

## RECOMMENDATION ITU-R F.1335\*

**TECHNICAL AND OPERATIONAL CONSIDERATIONS IN THE PHASED TRANSITIONAL APPROACH FOR BANDS SHARED BETWEEN THE MOBILE-SATELLITE SERVICE AND THE FIXED SERVICE AT 2 GHz\*\***

(Question ITU-R 208/9)

(1997)

The ITU Radiocommunication Assembly,

*considering*

- a) that the mobile-satellite service (MSS) (Earth-to-space) and the fixed service (FS) are allocated frequencies on a co-primary basis in the band 1 980-2 010 MHz in all Regions and in the band 2 010-2 025 MHz in Region 2;
- b) that the MSS (space-to-Earth) and the FS are allocated frequencies on a co-primary basis in the band 2 170-2 200 MHz in all Regions and in the band 2 160-2 170 MHz in Region 2;
- c) that these bands are widely used by the FS in many countries;
- d) that for many developing countries, the use of the 2 GHz band offers a substantial advantage for their radiocommunication networks and that it may not be attractive to transfer these systems to higher frequency bands because of the economic consequences that this would entail;
- e) that Resolution 716 (WRC-95) concerning the use of the 2 GHz band by the FS and MSS and associated transition arrangements, encouraged administrations where practicable to draw up plans for the gradual transfer of the frequency assignments to their FS stations in the shared 2 GHz MSS bands to non- overlapping bands, giving priority to the transfer of their frequency assignments in the Earth-to-space band 1 980-2 010 MHz in all Regions and 2 010-2 025 MHz in Region 2, considering the technical, operational and economic aspects;
- f) that the ITU-R has developed a new channel arrangement in Recommendation ITU-R F.1098 for the FS in the 2 GHz band which will facilitate the introduction of 2 GHz fixed systems in bands not overlapping the 2 GHz MSS band;
- g) that Resolution 716 (WRC-95) requests ITU-R to develop planning tools necessary to assist those administrations considering re-planning of their terrestrial networks to accommodate the MSS in the 2 GHz bands,

*recommends*

- 1** that administrations may take into account the material in the Annexes 1 to 4 when considering transitional arrangements for the MSS and FS at 2 GHz.

\* This Recommendation was developed jointly by Radiocommunication Study Groups 8 and 9, and any further revision should also be undertaken jointly. This Recommendation should be brought to the attention of Radiocommunication Bureau.

\*\* In accordance with Resolution 716 (WRC-95) of the World Radiocommunication Conference (Geneva, 1995), the frequency bands dealt with in this Recommendation are mainly in the bands 1 980-2 010 MHz (worldwide) and 2 010-2 025 MHz (Region 2) allocated to the MSS (Earth-to-space) and the bands 2 160-2 170 MHz (Region 2) and 2 170-2 200 MHz (worldwide) allocated to the MSS (space-to-Earth).

## Technical and operational considerations in the phased transitional approach for bands shared between the MSS and the FS at 2 GHz

### 1 Introduction

An administration may choose to transition between services to facilitate the introduction of the MSS. In such cases, there is a need to determine the criteria under which it is deemed that interference will be caused or received for a specific MSS system implementation, and the subsequent action or rules. This situation can arise either during a bilateral coordination, or when an administration has decided to implement one or more specific MSS systems. Tools which could be used for this determination, for a single MSS system are currently being addressed in Recommendation ITU-R M.1319. The impact on transition planning due to interference from multiple MSS systems is still under investigation by ITU-R.

The transition time-frame in this context is deemed to be between the time an administration makes spectrum available for MSS and the point at which it requires systems in the FS to move to spectrum outside that which is required for the implementation of the MSS system.

Two aspects are dealt with in this Annex:

- the continued operation of fixed systems within the spectrum identified for MSS implementation for a reasonable period of time; and
- the continued operation of the FS systems in the 2 GHz range beyond this transition period, including the necessary planning and coordination tools to move the system, or a portion of the system, to spectrum outside that which is required for MSS implementation. (See Resolution 716 (WRC-95) *Requests* 1.2.)

