



Recommendation ITU-R F.758-6
(09/2015)

**System parameters and considerations in
the development of criteria for sharing
or compatibility between digital fixed
wireless systems in the fixed service
and systems in other services and
other sources of interference**

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RECOMMENDATION ITU-R F.758-6*

**System parameters and considerations in the development of criteria
for sharing or compatibility between digital fixed wireless systems
in the fixed service and systems in other services
and other sources of interference**

(Question ITU-R 252/5)

(1992-1997-2000-2003-2005-2012-2015)

Scope

This Recommendation contains principles for the development of sharing criteria of digital systems in the fixed service. Considerations are mainly given on how to properly design performance and availability degradations due to interference within the allowable objectives, as specified in Recommendation ITU-R F.1094, under the various interference environments. It also contains information on representative technical characteristics and typical system sharing parameters of digital fixed wireless systems in the fixed service for use in sharing studies above about 30 MHz. In cases where analyses indicate sharing issues, additional information on specific fixed systems deployed by administrations can be found in Report ITU-R F.2108.

Keywords

Fixed service, sharing criteria, compatibility

The ITU Radiocommunication Assembly,

considering

- a) that it is necessary to establish sharing criteria between the fixed service (FS) and other services in frequency bands where both services are allocated with equal rights;
- b) that sharing may be managed by determining allowable values of performance and availability degradations of fixed wireless systems (FWS) caused by interference from other radio services allocated in the same frequency bands as the FS with equal rights;
- c) that compatibility with systems of other services having allocation in the same band on a secondary basis, unwanted emissions from any other systems of services outside the band under consideration, falling into a band allocated to the fixed service on a primary basis, and emissions from sources other than radio services need also to be taken into account;
- d) that principles for apportioning the performance and availability degradation among the different elements of the FWS and between each interference source, need to be established;
- e) that the technical characteristics of each service need to be understood in order to derive interference criteria corresponding to the allowable degradation in performance and availability of the FWS;
- f) that performance and availability degradation may result from both long-term and short-term interference and hence both long-term and short-term interference criteria need to be established;

* This Recommendation should be brought to the attention of Radiocommunication Study Groups 4, 6 and 7.

g) that availability of a basic methodology for the development of sharing criteria for the FS is useful for other ITU-R Study Groups,

noting

a) that characteristics of digital and analogue fixed systems based on previous versions of the Recommendation are contained in Report ITU-R F.2108;

b) that Recommendation ITU-R F.1094 provides the overall apportionment principle of the performance and availability degradations to the FS due to interference from other services or sources,

recommends

1 that the development of sharing criteria and assessment of interference conditions between the FS and other services and other sources of interference should be considered in accordance with the principles described in Annex 1;

2 that the information provided in Annex 2 should be considered as guidance to the technical characteristics and typical system parameters of digital fixed wireless FS systems that need to be taken into account when developing criteria for sharing with other services;

3 that the system parameters in the tables in Annex 3 may be used as supplementary information for the bands for which Annex 2 does not provide typical parameters.

Annex 1

Basic considerations in the development of sharing criteria

1 Overall performance objective

One of the functions of a radiocommunication planner is to design and implement a transmission network which meets the performance objectives laid down by the ITU-T and ITU-R. It is important, therefore, that real systems can meet the appropriate design objectives, recognizing the increasing use of the radio spectrum. There are various ITU-R F-Series Recommendations that relate to the overall performance objective for various types of circuit.

1.1 Error performance and availability objectives

1.1.1 ITU-T and ITU-R Reference Recommendation

Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections are given in Recommendation ITU-R F.1668, *Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections*, based on Recommendations ITU-T G.826, ITU-T G.828 and ITU-T G.829. It is the only Recommendation defining error performance objectives for all real digital fixed wireless links.

NOTE 1 – The applicability of older Recommendations ITU-R F.634, ITU-R F.696 and ITU-R F.697 is limited to systems designed prior to the approval of Recommendation ITU-T G.826 (December 2002).

Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections are given in Recommendation ITU-R F.1703, based on Recommendation ITU-T G.827. It is the only Recommendation defining availability objectives for all real digital fixed wireless links.

NOTE 2 – The applicability of older Recommendations ITU-R F.695, ITU-R F.696 and ITU-R F.697 is limited to systems designed prior to the approval of Recommendation ITU-R F.1703 (January 2005).

Most new applications are for systems using a single or a small number of hops (for example, for cellular network backhaul or for connecting remote areas to metropolitan area networks). Nevertheless, the interference protection of each hop continues to be based on the Recommendations cited above.

