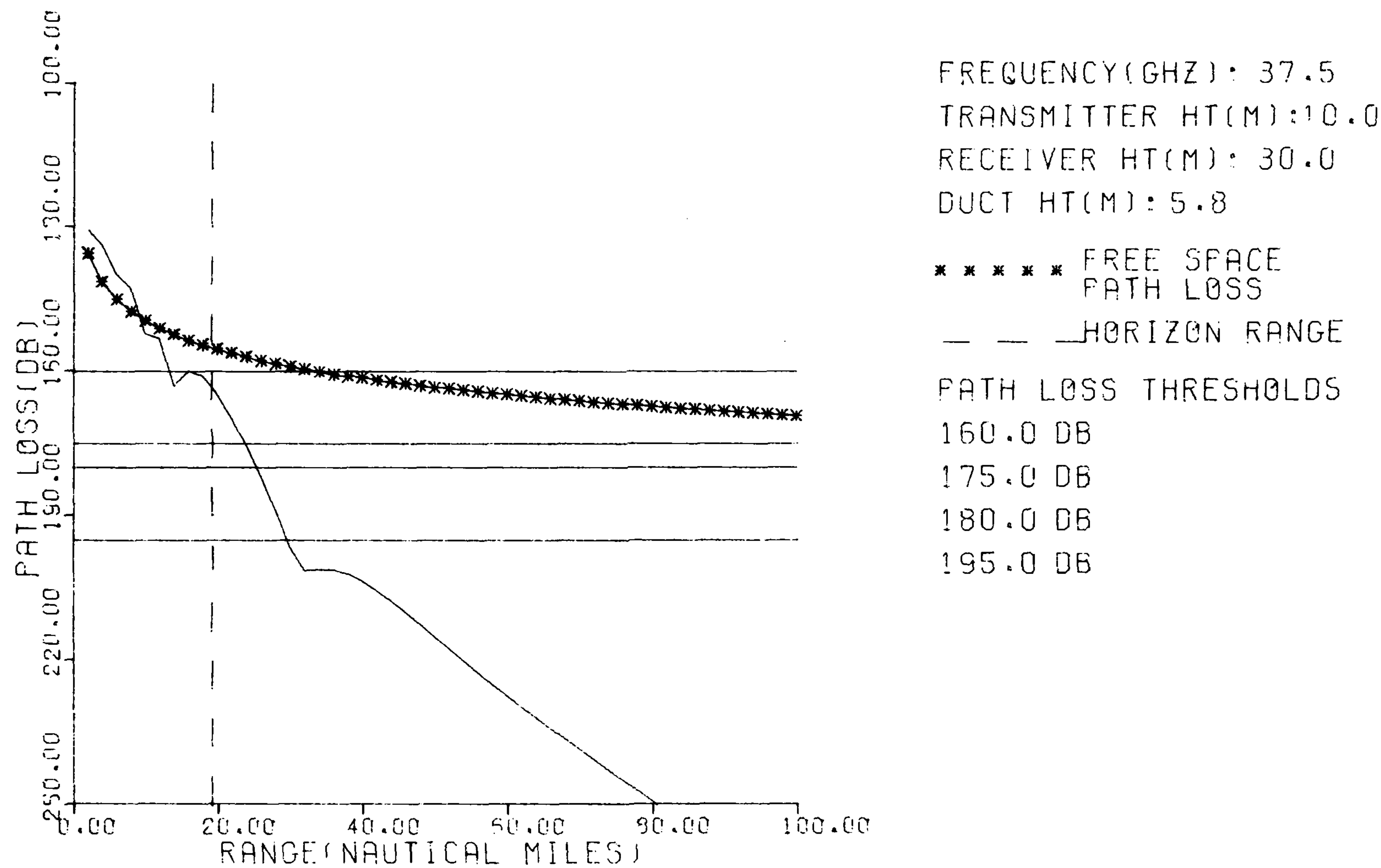

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 22.0
DUCT HT(M): 29.2
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
RANGE(NAUTICAL MILES)
20.00
40.00
60.00
80.00
100.00
130.00
160.00
190.00
220.00
250.00

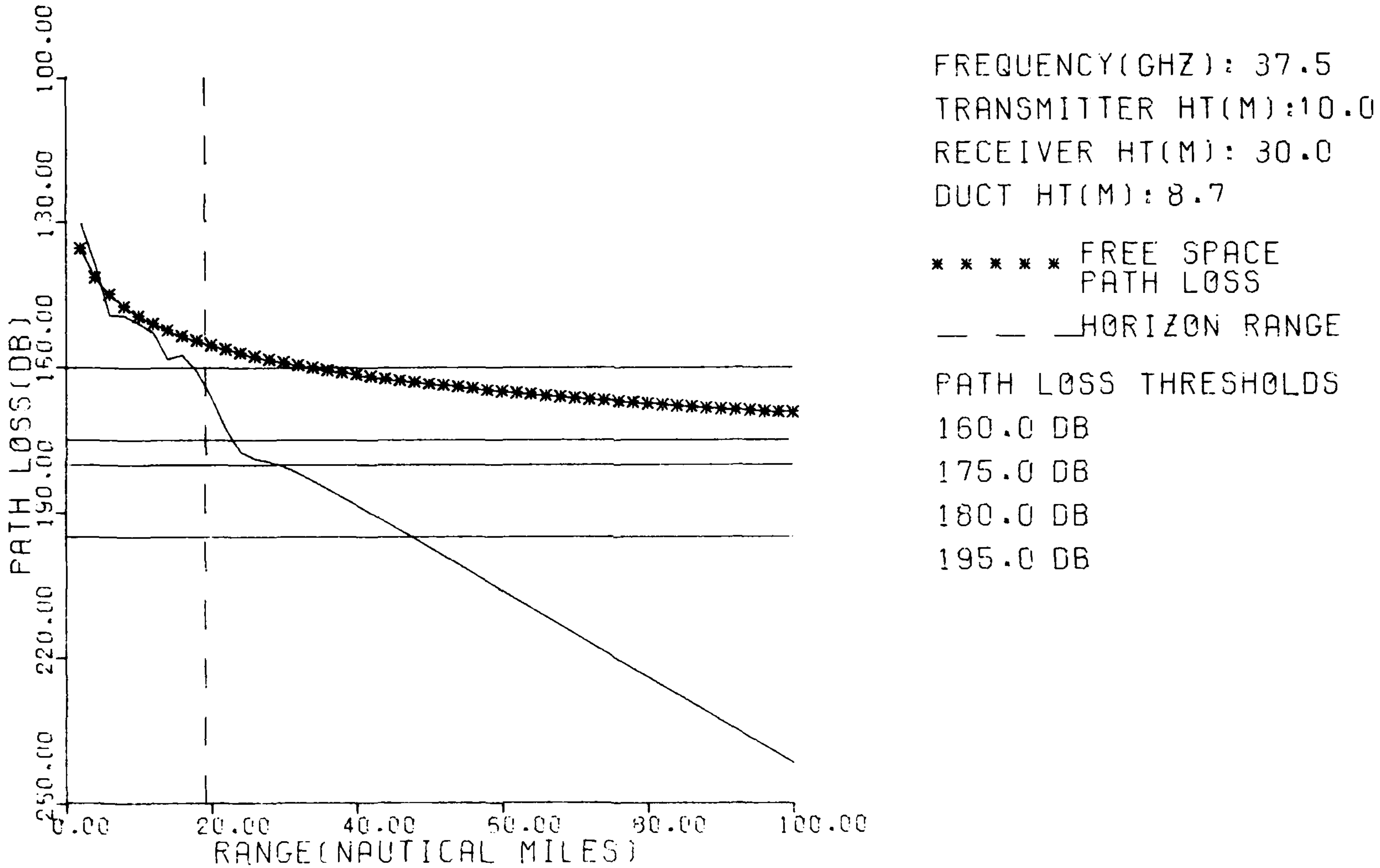


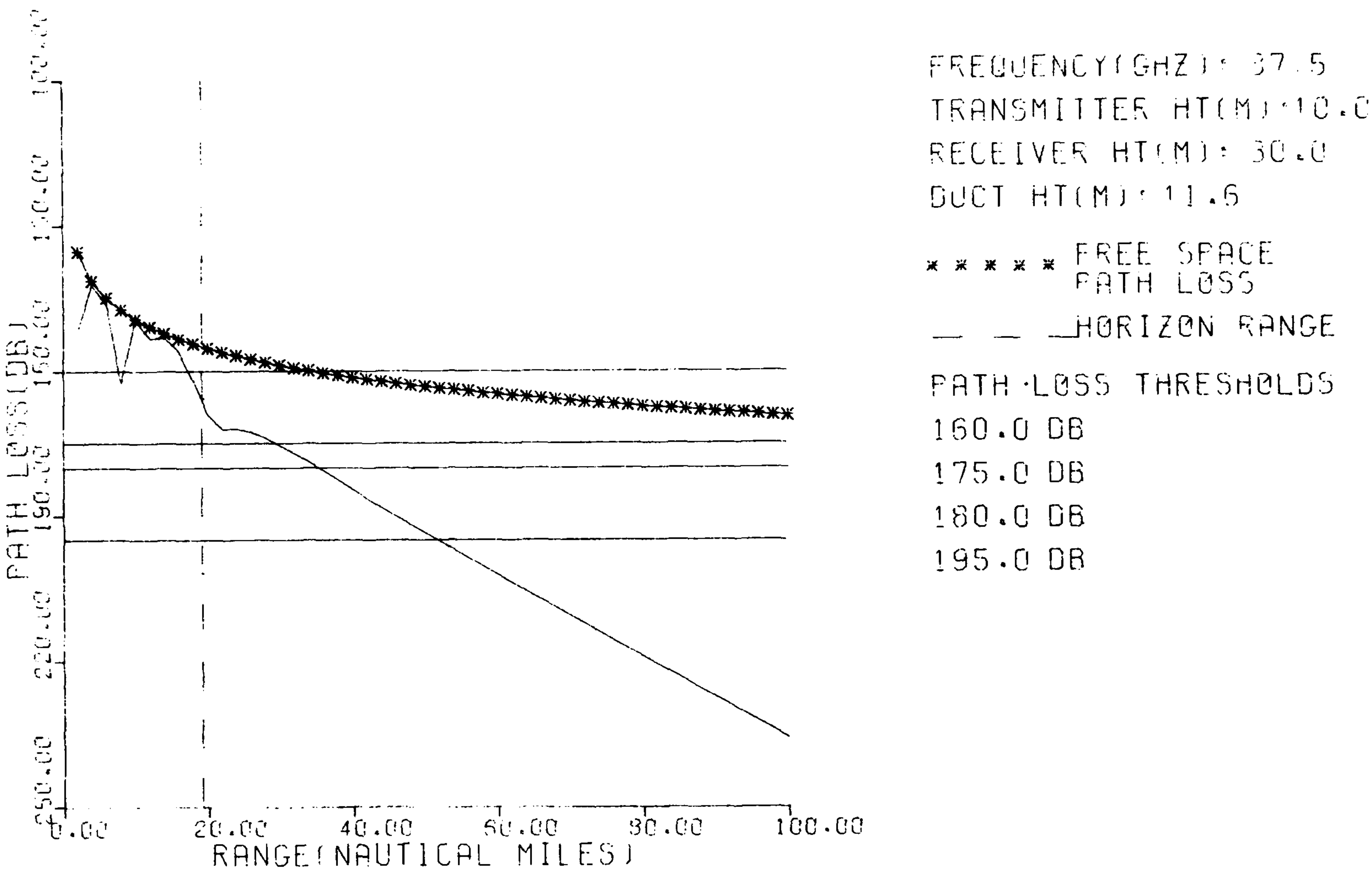
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 0.0
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

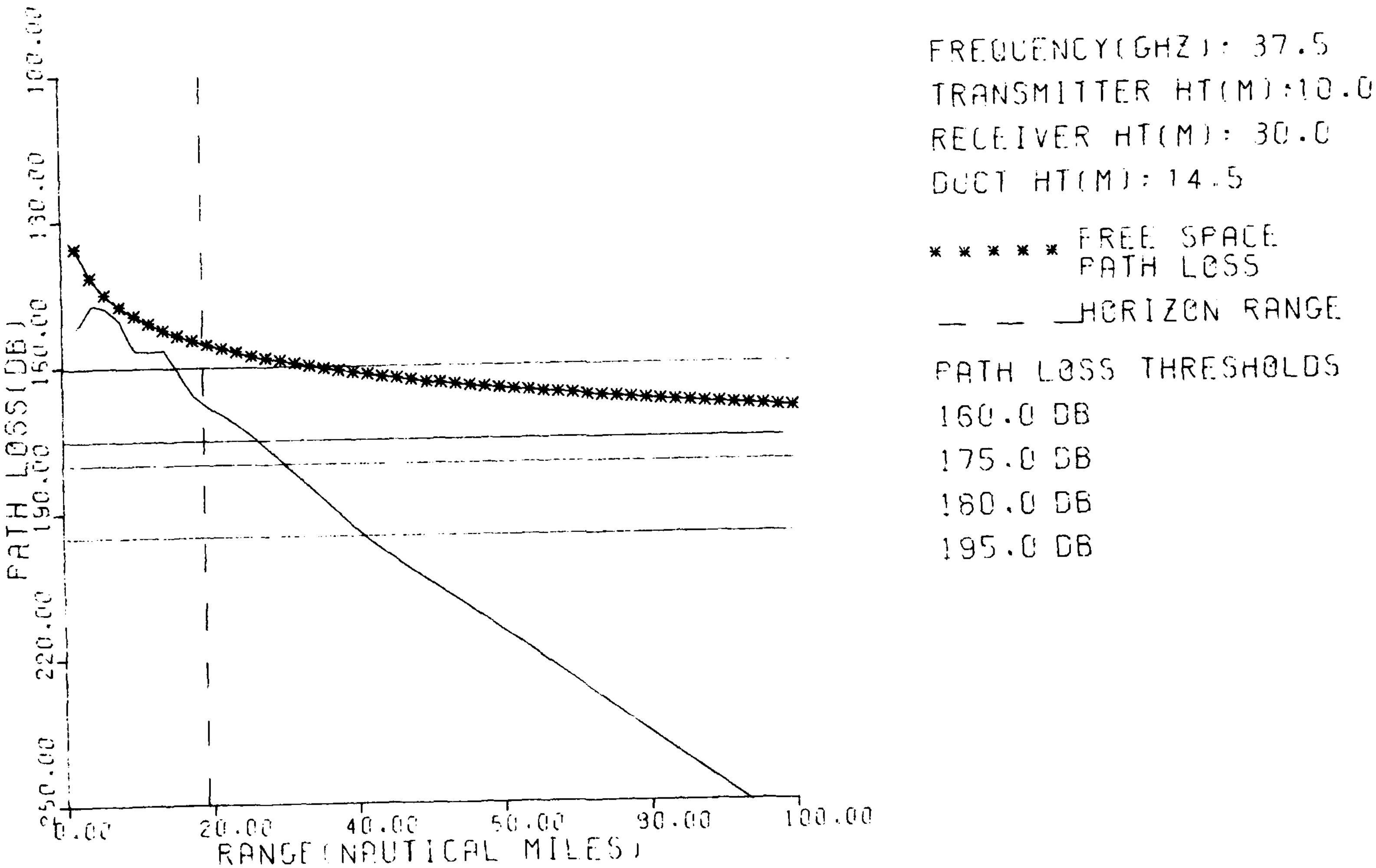


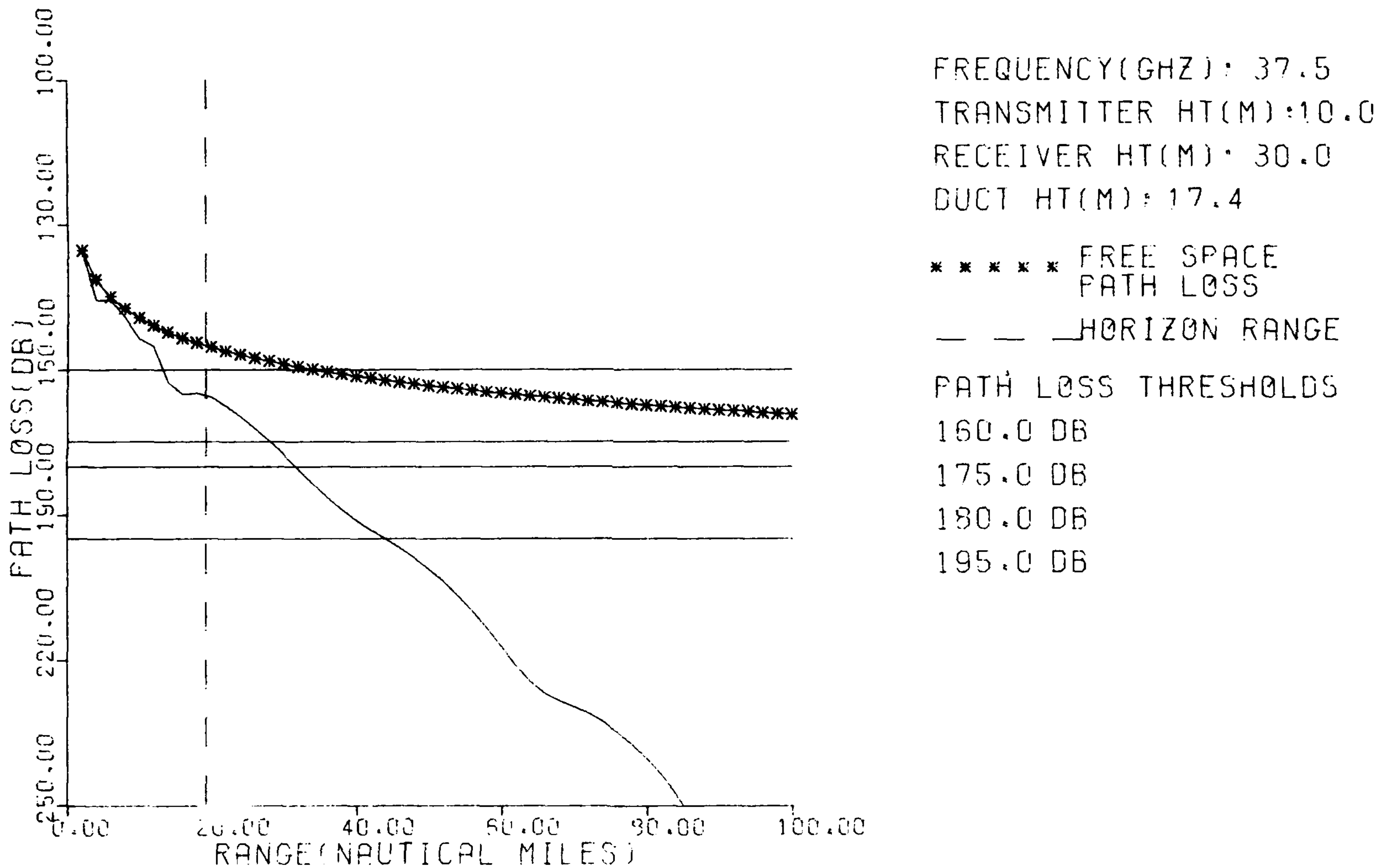
FREQUENCY(GHZ)· 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

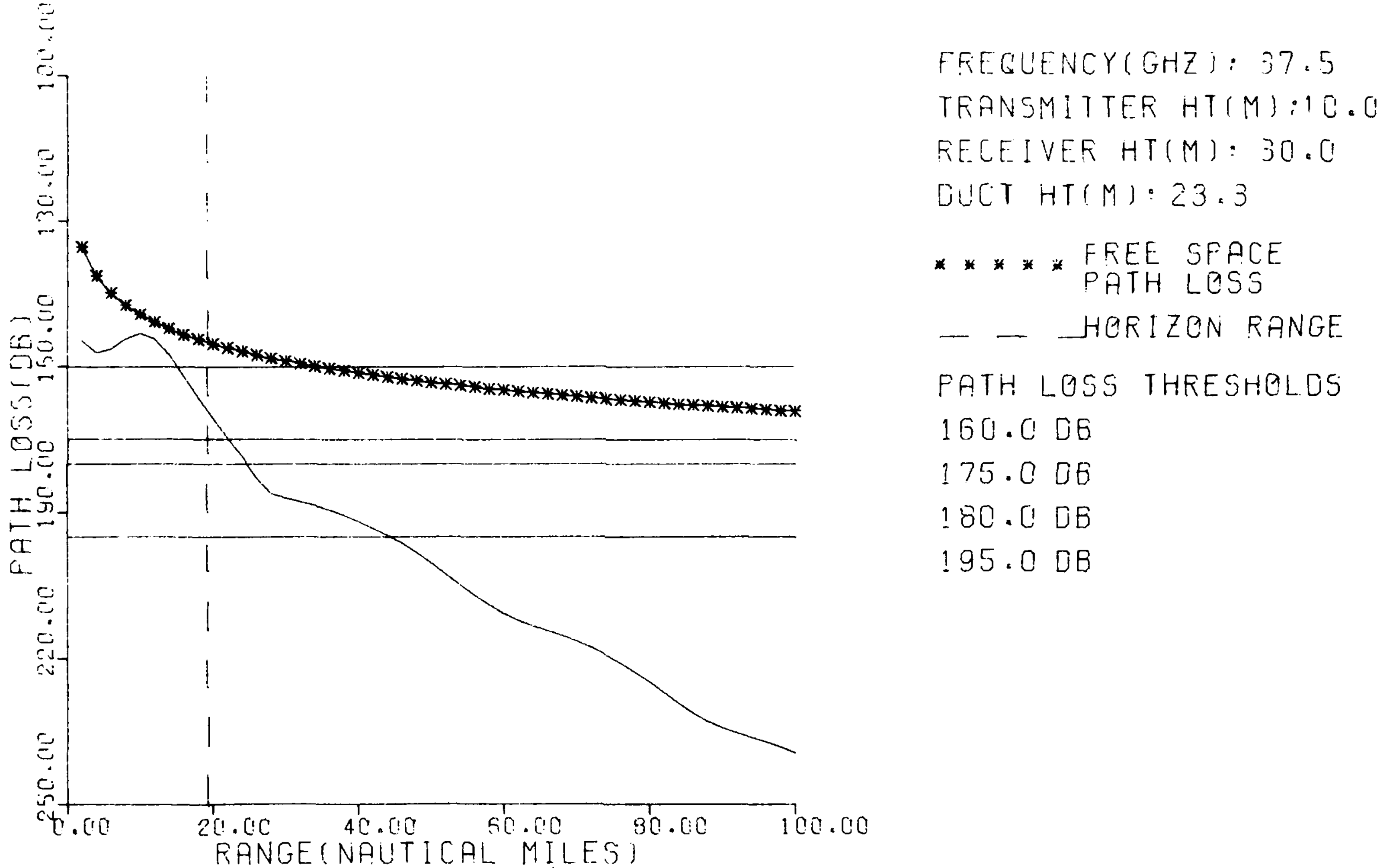

PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 5.8
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB

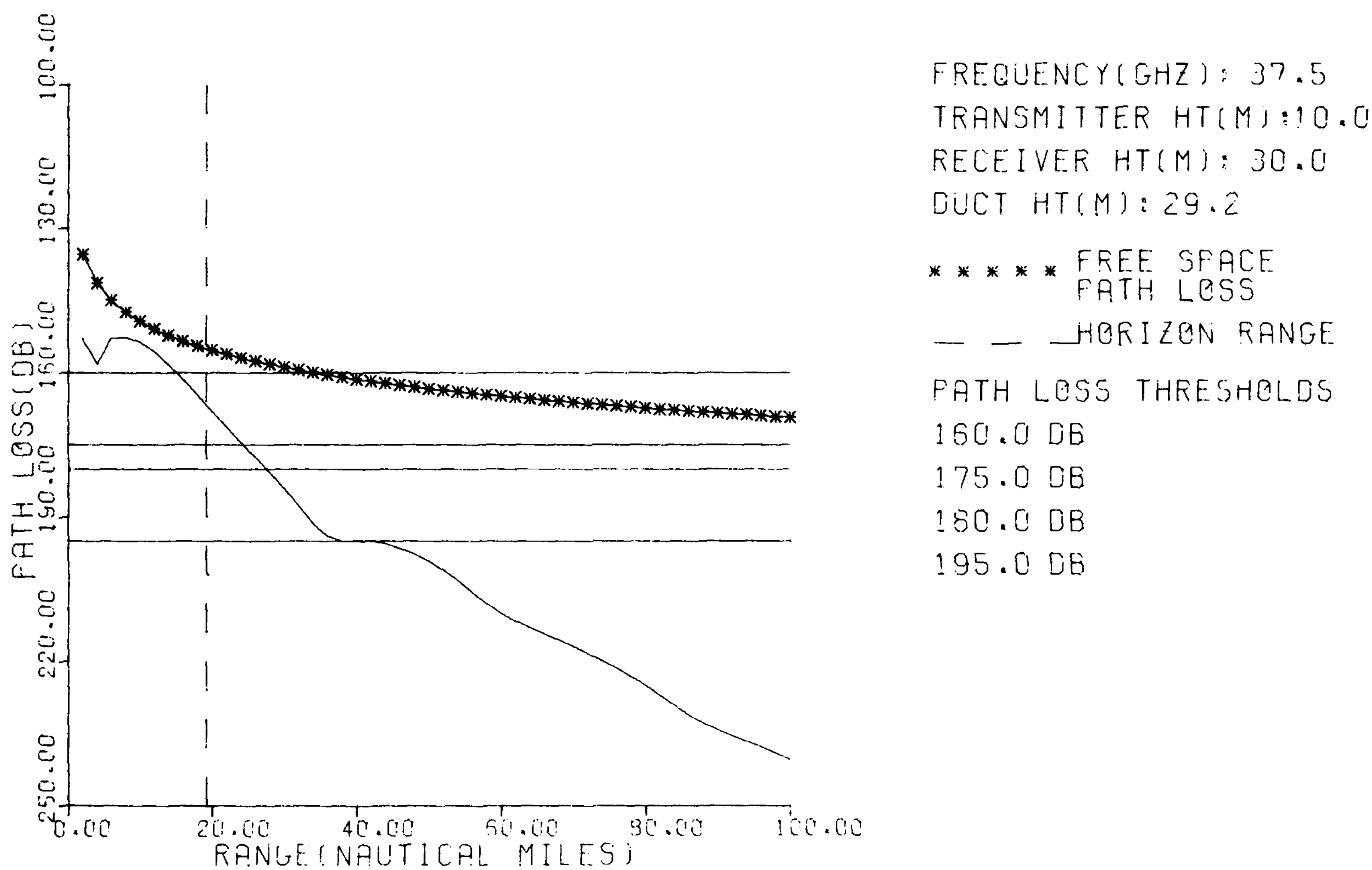

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 8.7
* * * * * FREE SPACE PATH LØSS
— — —HØRIZØN RANGE
PATH LØSS THRESHØLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

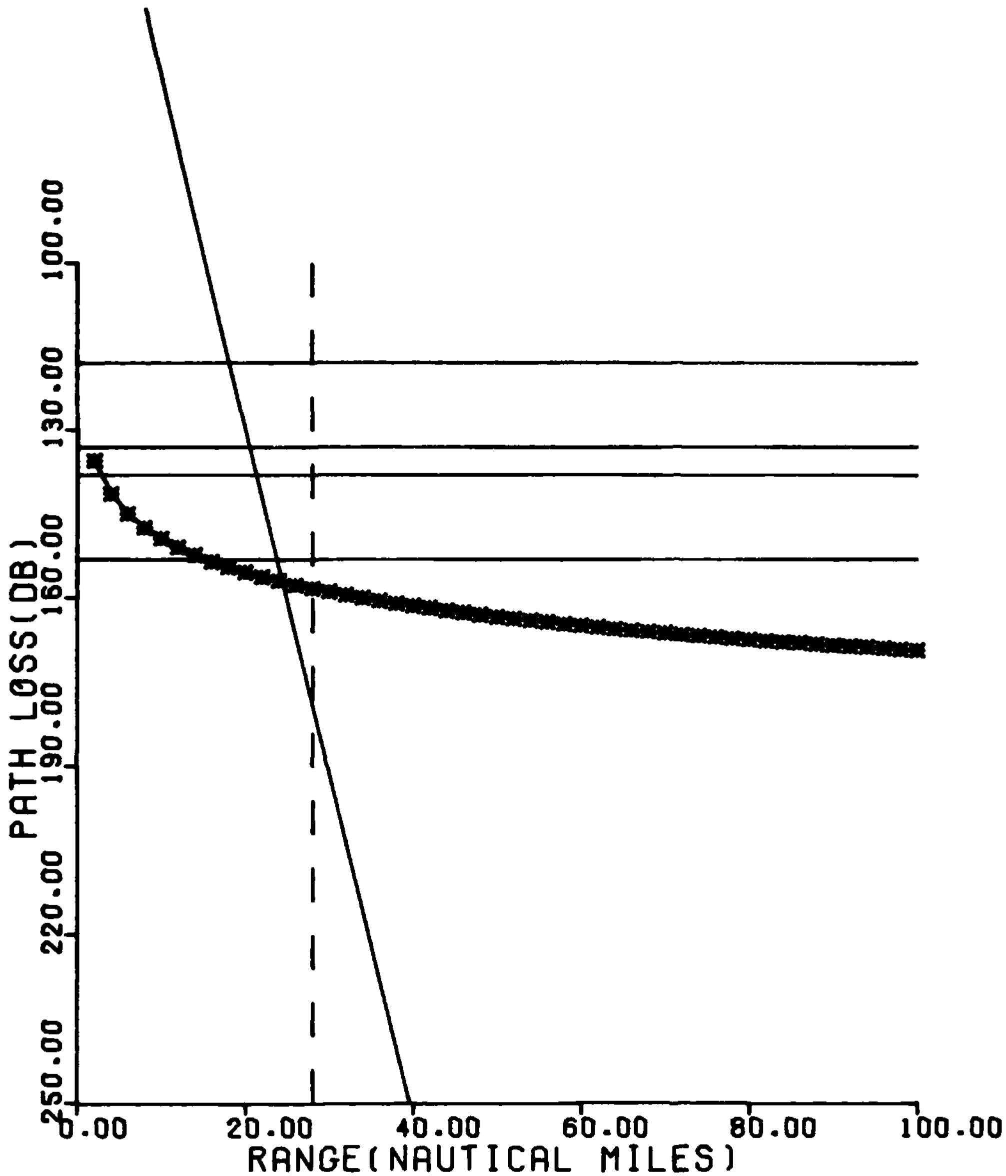

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M): 10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 11.6
* * * * * FREE SPACE PATH LOSS
_ _ _ HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 14.5
* * * * * FREE SPACE PATH LOSS
_ _ _ HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 17.4
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 23.3
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):10.0
RECEIVER HT(M): 30.0
DUCT HT(M): 29.2
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
160.0 DB
175.0 DB
180.0 DB
195.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

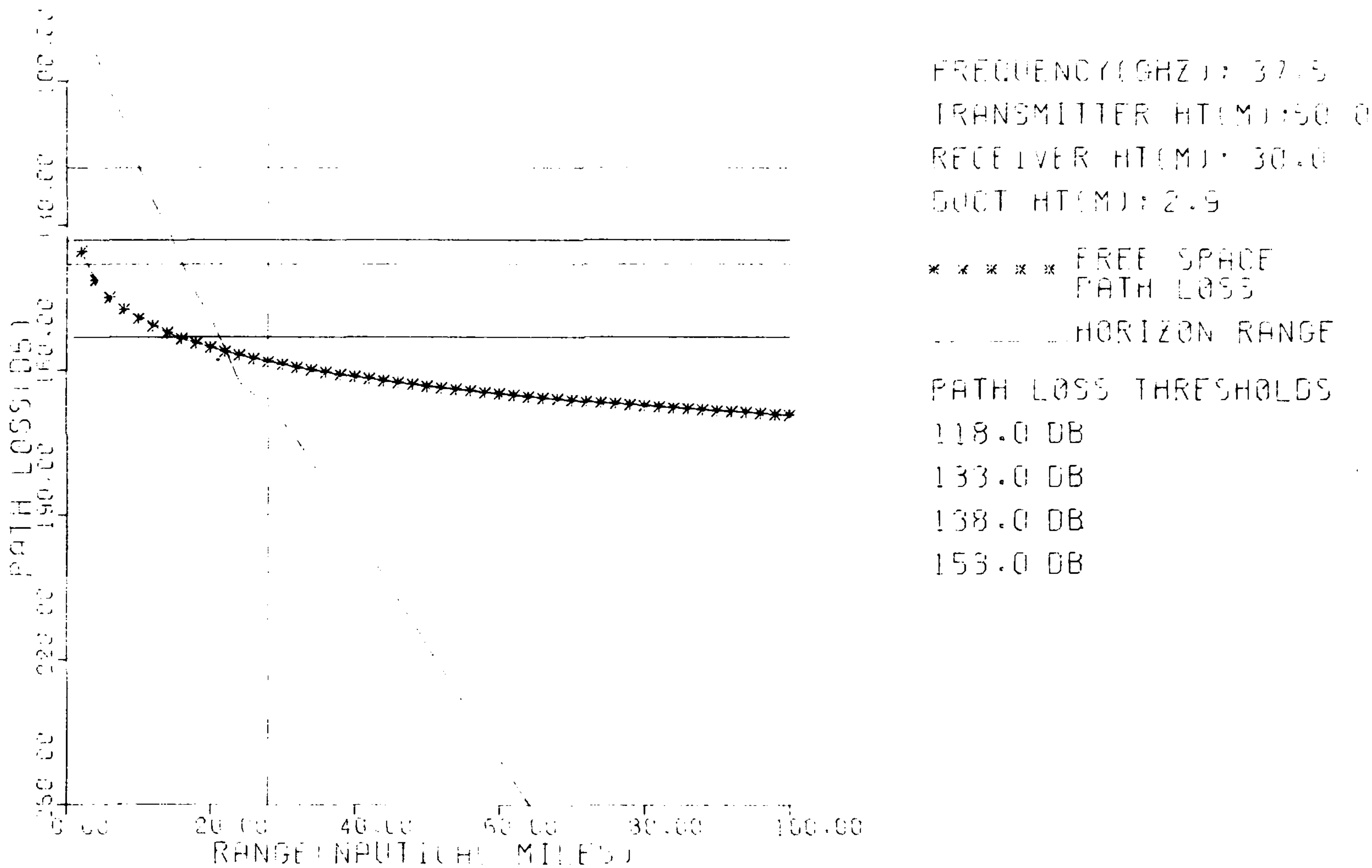


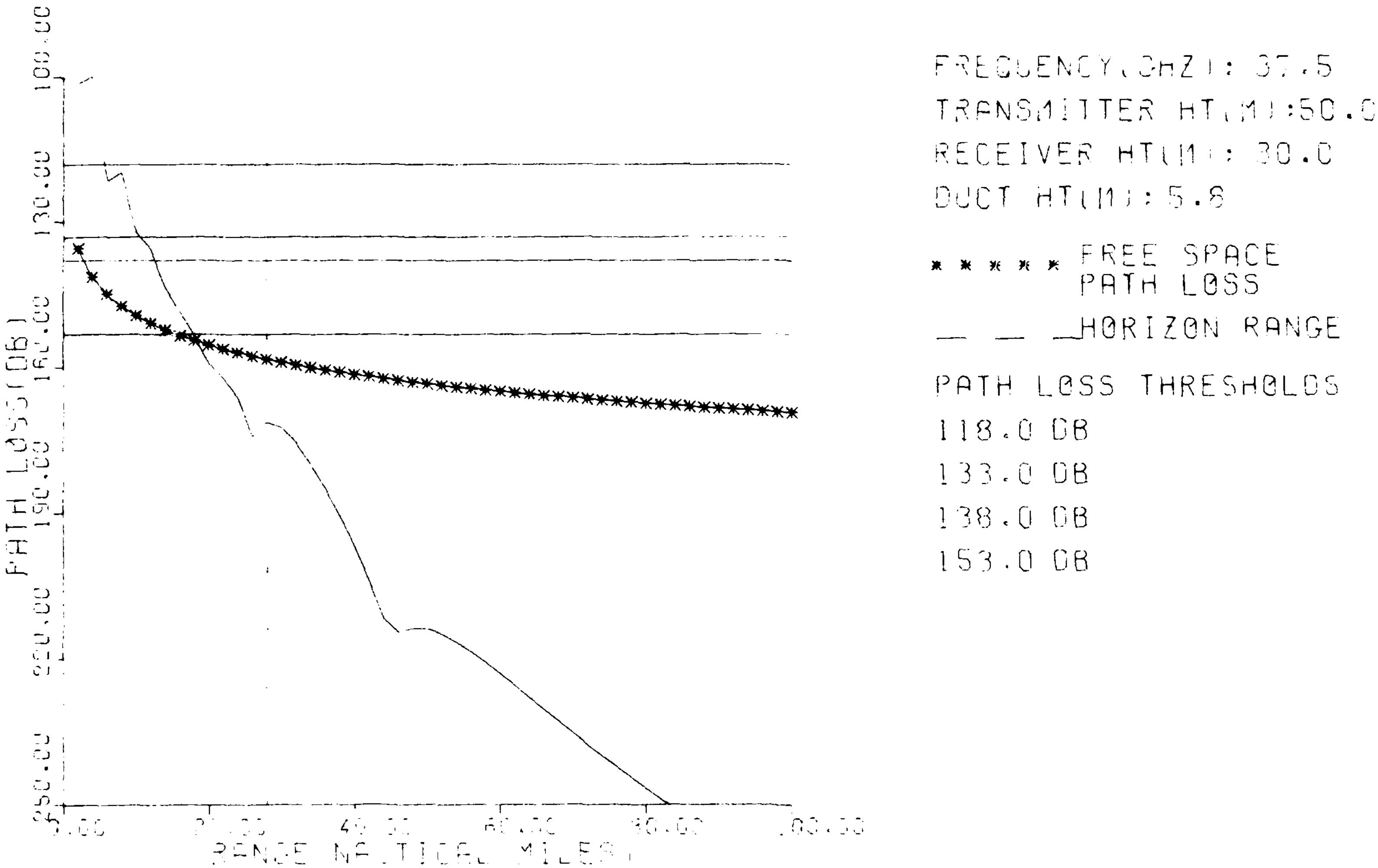
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 0.0

