REPORT 910-1

SHARING BETWEEN THE MARITIME MOBILE SERVICE AND THE AERONAUTICAL RADIONAVIGATION SERVICE IN THE BAND 415-526.5 kHz

(Question 53/8)

(1982–1986)

1. Introduction

Parts of the frequency band 415-526.5 kHz are allocated to both the maritime mobile service and the aeronautical radionavigation service.

In the maritime mobile service, the frequency 518 kHz is used exclusively for the transmission by coast stations of navigational warnings and urgent information to ships, by means of narrow-band direct-printing telegraphy (also called NAVTEX).

Because of differences in operational use, frequency planning, radiated power, etc., coexistence of these two radio services in the same bands may present problems. Particular attention is required with respect to the problems which have their origin in the difference in the power levels used.

The aeronautical radio navigation service, operating at power levels which are 20-30 dB lower than those of the maritime mobile service, has a more difficult problem in the protection against interference.

It is essential that suitable criteria, which will permit coexistence of the two services in the same band, be developed as soon as possible.

The following examination is restricted to:

(a) geographical separation (co-channel);

(b) frequency separation (co-location);

(c) combination of (a) and (b) with variable geographical distance and frequency separation.

Also certain variations in the power level radiated by stations in the maritime mobile service and the effect of a more selective automatic direction finding (ADF) receiver are examined.

2. Factors involved

2.1 *Differences in radiated power levels*

2.1.1 The maritime mobile service provides communications between coast stations and ship stations or between ship stations. There are no protection criteria in the Radio Regulations governing the maritime mobile service in the bands between 435 kHz and 526.5 kHz.

Normally the output power of coast station transmitters is of the order of 1-2 kW. With an antenna efficiency of 30% the e.r.p. is then 300-600 W. However, an antenna efficiency of 1-30% may be found in some cases.

The typical e.r.p. of NAVTEX transmitting stations is of the order of 10-50 W.

Technical characteristics of NAVTEX stations should be in accordance with Recommendation 540, (100 Bd F1B, with a necessary bandwidth of 304 Hz).

Ship stations normally use 400 W transmitters. If the antenna efficiency is 10%, the e.r.p. is 40 W.

2.1.2 In the aeronautical radionavigation service in some cases transmitters of about 50 W are used, but the e.r.p. is of the order of 0.5 W. A typical aeronautical beacon in the European area has a range of 50 NM with an e.r.p. of less than 1 W. In other areas, beacons with a range of about 200 NM are quite common.

The ICAO standard on radiated power states that, "The power radiated from a NDB shall not exceed by more than 2 dB that necessary to achieve the agreed rated coverage..." (Annex 10 to the Convention on International Civil Aviation, Vol. I, Part I, § 3.4.3.) Other characteristics of the beacon, both as prescribed by ICAO (Annex 10) and the operational use of the beacon, need also to be taken into consideration.

2.2 *Protection ratio desired/undesired signal in the aeronautical radionavigation service*

The protection figure of 15 dB quoted in the Radio Regulations No. 2854 applies to bands below those concerned in this Report. The Radio Regulations make no statement on the protection figure to be applied to aeronautical NDBs between 435 and 526.5 kHz. However, the figure of 15 dB has been taken as applicable for the purposes of this Report.

2.3 *Automatic direction finding (ADF) receiver selectivity*

The extent to which the ADF receiver is capable of suppressing undesired frequencies is governed by the ADF receiver selectivity curves (see Fig. 1).