1.1.2 Time basis for evaluation

1.1.2.1 General principles

Availability evaluation is made on a time basis of one year, as established by ITU-T (G.827) and is independent from the actual transport media.

Error performance evaluation is made on a time basis of one month, as established by ITU-T (G.826) and is independent from the actual transport media. In particular, since radio propagation is characterized by large variability depending on season and climate, the objectives are intended to be fulfilled in the worst month (which concept is clarified in Recommendation ITU-R P.581).

When necessary, for prediction purposes, conversion of annual statistics to worst-month statistics is addressed in Recommendation ITU-R P.841.

In case of radio connections affected by interference from any source, the overall error performance and availability evaluations include the additional effect of interference within the appropriate time basis above.

It should be noted that the concepts of “long-term” and “short-term” interference (see § 4.1 and 4.2 in this Annex 1) are not directly correlated with the “month” or “year” time basis. Both types of interference, depending on their time and level variability, may, in principle, affect the “error performance” (on month basis), but only interference longer than 10 consecutive seconds may affect the “availability” (on year basis) of FS systems.

The latter will normally only be seen in long-term interference, but in special cases may include short-term interference.

1.1.2.2 Practical applications

According to the principles described above, whenever a sharing or compatibility situation with FS systems arises, different studies are necessary for separately evaluating the impact of the interference on FS availability (on year basis) and FS error performance (on month basis).

However, in some practical cases, both studies are not necessary due to the expected physical situation of the wanted and unwanted paths.

In particular, when the interference into FS victim is constantly present (e.g. from a GSO space station), it is generally assumed that the acceptable level of interference should be sufficiently low for not affecting the FS system availability threshold, on a yearly basis. In this case, ensuring the suitable FS availability degradation, it is generally assumed that any related “error performance” degradation would be within the acceptable limits (in any month) and no specific study is required.

On the contrary, when the interference into the FS victim is relatively fast varying (e.g. from a non-GSO space station), it is generally assumed that, due to uncorrelated wanted and unwanted paths, the acceptable interference level may be higher, so that the “error performance” degradation would predominate over the possible “availability” degradation. In this case, the “error performance” degradation study should be carried out on the “worst month” basis (see example in Recommendations ITU-R F.1108 and ITU-R F.1495).

In principle, it is expected that, when the variability of the interference is slowing down (quasi static situations), there might be a speed threshold where both “availability” and “error performance” degradations might be equally impacted. In such cases, specific studies should be carried out for both cases with their appropriate time basis.

2 Sub-division of the performance and availability objectives

The previous section dealt with the overall performance objectives for digital reference connections. However, there are, in practice, a large number of potential sources of interference contributing to the degradation of performance of a fixed wireless system. In order to move towards a practical method for planning, the overall performance objectives need to be subdivided between individual sections of the overall hypothetical reference connections (HRX) and hypothetical reference path (HRP). Within a section, the performance objective is then apportioned between the various sources.

2.1 Apportionment of section error performance and availability objective

This is covered in Recommendation ITU-R F.1094, *Maximum allowable error performance and availability degradations to digital fixed wireless systems arising from radio interference from emissions and radiations from other sources*. The allowable performance objective is divided into an element of $X\%$ for the FS portion, $Y\%$ for frequency sharing on a primary basis, and $Z\%$ for all other sources of interference (it should be noted that $X\% + Y\% + Z\% = 100\%$) where X , Y , and Z are typically 89%, 10%, and 1%, respectively. There may be a further subdivision of the $X\%$ allowance to suit local requirements and this could be apportioned in such a way as to suit the grade of service (see § 4.1.3).

A particular point to note is that an interference source (say a transmitter Tx) may affect more than one hop of a system.

2.2 Apportionment of performance and availability degradation to different services

When establishing the sharing criteria with other co-primary services, it may be necessary to consider the apportionment of the error performance objective (EPO) and availability performance objectives (APO) to short-term and long-term interferences (see the introductory part in § 4). Then, the following points should be taken into consideration:

- a) For the band shared by the FS and one radio service on a primary basis, performance/availability degradation $Y1\%$ of the FS caused by the interference from other services should not exceed 10% of the objective in accordance with Recommendation ITU-R F.1094.
- b) After the establishment of the sharing criteria with the first co-primary service, performance/availability degradation $Y2\%$ of the FS caused by the interference from another co-primary service sharing the same band may be developed as follows:
 - multi-interference environment due to both services should carefully be examined, in particular the case leading to the allowance limit of $Y1\%$ and simultaneously receiving additional interference from the second co-primary service;
 - then the limit of $Y2$ could be derived from a typical interference model for the FS and the second co-primary service taking also into account potential effect of the first co-primary service in that model.