### 2 Co-primary MSS allocations at 2 GHz

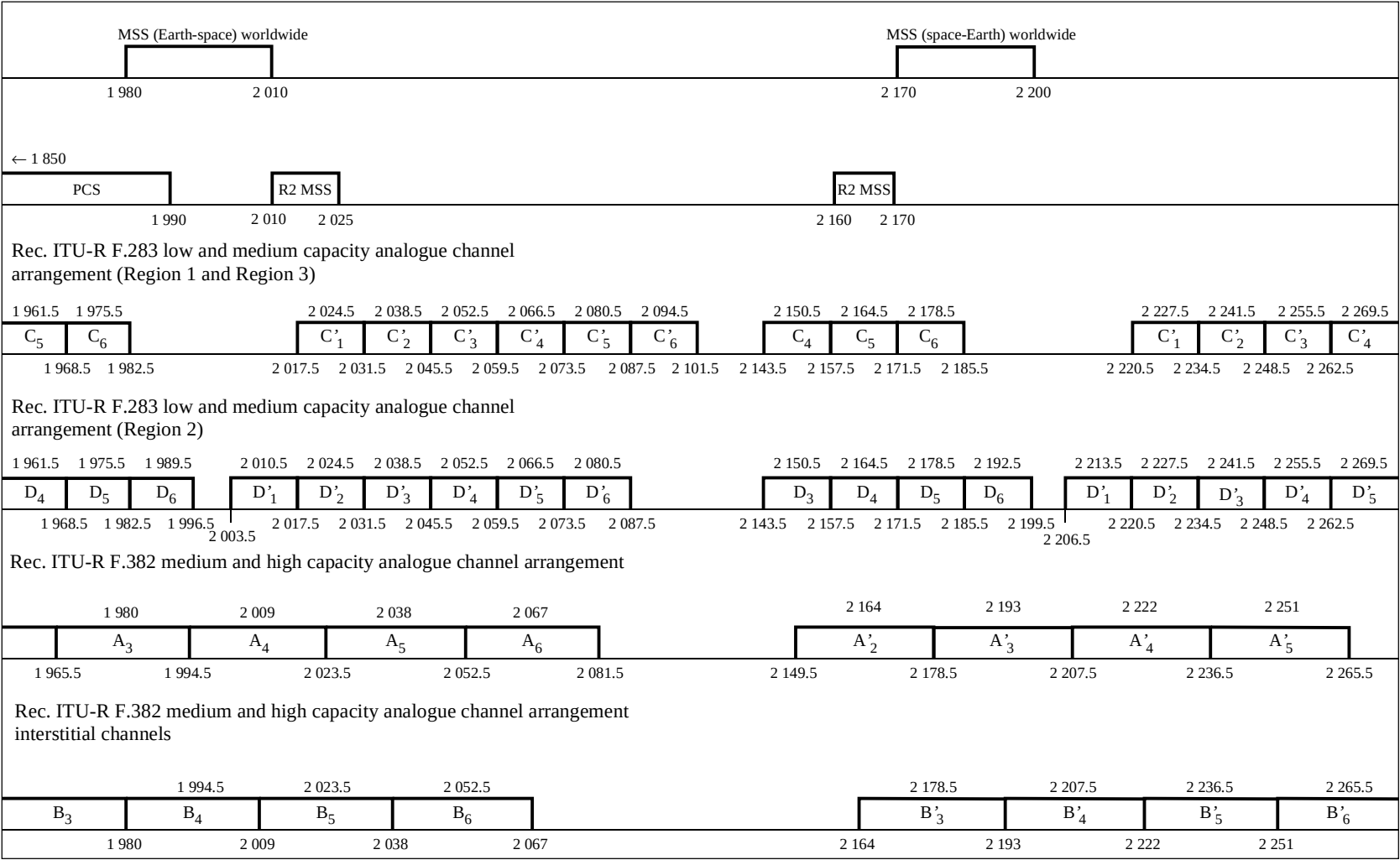
Presently, the bands 1 980-2 010 MHz and 2 170-2 200 MHz are allocated for MSSs on a worldwide basis co-primary with the FS and mobile service. In Region 2 the band 2 160-2 170 MHz is also a co-primary allocation. As a result of WRC-95, the band 2 010-2 025 MHz was allocated for MSS on a co-primary basis with the FS and mobile service in Region 2.