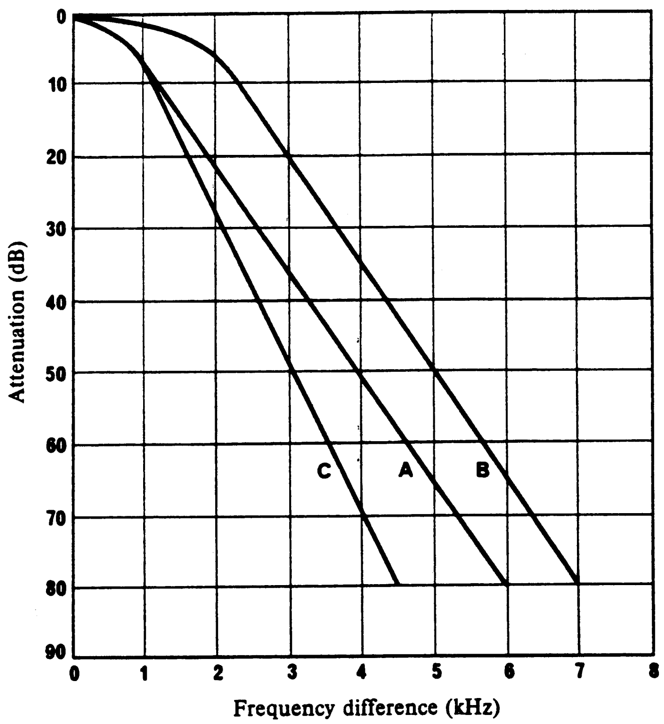

FIGURE 1 – *ADF receiver selectivity curves*

Curves **A**: Annex 10 Vol. I, Att. B to Part II, para 3
B: Annex 10 Vol. I, Att. B to Part II, para 2
C: arbitrary curve, better than A

Note. **– In congested areas curve A is used when planning LF/MF beacons in the aeronautical radionavigation service. It is to be noted that there are ADF equipments currently being used, which have selectivity characteristics that are not as stringent as specified in Curve A.**

For a given frequency separation between stations, a selectivity curve with steeper slopes will reduce the minimum geographical distance required between stations in the maritime mobile service and the aeronautical radionavigation service. However, because the ADF receiver is required to receive signals with a bandwidth of about 2 kHz, steeper slopes will have a negligible effect for frequency separations less than 1 kHz.

2.4 The separation distance required between a NDB and a coast station once established will remain fixed provided their respective frequencies and powers do not change. The required separation between a NDB and a ship station will vary depending on the position of the ship, its transmitter power and its frequency. To allow for these variable parameters an area extending inland from the coast will require particular consideration.

2.5 *NAVTEX considerations*

2.5.1 *Protection to NAVTEX receivers*

Annex I describes signal-to-interference and off-frequency rejection protection required for NAVTEX receivers, and provides an exemple of separation distances necessary to prevent interference to NAVTEX.

2.6 *Protection to ADF receivers from NAVTEX transmissions*

Because of the relatively small NAVTEX emission bandwidth, ADF selectivity curves of Fig. 1 can be used to describe the off-frequency rejection protection required for ADF receivers from NAVTEX transmissions. Annex II provides an example of separation distances necessary to prevent interference to the aeronautical radionavigation service.

2.7 Propagation of NAVTEX or aeronautical radiobeacon signals by sky wave could cause interference to either service. For that reason, aeronautical radiobeacon stations operating on or near 518 kHz in Regions 2 and 3 and NAVTEX stations operating on 518 kHz should take necessary precautions such as using the minimum power necessary to enable the coverage of the service area. This would reduce the risk of interference to other stations due to sky-wave propagation especially after dusk.

3. Examples of planning calculations for ground-wave propagation

3.1 For the examples of calculations given below the following assumptions are used:

3.1.1 *General*

Frequency:	500 kHz
Propagation conditions:	CCIR curve (see Recommendation 368-3) (Kyoto, 1978), Fig. 3 ($\sigma = 10^{-2}$ S/m; $\varepsilon = 4$) (only ground wave propagation has been taken into account).

3.1.2 *Maritime mobile service*

Coast stations:	e.r.p. 500 W
Ship stations:	e.r.p. 50 W.

3.1.3 *Aeronautical radionavigation service*

Field strength at limits of coverage:	70 μV/m (36.9 dB (μV/m)) (see Radio Regulations No. 2857)
Protection ratio:	15 dB
ADF receiver selectivity:	Convention on International Civil Aviation, Annex 10, Volume I, Att. B to Part II, § 3 (see Fig. 1, curve A).

3.2 The curves in Fig. 2 represent the minimum frequency separation between a station in the maritime mobile service and a station in the aeronautical radionavigation service as a function of the geographical separation between these stations.