3 Characteristics of interference

It is necessary to have information available on interference levels arising from other services, which would degrade system performance by specific amounts. This would be facilitated if, with the assistance from other Study Groups, a table were compiled giving information on the characteristics of emissions.

Two categories of interference are worth considering:

- for sharing studies, the interference arising from services sharing the same band on a primary basis that is likely to be within the receiver (Rx) bandwidth from digital modulations, in either carrier wave or burst emissions. Reference can be made to existing text where available in ITU-R F-Series and SF-Series Recommendations (e.g. Recommendation ITU-R SF.766);
- for compatibility studies, emissions from systems other than those sharing the same band on a primary basis that could be numerous and diverse, produced either by continuous or pulse and/or burst emissions, and may be considered in a similar way to the spurious emissions. Such emissions could be either from systems/applications operating in the same band on a secondary basis as well as from unwanted emissions from systems operating in other bands.

Ultimately, another table could be prepared, again with the assistance of other Radiocommunication Study Groups, which compares levels of interference or Gaussian noise required to produce a specified degradation in the channel performance.

4 Considerations on allowable performance/availability degradations due to interference and related interference criteria

Methods for characterizing interference levels into terrestrial FWS include power flux-density (pfd), the power level at the input to the antenna or the power level at the receiver input. It is worth noting that all of these methods are in use in ITU-R F- and ITU-R SF-Series Recommendations.

In general, the received power due to an interferer is not constant, but it varies because of varying propagation conditions of the interfering path or because of motion of the interfering transmitter. The propagation conditions that are of greatest significance on interfering paths are ducting and tropo-scatter. Propagation conditions, including multi-path fading, rain fading, and diffraction fading, may also cause the received power of the desired signal to vary (system fade), which requires the system to have an adequate fade margin. The variations in the received power of the desired and interfering signals may, or may not, be correlated depending on the frequency band and the interference geometry.

To simplify the analysis of interference, separate consideration is given to short-term interference, which is the term used to describe the highest levels of interference power that occur for less than 1 per cent of the time, and to long-term interference, which addresses the remaining portion of the interference power distribution.

When the desired signal fades, the percentage of time for which a performance threshold is violated will increase slightly because of the interference power that is present when the signal fades near the threshold. In considerations of the interference under these conditions, the interference is referred to as long-term interference. Long-term interference degrades the error performance and availability of a system by reducing the fade margin that is available to protect the fixed service system against fading. In sharing and compatibility studies, long-term interference is usually characterized as the interference power that is exceeded by 20% of the time, at the victim receiver input. This is the power level that would be used in Tables 2, 3A and 3B in the following §§ 4.1.1 and 4.1.2. For the percentages of time applied to the protection criteria see § 1.1.2.

Short-term interference requires separate consideration because the interference power may be high enough to produce degradation even when the desired signal is unfaded. Such interference must occur rarely enough and in events of short duration for the interference to be acceptable. A short-term interference criterion is set based on the interference power necessary to cause a particular error performance defect (such as an errored second) when the desired signal is unfaded. This is the approach taken in RR Appendix 7, and Recommendations ITU-R SM.1448, ITU-R F.1494, ITU-R F.1495, ITU-R F.1606, ITU-R F.1669 and ITU-R SF.1650.

Because permissible error performance defects can only occur for percentages of time that are much smaller than 1% of the time if error performance objectives are to be met, short-term interference studies require knowledge of the interference power that is exceeded for percentages of time much less than 1 per cent. The interference criterion for a particular error performance defect is specified by the power level (relative to the receiver noise) and the percentage of time allocated for this defect.

In sharing and compatibility studies in the frequency bands where multipath fading is the dominant propagation impairment for FS receivers (mostly in frequency bands below about 15 GHz), the fadings on the desired and interfering paths are uncorrelated. Under these conditions, Recommendation ITU-R F.1108 introduced the Fractional Degradation in Performance (FDP) method, which shows that it is appropriate to use the average value of the interference power as the critical value for long-term interference power. However, in this calculation, the average power must be determined while excluding periods of time when the interference power levels exceed the limit used for the short-term interference criteria. (Recommendation ITU-R F.1108 gives a relevant example applied to NGSO.)