### 3 Background

There are two principal radio-frequency channel arrangements used by the existing fixed systems, Recommendations ITU-R F.283 and ITU-R F.382. Recommendation ITU-R F.283 provides the channel arrangements for the two sub-bands 1 900-2 100 MHz and 2 100-2 300 MHz with six paired channels in each sub-band, each with a bandwidth of 14 MHz. Recommendation ITU-R F.382 provides channel arrangements for the band 1 900-2 300 MHz with six paired channels, each with a bandwidth of 29 MHz, using two 29 MHz channel arrangements overlaid at a 14.5 MHz offset. These arrangements and their relationship with the current MSS allocations are illustrated in Fig. 1.

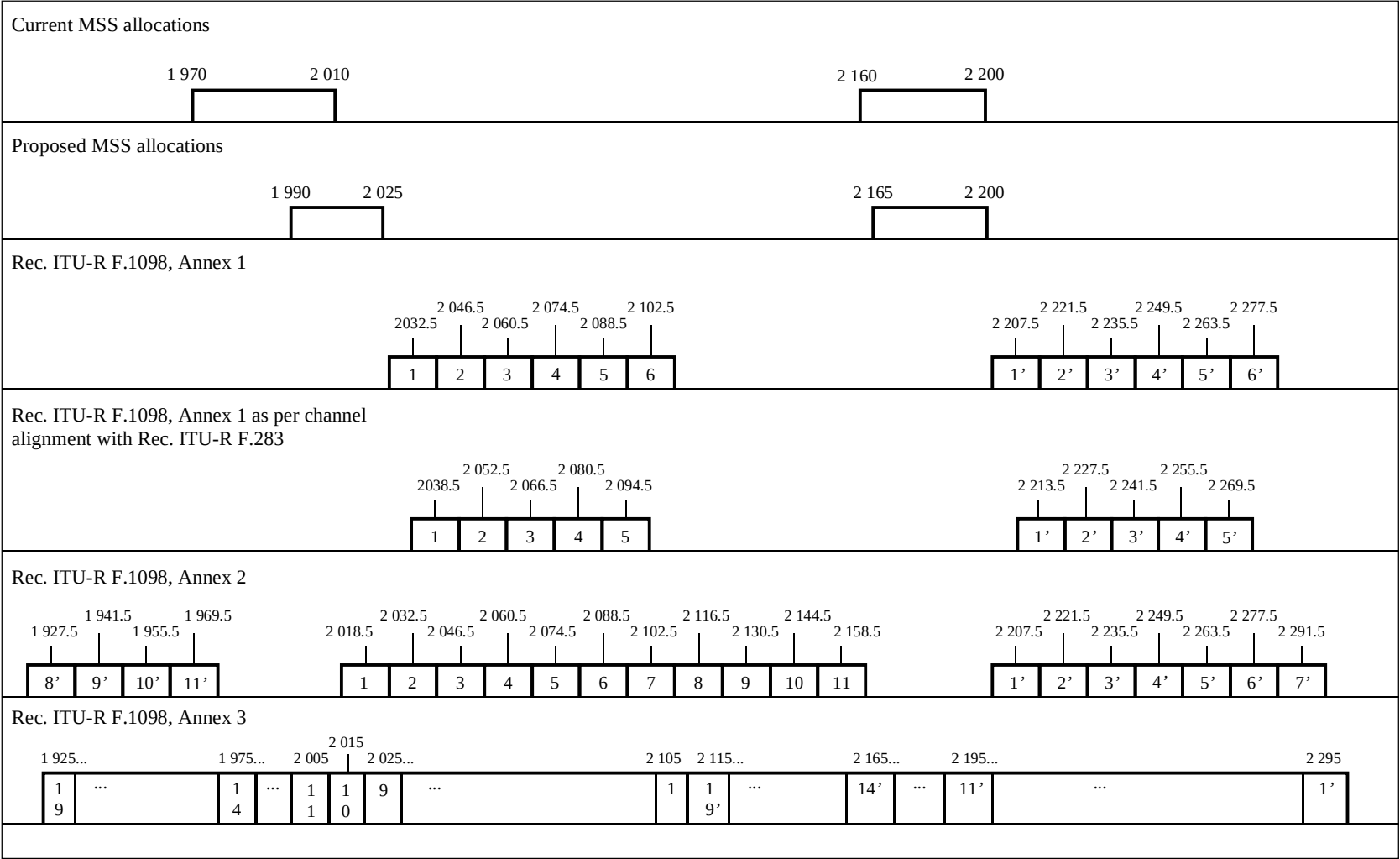
Recommendation ITU-R F.1098, developed in response to Resolution 113 (WRC-92) as a result of the World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum, Malaga-Torremolinos, 1992 (WARC-92) allocations, provides for three channel arrangements for new fixed systems in the band 1 900-2 300 MHz. It focuses on the “core” bands 2 025-2 110 MHz and 2 200-2 290 MHz wherein the FS, mobile and space operations, space research, earth exploration-satellite services (MS, SOS, SRS, EESS) share co-primary allocation space. These channel arrangement descriptions are illustrated in Fig. 2.