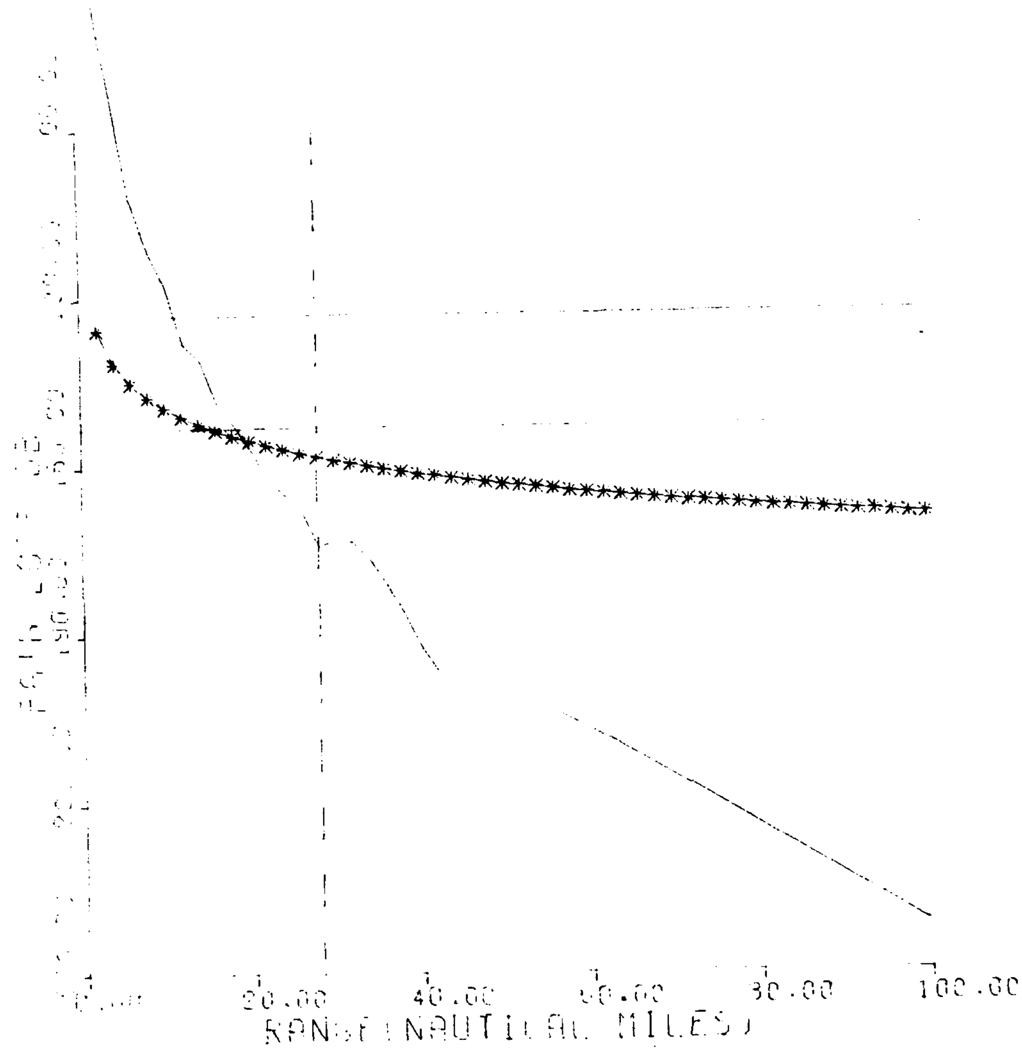
▪ ▪ ▪ ▪ ▪ FREE SPACE PATH LØSS

— — —HØRIZØN RANGE

PATH LØSS THRESHØLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
— — — HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00


100.00
130.00
160.00
190.00
220.00
250.00
PATH LOSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 5.8
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB



FREQUENCY(GHZ): 37.5

TRANSMITTER HT(M):50.0

RECEIVER HT(M): 30.0

DUCT HT(M): 8.7

* * * * * FREE SPACE PATH LØSS

__ __ __HØRIZØN RANGE

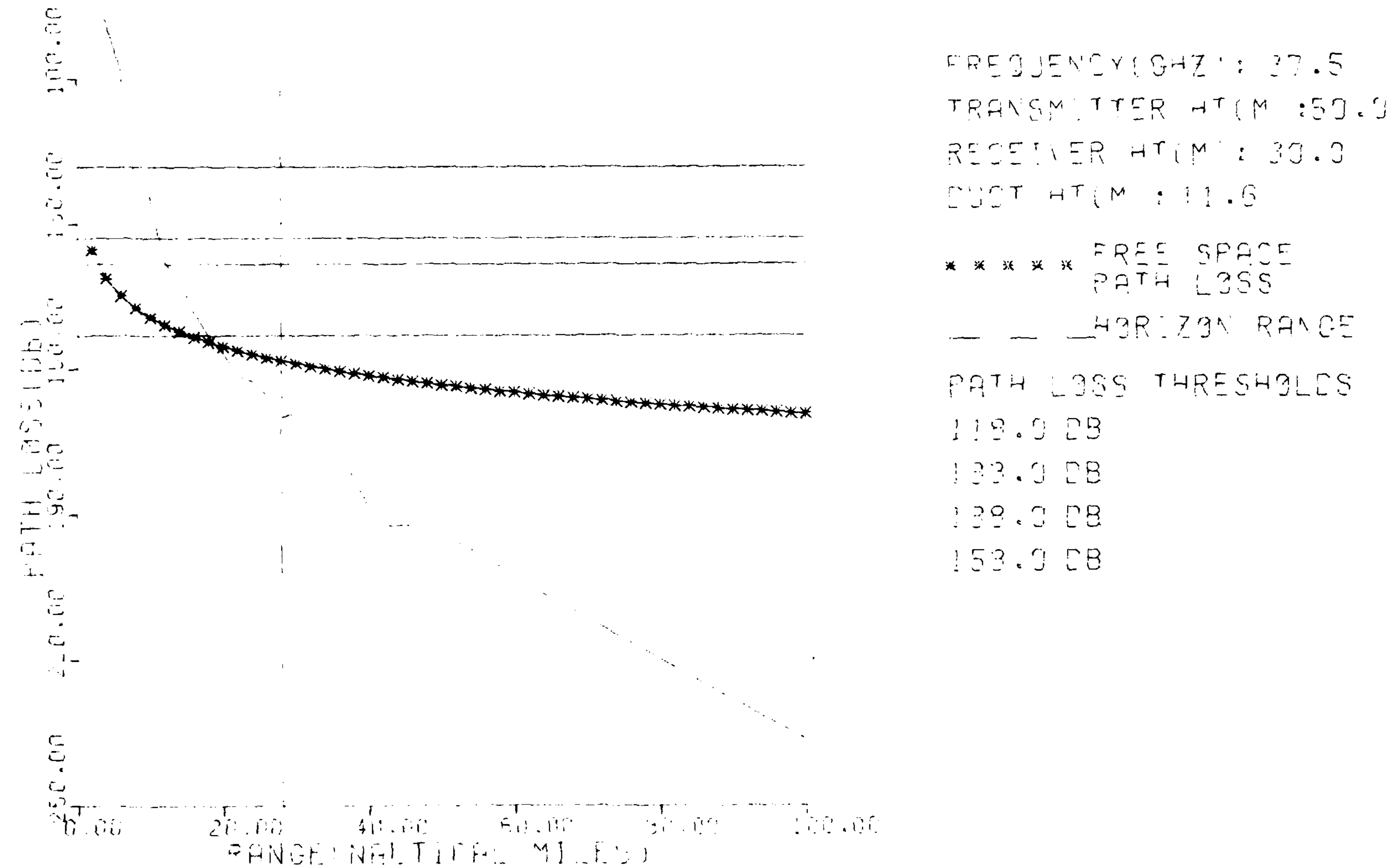
PATH LØSS THRESHØLDS

118.0 DB

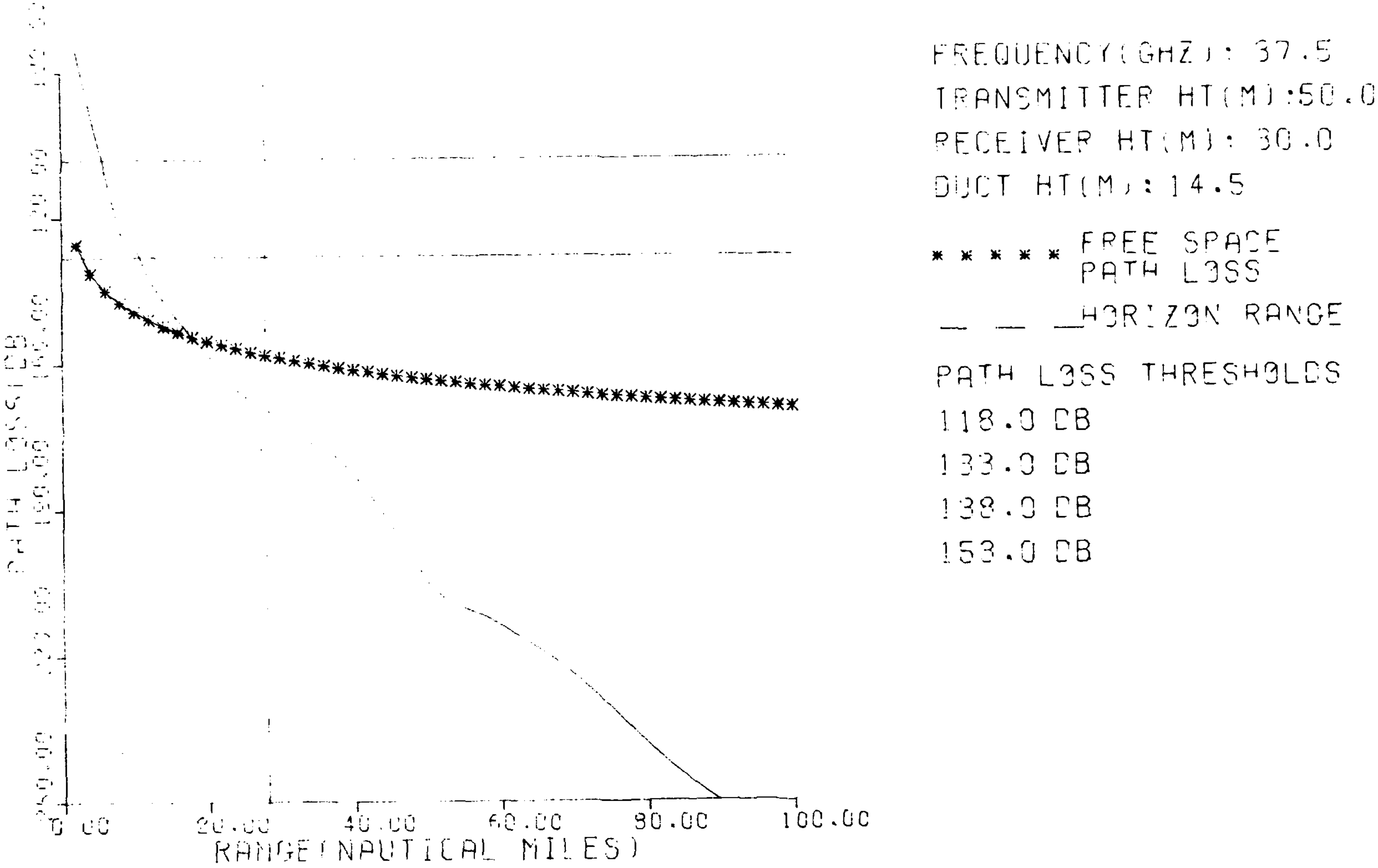
133.0 DB

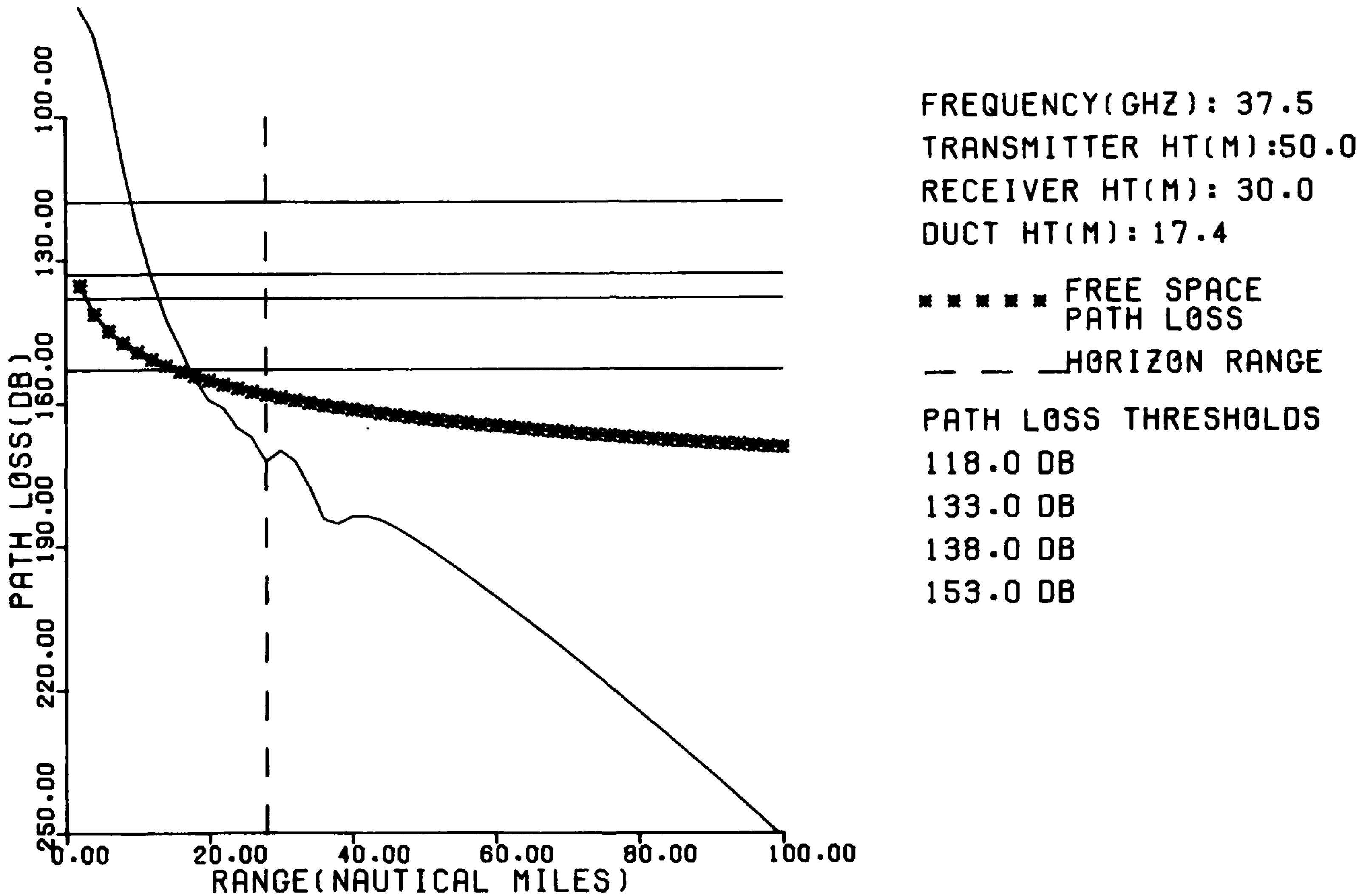
138.0 DB

153.0 DB

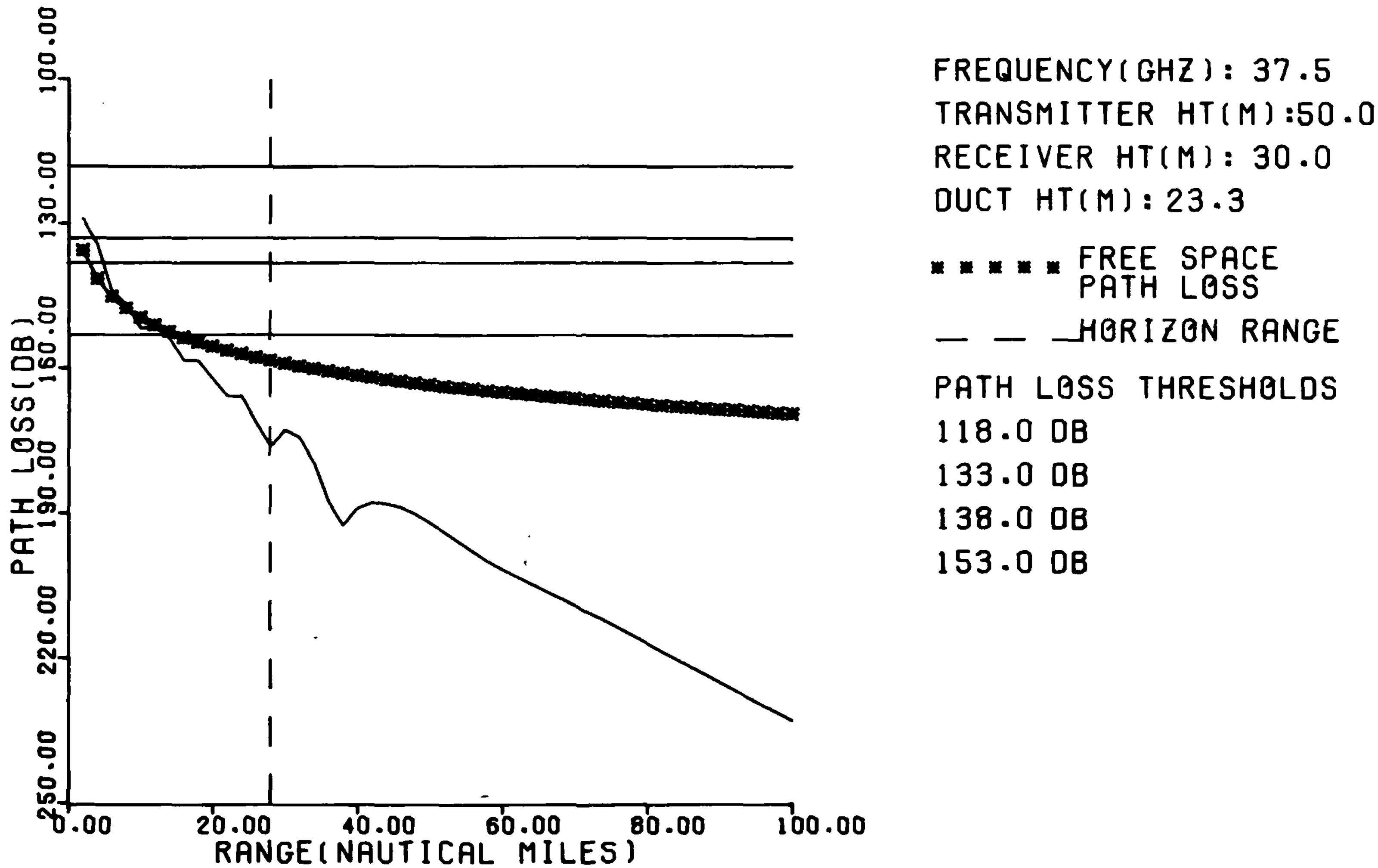


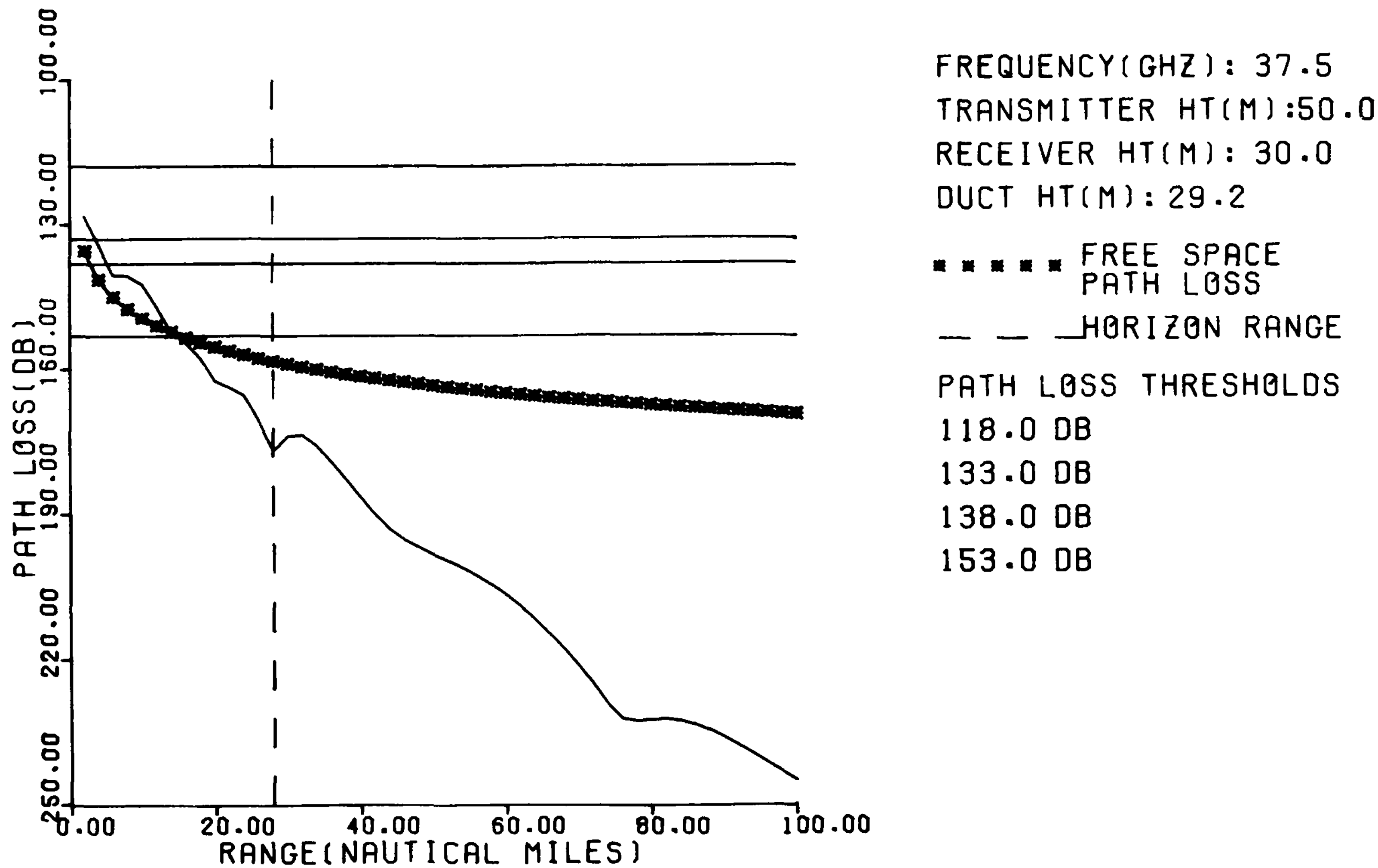
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M): 50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 11.6
* * * * * FREE SPACE PATH LOSS
__ __ __HORIZON RANGE
PATH LOSS THRESHOLDS
119.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

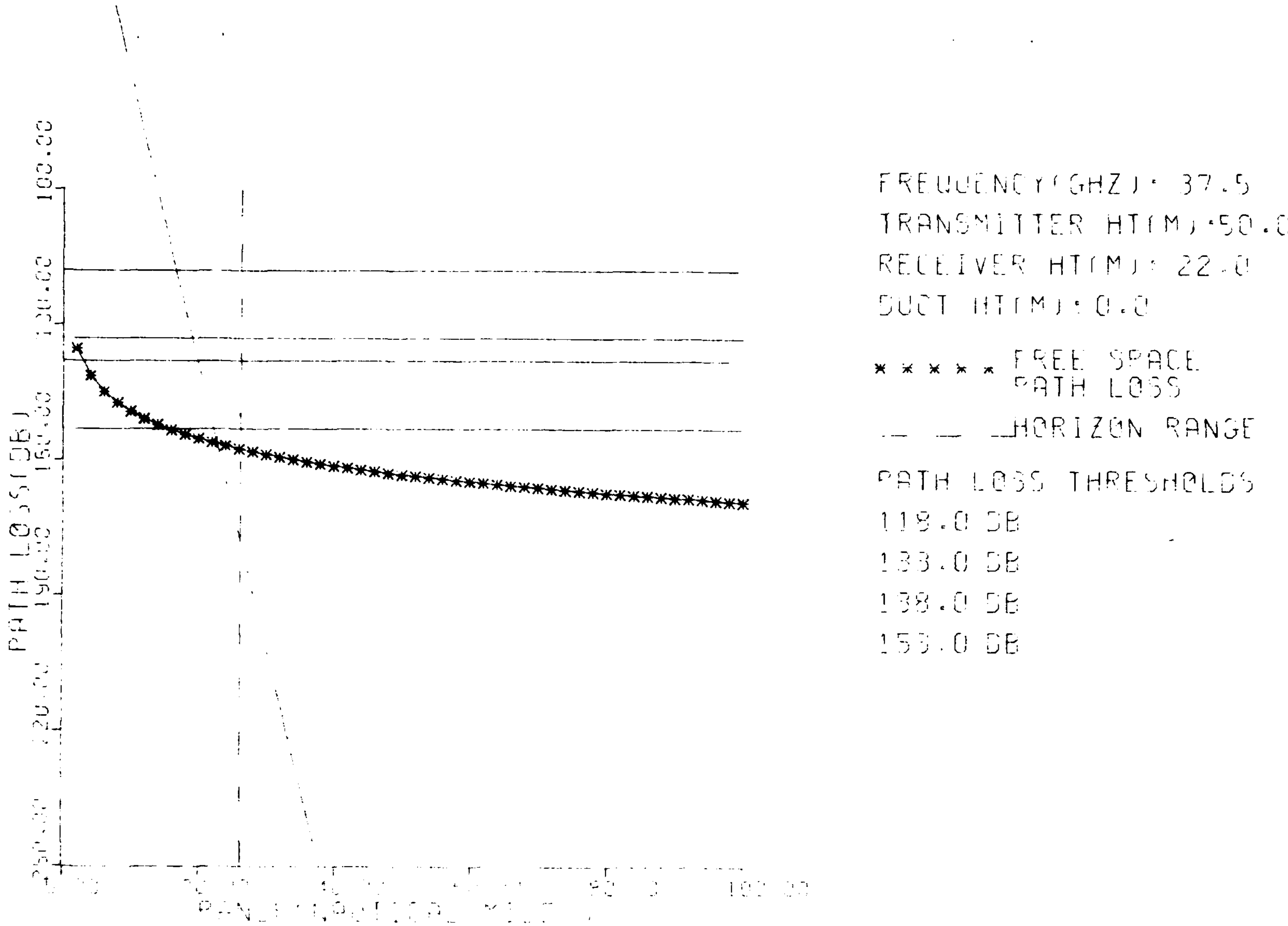

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 14.5
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
PATH LOSS

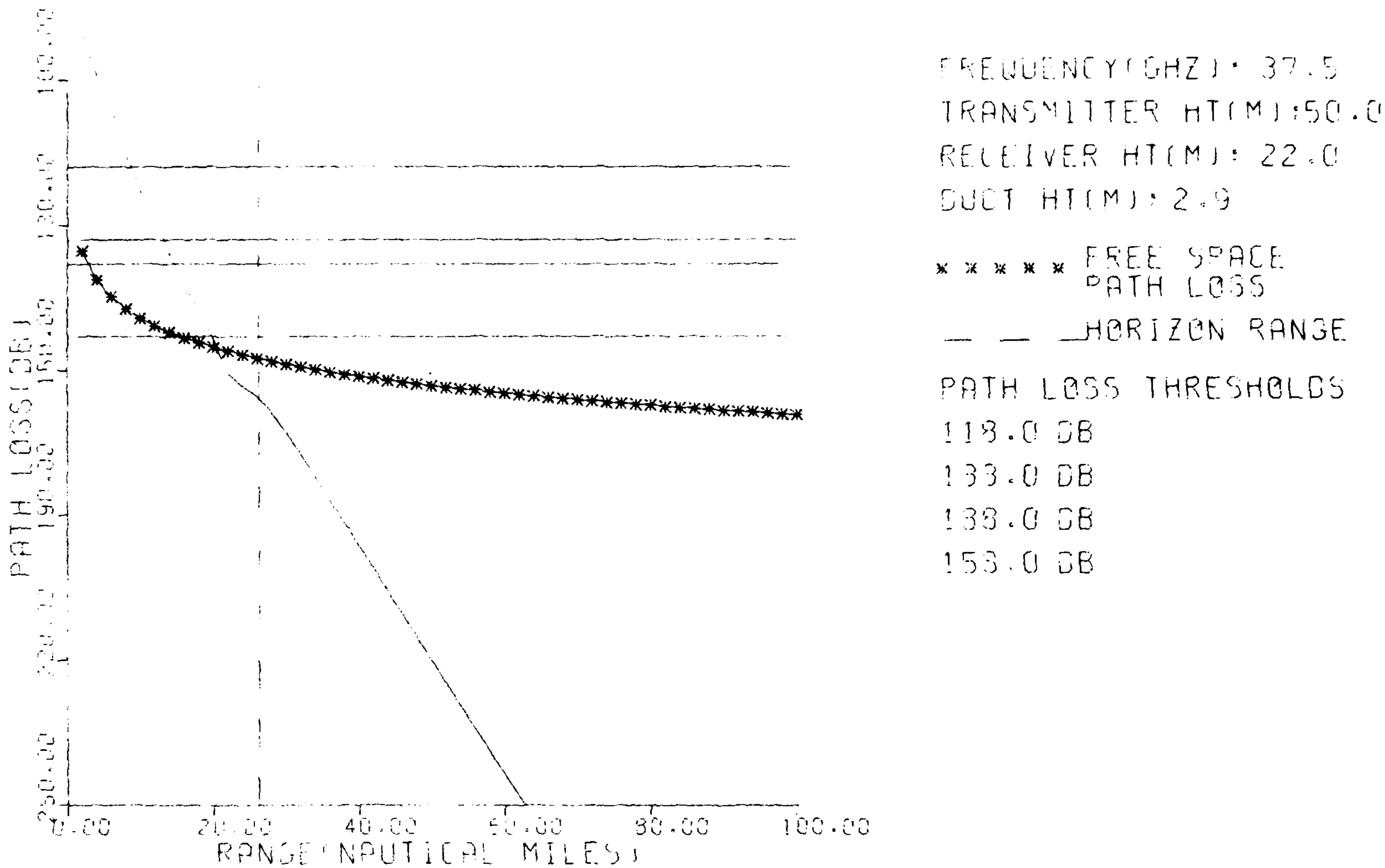


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 17.4
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