In frequency bands where rain is the dominant factor, the use of FDP in considerations of long-term interference is not appropriate for two reasons: 1) The distribution of the fading of the desired signal must be independent of the distribution of the received interference power so that their joint distribution density can be represented by the product of the individual distribution densities; 2) The percentage of time that a fade depth of the desired signal is exceeded must be decreased by a factor of 10 for a 10 dB increase in fade depth. This is the characteristic of multipath fading as noted in Recommendation ITU-R P.530. In these bands, it is considered sufficient to ensure that all degradation of error performance and availability requirements allocated to long-term interference are met using the level of the time-varying interference representing the 20% of time definition for long-term interference criterion, and that the interference power distribution meets the error performance degradation criteria developed for short-term interference. Interference power that is between the percentage of time defined for short-term criteria ($< 1\%$ of the time) and the time defined for the long-term criteria ($> 20\%$ of the time) could be evaluated on a case-by-case basis, but such considerations should take into account also the occurrence of interference power levels that are less than that expected for 20% of the time.

When continuously pulsed or burst interference emissions are considered, their impact on fixed service systems should be determined based on the coupling mechanism for the interference and not by the duty-cycle characteristics of the interfering signal. (E.g. a radar emission with less than 1% duty cycle should be evaluated both as a long-term and/or short-term interference, as appropriate.)

The number and values of the interference criteria necessary to protect a fixed wireless system will depend on the characteristics of the fixed wireless system and the interferer. In case of time varying interference, a single interference criterion may not be adequate; two or three values, corresponding to a long term (20% of time) and short terms ($< 1\%$ of time) have been specified in some Recommendations.

It should be noted that the events where error performance is degraded are events of very short duration because of the stringent requirements of error performance objectives.

The number of short-term interference criteria corresponds to the number of error performance criteria that are appropriate for the sharing scenario. The exact percentage of time associated with a short-term interference criterion is related to a performance objective for the system under consideration; more information on fulfilling short-term interference objectives can be found in Recommendations ITU-R F.1494, ITU-R F.1495 and ITU-R F.1606, all of which deal with protection criteria applicable to time-varying interference.

Table 1 lists the references relating to performance/availability objectives and sharing between the FS and other primary services concerning interference into the FS.

The error performance and availability objectives should be fulfilled independently whether they are resulting from long-term or short-term interference.

TABLE 1
**ITU-R Recommendations relating to frequency sharing between the FS
and other primary services**

Recommendation ITU-R	Title
F.1094	Maximum allowable error performance and availability degradations to digital fixed wireless systems arising from radio interference from emissions and radiations from other sources
F.1108	Determination of the criteria to protect fixed service receivers from the emissions of space stations operating in non-geostationary orbits in shared frequency bands
F.1334	Protection criteria for systems in the fixed service sharing the same frequency bands in the 1 to 3 GHz range with the land mobile service
F.1338	Threshold levels to determine the need to coordinate between particular systems in the broadcasting-satellite service (sound) in the geostationary-satellite orbit for space-to-Earth transmissions and the fixed service in the band 1 452-1 492 MHz
F.1494	Interference criteria to protect the fixed service from time varying aggregate interference from other services sharing the 10.7-12.75 GHz band on a co-primary basis
F.1495	Interference criteria to protect the fixed service from time varying aggregate interference from other radiocommunication services sharing the 17.7-19.3 GHz band on a co-primary basis
F.1565	Performance degradation due to interference from other services sharing the same frequency bands on a co-primary basis with real digital fixed wireless systems used in the international and national portions of a 27 500 km hypothetical reference path at or above the primary rate
F.1606	Interference criteria to protect fixed wireless systems from time varying aggregate interference produced by non-geostationary satellites operating in other services sharing the 37-40 GHz and 40.5-42.5 GHz bands on a co-primary basis
F.1668	Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections
F.1669	Interference criteria of fixed wireless systems operating in the 37-40 GHz and 40.5-42.5 GHz bands with respect to satellites in the geostationary orbit
F.1670	Protection of fixed wireless systems from terrestrial digital video and sound broadcasting systems in shared VHF and UHF bands
F.1703	Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

Recommendation ITU-R	Title
F.1706	Protection criteria for point-to-point fixed wireless systems sharing the same frequency band with nomadic wireless access systems in the 4 to 6 GHz range
SF.1006	Determination of the interference potential between earth stations of the fixed-satellite service and stations in the fixed service
SF.1650	The minimum distance from the baseline beyond which in-motion earth stations located on board vessels would not cause unacceptable interference to the terrestrial service in the bands 5 925-6 425 MHz and 14-14.5 GHz

4.1 Long-term interference

Recommendation ITU-R F.1094 lays the foundations for the apportionment of EPO and APO.