FIGURE 1  
Recommendations ITU-R F.283 and ITU-R F.382 channel arrangements



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FIGURE 2  
Recommendation ITU-R F.1098 channel arrangements



Annex 1 to Recommendation ITU-R F.1098 describes two channel arrangements which lie entirely within the core bands for up to six go and six return channels with a carrier spacing of 14 MHz. An alternate description provides for up to five go and return channel pairs where the centre frequencies align with the channels given in Recommendation ITU-R F.283.

Annex 2 to Recommendation ITU-R F.1098 describes a channel arrangement for the core bands as well as an extended channel arrangement for up to eleven “go” and “return” channel pairs with a carrier spacing of 14 MHz. The channel arrangement avoids the existing worldwide MSS allocation between 1 980-2 010 MHz and 2 170-2 200 MHz.

Annex 3 to Recommendation ITU-R F.1098 describes a channel arrangement for the core bands as well as an extended channel arrangement for up to nineteen “go” and “return” channel pairs with a carrier spacing of 10 MHz. The channel arrangements are based on the 190 MHz transmitter-receiver duplex spacing of the current MSS allocation pairing.

Allowance is made in Annexes 2 and 3 to Recommendation ITU-R F.1098 for extended channel arrangements where adequate geographical and/or frequency separation would make sharing possible with MSS or future public land mobile telecommunication systems (FPLMTS).

#### 4 Impact of worldwide MSS allocations on the fixed systems' Recommendations ITU-R F.283 and ITU-R F.382 channel arrangements

In the Recommendation ITU-R F.283 channel arrangement, the guardband between transmitter/receiver (Tx/Rx) in each of the sub-bands is 35 MHz and 39 MHz in Recommendation ITU-R F.382. The present MSS worldwide allocation takes up 27.5 + 14.5 MHz of this 35 MHz guardband in Regions 1 and 3 and 7 + 0.5 MHz in Region 2.