The various curves refer to different service ranges of the aeronautical radio beacon.

If the coast station lies within the operational range of the aeronautical beacon, the minimum frequency separation is a function of the difference in field strength of each service at the location of the coast station. If the coast station lies outside the operational range of the aeronautical beacon then the frequency separation is determined by the difference in field strength of each service at the limit of the coverage of the aeronautical beacon.

The maximum frequency separation is required when the operational range of the aeronautical radiobeacon is equal to the geographical separation of the two stations involved. This frequency separation is 6.4 kHz in the case of a coast station with an e.r.p. of 500 W. It can also be concluded that with a distance of 650-700 km between the two stations the minimum frequency separation is 0 kHz.

Note 1. – For frequencies lower than 500 kHz this distance will increase; for a frequency of 400 kHz this distance is about 950 km.

Note 2. – For sea-path propagation conditions ($\sigma = 5$ S/m; $\varepsilon = 80$) the minimum distance in the co-frequency case is 1400 km (at 500 kHz).

3.3 Figure 3 shows how the minimum frequency separation is affected by the power of the coast station transmitter in the case of the aeronautical beacon operational range of 75 km.

3.4 Figure 4 shows the effect on sharing possibilities of different selectivity curves for the ADF receivers.

Details of the selectivity curves used are given in Fig. 1.

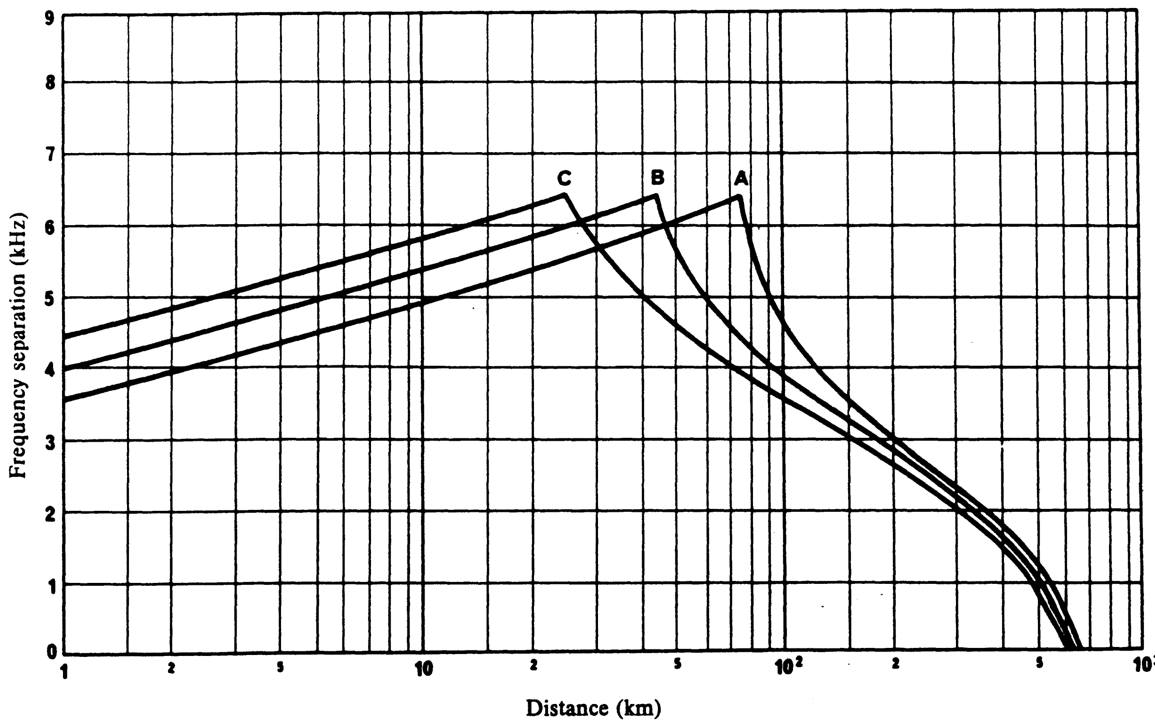

FIGURE 2 – *Minimum frequency separation between transmitters in the maritime mobile service and the aeronautical radionavigation service versus interference distance*

Curves **A**:	– coast station:	500 W e.r.p.
	– aeronautical beacon:	range 75 km (40 NM)
B:	– coast station:	500 W e.r.p.
	– aeronautical beacon:	range 45 km (25 NM)
C:	– coast station:	500 W e.r.p.
	– aeronautical beacon:	range 25 km (15 NM)

4. **Example of planning calculations for the more general case** (see Note)

Examples of planning calculations for the more general case are contained in Annexes I and II.