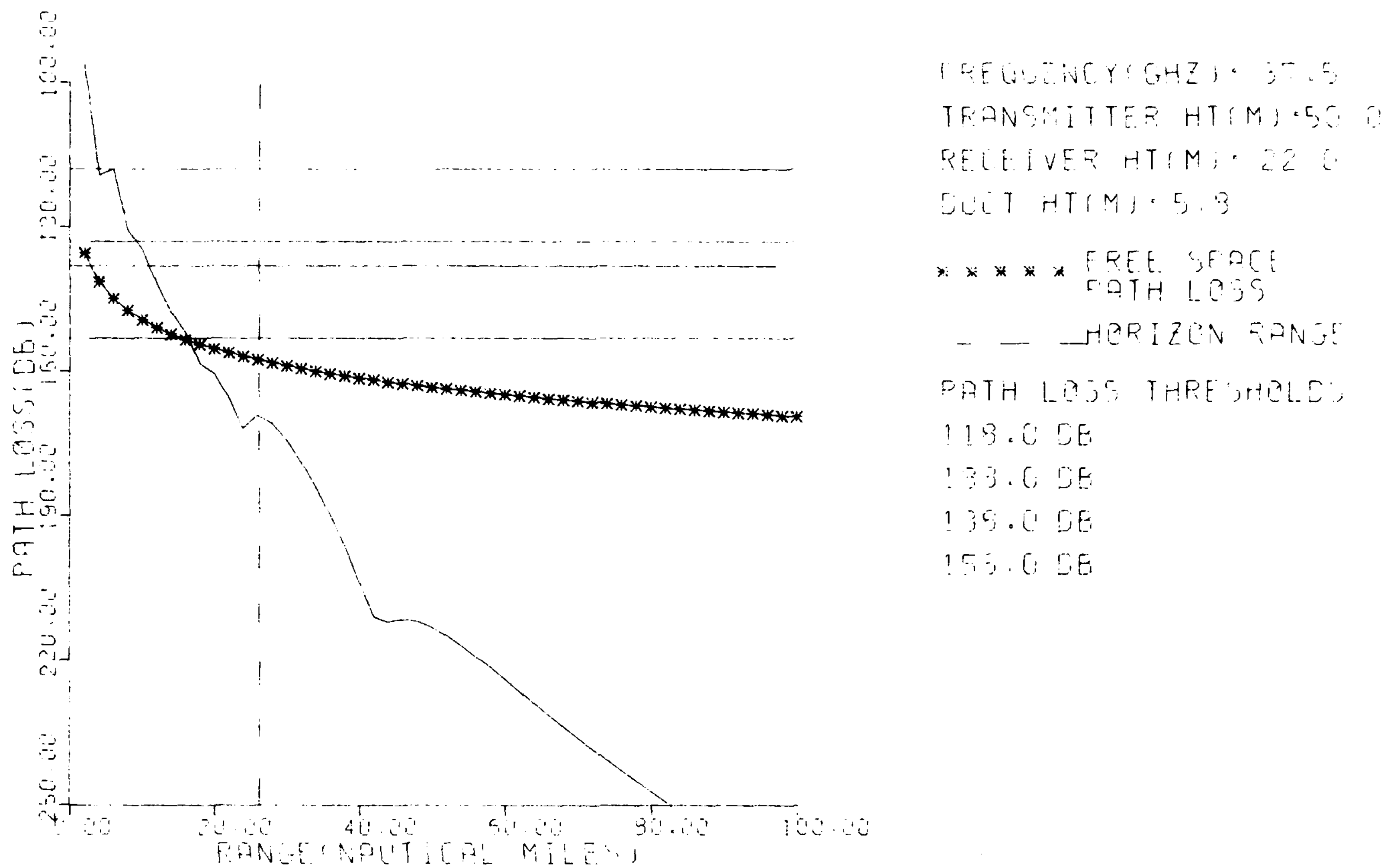

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 23.3
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

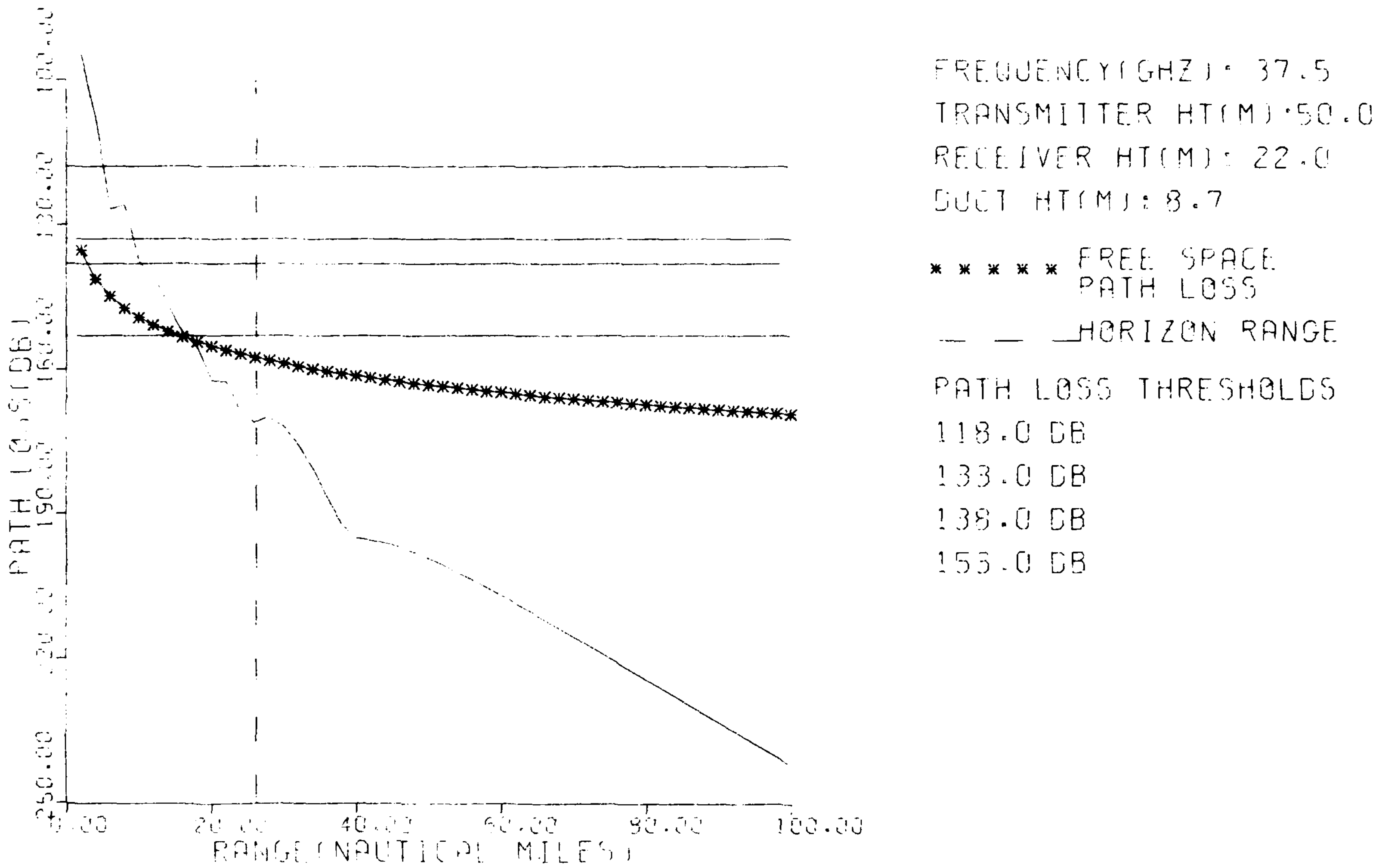

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 30.0
DUCT HT(M): 29.2
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

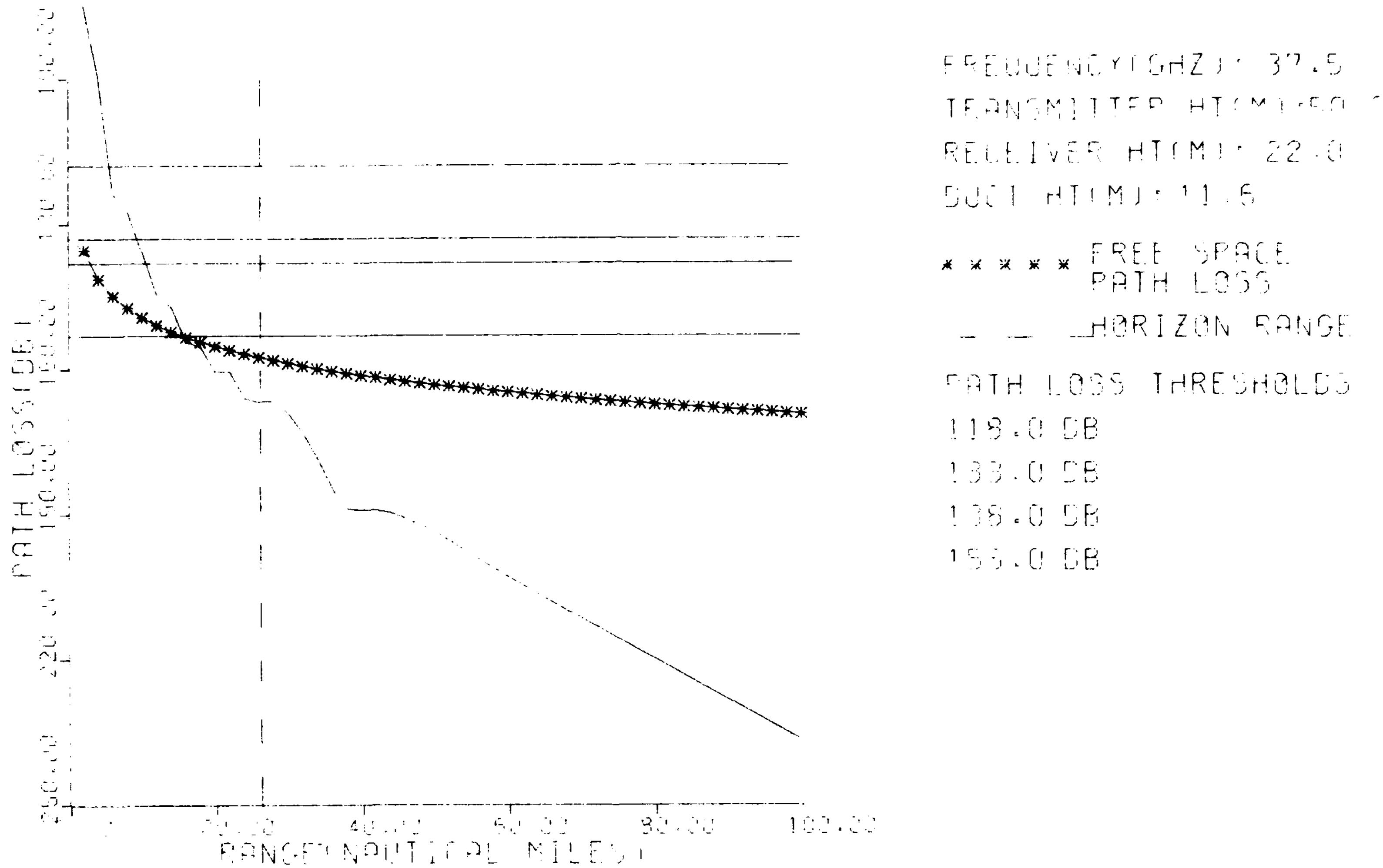

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 0.0
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
155.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
100.00

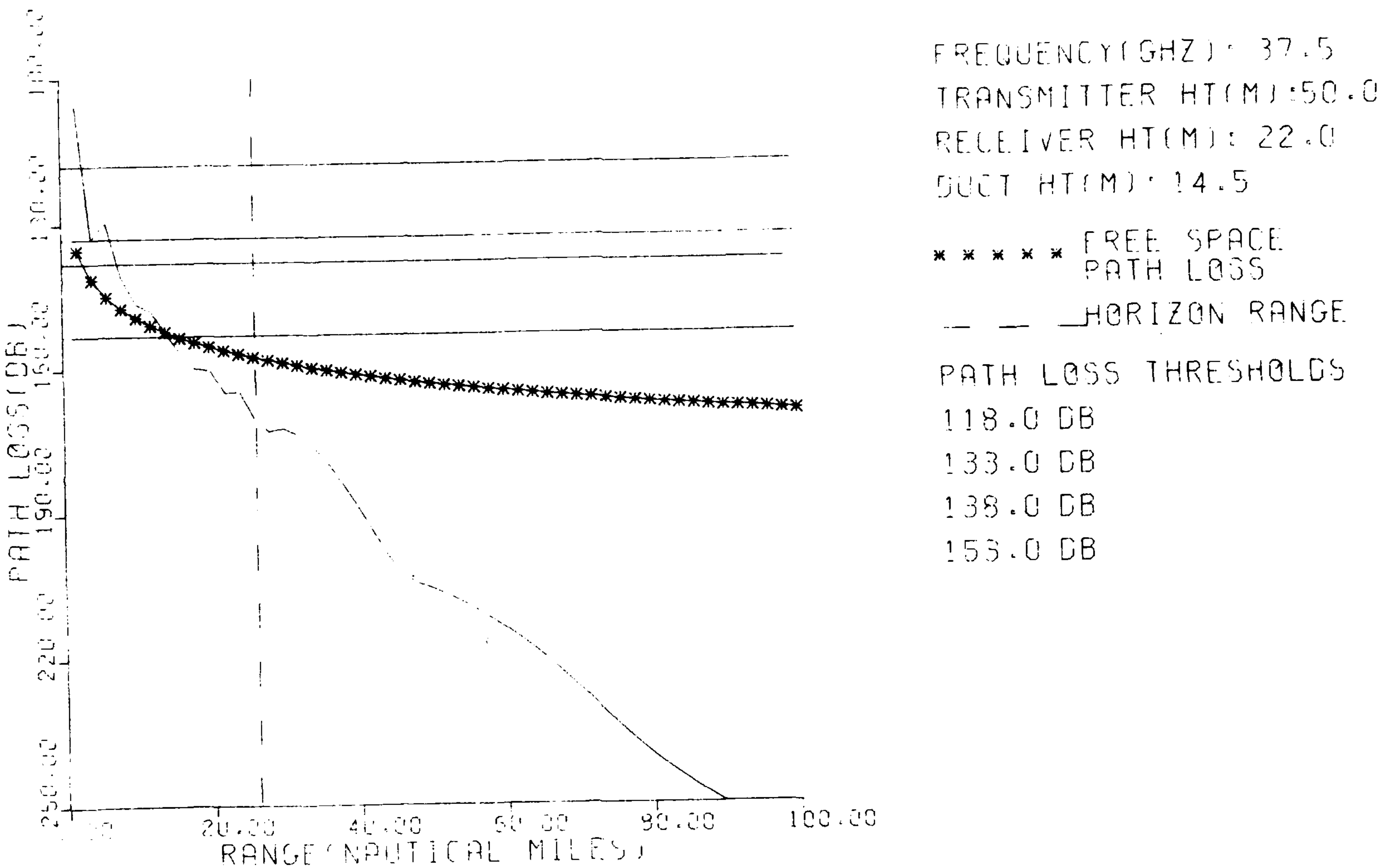


100.00
130.00
160.00
190.00
220.00
250.00
PATH LOSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB

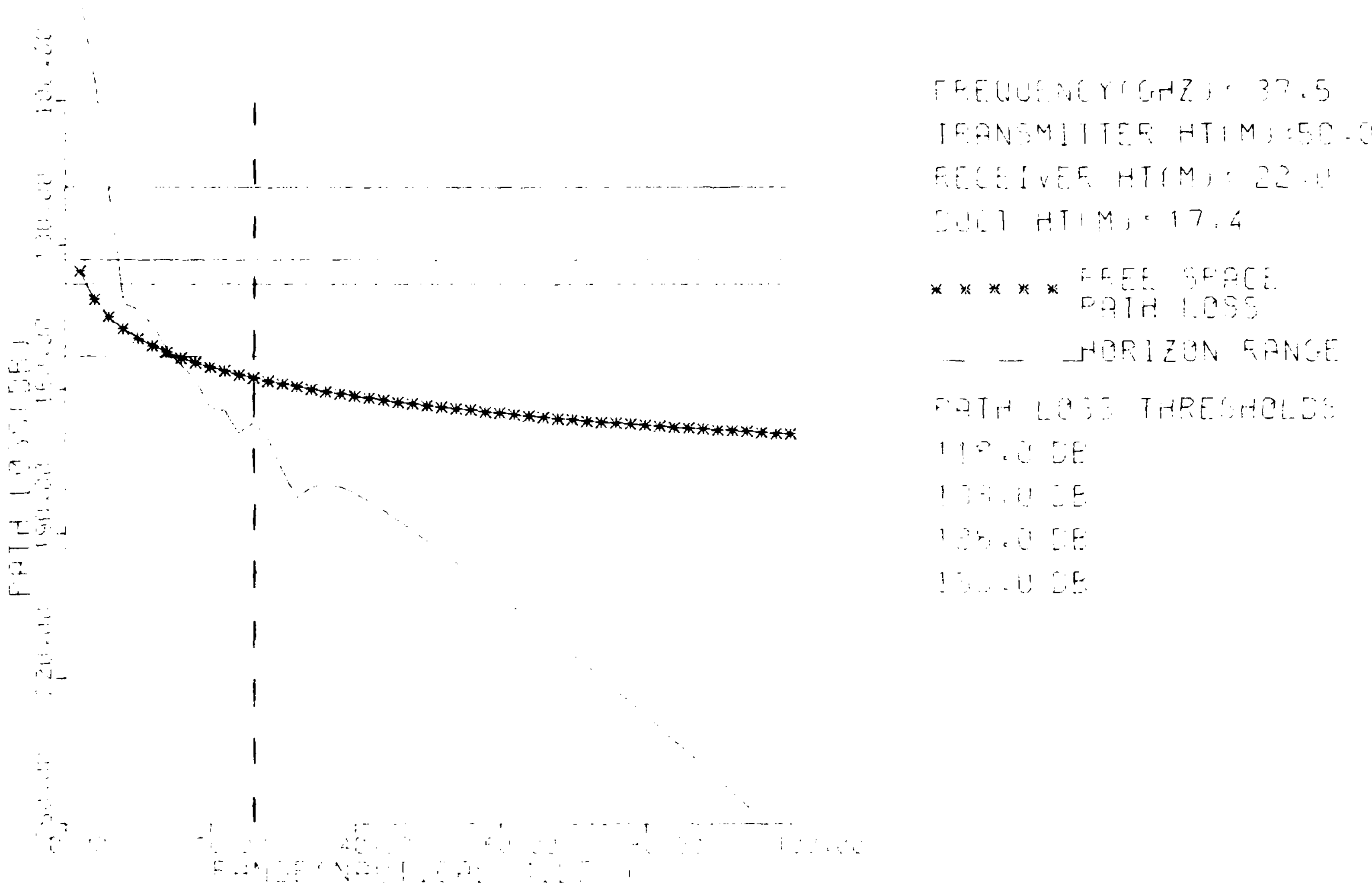

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 5.8
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
139.0 DB
155.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

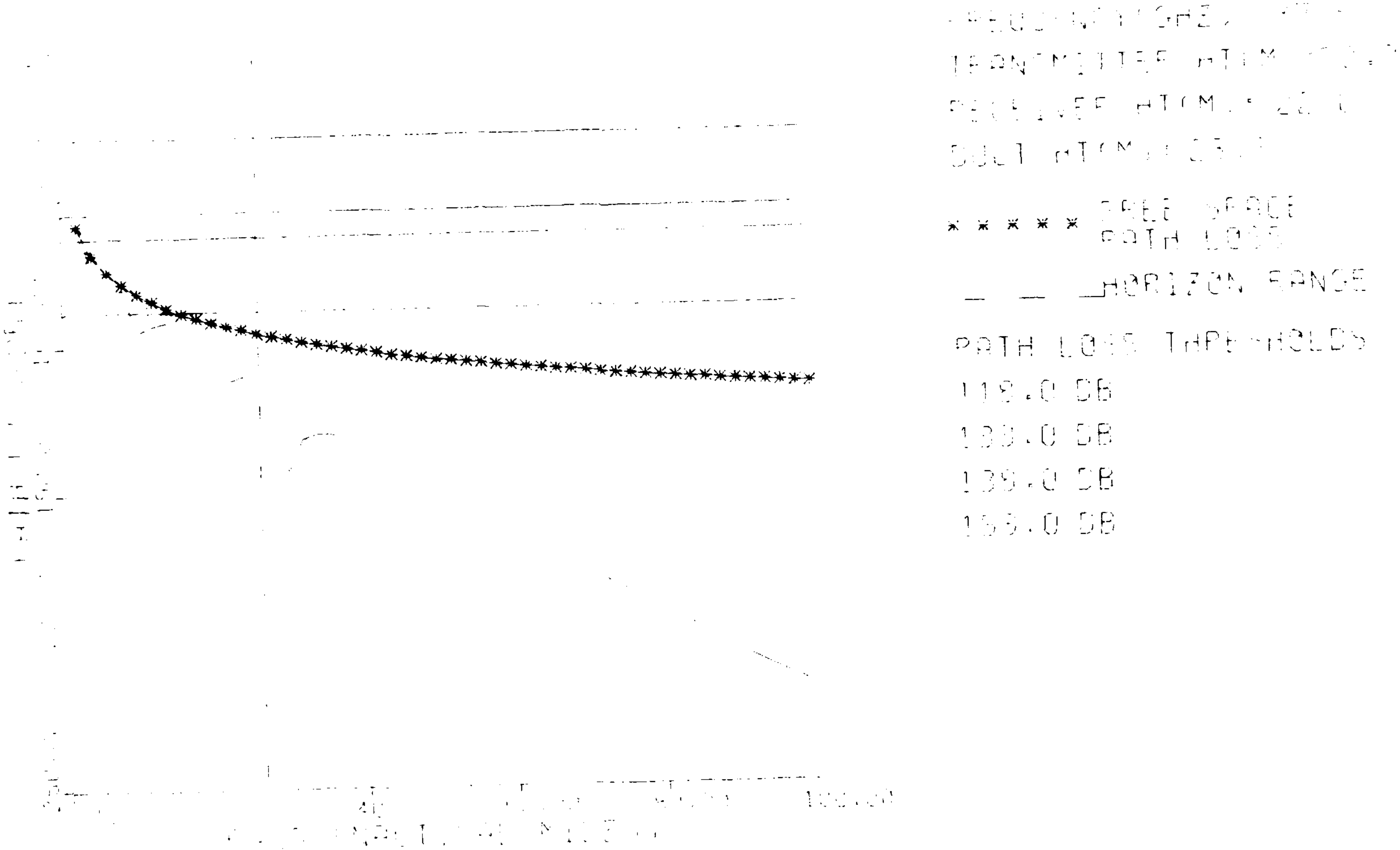

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 8.7
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
155.0 DB
PATH LOSS(DB)
RANGE(NAUTICAL MILES)
100.00

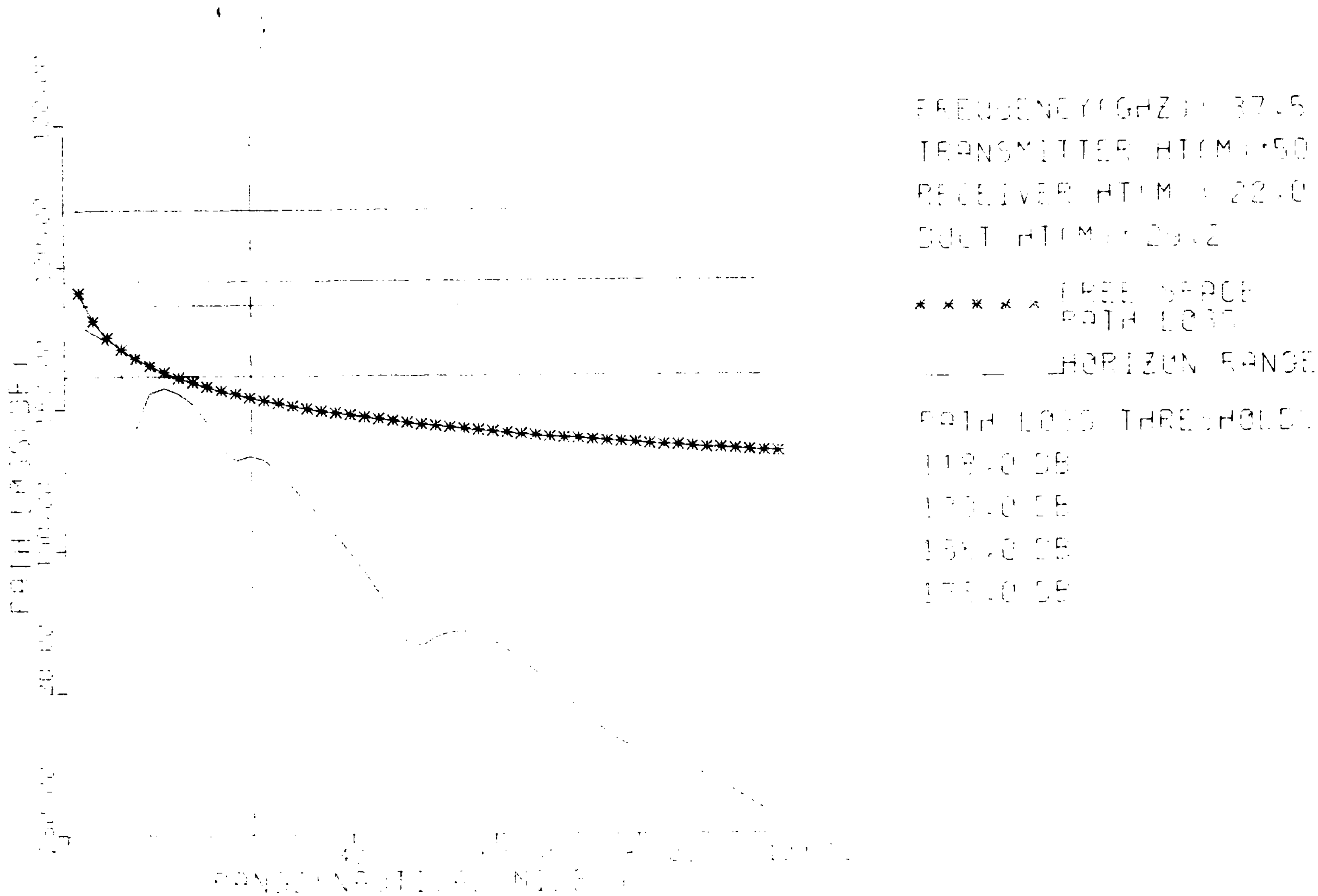

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 11.6
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
155.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
20.00
40.00
60.00
80.00
100.00



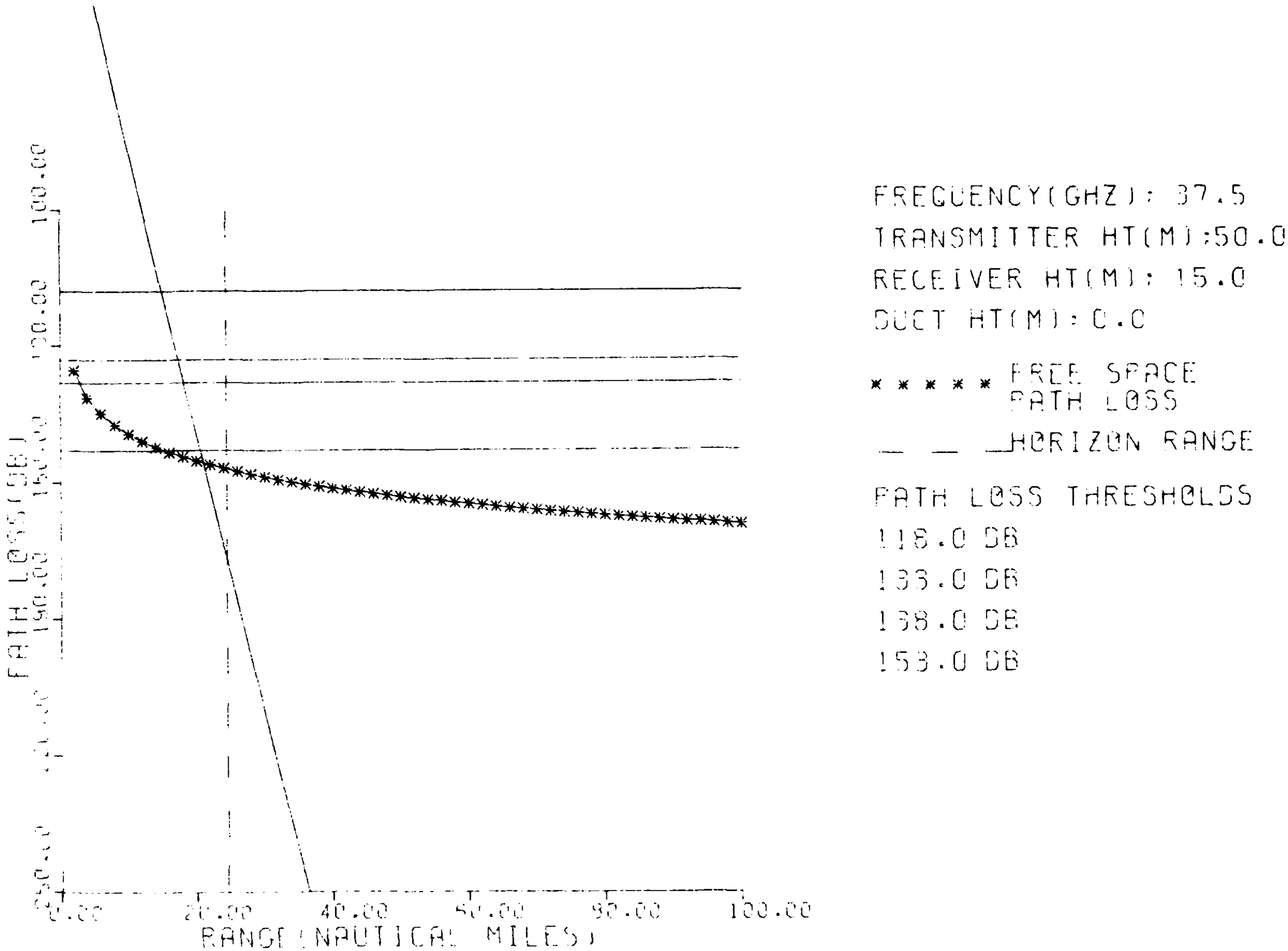
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 14.5
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
155.0 DB

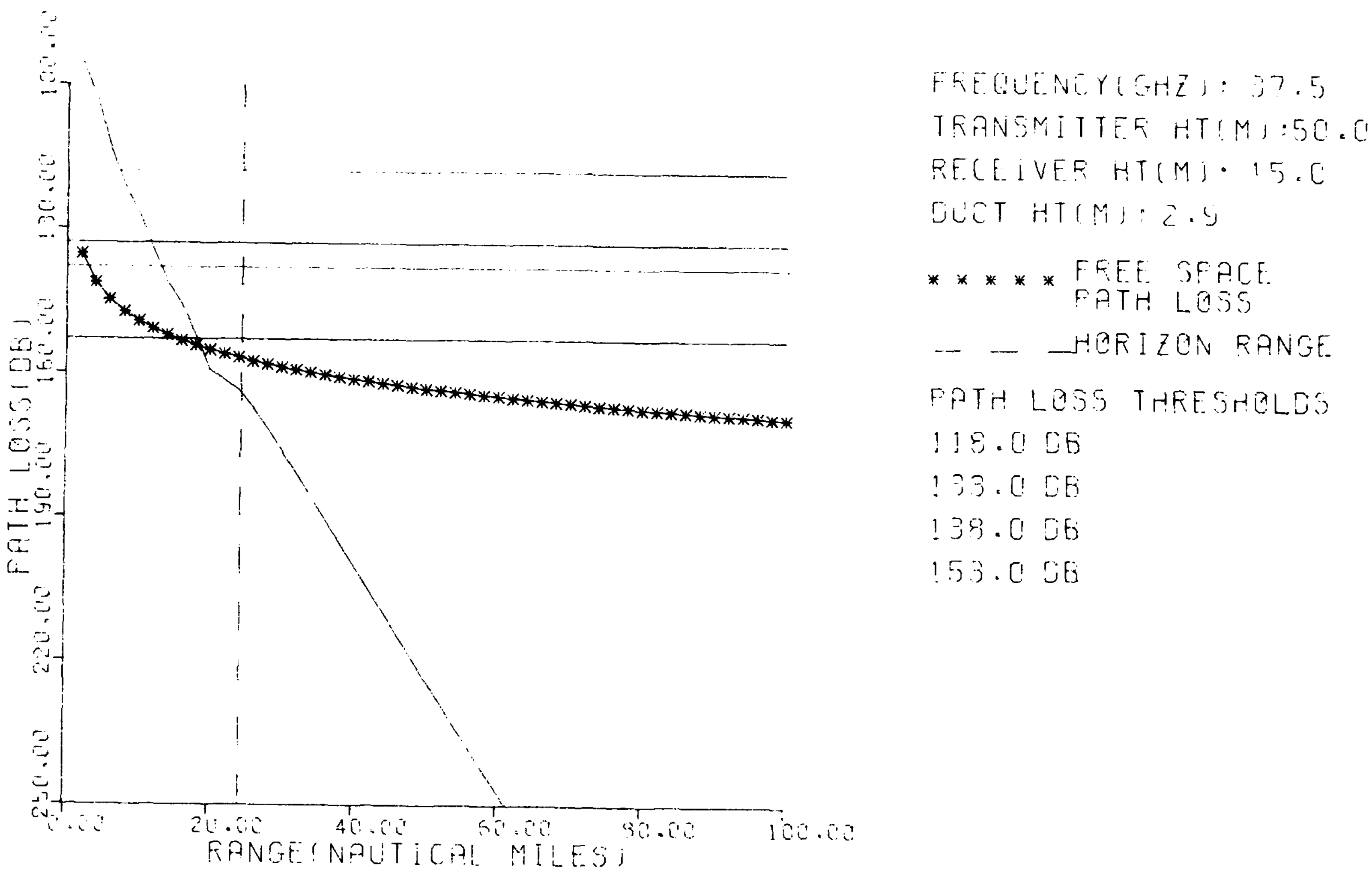

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 22.0
DUCT HT(M): 17.4
* * * * * FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLDS
PATH LOSS(DB)