The following is the impact of the MSS worldwide allocation on each of the Recommendations:

|                              |                      |                 |                 |
|------------------------------|----------------------|-----------------|-----------------|
| – Recommendation ITU-R F.283 | (Regions 1 and 3)    | 1 980-2 010 MHz | 2.5 MHz of C6   |
|                              | (Region 2)           | 1 980-2 010 MHz | 2.5 MHz of D5   |
|                              | (Region 2)           | 1 980-2 010 MHz | 14 MHz of D6    |
|                              | (Region 2)           | 1 980-2 010 MHz | 6.5 MHz of D1'  |
|                              | (Regions 1 and 3)    | 2 170-2 200 MHz | 1.5 MHz of C5   |
|                              | (Regions 1 and 3)    | 2 170-2 200 MHz | 14 MHz of C6    |
|                              | (Region 2)           | 2 170-2 200 MHz | 1.5 MHz of D4   |
|                              | (Region 2)           | 2 170-2 200 MHz | 14 MHz of D5    |
|                              | (Region 2)           | 2 170-2 200 MHz | 14 MHz of D6    |
| – Recommendation ITU-R F.382 | (Arrangement)        | 1 980-2 010 MHz | 14.5 MHz of A3  |
|                              | (Arrangement)        | 1 980-2 010 MHz | 15.5 MHz of A4  |
|                              | (Offset arrangement) | 1 980-2 010 MHz | 29 MHz of B4    |
|                              | (Offset arrangement) | 1 980-2 010 MHz | 1 MHz of B5     |
|                              | (Arrangement)        | 2 170-2 200 MHz | 8.5 MHz of A2'  |
|                              | (Arrangement)        | 2 170-2 200 MHz | 21.5 MHz of A3' |
|                              | (Offset arrangement) | 2 170-2 200 MHz | 23 MHz of B3'   |
|                              | (Offset arrangement) | 2 170-2 200 MHz | 7 MHz of B4'    |

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## 5 Impact of Region 2 MSS allocations on the fixed systems' Recommendations ITU-R F.283 and ITU-R F.382 channel arrangements

The following is the impact of the MSS Region 2 allocation on each of the Recommendations:

|                              |                      |                 |                |
|------------------------------|----------------------|-----------------|----------------|
| – Recommendation ITU-R F.283 | (Regions 1 and 3)    | 2 010-2 025 MHz | 7.5 MHz of C1' |
|                              | (Region 2)           | 2 010-2 025 MHz | 7.5 MHz of D1' |
|                              | (Region 2)           | 2 010-2 025 MHz | 7.5 MHz of D2' |
|                              | (Regions 1 and 3)    | 2 160-2 170 MHz | 10 MHz of C5   |
|                              | (Region 2)           | 2 160-2 170 MHz | 10 MHz of D4   |
| – Recommendation ITU-R F.382 | (Arrangement)        | 2 010-2 025 MHz | 13.5 MHz of A4 |
|                              | (Arrangement)        | 2 010-2 025 MHz | 1.5 MHz of A5  |
|                              | (Offset arrangement) | 2 010-2 025 MHz | 15 MHz of B5   |
|                              | (Arrangement)        | 2 160-2 170 MHz | 10 MHz of A2'  |
|                              | (Offset arrangement) | 2 160-2 170 MHz | 6 MHz of B3'   |

## 6 Impact on Recommendation ITU-R F.1098

The current MSS worldwide allocation affects Recommendation ITU-R F.1098 as follows:

- Annex 1 Not affected
- Annex 2 0.5 MHz go and return channel 11
- Annex 3 10 MHz of go and return channel 11  
10 MHz of go and return channel 12  
10 MHz of go and return channel 13  
10 MHz of go and return channel 14

The current MSS Region 2 allocation affects Recommendation ITU-R F.1098 as follows:

- Annex 1 Not affected
- Annex 2 13.5 MHz of channel 1  
5.5 MHz of channel 11
- Annex 3 10 MHz of channel 10  
5 MHz of channel 9  
10 MHz of channel 14

## 7 Operational dates for worldwide and Region 2 MSS allocations in the 2 GHz band

Usage of the worldwide MSS allocation bands 1 980-2 010 MHz and 2 170-2 200 MHz shall not commence before 1 January 2000 (see Radio Regulations (RR) No. S5.389A).