Note. – Takes into account propagation by ground wave, sky wave and the case when the receiving antenna is located well above the surface of the Earth.

5. Test results

Tests [EELAB, 1983] were performed in Region 2 between a temporarily installed 100 W, 1020 Hz A2A aeronautical radiobeacon on 522 kHz and a 1 kW NAVTEX station (20 W e.r.p.) at a distance of 35 km, on 518 kHz. Because of the radiobeacon antenna characteristics, the NAVTEX transmitting facility was near the edge of the radiobeacon service area. Results indicated that a NAVTEX receiver installed 15 m from the radiobeacon (unwanted to wanted signal strength 60 dB) showed no reception error, while an ADF installed on a helicopter showed interference (indicator deflection) when within 2.2-2.5 NM (4-4.6 km) of the NAVTEX station.

6. Conclusions

6.1 Coexistence of the aeronautical radionavigation service and the maritime mobile service is possible when account is taken of protection requirements, e.r.p. and propagation loss for individual cases.

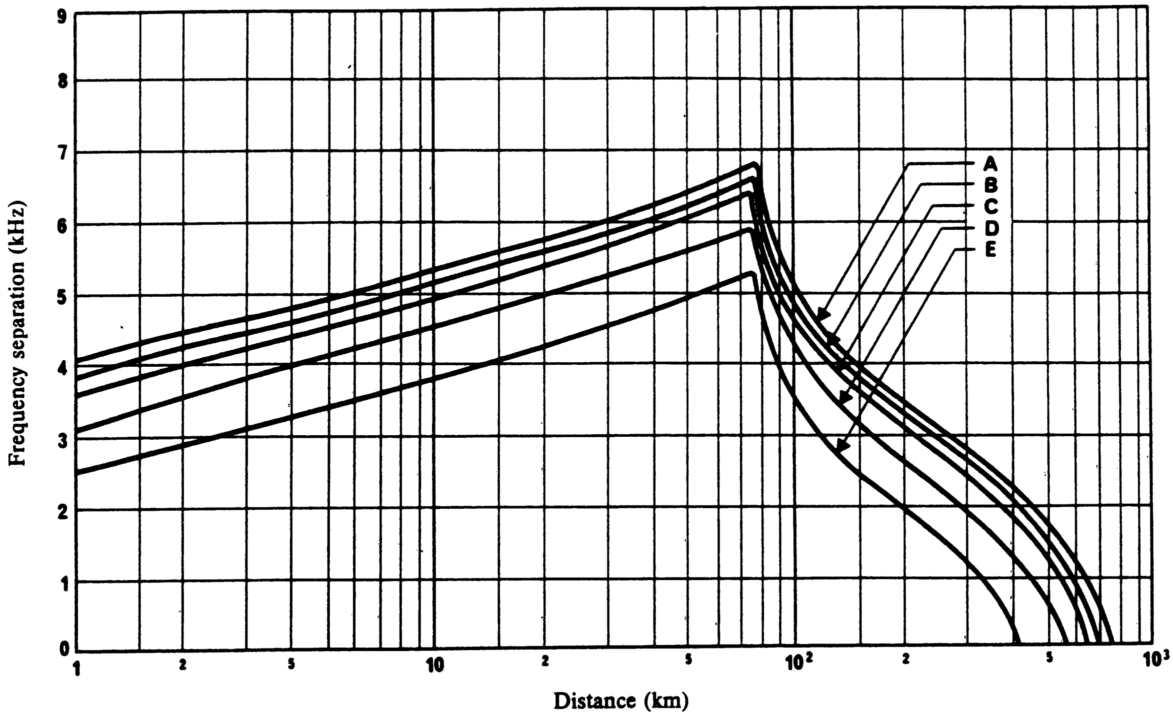

FIGURE 3 – *Minimum frequency separation between transmitters in the maritime mobile service and the aeronautical radionavigation service versus interference distance*