In this section, relations between the following two issues a) and b) are considered with the exclusion of short-term interference considerations:

- a) Degradation in the error performance (EP) or the availability performance (AP) resulting from interference from the co-primary service, which is clearly specified as 10% in Recommendation ITU-R F.1094 (and also in Recommendation ITU-R F.1565).
- b) Degradation in fade margin due to the interference, which is directly calculated from (I/N) value, as $10 \log ((N + I)/N) = 10 \log ((1 + (I/N)))$ (dB).

It should be noted that the I/N ratio is generally defined in terms of mean (root-mean-square (rms)) power of both noise and interference; however, when continuously pulsed/burst interference emissions are concerned, their peak-to-mean power ratio might play a significant role in defining the protection criteria.

When the peak-to-mean power ratio becomes very high and the fixed service receiver bandwidth becomes large, it may be necessary to take into account an I/N objective in terms of peak interference integrated over the whole victim bandwidth to correctly evaluate the fade margin degradation due to the interference. Background on high peak interference impact and protection criteria may be found in Recommendation ITU-R F.1097, for radar interference, and Recommendation ITU-R SM.1757, further detailed in Report ITU-R SM.2057, for UWB-SRR (ultra-wideband short-range radars) interference.

In the following sections, guidance is given only for the more usual cases where the mean (rms) interference power evaluation is appropriate.

4.1.1 Effect of fade margin reduction in bands where multipath is a dominant factor

In cases where the performance of digital systems is dominated by multipath fading (e.g. at frequencies below about 17 GHz), the introduction of an aggregate interference contribution that is 10 dB below the system noise floor causes a 10% increase in the time that the system carrier-to-noise plus interference ($C/(N + I)$) ratio is below a critical value. Any temporal characteristics of the exposure of the FS to interference will also need to be taken into account with respect to the error performance objectives in determining the degradation in performance.

Furthermore, it should be noted that many FWS employ space diversity reception in the bands where multipath is the dominant fade effect, and that the receiving power in systems using diversity is subject to more moderate distribution than Rayleigh fading. Therefore, such systems achieve the same performance as a non-diversity implementation, but with a much smaller fade margin. The same degradation in fade margin will more impact systems with diversity reception resulting in about two times EP degradation. Table 2 indicates these relations between them for three (I/N) values.

TABLE 2

Degradation in error performance due to multipath fading

Interference level relative to receiver thermal noise (dB)	Resultant degradation in fade margin (dB)	Resultant degradation in EP (Note 1)	
		Systems without space diversity	Systems with space diversity
–6	1	25%	50%
–10	0.5	10%	20%
–13	0.2	5%	10%

NOTE 1 – Multipath fading subject to Rayleigh distribution and the typical space diversity effect are considered. The numbers would be different for different fading distributions.

4.1.2 Effect of fade margin reduction in bands where rainfall is a dominant factor

In case of rainfall, the relation between:

- a) availability performance (AP) degradation due to the interference; and
- b) fade margin degradation due to the interference,

is not simple, since the distribution of rain attenuation varies depending on many parameters, e.g. radio frequency, rain zone, link length, specified APO, etc.

Using typical parameters and probabilistic distributions given in Recommendation ITU-R P.530, example calculation results are given in Tables 3A and 3B, each providing relations between the (I/N) value and resultant AP degradation for a link with a hop length of 6 km and 3 km, respectively. Interpretation of the figures in Tables 3A and 3B, for example, is that, if the nominal margin 42.9 dB is degraded by 1 dB (down to 41.9 dB), the link AP specified at an unavailability ratio of 0.001% in the absence of interference will increase to 0.001085% (8.5% increase) with interference.

General observation is that resultant degradation in AP is greater in systems having a smaller nominal fade margin. System designers should consider all the related parameters including propagation information when developing a sharing criterion in terms of (I/N) value.

It should be noted that the example calculations of the resultant degradations of AP and fade margin in Tables 3A and 3B are based on uncorrelated rain fade. If the effects of correlated rain fade are taken into account, the resultant numbers may become smaller values. An example of this effect can be found in Recommendation ITU-R F.1669.