FREE SPACE
PATH LOSS
HORIZON RANGE
119.0 DB

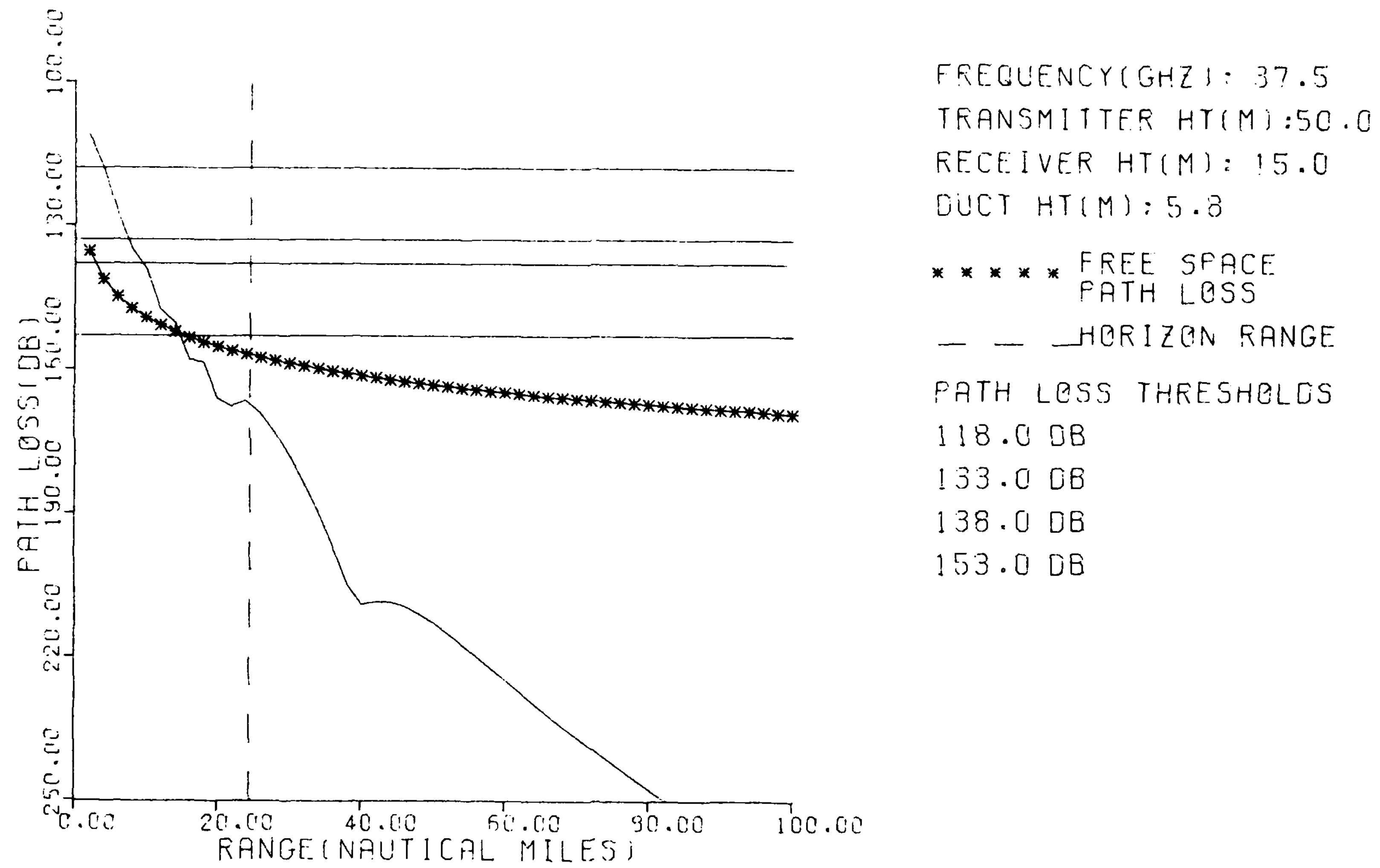


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M): 50.0
RECEIVER HT(M): 22.0
FREE SPACE PATH LOSS
HORIZON RANGE
PATH LOSS THRESHOLD
PATH LOSS(DB)

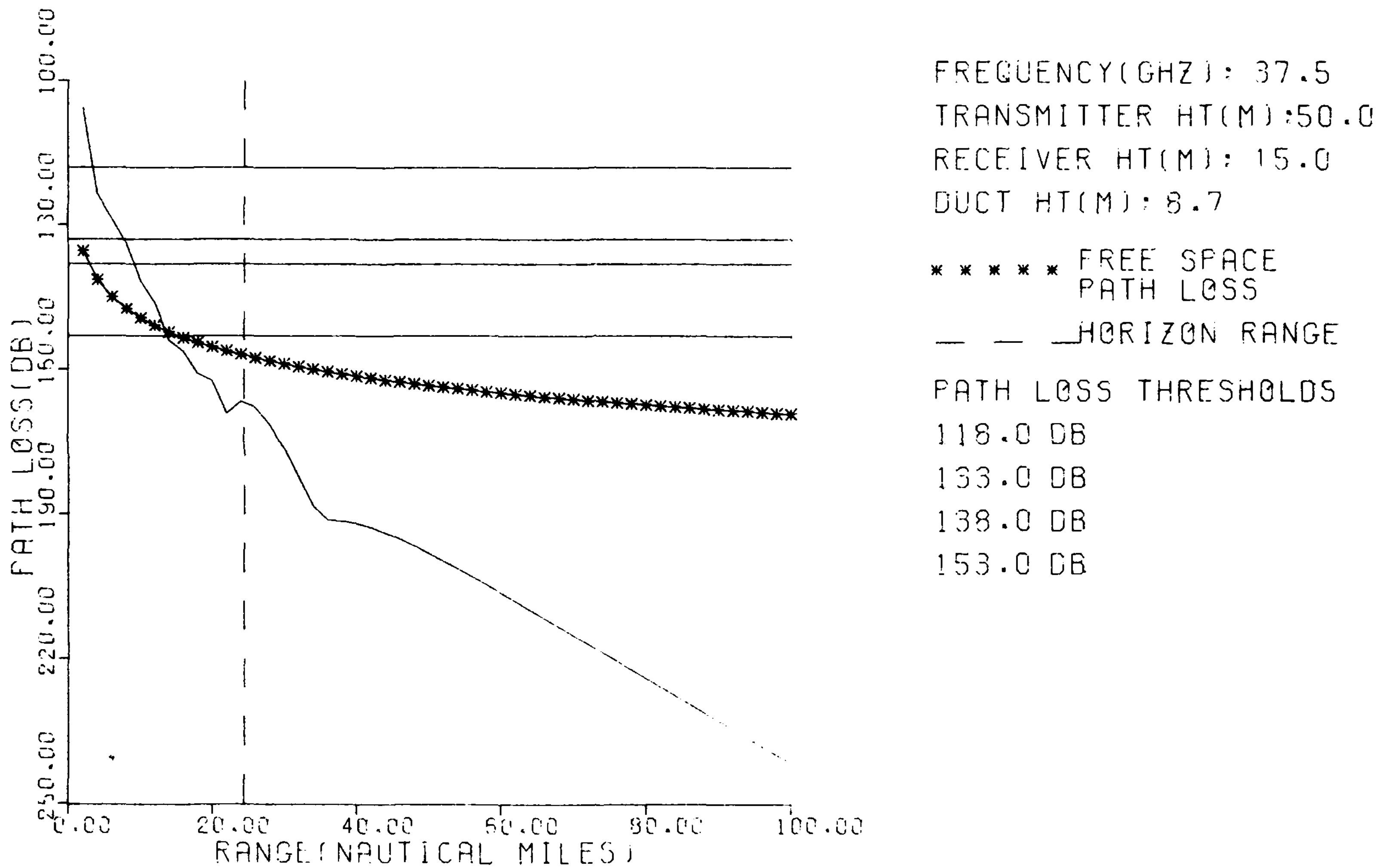

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 0.0
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
120.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
100.00



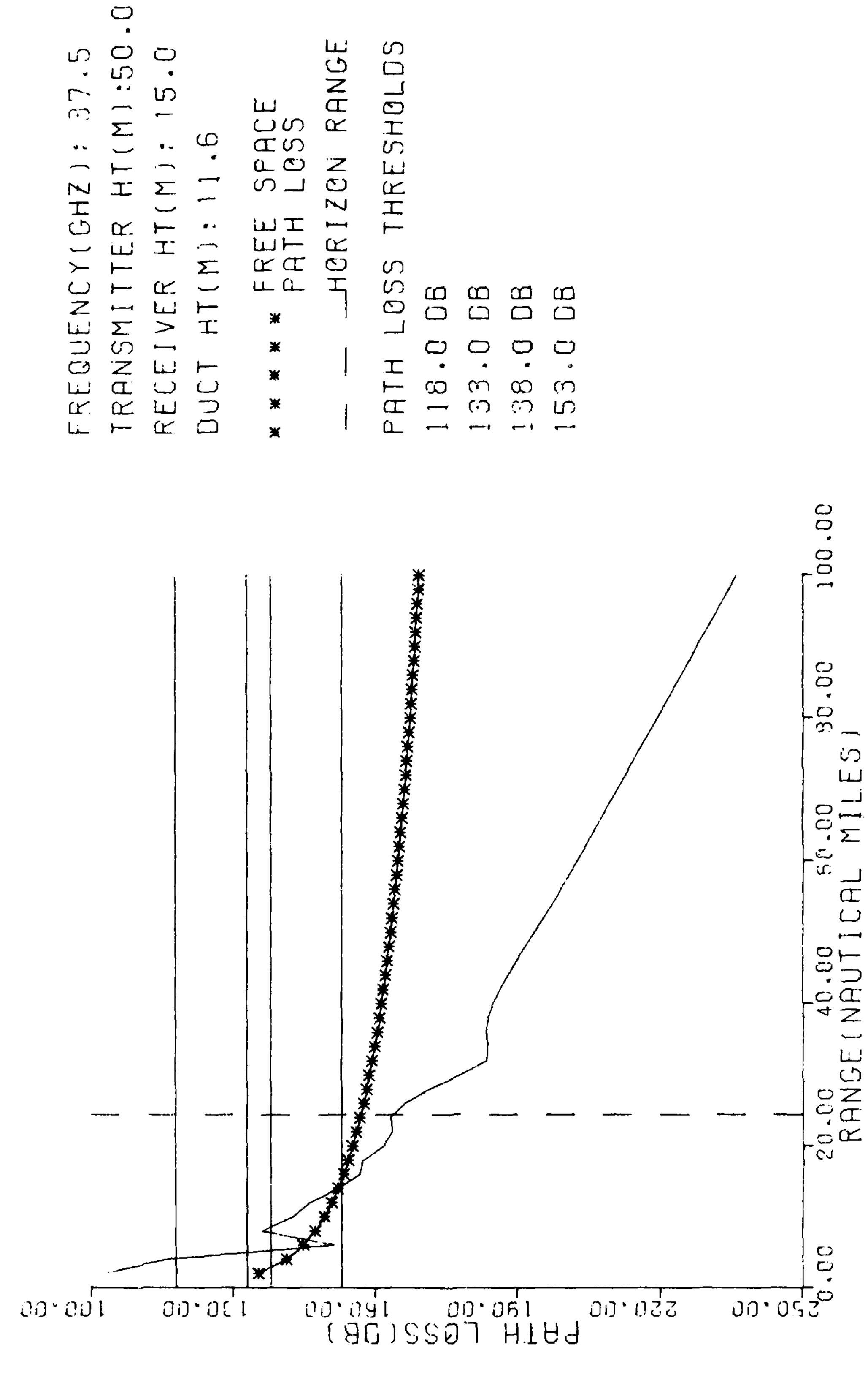
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 2.9
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

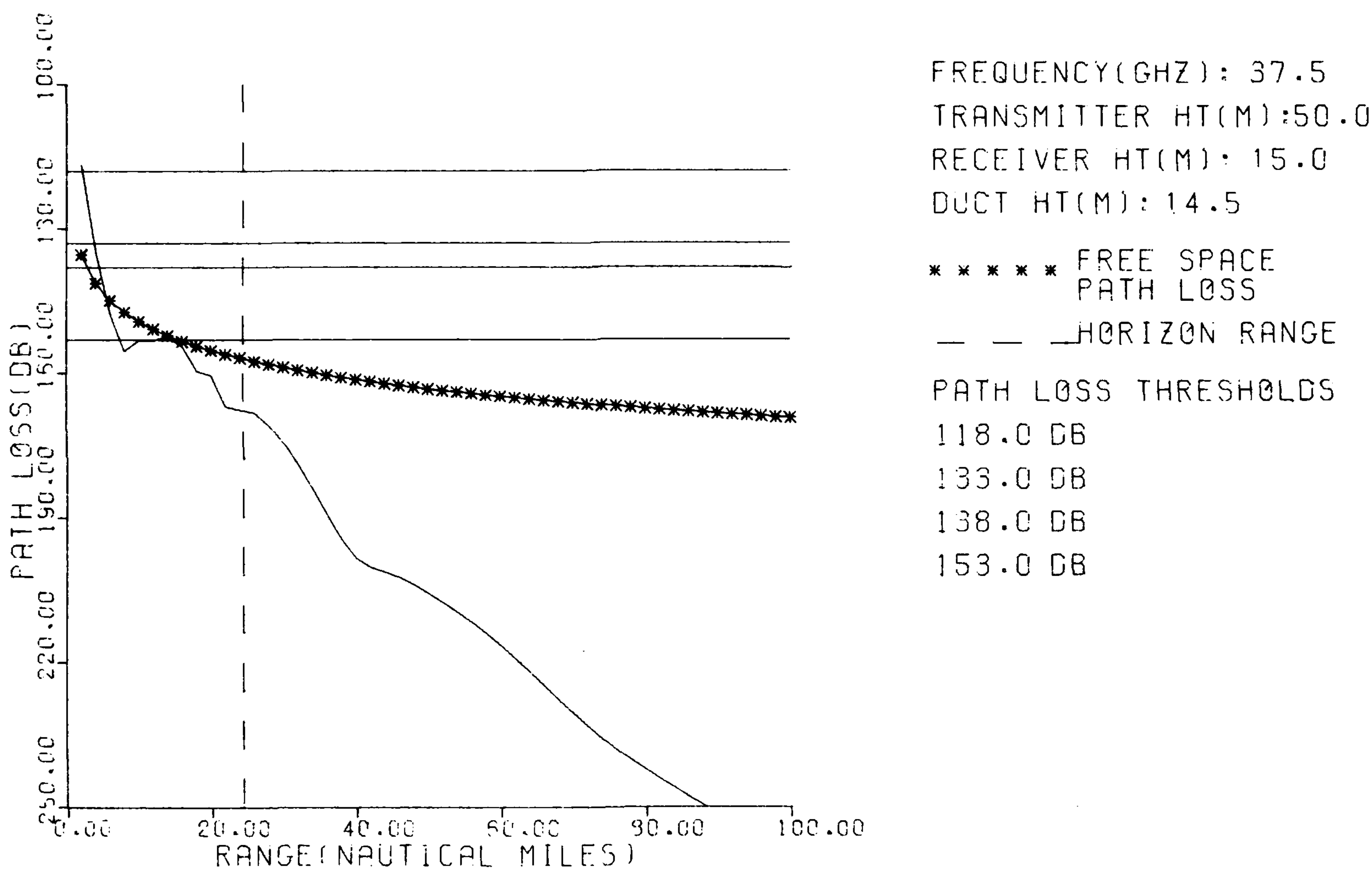


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 5.8
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

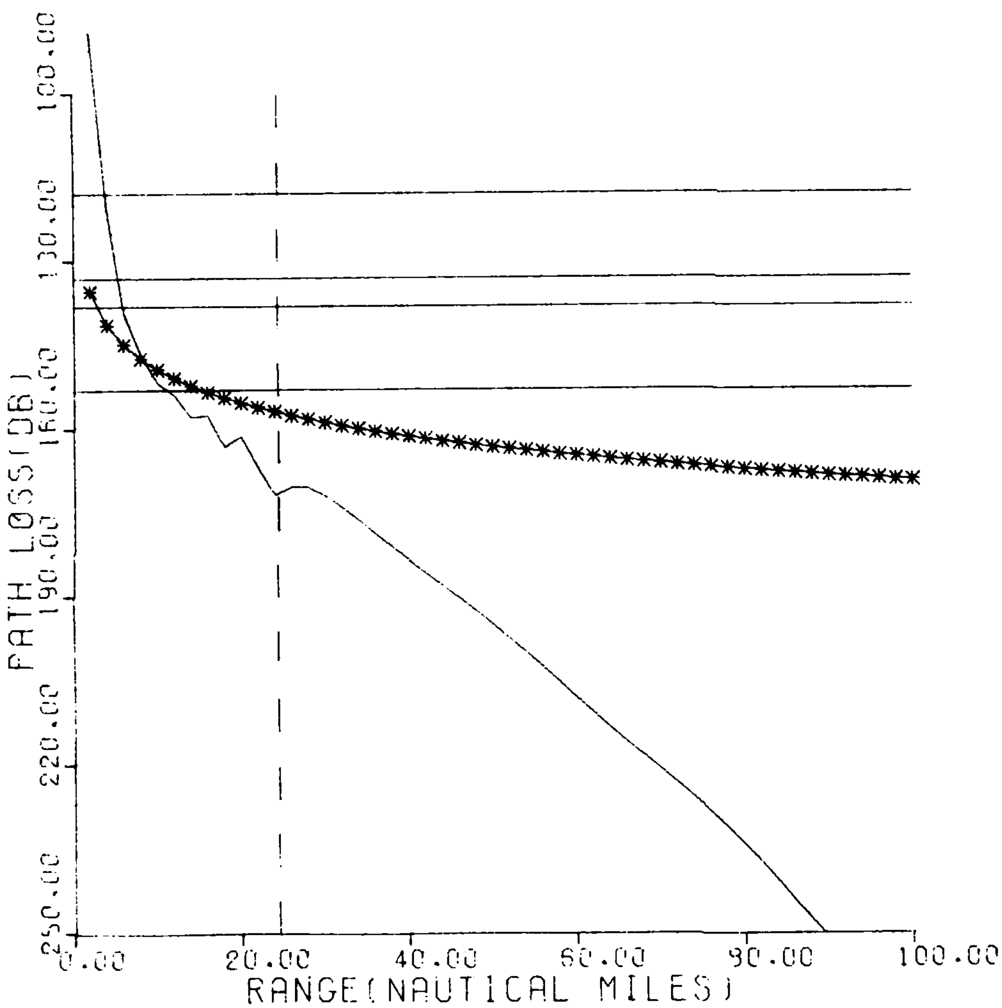


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 8.7
* * * * * FREE SPACE PATH LOSS
— — —HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 11.6
* * * * FREE SPACE PATH LOSS
— — HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
RANGE(NAUTICAL MILES)
0.00
20.00
40.00
60.00
80.00
100.00



100.00
130.00
160.00
190.00
220.00
250.00
PATH LØSS(DB)
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)
FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 14.5
* * * * * FREE SPACE PATH LØSS
— — —HØRIZØN RANGE
PATH LØSS THRESHØLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB



FREQUENCY(GHZ): 37.5

TRANSMITTER HT(M):50.0

RECEIVER HT(M): 15.0

DUCT HT(M): 17.4

* * * * * FREE SPACE PATH LØSS

— — —HØRIZØN RANGE

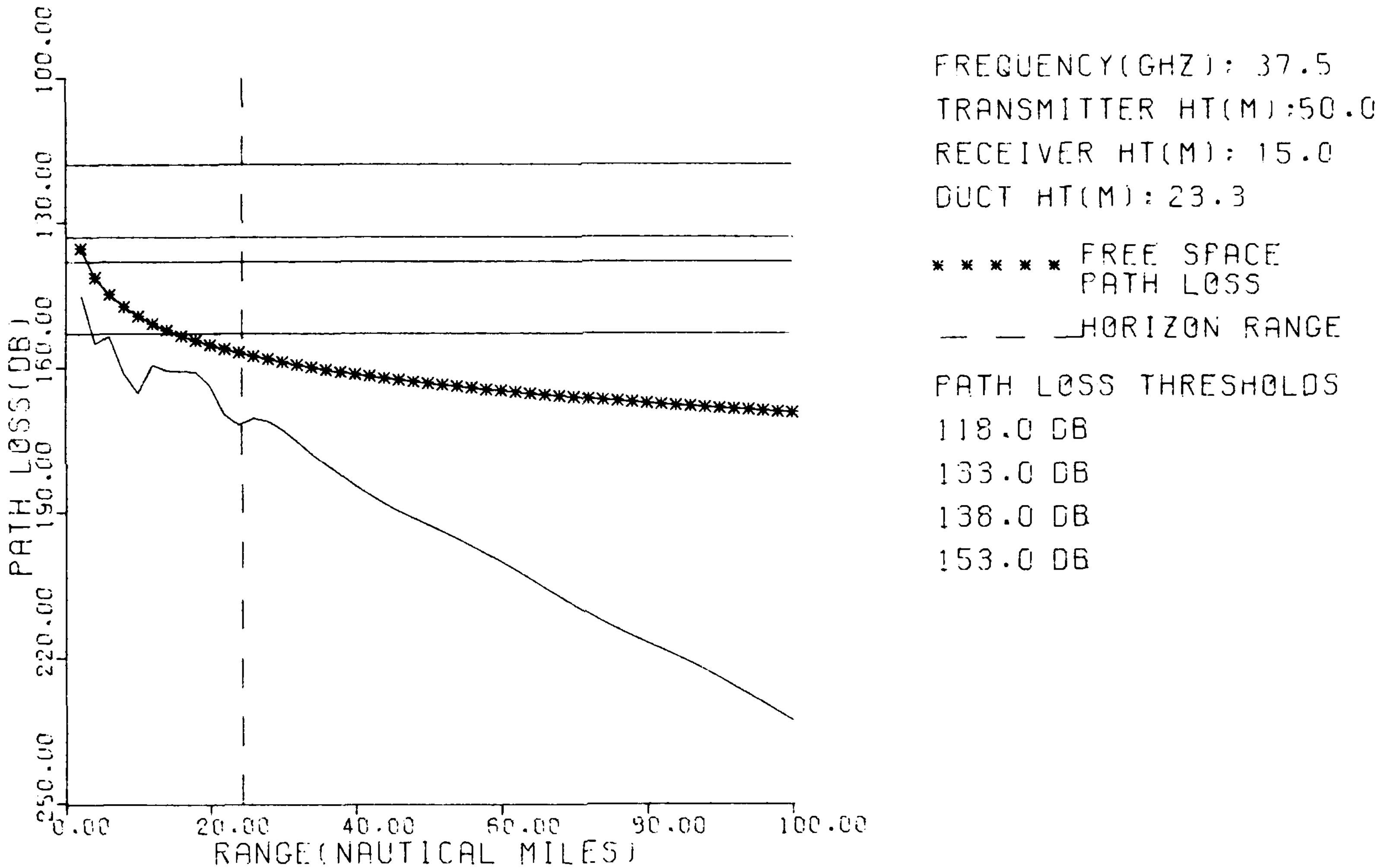
PATH LØSS THRESHØLDS

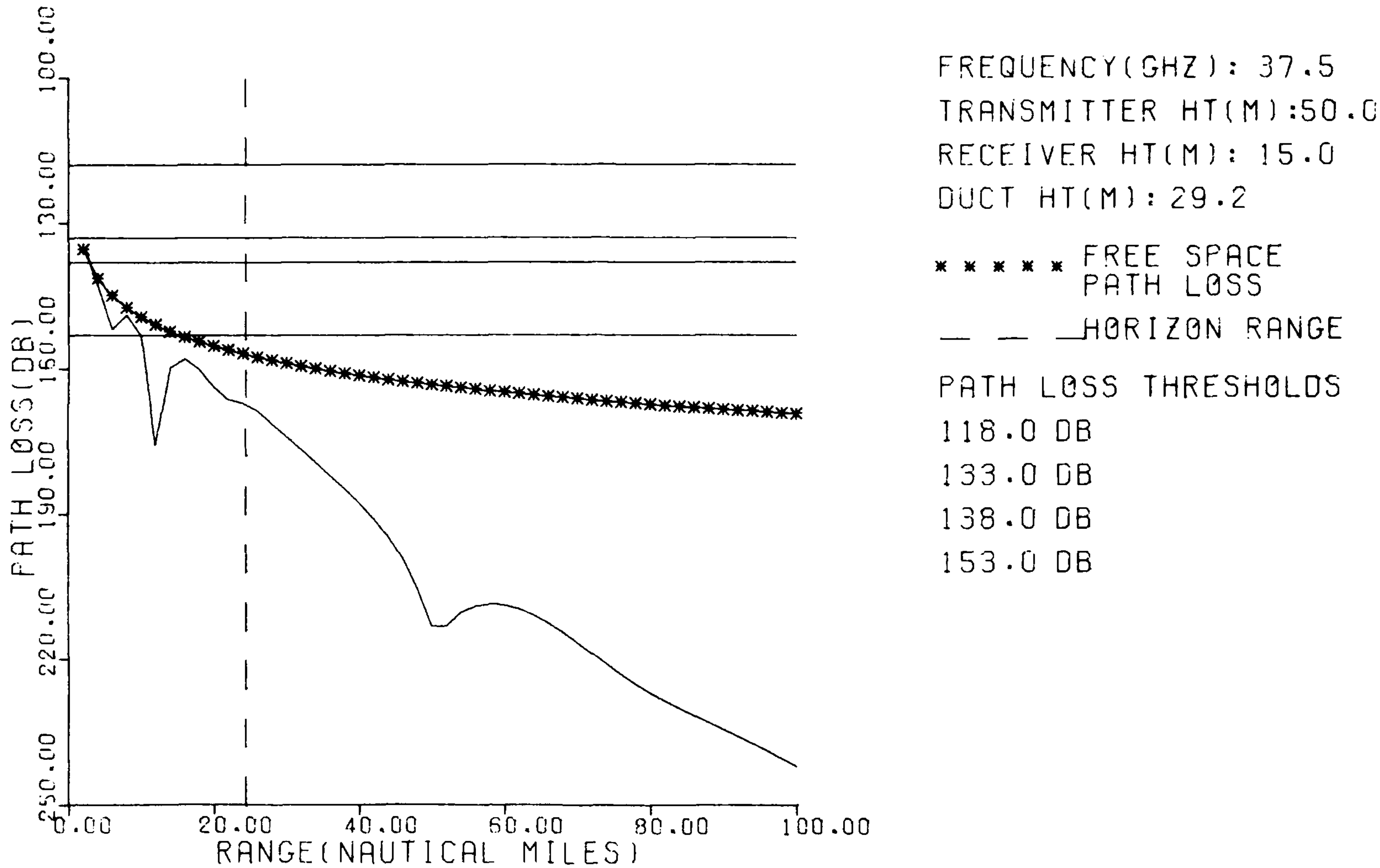
118.0 DB

133.0 DB

138.0 DB

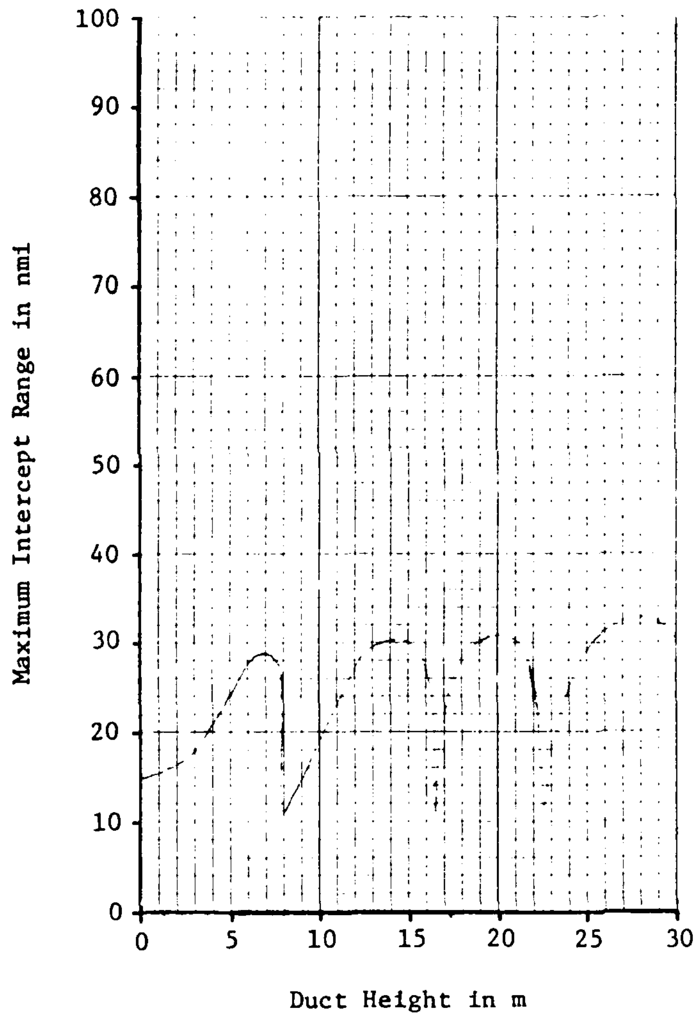
153.0 DB


FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 23.3
* * * * * FREE SPACE PATH LOSS
_ _ _HORIZON RANGE
PATH LOSS THRESHOLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LOSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

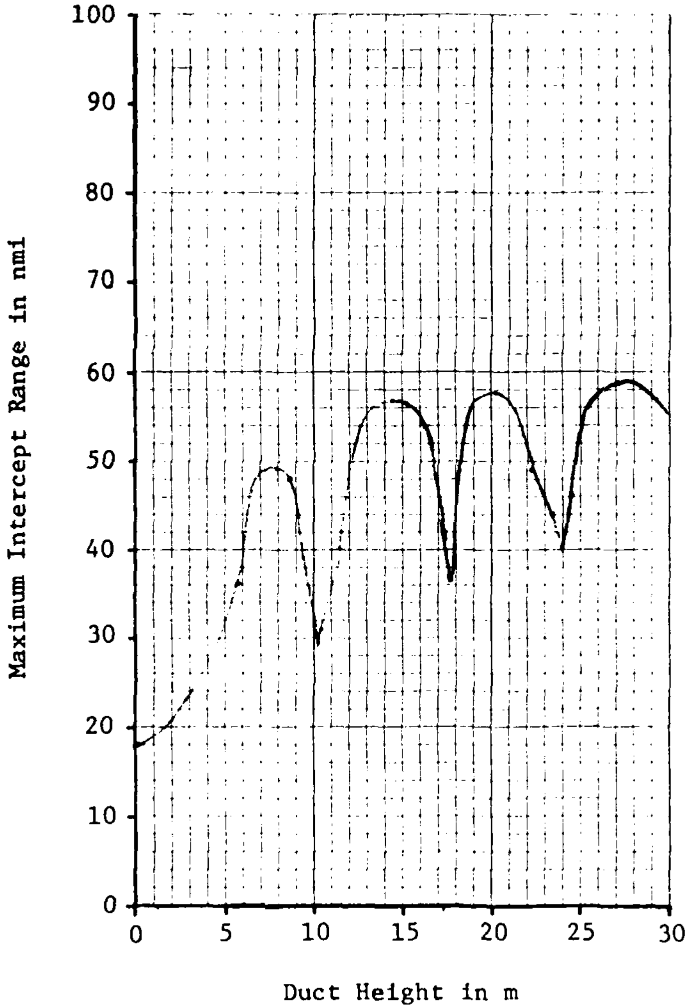

FREQUENCY(GHZ): 37.5
TRANSMITTER HT(M):50.0
RECEIVER HT(M): 15.0
DUCT HT(M): 29.2
FREE SPACE PATH LØSS
HØRIZØN RANGE
PATH LØSS THRESHØLDS
118.0 DB
133.0 DB
138.0 DB
153.0 DB
PATH LØSS(DB)
100.00
130.00
160.00
190.00
220.00
250.00
0.00
20.00
40.00
60.00
80.00
100.00
RANGE(NAUTICAL MILES)

APPENDIX B

Maximum Intercept Range versus Duct Height Curves



Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	15
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	160