Curves **A**: – coast station: 2 kW e.r.p.
– aeronautical beacon: range 75 km
B: – coast station: 1 kW e.r.p.
– aeronautical beacon: range 75 km
C: – coast station: 0.5 kW e.r.p.
– aeronautical beacon: range 75 km
D: – coast station: 100 W e.r.p.
– aeronautical beacon: range 75 km
E: – coast station: 10 W e.r.p.
– aeronautical beacon: range 75 km

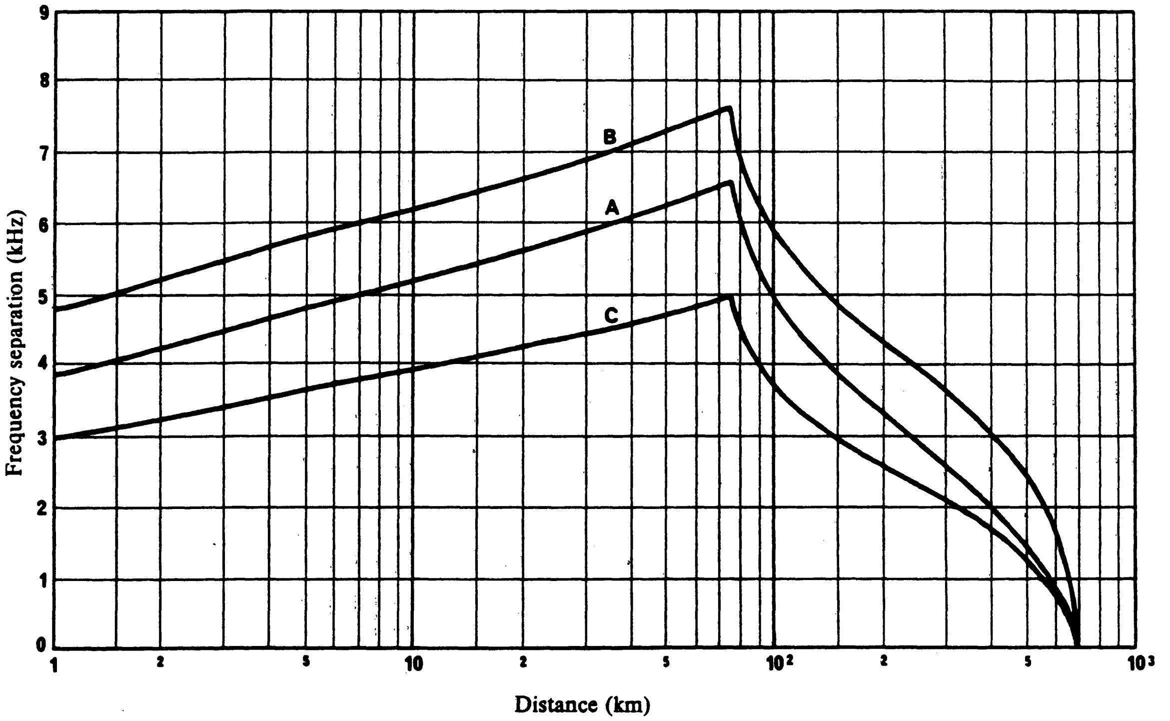

FIGURE 4 – *Minimum frequency separation between transmitters in the maritime mobile service and the aeronautical radionavigation service versus interference distance*

All curves: – coast station: 1 kW e.r.p.
– aeronautical beacon: range 75 km

Curves **A**: RF selectivity ADF Receiver (see curve A in Fig. 1)
B: RF selectivity ADF Receiver (see curve B in Fig. 1)
C: RF selectivity ADF Receiver (see curve C in Fig. 1)

6.2 Before a frequency could be assigned to either an aeronautical radiobeacon or a coast station, a full assessment of the interference potential would need to be made taking into account the following:

– the e.r.p. of the coast station, the highest possible ship station e.r.p. and the aeronautical radiobeacon e.r.p.;
– the protection requirements of each service;
– the assessed propagation loss between the stations of the two services, taking into account a mixed land and sea propagation path in the case of a ship station.