Usage of the worldwide MSS allocation band 1 980-1 990 MHz in Region 2 and of Region 2 MSS bands 2 010-2 025 MHz and 2 160-2 170 MHz shall not commence before 1 January 2005 (see RR No. S5.389A and RR No. S5.389C) with the exception that in Canada and the United States of America usage of the latter bands by the MSS shall not commence before 1 January 2000 (see RR No. S5.389D).

## 8 Transition principles

When an administration decides to implement MSS, the following principles could be observed during the transition period.

To ease implementing MSS, the universe of FS's could be frozen:

- no expansion of existing fixed networks in bands that overlap MSS bands; and
- no new deployment of networks of existing fixed systems.

When MSS is introduced initially into FS bands, every effort should be made to coordinate and share spectrum between existing FS and new MSS service. These coordinating efforts should take into consideration that:

- transition be considered where interference criteria predicts unacceptable interference to incumbent fixed networks or links or into MSS systems;
- transition be prioritized in MSS Earth-to-space bands, given the difficulties of sharing of FS systems with MSS uplinks (see Resolution 716 (WRC-95) *resolves* 4.3);
- in the long term as MSS traffic increases, total relocation may be desirable.

Given that existing FS networks will be transitioned out of spectrum identified for MSS implementation, alternative spectrum (and/or alternative non-radio technology) could be identified to accommodate re-located existing fixed systems:

- alternative spectrum should be bands that do not overlap spectrum identified for MSS (e.g. Recommendation ITU-R F.1098 or in higher frequency FS bands);
- expansion of existing FSs and new deployment of existing FSs should be implemented in alternative spectrum.

Transition of existing fixed systems can occur over a reasonable time period, balancing the interests of existing FS operators and new MSS operators.

- when existing licences expire or when equipment is amortized;
- after a reasonable period, fixed systems could continue to operate in spectrum required for MSS implementation on a no interference no protection basis.

When a point has been reached when the FS systems are required to move outside the spectrum required to implement MSS, the usual planning tools for system implementation can be used (Note 1).

NOTE 1 – For example, fixed systems can be accommodated in the Recommendation ITU-R F.1098 channel arrangement or in channel arrangements in higher bands as indicated in Recommendation ITU-R F.746.

Retuning to channels within the same channel arrangement or moving to new channels within the same frequency range under new channel arrangements which lie outside the spectrum required for MSS implementation provides the benefit of retaining most of the existing infrastructure. This is particularly important for longer links which would be more difficult to achieve in higher frequency ranges.

## 9 Additional information concerning the transitional arrangements

Annex 2 gives an overview concerning frequency sharing between the MSS and the FS in the 2 GHz range.

Annex 3 offers some techniques for revisiting existing frequency division multiplex-frequency modulation (FDM-FM) systems to improve performance in the presence of interference from MSS and to take advantage of additional system capacity where it is available.

Annex 4 describes an approach for evaluating the impact of replanning existing FS systems in order to avoid overlap with the spectrum identified for MSS. This could be considered in conjunction with current existing Recommendations dealing with coordination methodologies such as Recommendation ITU-R F.1095 dealing with a procedure for determining coordination area between radio-relay stations of the FS.

## Frequency sharing between the MSS and the FS in the 2 GHz range

### 1 FS shared with MSS space-to-Earth allocations

Recommendations ITU-R M.1141 and ITU-R M.1142 give coordination threshold levels between non-GSO (geostationary satellite orbit) MSS (space-to-Earth) and GSO MSS (space-to-Earth) on one hand and FS systems on the other hand sharing the same frequency bands in the 1-3 GHz range, respectively.

