

6.2.3.8 Some States have recorded data on NDBs and their effective coverage; and collection of similar information would be a practical way of obtaining an assessment of effective coverage in terms of rated coverage of facilities in a given area. This information would also be useful for future regional planning. In order to reduce the number of factors involved in assessing effective coverage, it would be desirable to establish criteria for determining the limit of useful coverage in terms of the reaction of the bearing indicator. The data referred to previously, together with measurements of actual field strength within the coverage of the NDB, would also permit determination of the effectiveness of existing installations and provide a guide to improvements that may be necessary to achieve a desired effective coverage.

6.3 Coverage of NDBs

6.3.1 Introduction

6.3.1.1 The following studies have been based on the latest propagation and noise data available to the ITU. They are included in this Attachment as general guidance in respect of NDB planning. Attention is called particularly to the assumptions made.

6.3.1.2 When applying the material, the validity of the assumptions in respect of the particular conditions under consideration should be carefully examined and, in particular, it should be noted that the assumed signal-to-noise ratios require considerable further study before they can be accepted as representative of the ratios limiting useful reception.

6.3.2 Assumptions

1. Operating frequency — 300 kHz.
Reference is made, however, where appropriate, to frequencies of 200 kHz and 400 kHz.
2. a) Average soil conductivity:
($\sigma = 10^{-13}$ e.m.u.)

b) Average seawater conductivity:
($\sigma = 4 \cdot 10^{-11}$ e.m.u.)
3. The level of atmospheric noise (RMS) which is likely to prevail: 1) by day, 2) by night, over land masses, within the belts of latitude mentioned. [The values of expected noise have been derived from Recommendation ITU-R P.372-6 and have been taken as the average noise by day and by night during equinox periods, i.e. the values which are likely to be exceeded 20–25 per cent of the year.]
4. Input powers to the antenna of the NDB of:
 - a) 5 kW
 - b) 1 kW
 - c) 500 W
 - d) 100 W
 - e) 50 W
 - f) 10 W

5. The following average values of radiation efficiencies of antennas, i.e. the ratio of:

$$\left[\frac{\text{Radiated power}}{\text{Input power to antenna}} \right]$$

	<i>Input power to antenna</i>	<i>Radiation efficiency of antenna</i>
a)	5 kW	20% (−7 dB)
b)	5 kW	10% (−10 dB)
c)	1 kW	8% (−11 dB)
d)	500 W	5% (−13 dB)
e)	100 W	3% (−15 dB)
f)	50 W	2% (−17 dB)
g)	10 W	1% (−20 dB)
h)	10 W	0.3% (−25 dB)

i) The figure for a) is included because it is possible to realize this efficiency by the use of a more elaborate antenna system than is usually employed.

ii) The figure for h) is included because many low power NDBs use very inefficient antennas.

6. An admittance band of the ADF receiver of 6 kHz.

7. Required ratios of signal-(median) to-noise (RMS) of:

a) 15 dB by day;

b) 15 dB by night.

6.3.3 Results of studies

A.— Minimum field strengths required at the boundary of the rated coverage:

<i>Latitude</i>	<i>By day for 15 dB S/N ratio</i>	<i>By night for 15 dB S/N ratio</i>
5°N – 5°S	320 µV/m (+50 dB)	900 µV/m (+59 dB)
5° – 15°N&S	85 µV/m (+39 dB)	700 µV/m (+57 dB)
15° – 25°N&S	40 µV/m (+32 dB)	320 µV/m (+50 dB)
25° – 35°N&S	18★µV/m (+25 dB)	120 µV/m (+42 dB)
>35°N&S	18★µV/m (+25 dB)	50 µV/m (+35 dB)

A star shown against a figure indicates that a higher value of field strength — probably 2 or 3 times the values shown (plus 6 to plus 10 dB) — may be necessary in the presence of high aircraft noise and/or industrial noise.

B.— Coverage of NDBs (expressed in terms of the radius of a circle, in kilometres, with the NDB at the centre) which may be expected under the assumptions made:

- 1) By day, over land, and for 15 dB S/N ratio at the boundary of the coverage:

Latitude	Input power to antenna			
	(a) 5 kW	(b) 5 kW	(c) 1 kW	(d) 500 W
5°N – 5°S	320	300	170	120
5° – 15°N&S	510	470	320	250
15° – 25°N&S	>600	600	450	350
25° – 35°N&S	>600★	>600★	600★	500★
>35°N&S	>600★	>600★	>600★	500★

Latitude	Input power to antenna			
	(e) 100 W	(f) 50 W	(g) 10 W	(h) 10 W
5°N – 5°S	50	30	10	<10
5° – 15°N&S	150	90	40	10
15° – 25°N&S	220	160	70	45
25° – 35°N&S	330★	250★	130★	80★
>35°N&S	330★	250★	130★	100★

- 2) By night, over land, and for 15 dB S/N ratio at the boundary of the coverage:

Latitude	Input power to antenna			
	(a) 5 kW	(b) 5 kW	(c) 1 kW	(d) 500 W
5°N – 5°S	190	150	85	50
5° – 15°N&S	210	180	110	70
15° – 25°N&S	320	300	170	120
25° – 35°N&S	390	390	280	200
>35°N&S	390	390	390	310

Latitude	Input power to antenna			
	(e) 100 W	(f) 50 W	(g) 10 W	(h) 10 W
5°N – 5°S	20	<10	<10	<10
5° – 15°N&S	25	15	<10	<10
15° – 25°N&S	50	30	10	<10
25° – 35°N&S	100	70	25	15
>35°N&S	180	120	50	30

6.3.3.1 In all of the above tables, it has to be noted that:

- a) the distances are given in kilometres, in accordance with ITU practice;
- b) the figures in the final columns, with the heading 10 W, are calculated on the assumption that the low power NDB uses a very inefficient antenna (see 6.3.2, assumption 5 h));
- c) a star shown against a figure indicates that the coverage may be limited by aircraft and industrial noises.