6.3 Since sky-wave propagation of signals by either service may cause interference to both services, stations should take necessary precautions to reduce the potential of such interference.

REFERENCES

EELAB [1983] Project L2530. US Coast Guard Electronics Engineering Center, Alexandria, VA, USA.

ANNEX I

PROTECTION TO NAVTEX RECEIVERS FROM RADIOBEACON TRANSMISSIONS

1. Protection criteria

1.1 *NAVTEX selectivity and sensitivity*

The assumed NAVTEX receiver selectivity is as follows:

± 150 Hz	−3 dB
± 500 Hz	−40 dB
± 1000 Hz	−60 dB

With consideration of minimum atmospheric noise levels, the minimum field strength in which a NAVTEX receiving installation can be expected to work is 18 μV/m (25 dB(μV/m)).

The required co-channel wanted signal to unwanted signal protection ratio is assumed to be 1 dB for the purpose of this example (this value needs further study (see Note).

Note. – The Regional Administrative Radio Conference for the Maritime Mobile Service, and the Aeronautical Radionavigation Service in certain parts of the MF band in Region 1 (Geneva, 1985) established the co-channel wanted signal to unwanted signal protection ratio to be 8 dB.

1.2 Aeronautical radiobeacon transmitter characteristics are as described in § 3.1.3; the modulation characteristics taken into account were:

modulation type:	A2A,
modulation tone:	1020 Hz,
modulation depth:	70%.

1.3 Using the data described above, the off-frequency rejection characteristics for a NAVTEX receiver were calculated and are presented in Fig. 5.

2. Example of separation distance calculations

As an exemple, separation distances required between an aeronautical radiobeacon and a NAVTEX coverage area can be calculated using the criteria of § 1, using Recommendation 435 and the ground-wave propagation curves of Recommendation 368. The following is a sample calculation of necessary protection criteria, assuming an inland radiobeacon and a NAVTEX facility near the coast. Actual protection required will depend upon such factors as radiobeacon transmitted power, earth conductivity and permittivity between the beacon and the NAVTEX service area, actual radiobeacon modulation, propagation mode (see § 4.3), and the atmospheric noise values for the NAVTEX service area:

– output power of NDB (P_{NDB}): 1 kW;
– antenna efficiency: 30%;
– beacon field strength at edge of service range: 70 μV/m (36.9 dB(μV/m));
– ground-wave propagation:
  – wet ground (conductivity = 0.01 S/m, relative permittivity = 30) and
  – medium dry ground (conductivity = 0.001 S/m, relative permittivity = 15);
– NAVTEX sensitivity: 18 μV/m (minimum atmospheric noise) (25 dB(μV/m)).

3. Procedure used

Step 1: Determine the minimum distance between the aeronautical radiobeacon and the edge of the service area of the NAVTEX receiver using a field strength (see ground-wave propagation curves of Recommendation 368):

$$E = 20 \log (18\ \mu V/m) - 1\ dB - 10 \log (P_{NDB}(kW) \times n) + A$$

where:

A : attenuation specified in Fig. 5

n : antenna efficiency

protection ratio = 1 dB

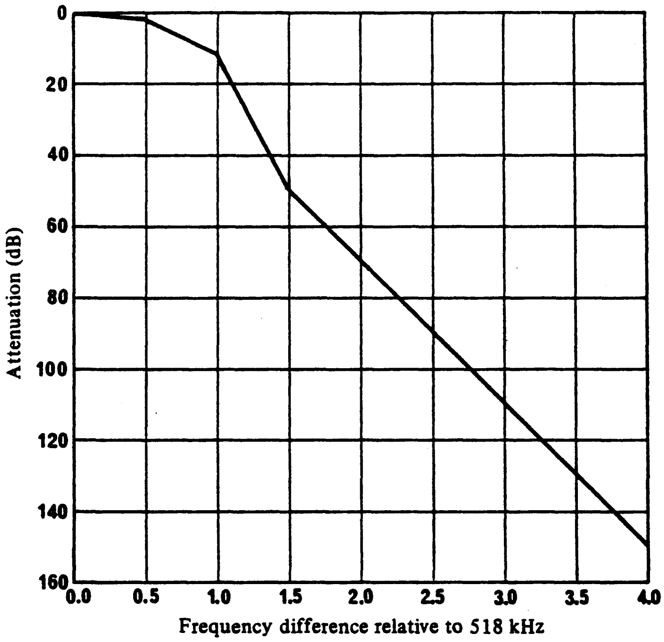

FIGURE 5 – *NAVTEX off-frequency rejection curve. F1B wanted; 1020 Hz, A2A unwanted*

TABLE I – *Distance between aeronautical radiobeacon and edge of the NAVTEX area*

Frequency difference relative to 518 kHz (kHz)	Minimum distance (km)	
	$\sigma = 10^{-2}$ S/m	$\sigma = 10^{-3}$ S/m
0.0	505	180
0.5	480	170
1.0	330	105
1.5	30	16
2.0	3	2.3

Step 2: Determine the minimum distance between the aeronautical radiobeacon and the edge of the service area of the NAVTEX receiver, considering the field strength due to sky-wave propagation (Recommendation 435). The aeronautical radiobeacon is assumed to be at coordinates (19°51'S/43°57' W) with direction of propagation at 210° magnetic north.

TABLE II – *Distance between aeronautical radiobeacon and edge of the NAVTEX service area at night (sky wave)*

Frequency difference relative to 518 kHz (kHz)	Minimum distance (km)
0.0	2420
0.5	1990
1.0	990
1.1	480
1.2	0

Step 3: **From Tables I and II, draw Table III representing the minimum distance between an aeronautical radiobeacon and the edge of the service area of the NAVTEX receiver, considering both mechanisms of propagation.**

TABLE III – ***Distance between aeronautical radiobeacon and edge of the NAVTEX area combining ground-wave and sky-wave propagation***

Frequency difference relative to 518 kHz (kHz)	Minimum distance (km)	
	$\sigma = 10^{-2}$ S/m	$\sigma = 10^{-3}$ S/m
0.0	2420	2420
0.5	1990	1990
1.0	990	990
1.1	480	480
1.5	30	12
2.0	2	1.8

Note. – This example is based upon the protection of the NAVTEX receiver in respect to its sensitivity. Other protection criteria, e.g. based upon the actual field strength within a specified service area, may also be applicable.

ANNEX II

PROTECTION TO ADF RECEIVERS FROM NAVTEX TRANSMISSIONS

1. Example of separation distance calculations

Separation distances required between a NAVTEX station operating at 518 kHz and the edge of an aeronautical radiobeacon service area can be calculated using the criteria of § 2.2 and 2.6 (see Fig. 1, curves A and B), using ground-wave propagation curves of Recommendation 368 and applying height gain in accordance with the CCIR GRWAVE program (for a transmitting antenna height of 1 m with airborne receiving antenna heights of 3 km and 6 km) and Recommendation 435 for sky-wave propagation. The following is a sample calculation of necessary protection criteria. Actual protection required will depend upon such factors as NAVTEX transmitted power and earth conductivity and permittivity between the NAVTEX station and the radiobeacon service area:

- output power of NAVTEX station (P_{NAV}): 1 kW;
- antenna efficiency: 30%;
- ground-wave propagation:
  - wet ground (conductivity = 0.01 S/m, relative permittivity = 30) and
  - medium dry ground (conductivity = 0.001 S/m relative permittivity = 15);
- beacon field strength at limit of coverage: 70 μV/m (36.9 dB(μV/m));
- ADF signal-to-interference protection ratio: 15 dB.