Frequency (GHz) ____ 18.0

Emitter Antenna Height (m) ____ 10

Receiver Antenna Height (m) ____ 15

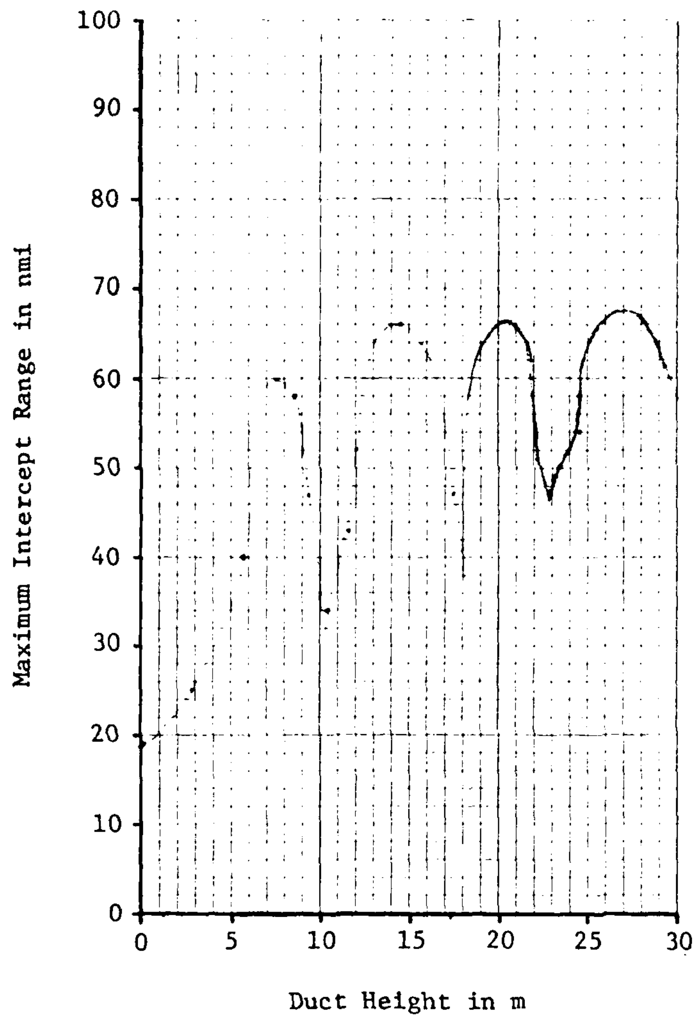
Emitter Power (kW) ____ 100

Emitter Antenna Gain (dBi) ____ 40

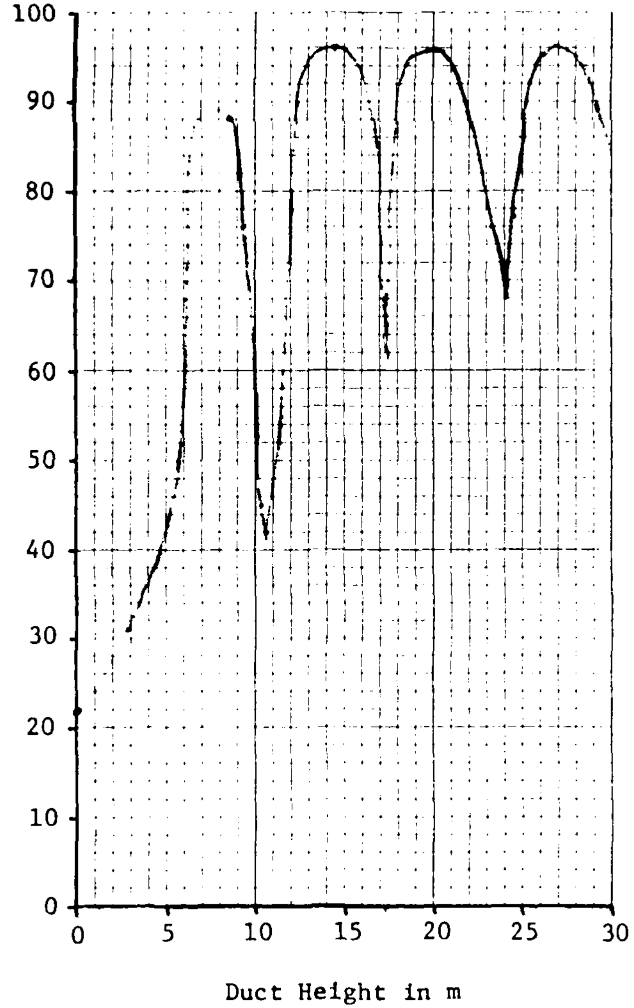
Receiver Sensitivity (dBm) ____ -40

Receiver Antenna Gain (dBi) ____ 15

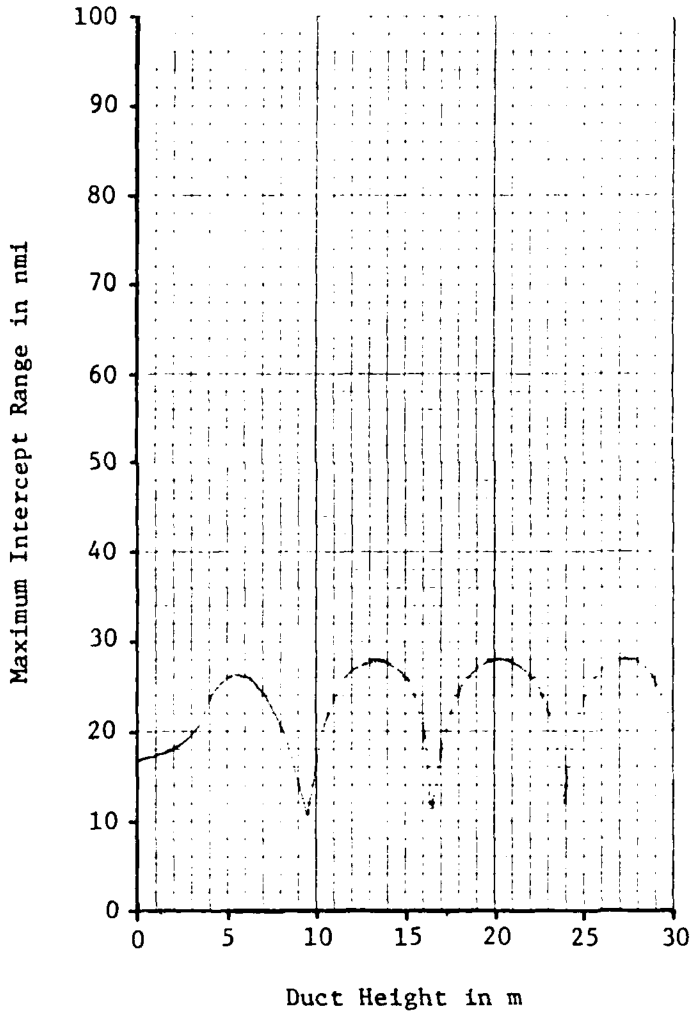
Path Loss Threshold (dB) ____ 175



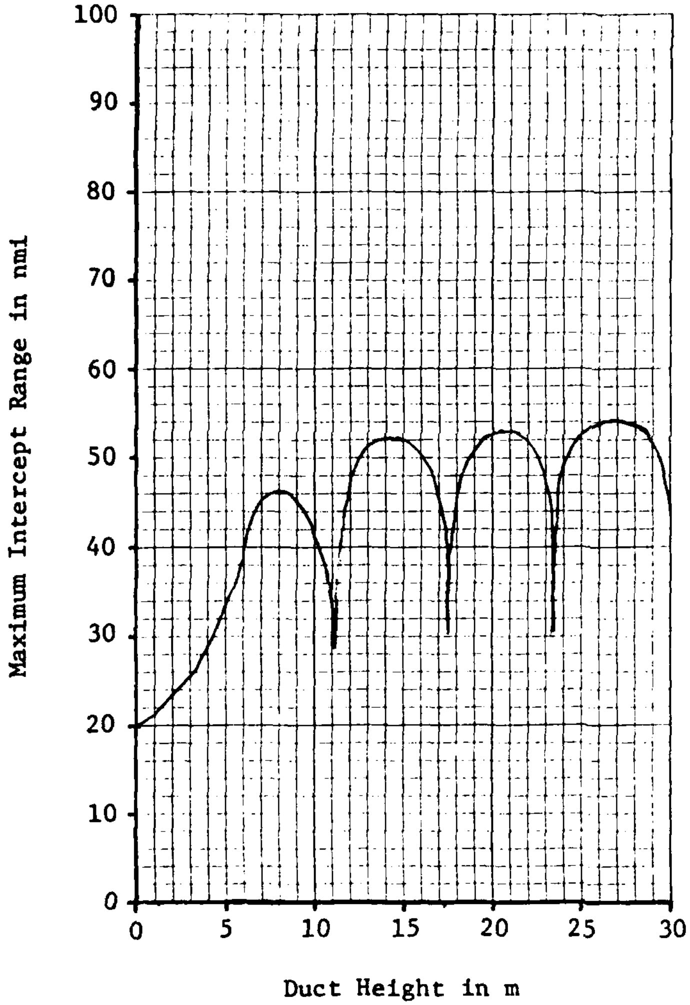
Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	15
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	180



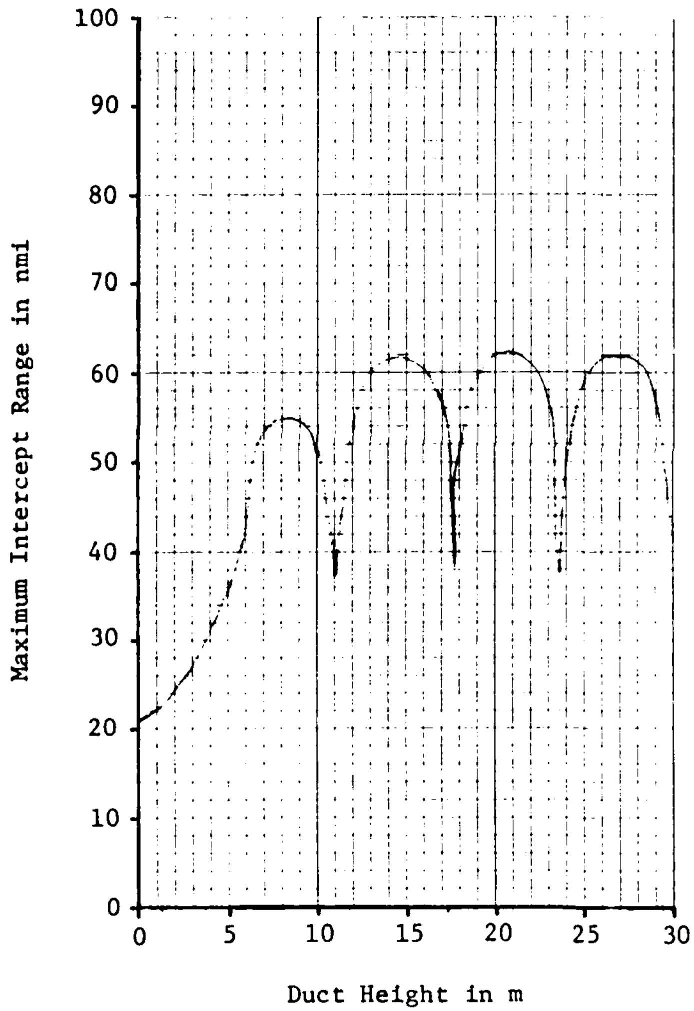
Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	15
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	195



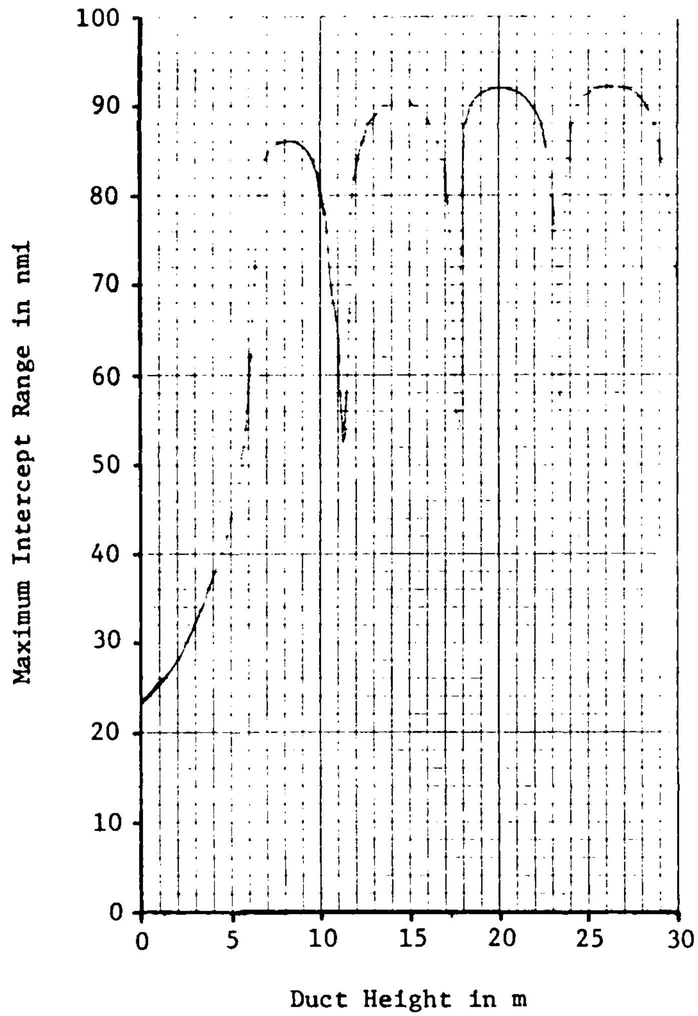
Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	160



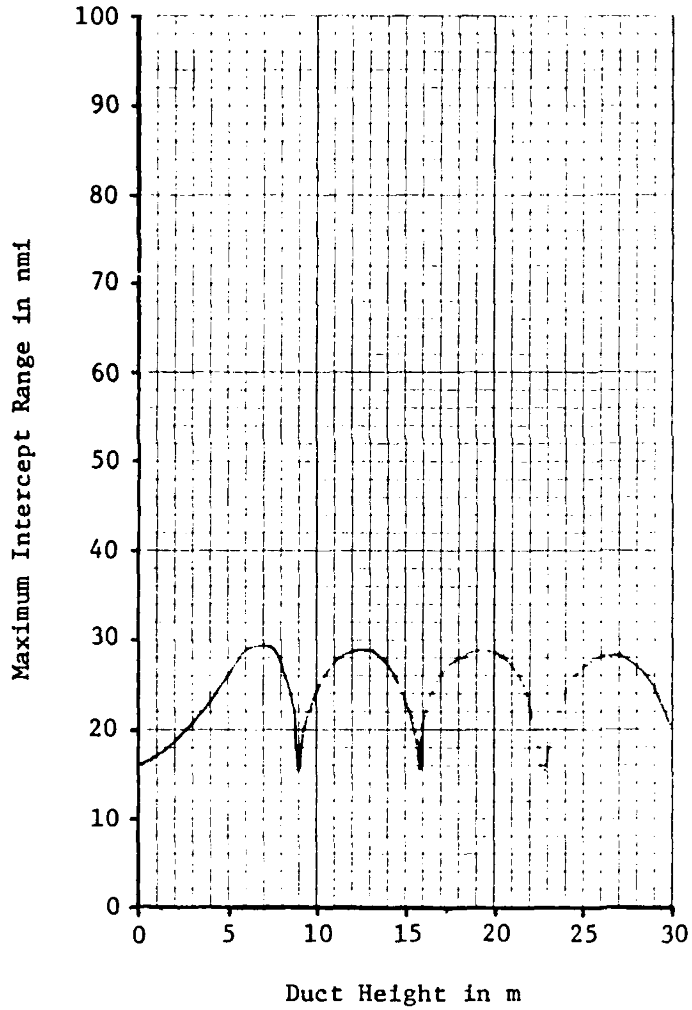
Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	175



Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	180



Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	195



Frequency (GHz) 18.0

Emitter Antenna Height (m) 10

Receiver Antenna Height (m) 30

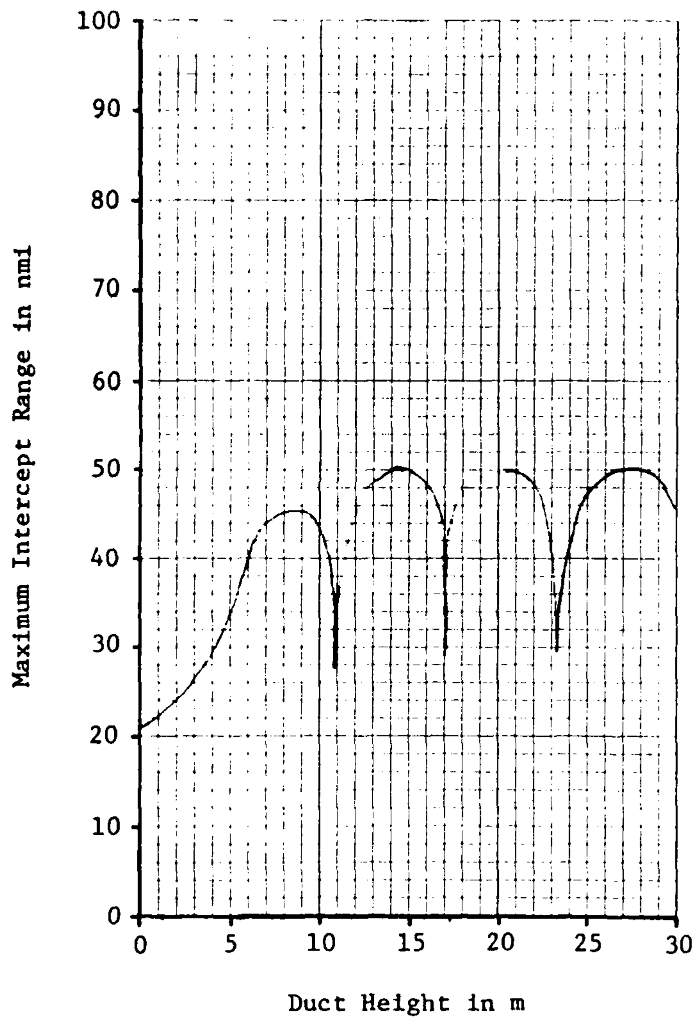
Emitter Power (kW) 100

Emitter Antenna Gain (dBi) 40

Receiver Sensitivity (dBm) -40

Receiver Antenna Gain (dBi) 0

Path Loss Threshold (dB) 160



Frequency (GHz) 18.0

Emitter Antenna Height (m) 10

Receiver Antenna Height (m) 30

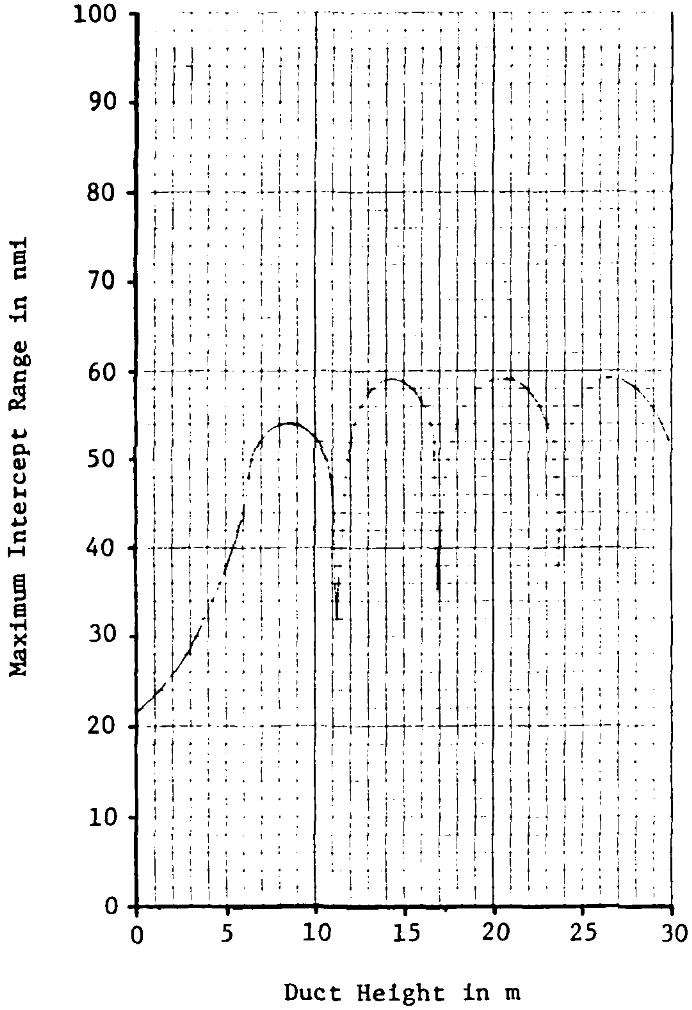
Emitter Power (kW) 100

Emitter Antenna Gain (dBi) 40

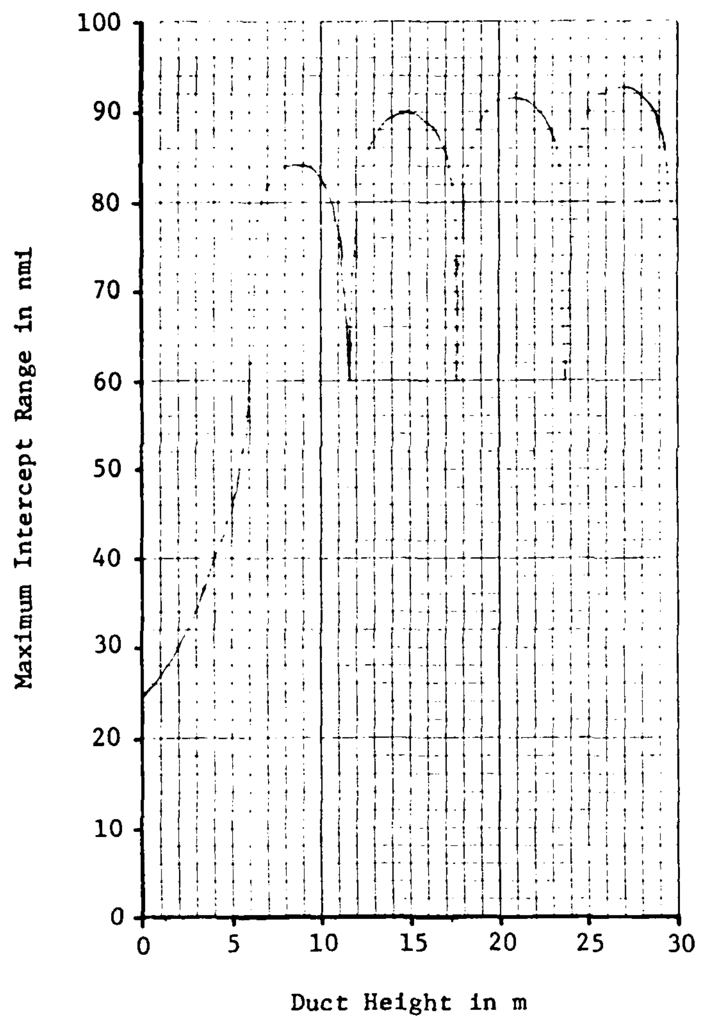
Receiver Sensitivity (dBm) -40

Receiver Antenna Gain (dBi) 15

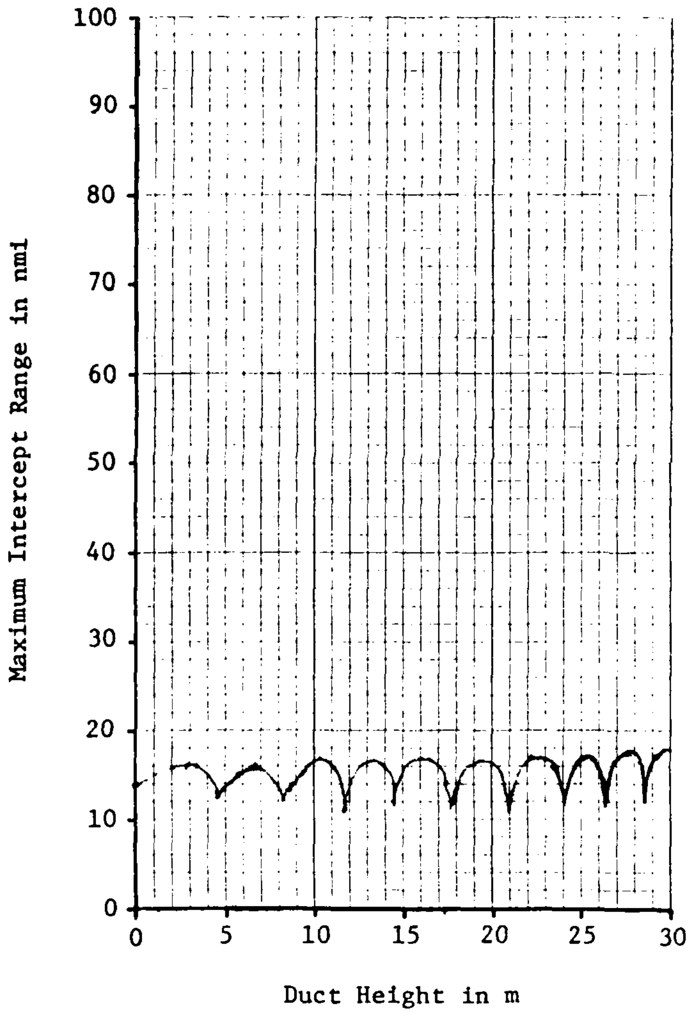
Path Loss Threshold (dB) 175



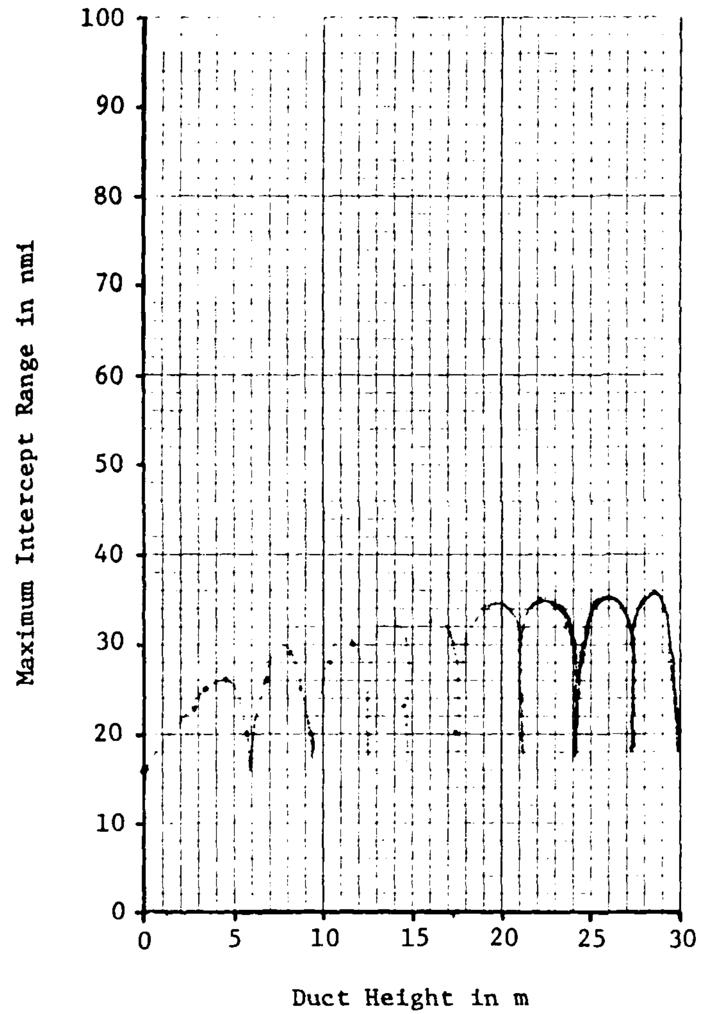
Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	30
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	180



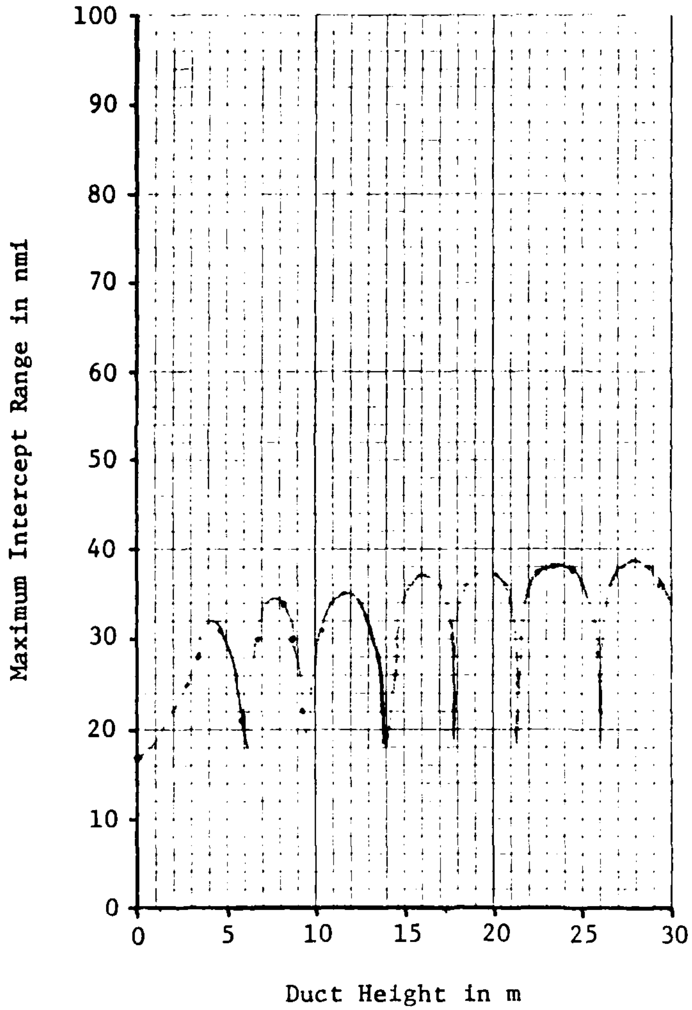
Frequency (GHz)	18.0
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	30
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	195



Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	15
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	160



Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	15
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	175



Frequency (GHz) 37.5

Emitter Antenna Height (m) 10

Receiver Antenna Height (m) 15

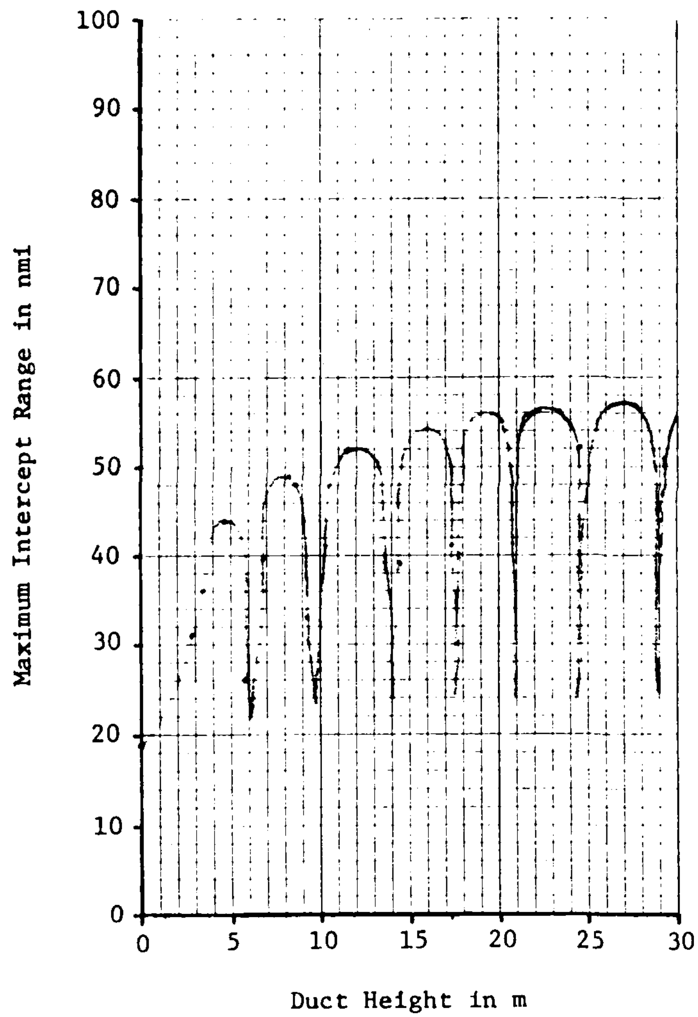
Emitter Power (kW) 100

Emitter Antenna Gain (dBi) 40

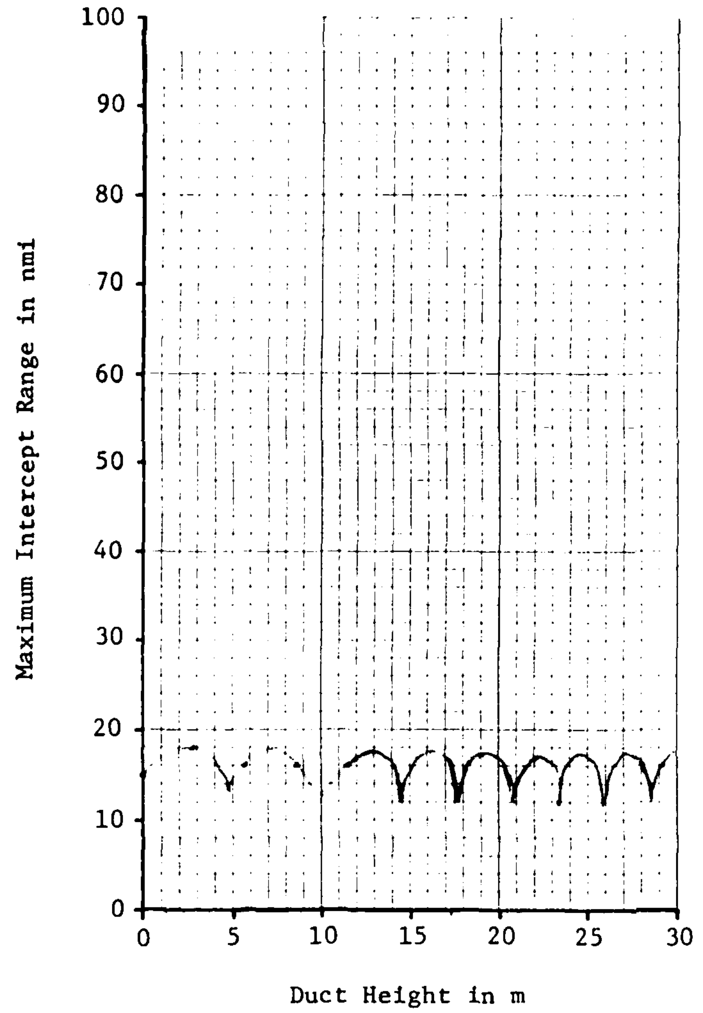
Receiver Sensitivity (dBm) -60

Receiver Antenna Gain (dBi) 0

Path Loss Threshold (dB) 180



Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	15
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	195