Recommendation ITU-R M.1143 Annex 2 and Annex 3 gives a system specific methodology for coordination of non-GSO MSS space stations (space-to-Earth) with the FS sharing the same frequency bands.

In addition, ITU-R developed Recommendation ITU-R M.1319 for considering, in detailed coordination, the impact of MSS satellite interference to 2 GHz line-of-sight FS systems. This Recommendation details the basis for a methodology to be used in order to compute the radio-frequency  $C/(N+I)$  statistics of FS systems, taking into account MSS interfering carrier,  $I$ , and wanted FS carrier,  $C$ , levels. The wanted FS carrier levels are estimated taking into account parameters on relevant FS station, carrier, antenna path and intra-FS degradation together with predictions of typical multi-path levels according to the latest version of Recommendation ITU-R P.530-6 (Geneva, 1995) or alternative propagation models as appropriate. The MSS interfering levels are estimated taking into account MSS constellation orbital parameters, MSS spot beam carrier and antenna parameters and if needed MSS spot beam traffic loading and frequency plans.

The  $C/(N+I)$  statistics can be compared with applicable ITU-R Recommendations for performance of digital and analogue FS systems in order to assess, for example, if these ITU-R performance objectives are still respected for a given FS system subject to interference from the given MSS system.

The ITU-R is studying the methodology to assess the interference from mobile earth stations to FS systems. This applies Recommendations ITU-R P.452 and ITU-R P.617 propagation models as appropriate.

#### 1.1 Effects on analogue FS systems for telephony

Analogue FS systems for telephony in the 1-3 GHz range are generally used for low to medium capacity of 960 channels or less. There are two approaches to consider the effect of channel capacity on interference from MSS space stations.

##### 1.1.1 First approach

In the first approach, it is assumed that at any channel capacity, the radio-relay route is so designed that the overall noise performance will just meet the maximum allowable noise objectives of a real link specified in Recommendation ITU-R F.395 (Volume IX-1 (Düsseldorf 1990)). In this case, the received power level at a receiving station for a system with lower capacity will be correspondingly low. Therefore, under this assumption, roughly speaking, the effect of MSS interference will be almost the same regardless of channel capacity.

However, even in this case, the energy dispersion effect of interference through the FM demodulation process is greater at a lower capacity (see Annex 1 to Recommendation ITU-R F.1246). Therefore, the overall effect of MSS interference will be somewhat smaller at FS systems with lower capacity.

### 1.1.2 Second approach

The above first approach may not be realistic, because in general it is more difficult for a radio-relay system with higher capacity to select repeater stations which satisfy the required noise performance objectives specified in Recommendation ITU-R F.395.

As an extreme case, it is assumed that the received power level at a receiving station for a radio-relay system is constant regardless of channel capacity. In this case, the effect of interference is roughly proportional to the square of the highest baseband frequency. For example, the interference to a 600 channel system is 4 dB lower than that to a 960 channel system. To this should be added an additional amount due to energy dispersion effect referred to in the § 1.1.1.

### 1.1.3 Summary

The actual effect of MSS interference on analogue FS systems will depend on the parameters of each radio-relay system. But generally speaking, it will be somewhere between the first and second approaches, and the effect of MSS interference will be smaller at analogue FS systems with lower channel capacity.

## 1.2 Effects on digital FS systems

Digital FS systems in the 1-3 GHz range are generally used for low to medium capacity of 2 Mbit/s to 45 Mbit/s or less. Most of the comments in the preceding sections (except for that relating to the energy dispersion effect which is unique to analogue FS systems) also apply to digital FS systems. Therefore, the effect of MSS interference will generally be smaller at digital FS systems with lower capacity.

In the detailed coordination process, the impact of MSS systems on actual FS systems can be determined. This will allow for the identification of any need for transitional arrangements.