6.3.3.2 It has also to be noted that:

- a) if a frequency of 200 kHz were used in place of 300 kHz, this would not appreciably affect the coverage of low power short range NDBs, but the coverage of the higher power, longer range beacons (for example, those with a range of 150 km or more) would be increased, as compared with those shown in the tables, by about 20 per cent;
- b) if a frequency of 400 kHz were used in place of 300 kHz this would not appreciably affect the coverage of low power short range NDBs, but the coverage of the higher power, longer range beacons (for example, those with a range of 150 km or more) would be decreased, as compared with those shown in the tables, by about 25 per cent;
- c) use of an ADF receiver with a narrower band would, other things being equal, provide wider coverage for the same radiated power of the NDB or, for the same coverage, an improved effective signal-to-noise ratio.

For example, if an admittance band of 1 kHz instead of 6 kHz were used, the coverage might be increased by as much as 30 per cent for the same radiated power or, alternatively, the effective signal-to-noise ratio might be increased by as much as 8 dB;

- d) if a sector of the coverage of an NDB is over seawater, a greater coverage may be expected within that sector due to:
 - 1) better ground wave propagation over seawater than over land;
 - 2) the noise level, which is highest over land, often drops fairly steeply with increasing distance from the land. It might be assumed, therefore, that the distances shown in the tables could be increased by about 30 per cent by day, and by about 20 per cent by night, when the path is over seawater;
- e) if, however, the beacon is sited on an island remote from land masses (for example, in mid-Pacific or mid-Atlantic, but not in the Caribbean), the coverage of the beacon is likely to be much greater, particularly in tropical latitudes, than is indicated in the tables; and in such cases figures for coverage similar to those shown for latitudes more than 35°N and S may be assumed for all latitudes, due to the much lower level of atmospheric noise which prevails in mid-ocean as compared with that experienced over, or in proximity to, land masses.

6.3.4 Limitation of coverage of a beacon at night due to “night effect”.

- a) The distances, at night, at which the ground wave and sky wave components of the received field are likely to be equal are as follows:

<i>Frequency</i>	<i>Over land</i>	<i>Over sea</i>
200 kHz	500 km	550 km
300 kHz	390 km	520 km
400 kHz	310 km	500 km

- b) The distances, at night, at which the ground wave component of the received field is likely to exceed the sky wave component by 10 dB are as follows:

<i>Frequency</i>	<i>Over land</i>	<i>Over sea</i>
200 kHz	300 km	320 km
300 kHz	230 km	300 km
400 kHz	200 km	280 km

- c) It is, therefore, unlikely that reliable bearings can be obtained, at night, due to interaction of the two components of the received field, at much greater distances than those shown in 6.3.4 b). *These distances are independent of the power of the NDB.*
- d) It has to be noted, moreover, that, while with overland paths of good conductivity, night effect will only be serious at somewhat greater distances than those indicated over paths of poor conductivity, night effect may become pronounced at much shorter ranges. This will also depend to some extent upon the characteristics of the radiation system.

6.4 Considerations affecting operations of NDBs

6.4.1 *Depth of modulation*

6.4.1.1 In specifying that the depth of modulation should be maintained as near to 95 per cent as is practicable, it must be noted that, at the frequencies used for NDBs, the small antennas generally in use can affect the effective modulation depth of the NDB system due to attenuation of the sidebands.

6.4.1.2 At this order of frequency, the antennas are normally only a small fraction of a wavelength long; they are therefore highly reactive and tend to have a high Q.

6.4.1.3 The effect is illustrated in Figure C-19, which was compiled from measurements made by one State. The modulating frequency in these measurements was 1 020 Hz. If a lower modulating frequency were used, the effect would be less.

6.4.1.4 In order to reduce the attenuation, attempts should be made to reduce the Q of the antenna. This can be done in two ways, by increasing either its capacity or resistance.

6.4.1.5 Inserting additional resistance in an antenna wastes power, whereas increasing the capacity does not. Additionally, the effect of increasing the capacity is to reduce the voltage across the system and hence to reduce the insulation problems.

6.4.1.6 For these reasons, it is considered desirable to increase antenna capacity by the use of a top load as, for example, in the so-called umbrella top capacity.

6.4.2 *Earth systems*

Frequency planning is done on the assumption that the field strength will be maintained at the correct value. If the earth resistance is high (i.e. an insufficient earth system), not only will the radiation efficiency be low but the power radiated will be sensitive to changes in climatic conditions and other factors affecting the earth loss. In all cases, the earth system needs to be the best possible, taking into account all local circumstances.