Frequency (GHz) 37.5

Emitter Antenna Height (m) 10

Receiver Antenna Height (m) 22

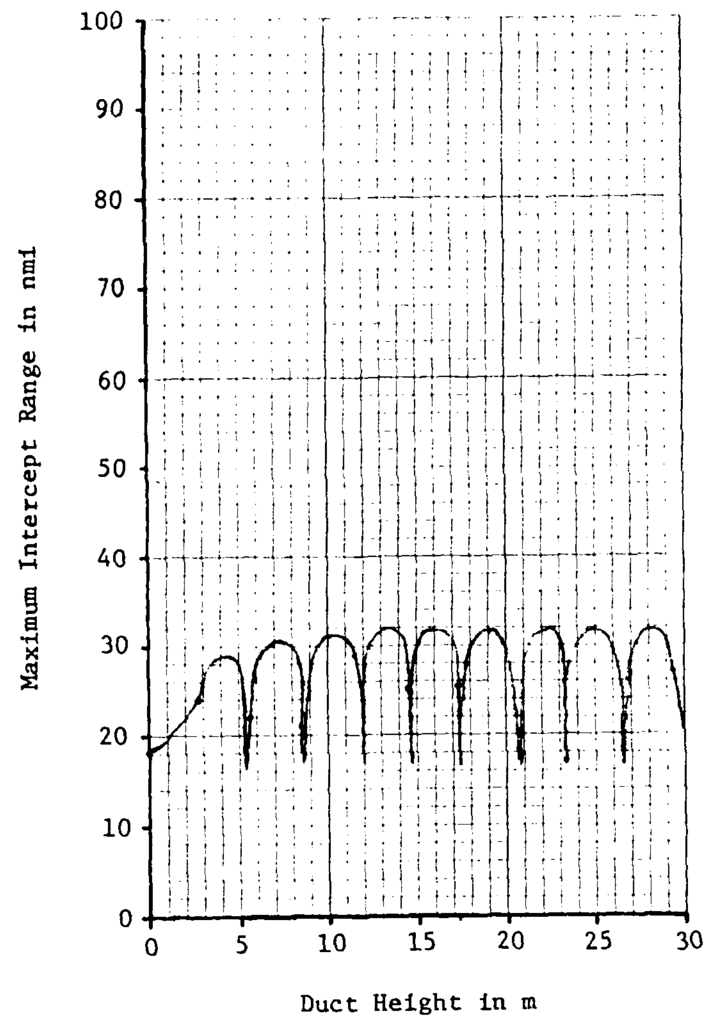
Emitter Power (kW) 100

Emitter Antenna Gain (dBi) 40

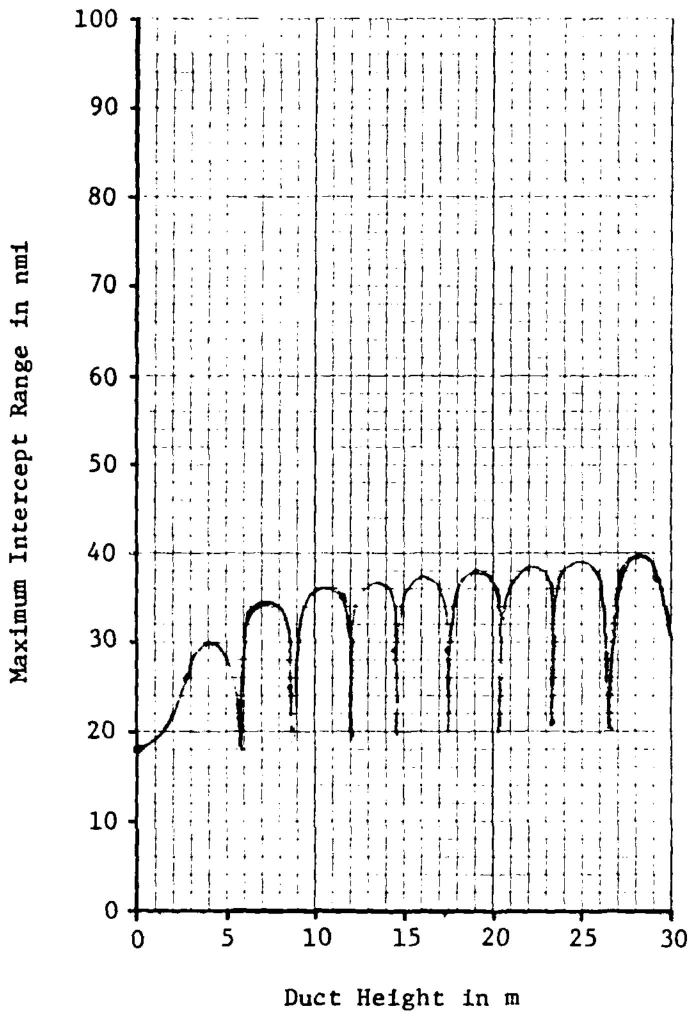
Receiver Sensitivity (dBm) -40

Receiver Antenna Gain (dBi) 0

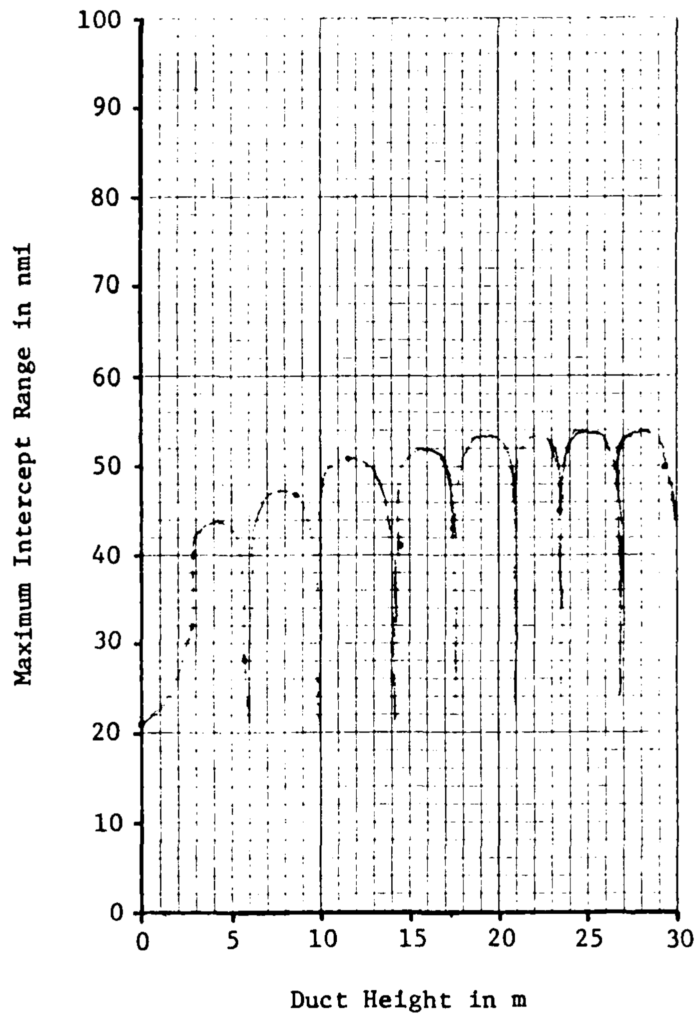
Path Loss Threshold (dB) 160



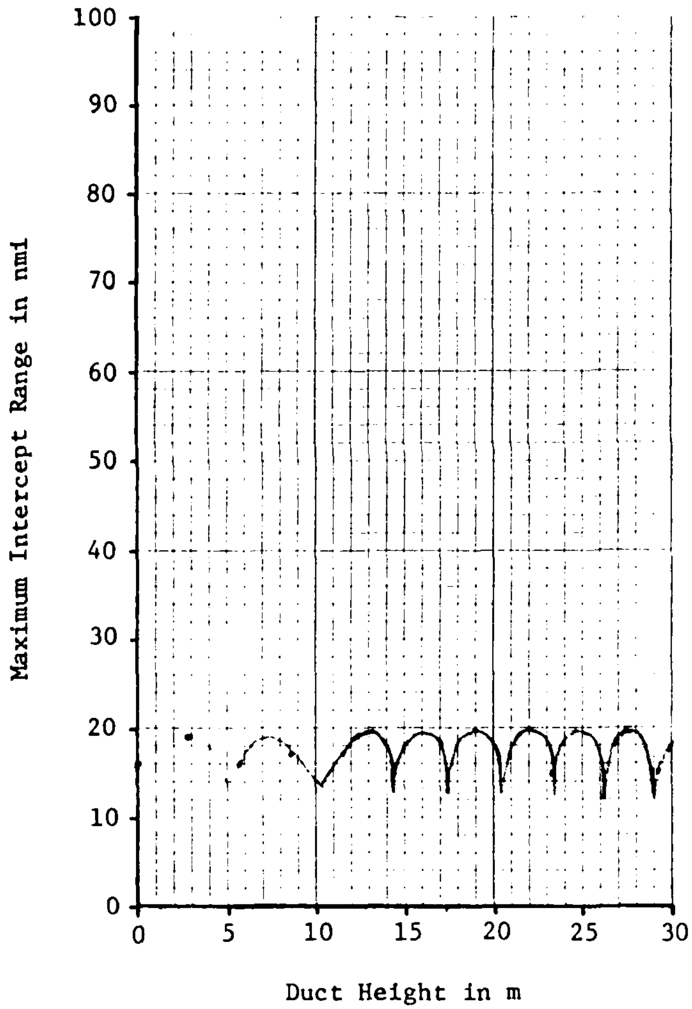
Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	175



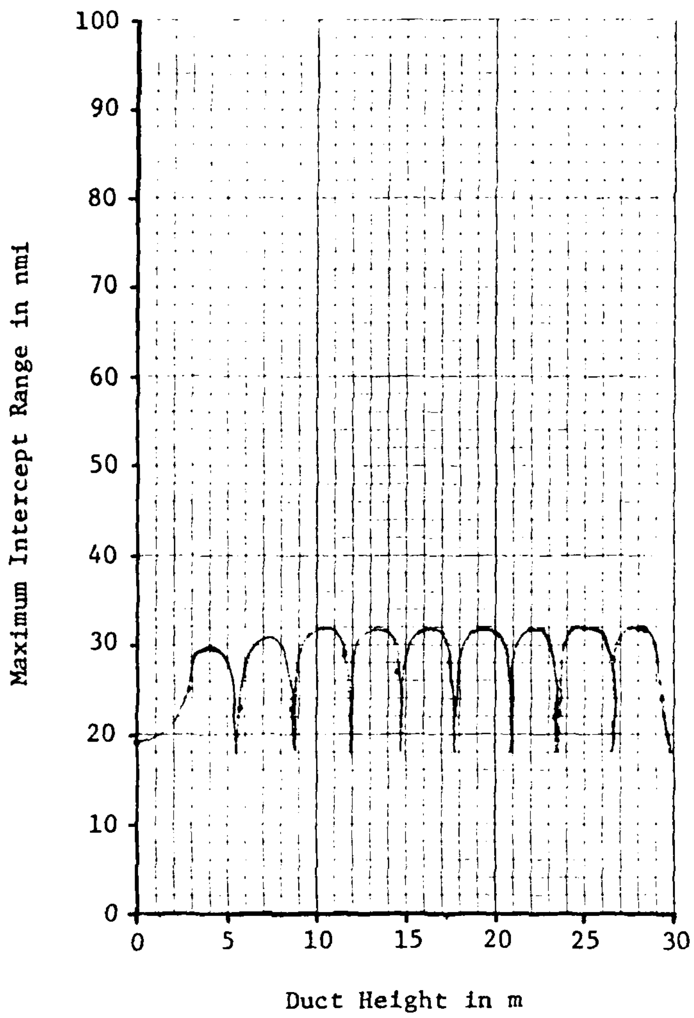
Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	180



Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	22
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	195



Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	30
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-40
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	160



Frequency (GHz) 37.5

Emitter Antenna Height (m) 10

Receiver Antenna Height (m) 30

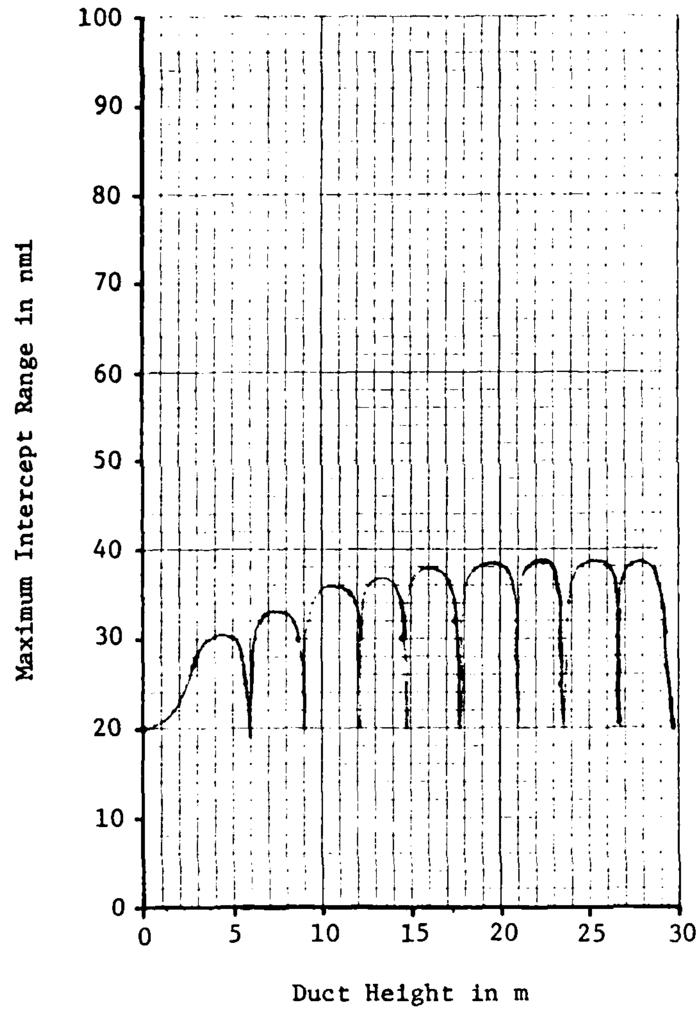
Emitter Power (kW) 100

Emitter Antenna Gain (dBi) 40

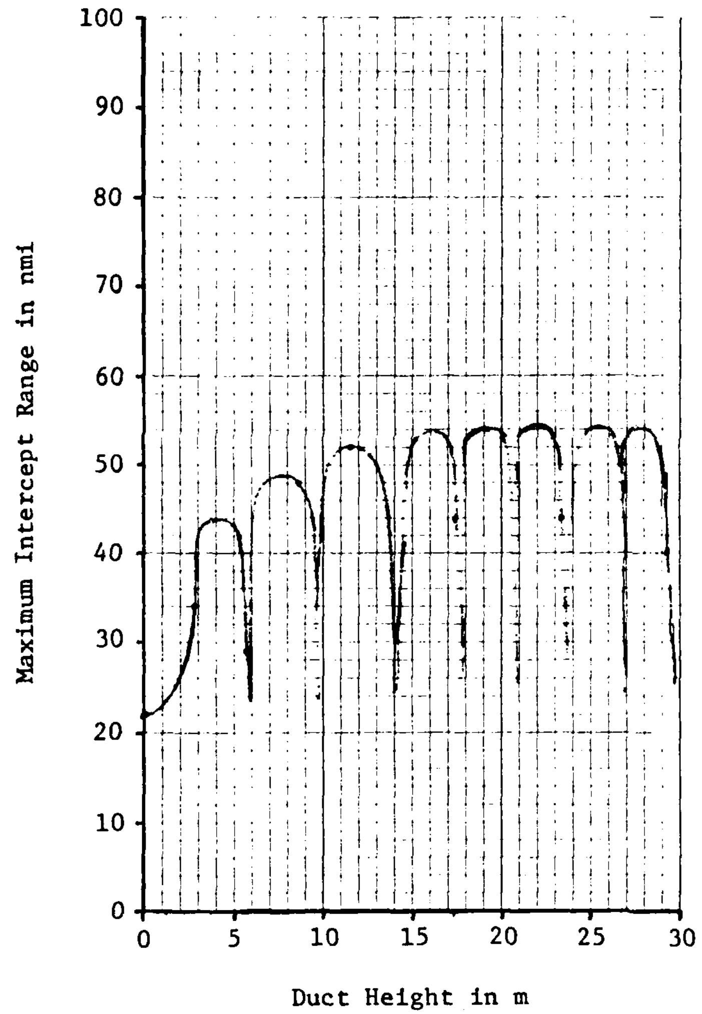
Receiver Sensitivity (dBm) -40

Receiver Antenna Gain (dBi) 15

Path Loss Threshold (dB) 175



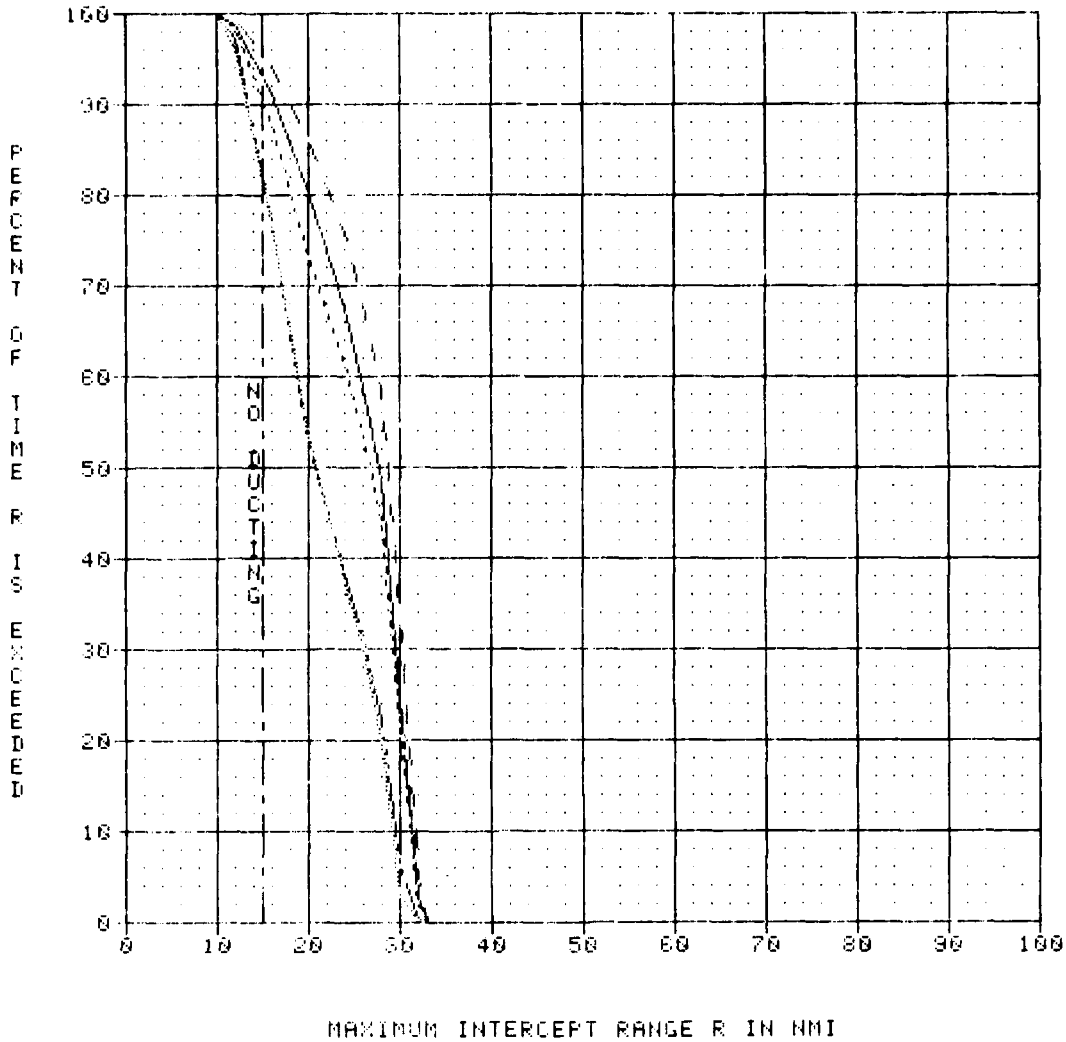
Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	30
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	0
Path Loss Threshold (dB)	180



Frequency (GHz)	37.5
Emitter Antenna Height (m)	10
Receiver Antenna Height (m)	30
Emitter Power (kW)	100
Emitter Antenna Gain (dBi)	40
Receiver Sensitivity (dBm)	-60
Receiver Antenna Gain (dBi)	15
Path Loss Threshold (dB)	195

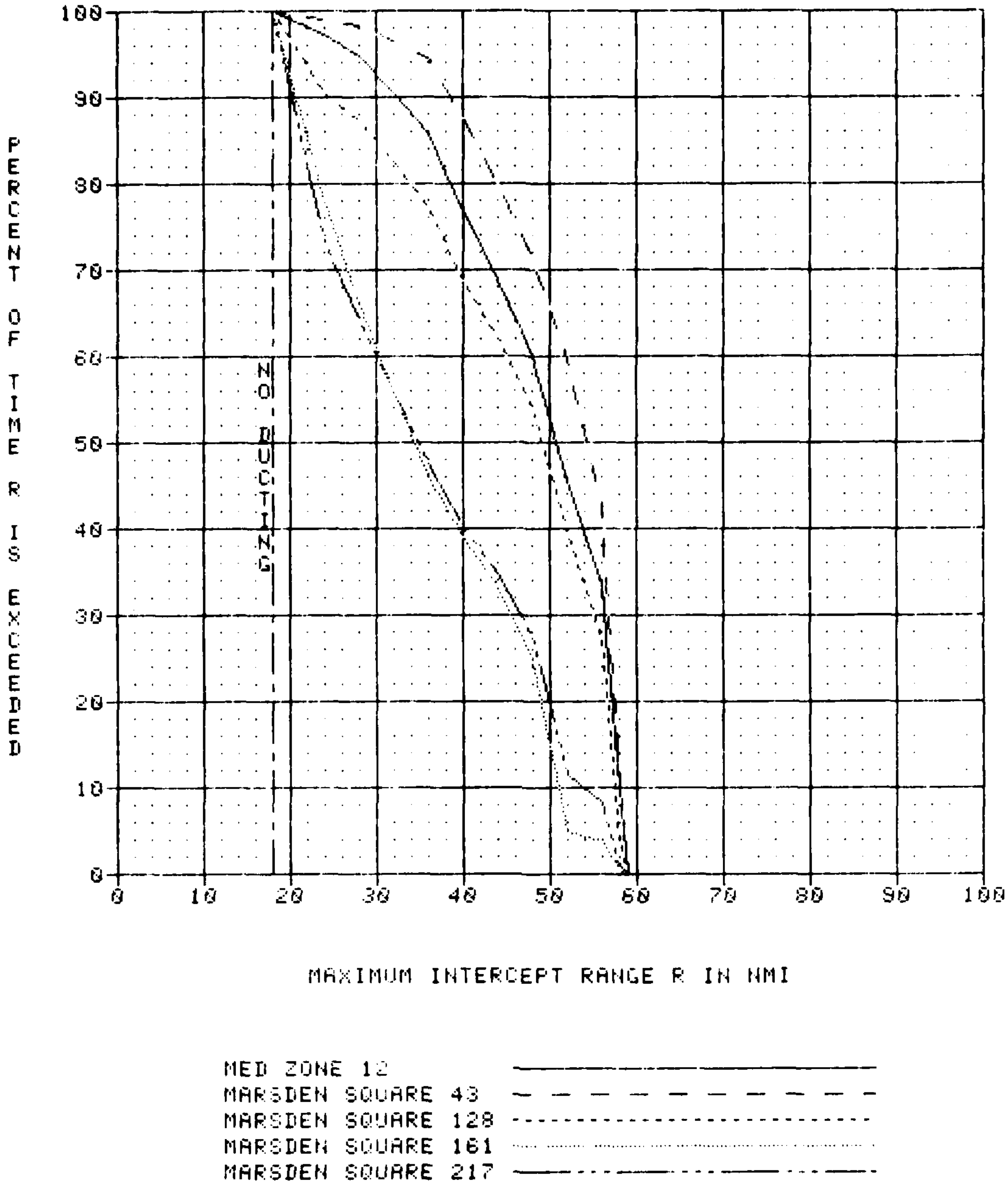
APPENDIX C

Accumulated Frequency Distributions of Maximum Intercept Range

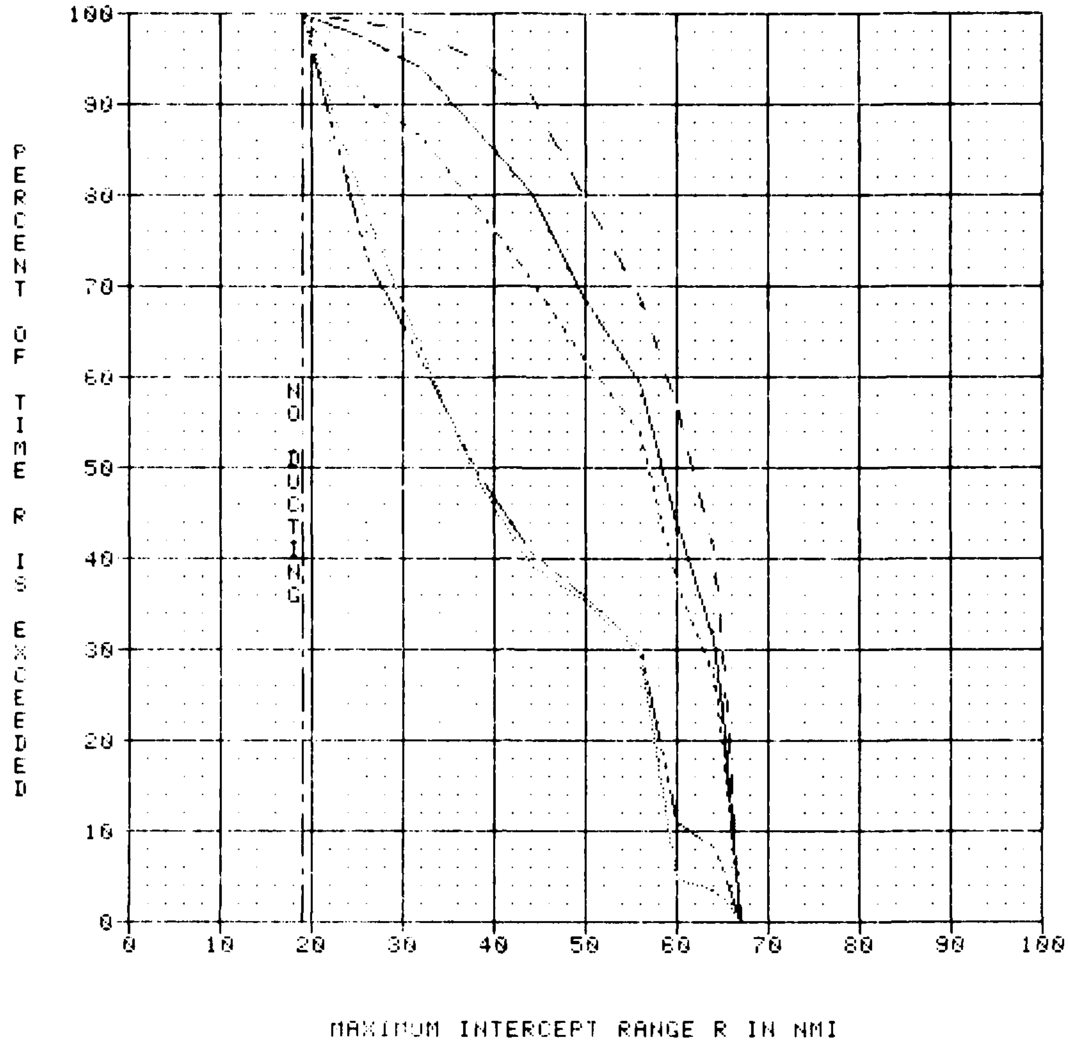


MEL ZONE 12
MARSDEN SQUARE 43
MARSDEN SQUARE 128
MARSDEN SQUARE 161
MARSDEN SQUARE 217

Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 160

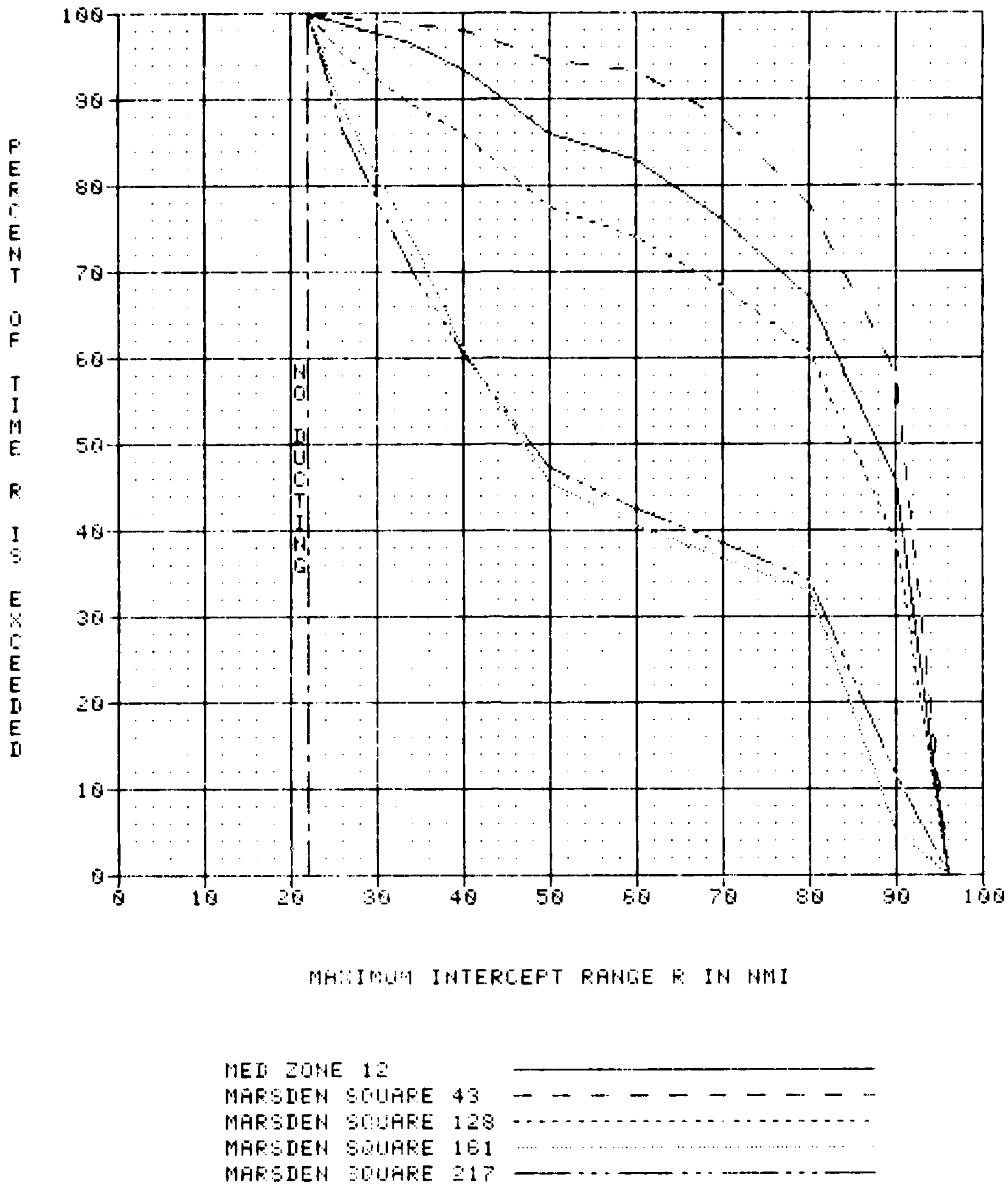


Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 175

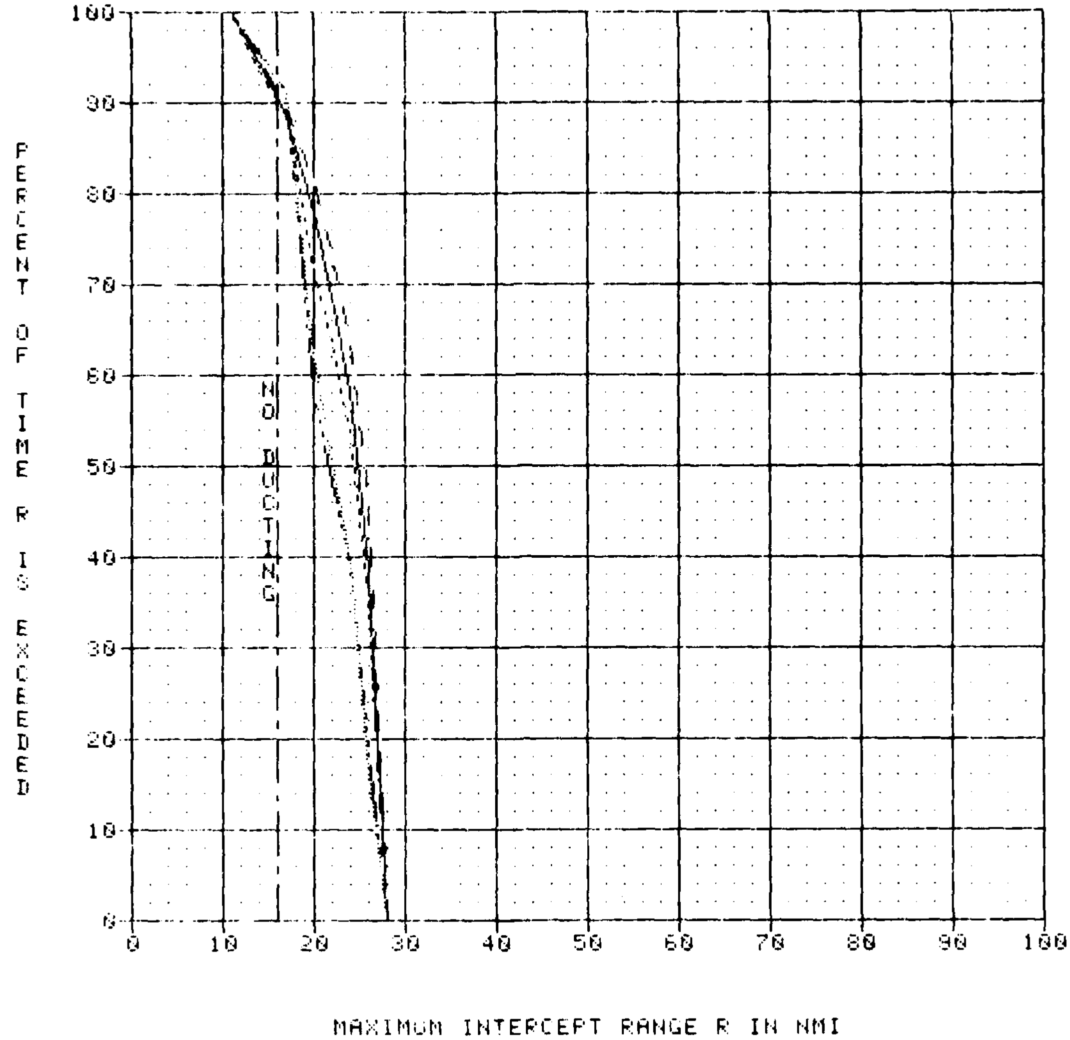


MED JUNE 12 ————————
MARSDEN SQUARE 43 — — — — —
MARSDEN SQUARE 128 - - - - - - - -
MARSDEN SQUARE 161 ··············
MARSDEN SQUARE 217 —·—·—·—

Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 180

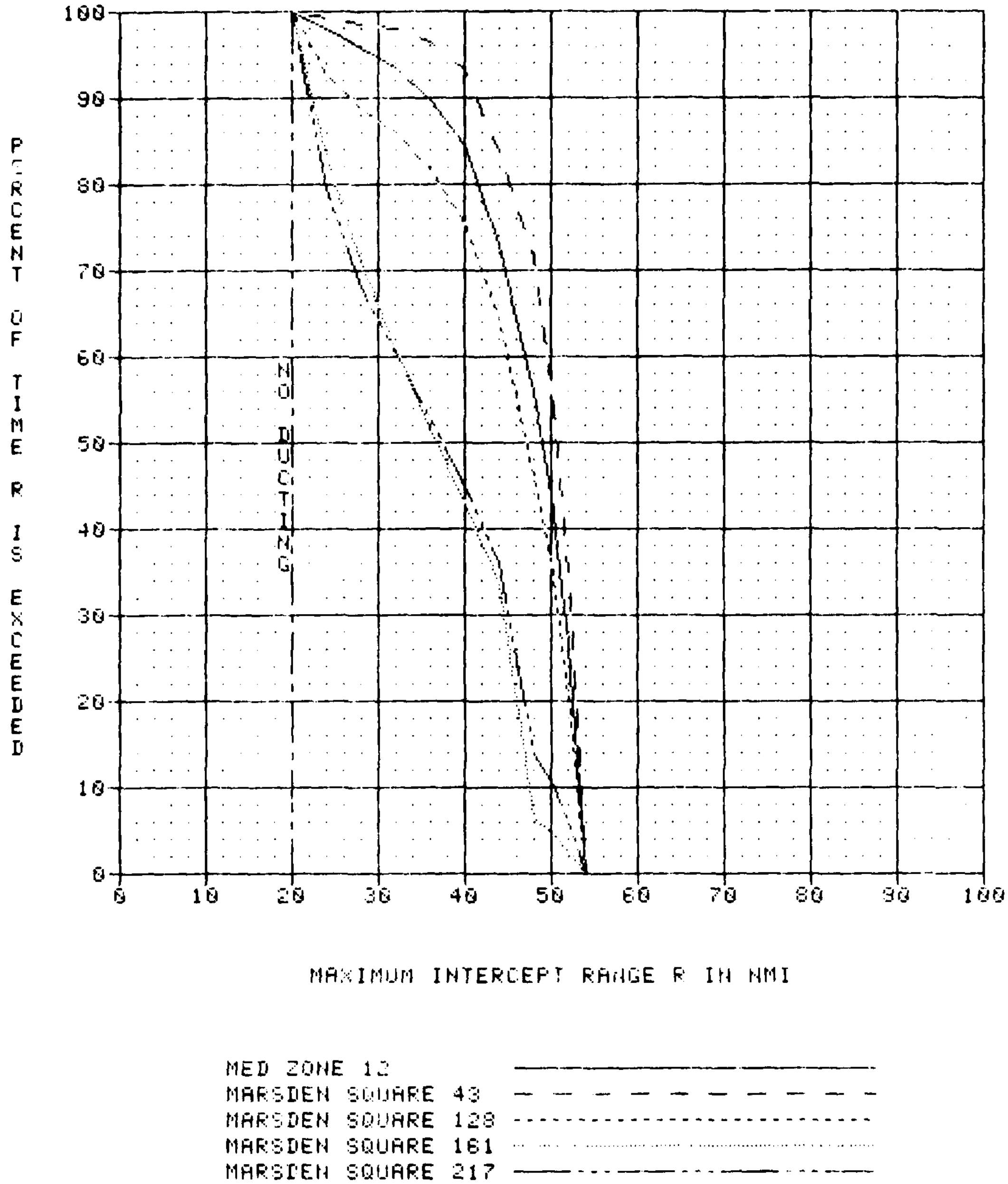


Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 195

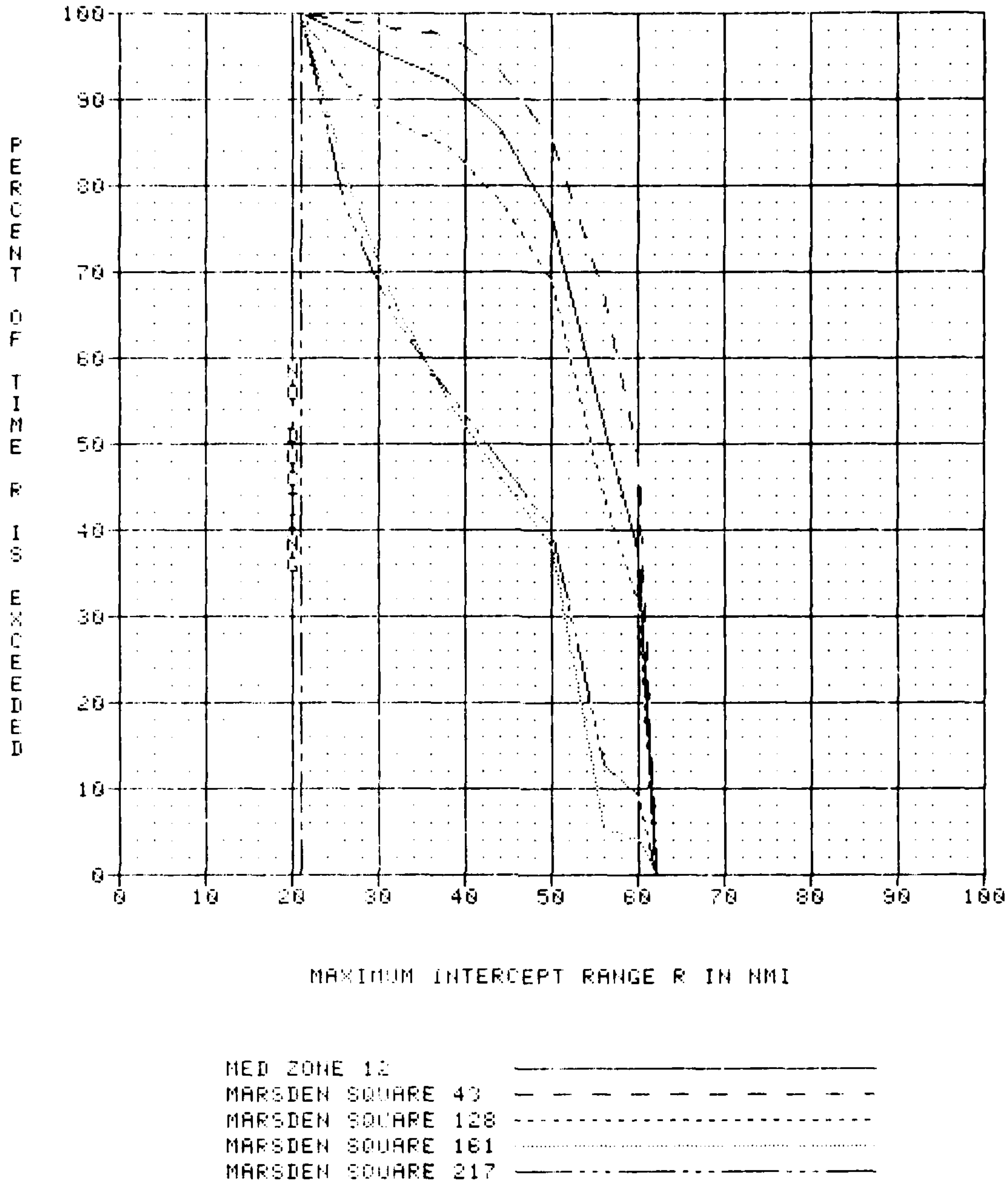


MED ZONE 12
MARSDEN SQUARE 43
MARSDEN SQUARE 128
MARSDEN SQUARE 161
MARSDEN SQUARE 217

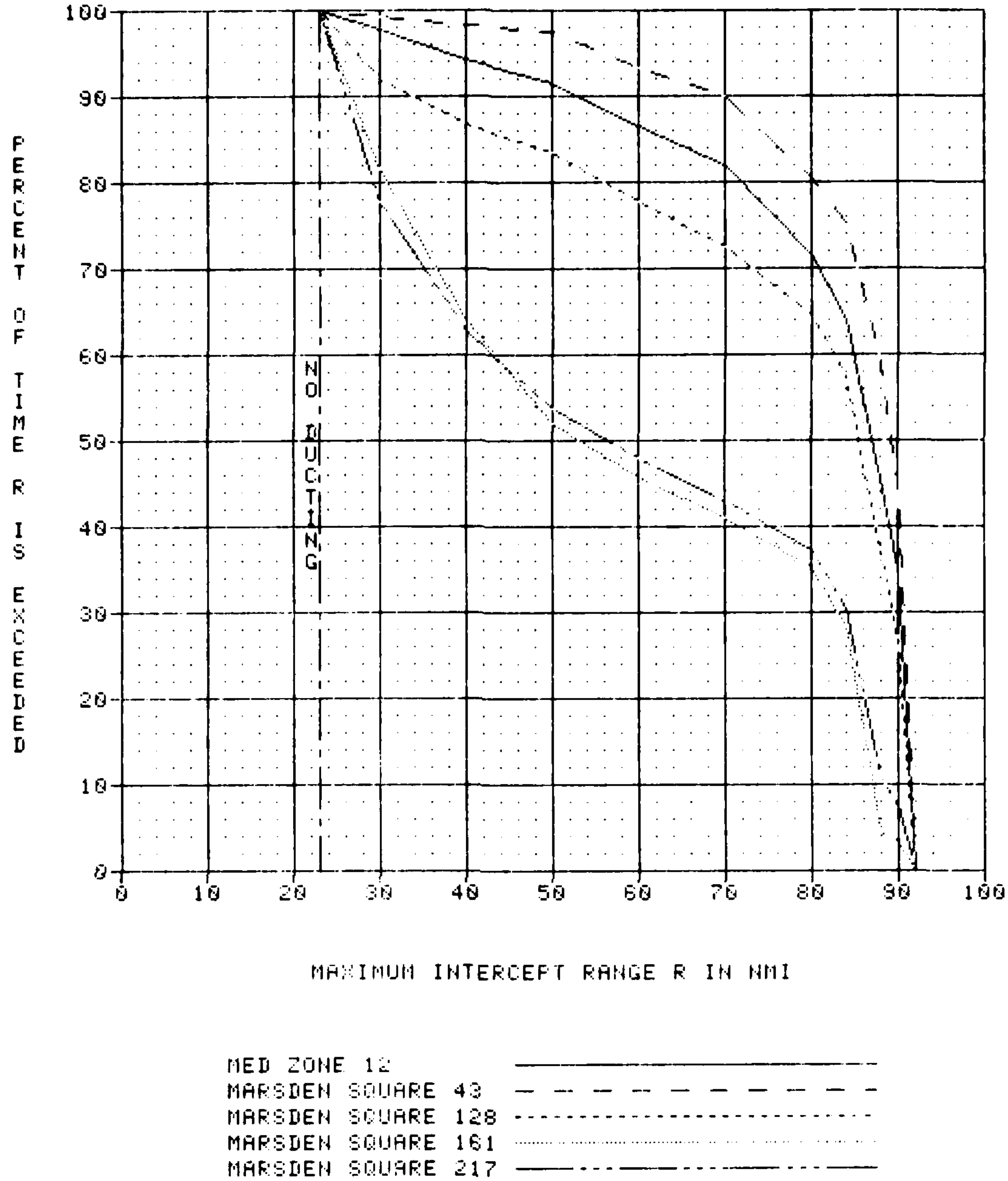
Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 160



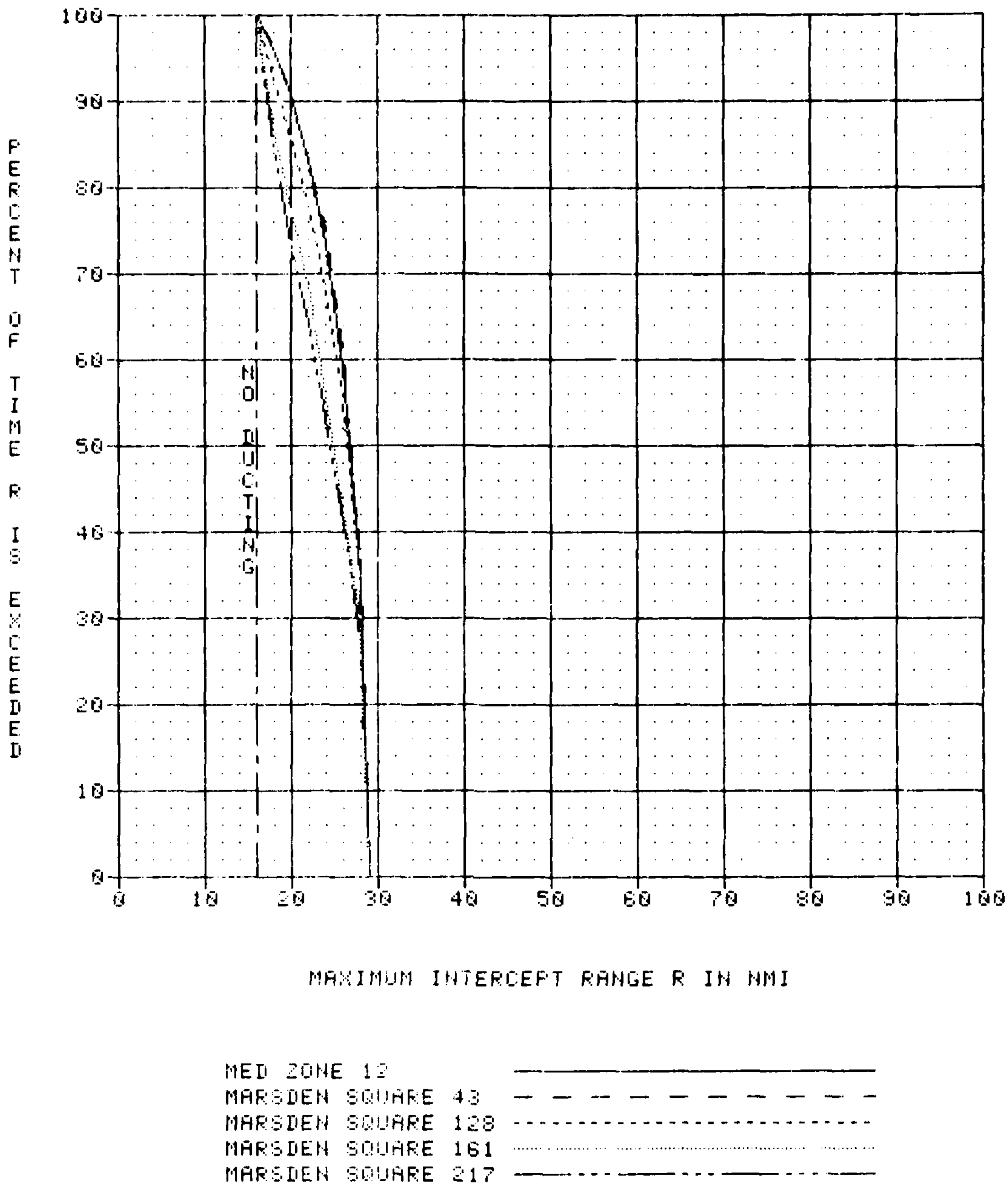
Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 175



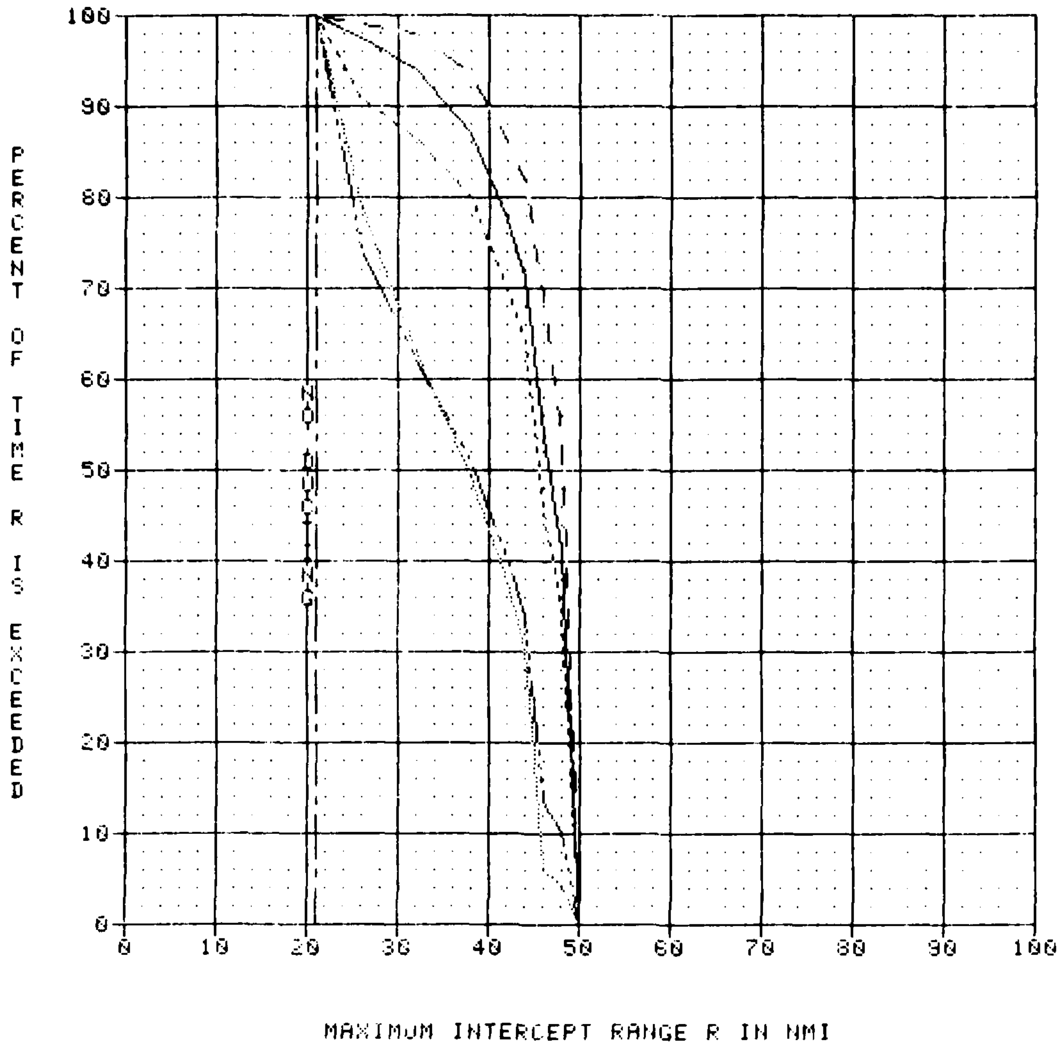
Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 180



Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 195

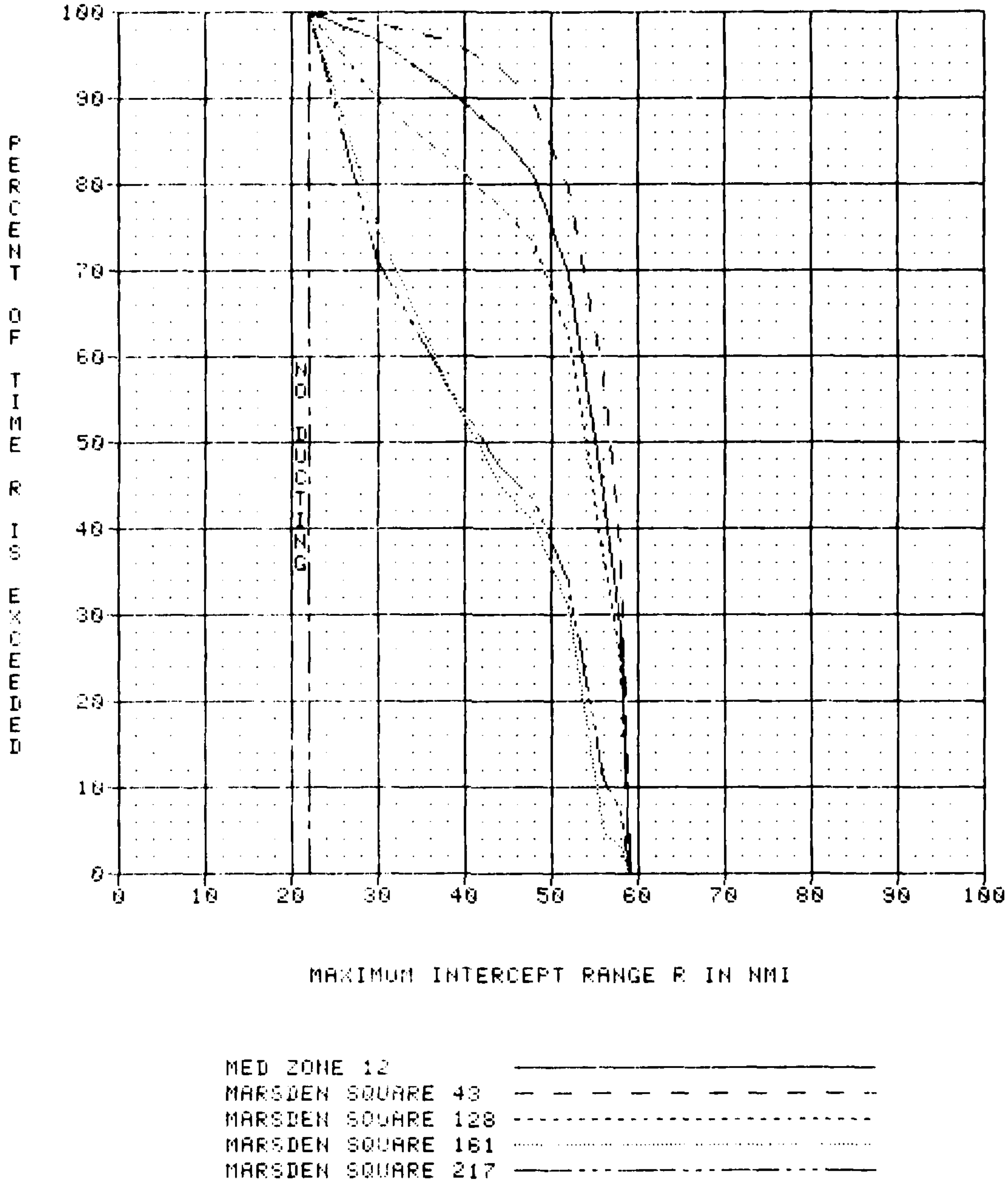


Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 160

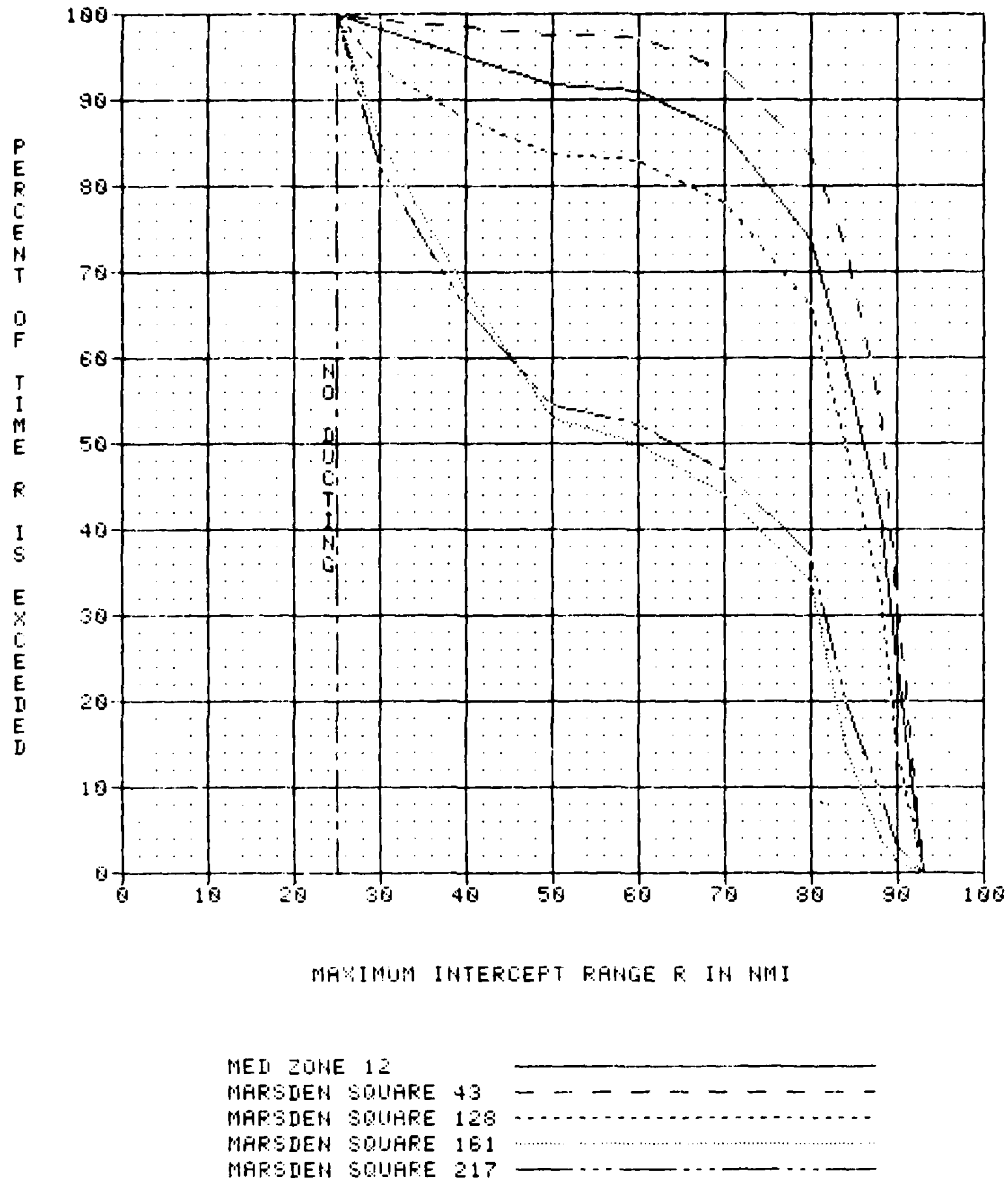


MED ZONE 12
MARSDEN SQUARE 43
MARSDEN SQUARE 128
MARSDEN SQUARE 161
MARSDEN SQUARE 217

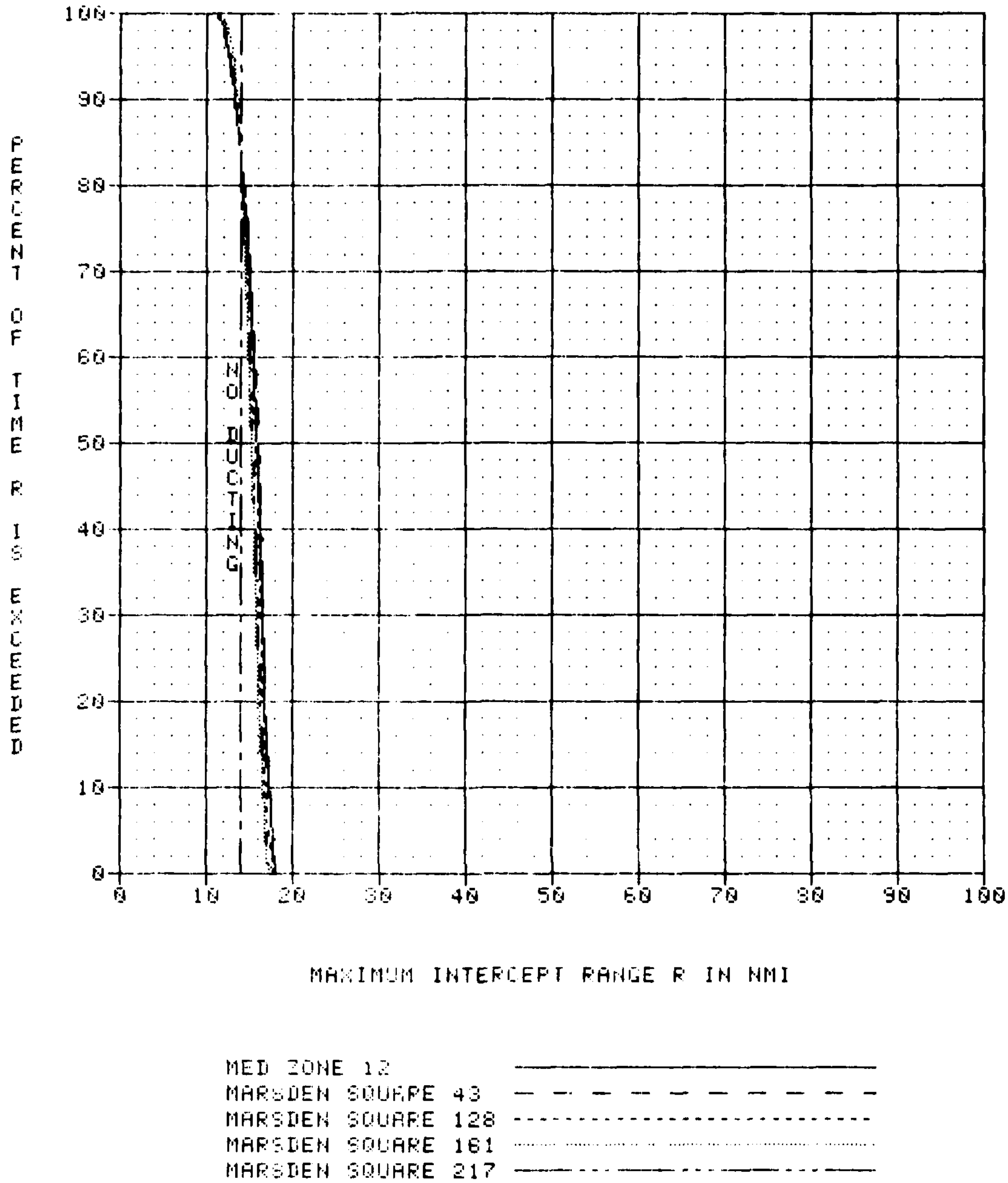
Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 175



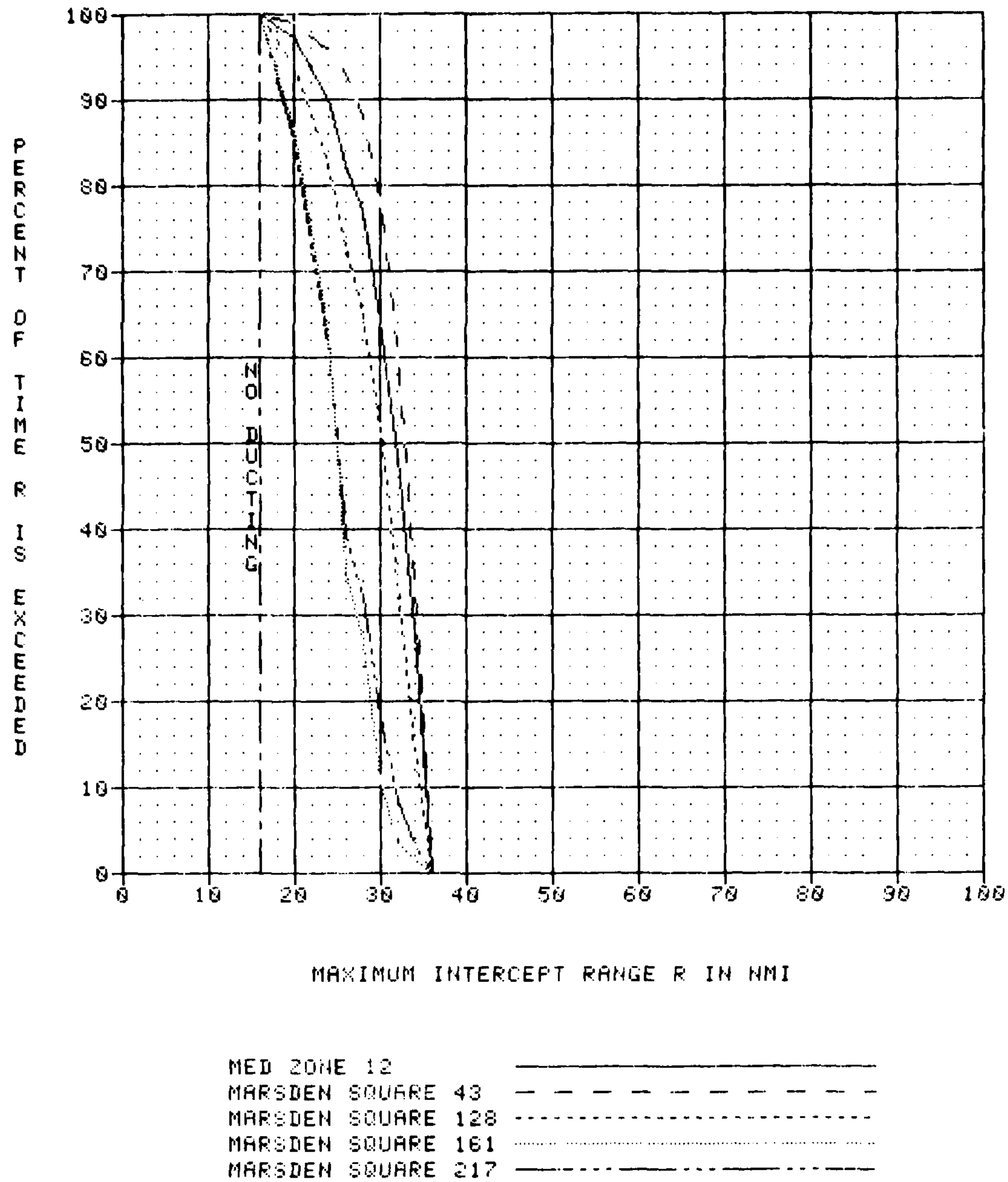
Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 180



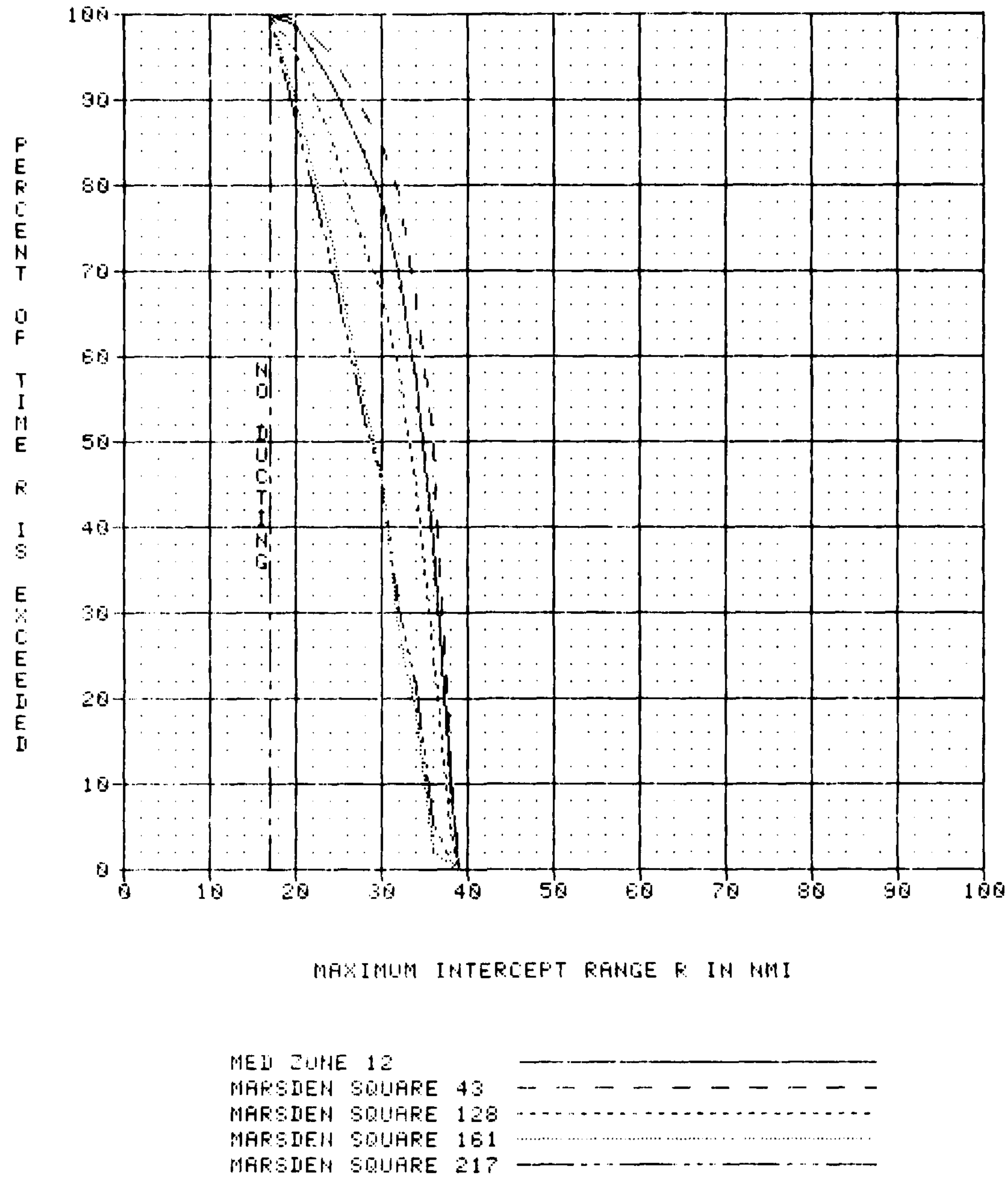
Frequency (GHz) = 18.0
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 195