## 2 FS shared with MSS Earth-to-space allocations

Recommendations ITU-R M.1141 and ITU-R M.1142 deal with sharing in the frequency bands in the 1-3 GHz range between non-GSO and GSO space stations operating in the MSS and the FS, respectively.

Annex 2 to Recommendation ITU-R M.1141 states that sharing studies have shown that co-channel operation of the transmitting stations of the new FS and receivers of non-GSO MSS space stations in the 1 980-2 010 MHz band would not in general be possible.

Annex 2 to Recommendation ITU-R M.1142 states that co-channel sharing in the 1-3 GHz range is not feasible for GSO mobile-satellite space stations employing global beam antennas and impractical for GSO space stations employing spot beams (e.g., for subregional or domestic coverage or for multiple beam spacecraft providing global coverage) due to the low e.i.r.p. density restrictions, the requirement for future fixed stations to avoid the GSO by 5° and the impracticality in developing regulatory controls on the total number of FSs.

The above finding led to *resolves* 4.3 of Resolution 716 (WRC-95), in which administrations are encouraged, where practicable, to draw up plans for gradual transfer of the frequency assignments to their FS stations in the bands shared with the MSS in the 2 GHz range to non-overlapping bands, considering the technical, operational and economical aspects.

## Some transitional arrangements for analogue radio-relay systems for telephony in the 2 GHz range

### 1 Review of optimum frequency deviation

Preferred frequency deviation for analogue radio-relay systems for telephony using FDM-FM is given in Recommendation ITU-R F.404-2 (Volume IX-1 ((Düsseldorf, 1990))). The values applicable to capacities of 960 channels or less are reproduced in Table 1.

TABLE 1  
Frequency deviation without pre-emphasis

| Maximum number of channels | Root mean square (r.m.s.) deviation per channel <sup>(1)</sup> (kHz) |
|----------------------------|----------------------------------------------------------------------|
| 12                         | 35                                                                   |
| 24                         | 35                                                                   |
| 60                         | 50, 100, 200                                                         |
| 120                        | 50, 100, 200                                                         |
| 300                        | 200                                                                  |
| 600                        | 200                                                                  |
| 960                        | 200                                                                  |

<sup>(1)</sup> For 1 mW, 800 Hz tone at a point of zero reference level.

Where pre-emphasis is used, the pre-emphasis characteristic should preferably be such that the effective (r.m.s.) deviation due to the multichannel signal is the same with and without pre-emphasis.

The reason for choosing the preferred values in Table 1 is considered as follows.

The performance of FDM-FM analogue radio-relay system is usually measured using a continuous uniform spectrum signal (see Recommendation ITU-R F.399-3 (Volume IX-1 ((Düsseldorf, 1990))). Generally the baseband signal-to-noise ( $S/N$ ) ratio shows the characteristic of Fig. 3 as a function of r.m.s. frequency deviation per channel (loading level).

The solid curve in Fig. 3 corresponds to the  $S/N$  curve measured under normal propagation conditions. If the loading level is much lower than the nominal value,  $S/N$  is degraded mainly due to higher thermal noise. On the other hand, if the loading level is much higher than the nominal value,  $S/N$  is again degraded mainly due to higher intermodulation noise.  $S/N$  reaches a highest value at a certain loading level which is generally a couple of decibels below the nominal value. This is because it is necessary to take into account some degradation of thermal noise due to fading.

Therefore, ideally  $S/N$  reaches its maximum value at the nominal loading level under faded conditions (see the dashed curve). The preferred values of r.m.s. frequency deviation per channel as given in Table 1 were determined from this consideration.

However, the following factors may be pointed out:

- the preferred values of Table 1 were determined many years ago, when the intermodulation noise due to equipment imperfections was a serious constraint. More recent analogue radio-relay systems may show better performance with respect to intermodulation noise. This may allow increasing r.m.s. frequency deviation per channel;
- the preferred values of Table 1 were determined without taking account of interference from the MSS.