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(11/2019)

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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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R F.758-7*

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)

(1992-1997-2000-2003-2005-2012-2015-2019)

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

Abbreviations

AP	Availability performance
APO	Availability performance objective
ATPC	Automatic transmit power control
BER	Bit error ratio
e.i.r.p.	equivalent isotropically radiated power
EP	Error performance
EPO	Error performance objective
FS	Fixed service
FSK	Frequency shift keying
FWS	Fixed wireless system
NF	Noise figure
PMP	Point-to-multipoint
PP	Point-to-point
QAM	Quadrature amplitude modulation
QPSK	Quaternary phase shift keying

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

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Related ITU Recommendations and Reports

Recommendation ITU-R F.634 Error performance objectives for real digital radio-relay links forming part of the high-grade portion of international digital connections at a bit rate below the primary rate within an integrated services digital network

Recommendation ITU-R F.695 Availability objectives for real digital radio-relay links forming part of a high-grade circuit within an integrated services digital network

Recommendation ITU-R F.696 Error performance and availability objectives for hypothetical reference digital sections forming part or all of the medium-grade portion of an ISDN connection at a bit rate below the primary rate utilizing digital radio-relay systems

Recommendation ITU-R F.697 Error performance and availability objectives for the local-grade portion at each end of an ISDN connection at a bit rate below the primary rate utilizing digital radio-relay systems

Recommendation ITU-R F.699 Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to 86 GHz

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

Recommendation ITU-R 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

Recommendation ITU-R F.1245 Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz

Recommendation ITU-R F.1336 Reference radiation patterns of omnidirectional, sectoral and other antennas for the fixed and mobile service for use in sharing studies in the frequency range from 400 MHz to about 70 GHz

Recommendation ITU-R 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

Recommendation ITU-R 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

Recommendation ITU-R F.1565 Performance degradation due to interference from other services sharing the same frequency bands on a co-primary basis, or from other sources of interference, 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

Recommendation ITU-R 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

Recommendation ITU-R F.1668 Error performance objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

Recommendation ITU-R 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

Recommendation ITU-R F.1703 Availability objectives for real digital fixed wireless links used in 27 500 km hypothetical reference paths and connections

Recommendation ITU-T G.826 End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections

Recommendation ITU-T G.827 Availability performance parameters and objectives for end-to-end international constant bit-rate digital paths

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Recommendation ITU-T G.828 Error performance parameters and objectives for international, constant bit-rate synchronous digital paths

Recommendation ITU-T G.829 Error performance events for SDH multiplex and regenerator sections

Recommendation ITU-R P.581 The concept of "worst month"

Recommendation ITU-R SF.766 Methods for determining the effects of interference on the performance and the availability of terrestrial radio-relay systems and systems in the fixed-satellite service

Recommendation ITU-R 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

Recommendation ITU-R SM.1448 Determination of the coordination area around an earth station in the frequency bands between 100 MHz and 105 GHz

Report ITU-R F.2108 Fixed service system parameters for different frequency bands

The ITU Radiocommunication Assembly,

considering

a) that it is necessary to establish sharing criteria between the fixed service (FS) and other services and their associated application 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 for compatibility between FS and systems of other services, including their associated application 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 system are normally determined 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;

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;

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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.

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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 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.

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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.

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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. 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 *Y*1% 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 *Y*2% 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 *Y*1% and simultaneously receiving additional interference from the second co-primary service;

   – then the limit of *Y*2 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.

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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, 3 and 4 in §§ 4.1.1 and 4.1.2. For the percentages of time applied to the protection criteria see § 1.1.2.

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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.

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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

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