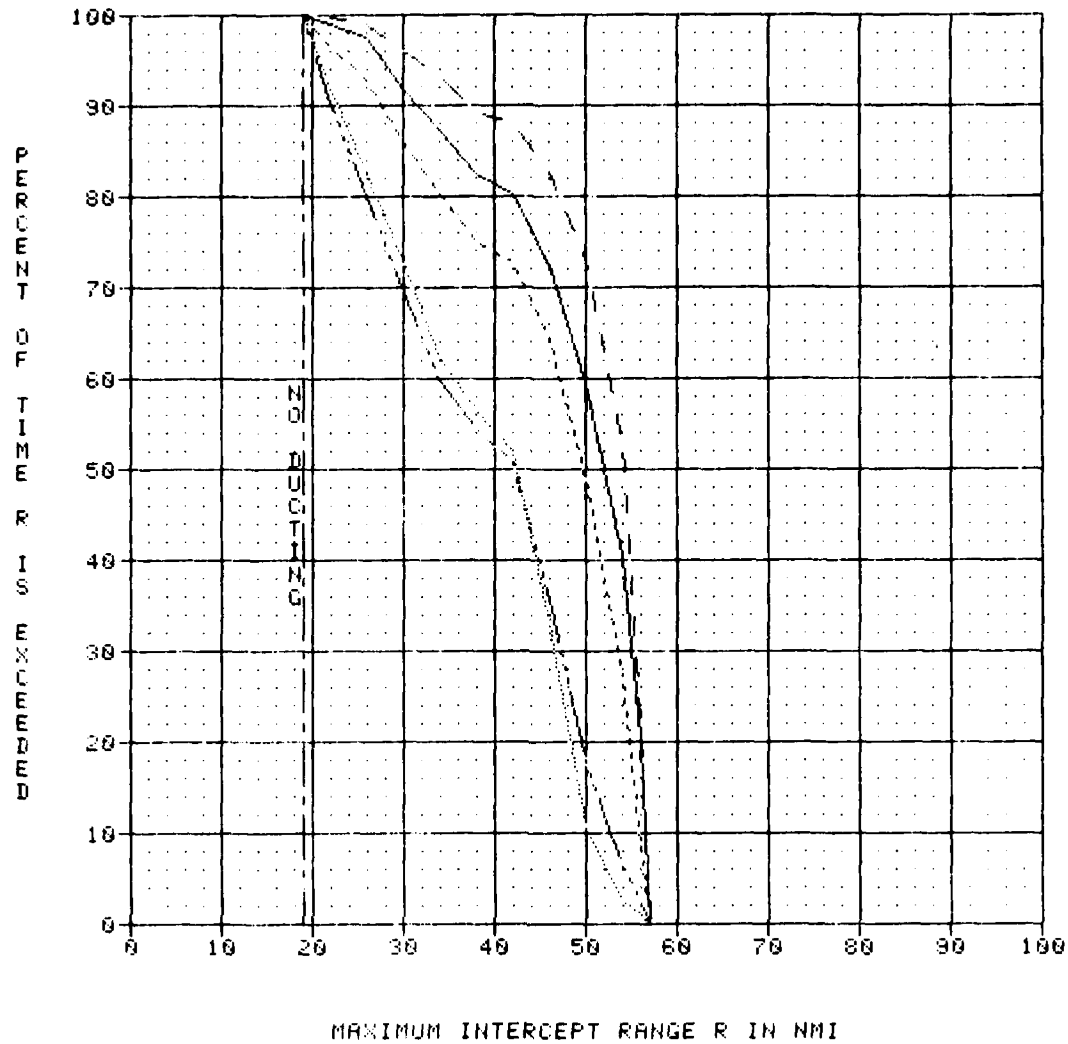
Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 160



Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 175

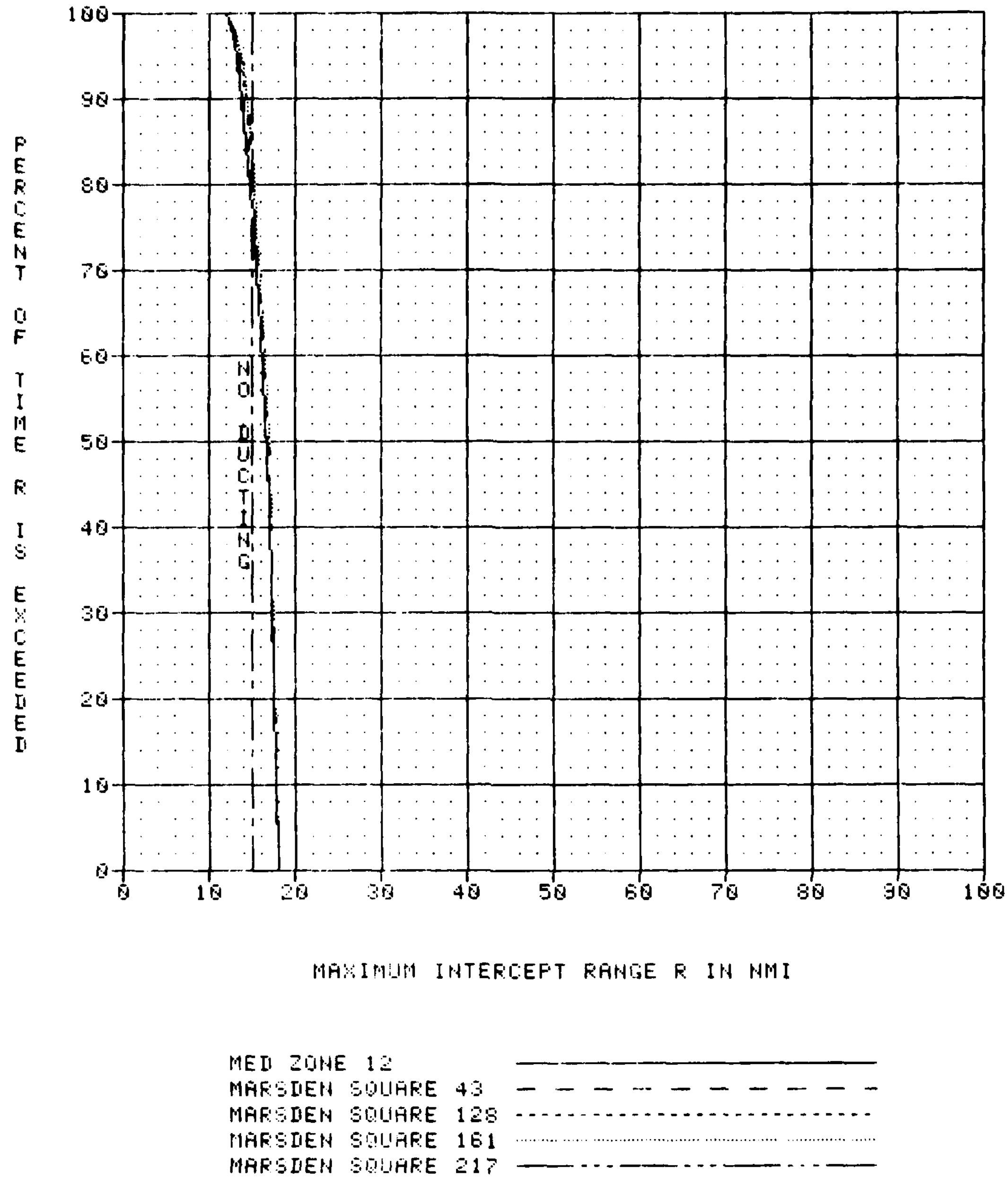


Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 180

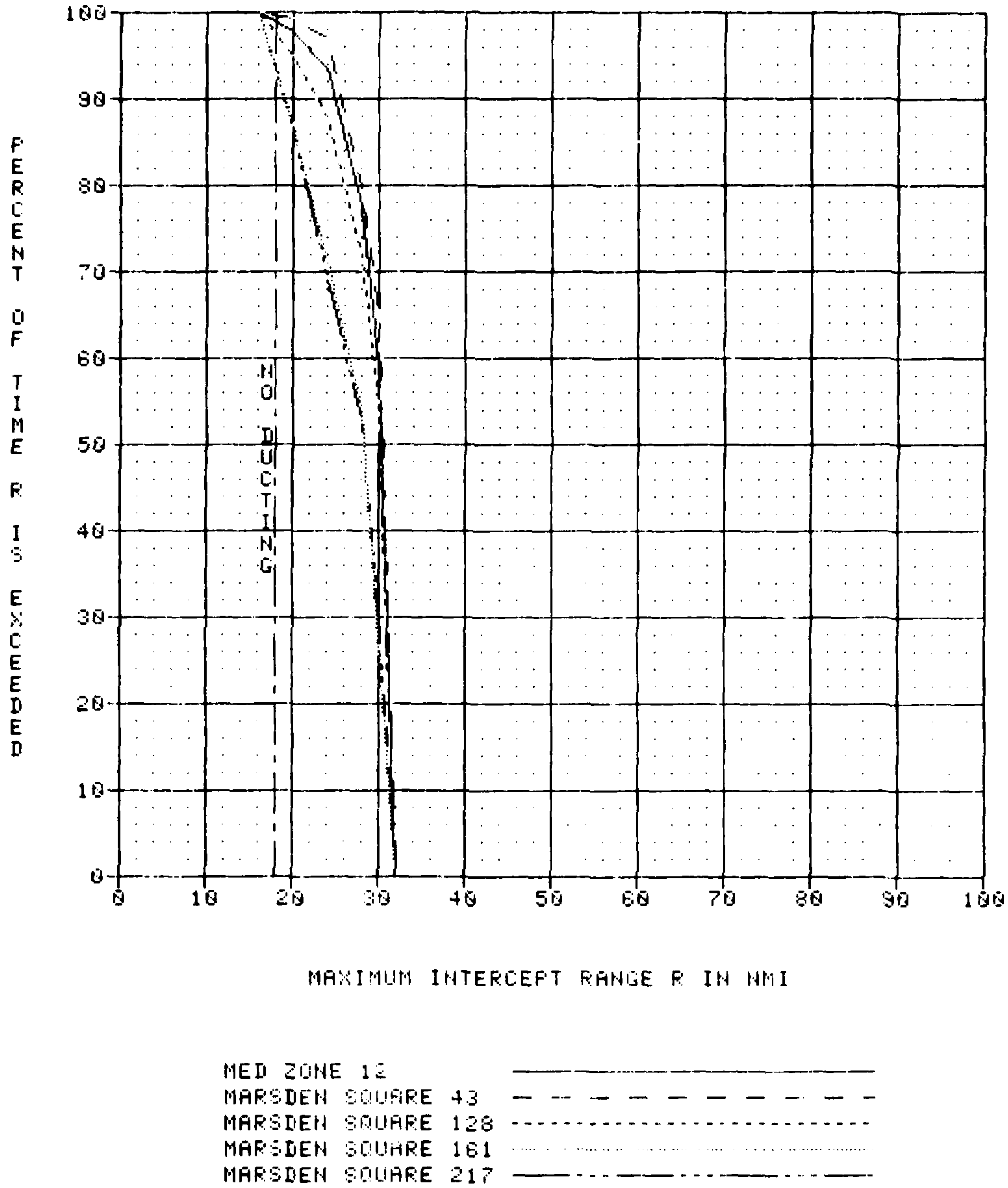


MED ZONE 12 ————————
MARSDEN SQUARE 43 — — — — — —
MARSDEN SQUARE 128 ----------------
MARSDEN SQUARE 161 ....
MARSDEN SQUARE 217 ——-——-——

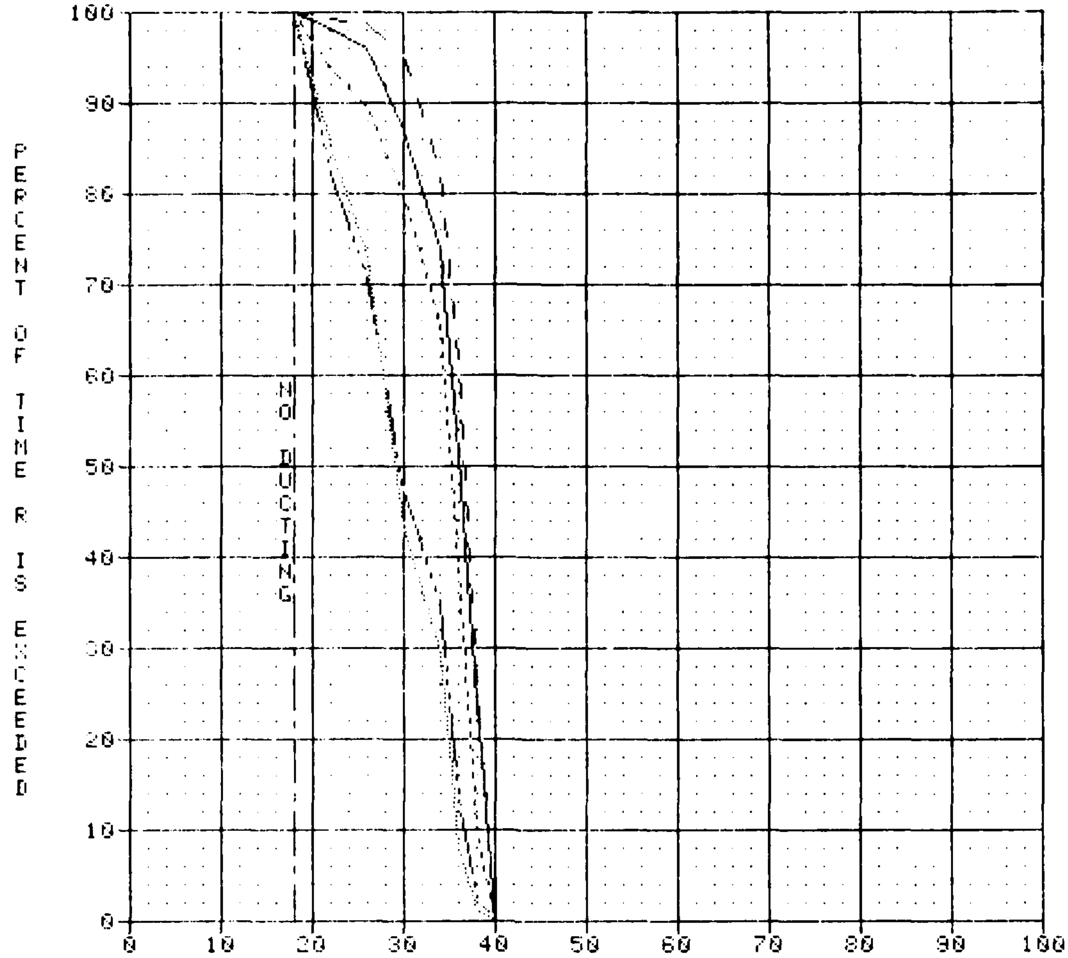
Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 15
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 195



Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 160



Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 175



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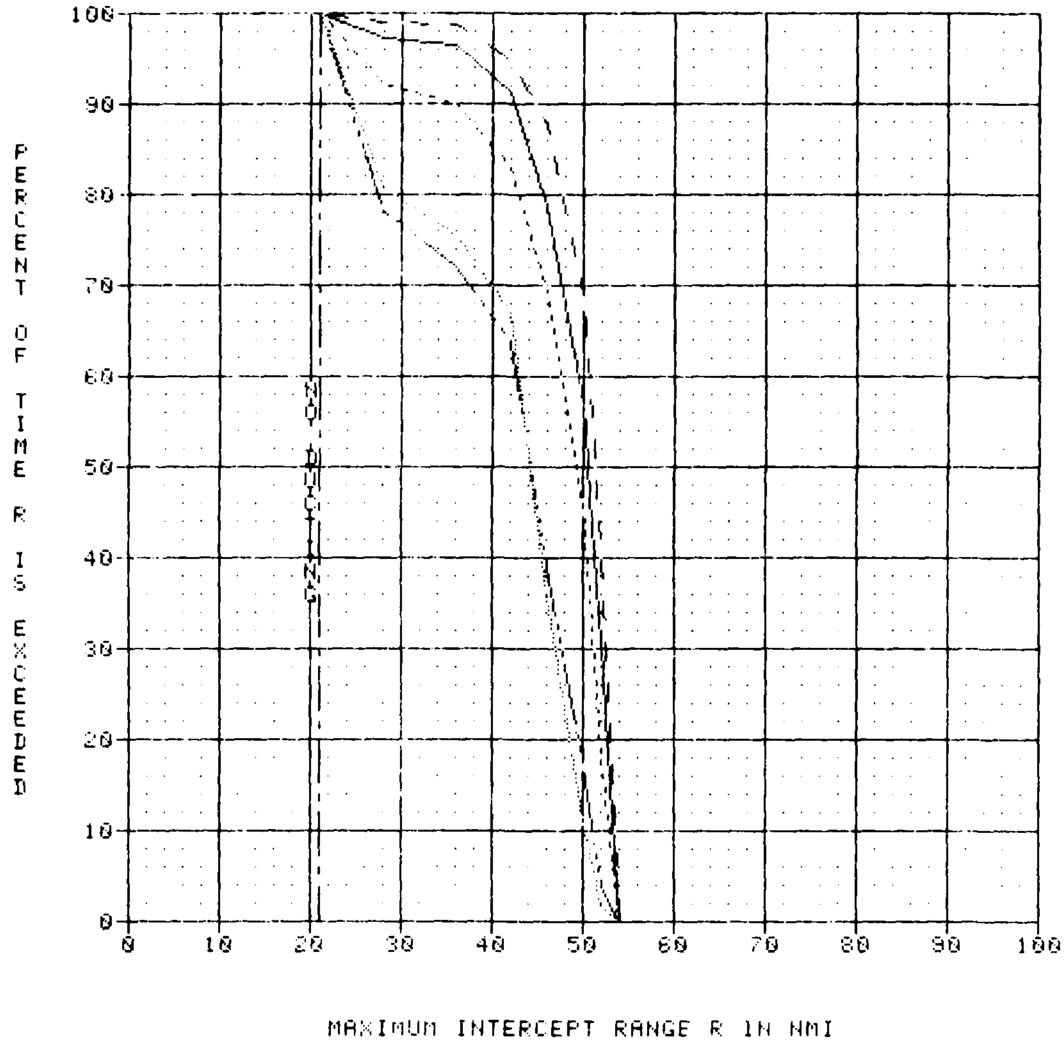
MED ZONE 12 ————————
MARSDEN SQUARE 43 — — — — —
MARSDEN SQUARE 128 - - - - - - - -
MARSDEN SQUARE 181 ....
MARSDEN SQUARE 217 ——-——-——

Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 180



MED ZONE 12
MARSDEN SQUARE 43
MARSDEN SQUARE 128
MARSDEN SQUARE 161
MARSDEN SQUARE 217

Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 22
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 195

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UNCLASSIFIED NOSC/TR-582 NL

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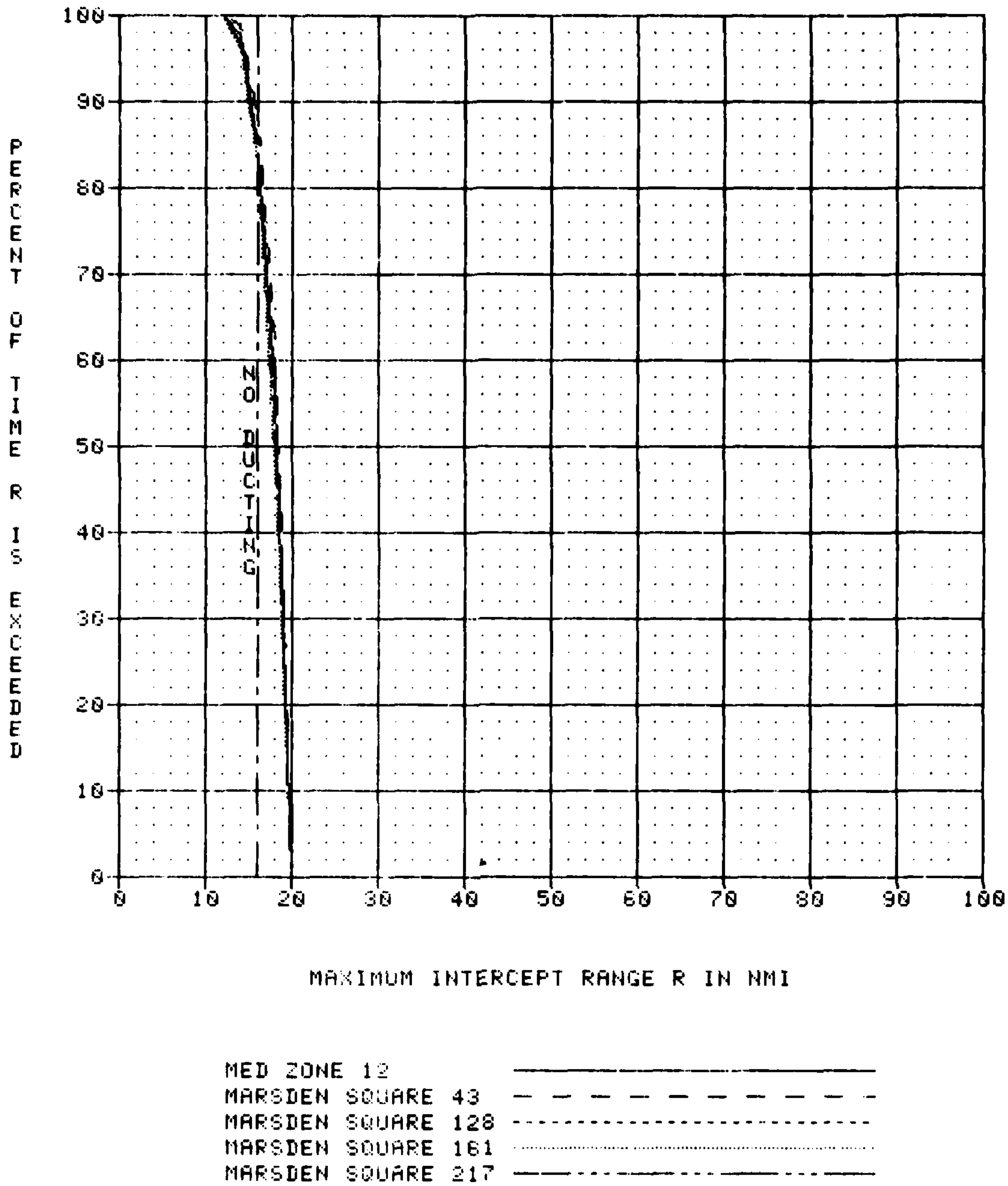
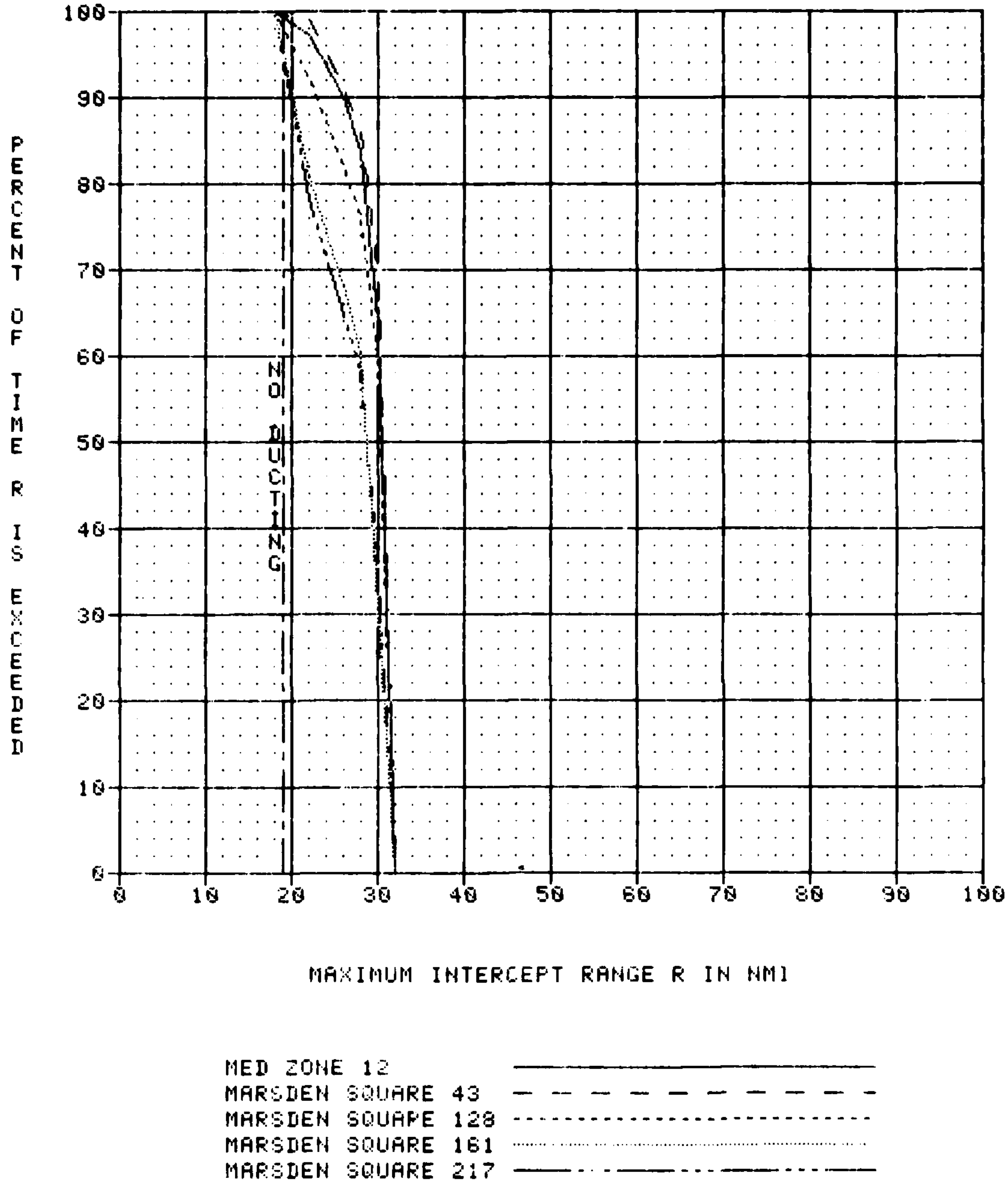


Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 160



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Emitter Power (kW) = 100
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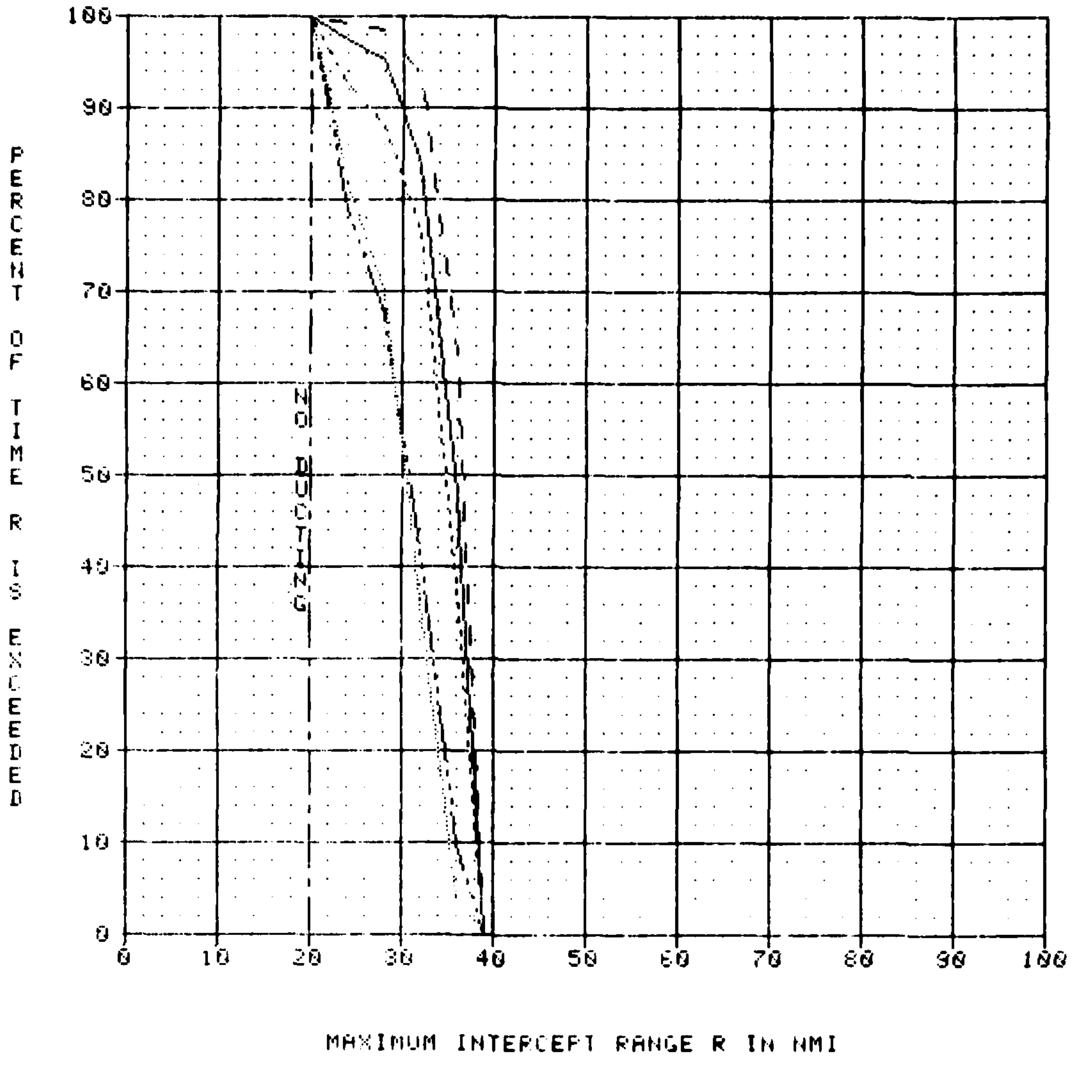
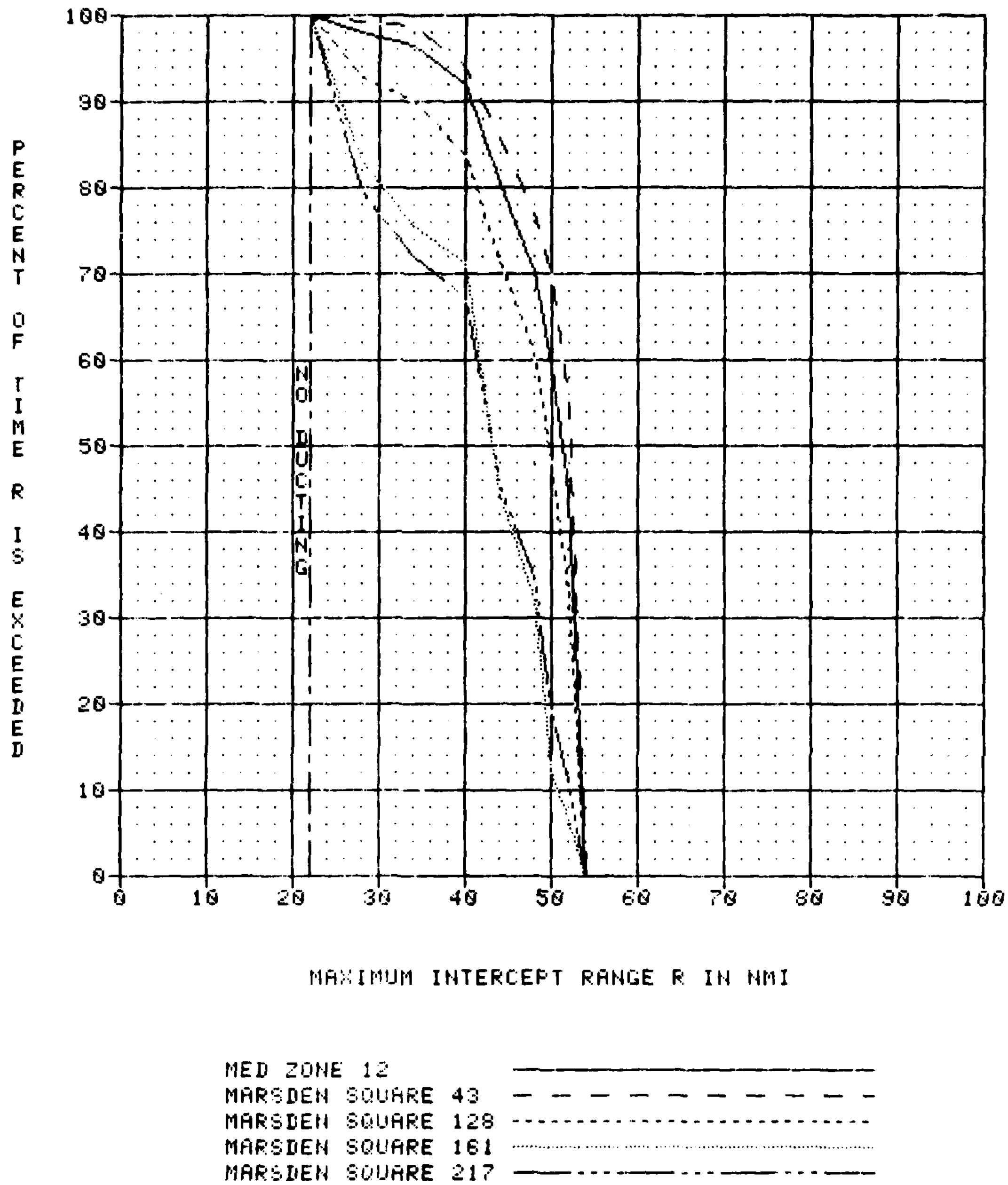
Receiver Sensitivity (dBm) = -40
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 175



MED ZONE 12
MARSDEN SQUARE 43
MARSDEN SQUARE 128
MARSDEN SQUARE 161
MARSDEN SQUARE 217

Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 0
Path Loss Threshold (dB) = 180



Frequency (GHz) = 37.5
Emitter Antenna Height (m) = 10
Receiver Antenna Height (m) = 30
Emitter Power (kW) = 100
Emitter Antenna Gain (dBi)= 40
Receiver Sensitivity (dBm) = -60
Receiver Antenna Gain (dBi) = 15
Path Loss Threshold (dB) = 195