2. Calculation method

Step 1: Determine the range of the aeronautical radionavigation service using Fig. 3 and 5 of Recommendation 368 and applying height gain in accordance with the CCIR GRWAVE program for a field strength:

$$E = 20 \log 70 \ \mu\text{V/m} - 10 \log (P_{NDB}(\text{kW}) \times n),$$

which in this case takes the value of E = 42.1 dB(μV/m) where n is the antenna efficiency.

TABLE IV – *Range of aeronautical radiobeacon station*

Airborne receiving antenna heights (km)	Range (km)	
	$\sigma = 10^{-2}$ S/m	$\sigma = 10^{-3}$ S/m
0	330	100
3	330	180
6	390	235

Step 2: Determine the minimum distance between a NAVTEX transmitter and the edge of the service area of the aeronautical radiobeacon, using a field strength (see propagation curves of Recommendation 368) and applying height gain in accordance with the GRWAVE program:

$$E = 20 \log (70 \ \mu\text{V/m}) - 15 \text{ dB} - 10 \log (P_{NAV}(\text{kW}) \times n) + B$$

where:

B: attenuation specified in Fig. 1 (curve B)

n: antenna efficiency

protection ratio = 15 dB.

TABLE V – *Distance between NAVTEX station and edge of the aeronautical radiobeacon service area (ground wave)*

Frequency difference relative to 518 kHz (kHz)	Minimum distance (km)					
	$\sigma = 10^{-2}$ S/m			$\sigma = 10^{-3}$ S/m		
	Airborne receiving antenna heights (km)					
	0	3	6	0	3	6
0	550	550	630	200	330	410
1	530	530	615	190	315	395
2	460	460	530	155	265	335
3	260	260	310	75	135	180
4	120	120	135	35	55	70
5	42	42	48	15	30	44
6	8	–	–	4.6	–	–
7	1.4	–	–	1.3	–	–

Step 3: Determine the minimum distance between a NAVTEX transmitter and the edge of the service area of the aeronautical radiobeacon, considering the field strength due to sky-wave propagation (Recommendation 435) (see Step 2 of Annex I).

TABLE VI – *Distance between NAVTEX station and edge of the aeronautical radiobeacon service area (sky wave)*

Frequency difference relative to 518 kHz (kHz)	Minimum distance (km)
0	2000
1	1880
2	1300
3	200

Step 4: From Tables IV, V and VI, draw Table VII representing the required distance between an aeronautical radiobeacon and the NAVTEX transmitter, considering the three mechanisms of propagation.

TABLE VII – *Distance between NAVTEX and aeronautical radiobeacon stations combining sky wave and ground wave*

Frequency difference relative to 518 kHz (kHz)	Minimum distance (km)					
	$\sigma = 10^{-2}$ S/m			$\sigma = 10^{-3}$ S/m		
	Airborne receiving antenna heights (km)					
	0	3	6	0	3	6
0	2330	2330	2390	2100	2180	2235
1	2210	2210	2270	1980	2060	2115
2	1630	1690	1690	1400	1480	1535
3	530	530	590	300	380	435
4	450	450	465	135	235	305
5	372	372	378	115	210	279
6	338	–	–	104.6	–	–
7	331.4	–	–	101.3	–	–

REPORT 911

FREQUENCY SHARING BETWEEN SERVICES IN THE BAND 4 TO 30 MHz

(Question 56/8)

(1982)

1. Introduction

1.1 The World Administrative Radio Conference (Geneva, 1979) allocated several bands between 4 to 30 MHz on a shared basis to various services including the mobile services. At the Study Group 8 Interim Meeting, 26 November-19 December 1980, Question 56/8 was adopted.

1.2 This Report responds to that question by identifying technical parameters and operational considerations which should be taken into account to permit satisfactory frequency sharing between the fixed and mobile services in the frequency bands between 4 to 30 MHz.

2. Service requirements

2.1 The operational constraints for a particular sharing situation are related to the specific fixed mobile requirements involved. In the band 4 to 30 MHz, the following services have been allocated by the WARC-79 Table of Frequency allocations (Article 8) on a shared basis:

2.1.1 Fixed

2.1.2 Aeronautical mobile (OR)

2.1.3 Land mobile

2.1.4 Maritime mobile