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Recommendation ITU-R M.1825

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Guidance on technical parameters and methodologies for sharing studies related to systems in the land mobile service

M Series

Mobile, radiodetermination amateur and related satellite services

International Telecommunication Union

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SNG	Satellite news gathering
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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 M.1825

Guidance on technical parameters and methodologies for sharing studies related to systems in the land mobile service

(Question ITU-R 7/8)

(2007)

Scope

This Recommendation gives guidance to perform sharing studies related to systems in the land mobile service. It establishes a list of parameters, that characterize a system to assist in sharing studies, provides information on the methodologies that can be used for sharing analyses involving the land mobile service and describes mitigation techniques that can improve spectrum sharing. It also contains a list of relevant ITU-R Recommendations, Reports and Handbooks.

The ITU Radiocommunication Assembly,

considering

a) that the technical characteristics of systems in the land mobile service can vary;

b) that there is a potential for the introduction of new types of systems or services in the bands used by the land mobile service;

c) that representative technical and operational characteristics of systems operating in bands allocated to the land mobile service are required to determine the feasibility of introducing new types of systems;

d) that procedures and methodologies are needed to analyse compatibility between systems operating in the land mobile service and systems in other services,

noting

a) the list of relevant Recommendations, Reports and Handbooks listed in Annex 3,

recommends

1 that the list of parameters in Annex 1 should be used as guidance on characteristics of systems in the land mobile service appropriate for use in sharing studies;

2 that the methodologies in Annex 2 should be used for sharing studies between systems in the land mobile service (intra-service sharing) and between systems in the land mobile service and systems in other services (inter-service sharing).

Annex 1

Technical parameters of land mobile systems for sharing studies

1 Introduction

For any sharing study it is necessary to have the characteristics of the systems that need to share the spectrum. Section 2 provides a list of parameters whose values should be able to characterize a system for the purpose of sharing studies.

2 General list of parameters

It is desirable that the land mobile service characteristics in the table below be used in sharing studies. However, it should be noted that not all the parameters below are relevant for each land mobile system and as such, may not be found in the associated standards. As a result, care should be taken in determining the relevant parameters and their values for sharing studies between specific systems.

General Frequency band (MHz) Type of emission Deployment type (e.g. cellular …) Access technique Number of sectors Frequency reuse factor Antennas per sector Type of antenna systems Co-located antenna minimum coupling loss (dB)	**System** Channel bandwidth (kHz) Modulation type Duplex method Typical BER or SINAD or FER
Transmitter Output power (W) ERP or EIRP (dBW or dBm) Necessary channel bandwidth (kHz) ACLR (adjacent channel leakage ratio) or out-of-band emission mask Antenna gain (dBd or dBi) Antenna height (m) Radiation pattern Antenna polarization	**Receiver** Noise figure (dB) IF filter bandwidth (kHz) Sensitivity (dBm) Off-channel-sensitivity: – ACS (adjacent channel selectivity) – Blocking characteristics (in-band and out-of-band) Protection criteria Intermodulation spurious response attenuation (dB) Antenna gain (dBd or dBi) Antenna height (m) Radiation pattern Antenna polarization

Depending on the type of system, additional characteristics for sharing studies may include:

– cell size or coverage area;
– down-tilt angle;
– feeder loss (if not already included in the antenna gain);
– required data rates;
– transmit power range due to power control;
– SNR targets for uplink and downlink;
– propagation model (Note the applicable P-Series Recommendations listed in Annex 3).

Annex 2

Methodologies for sharing related to systems operating in the land mobile service

1 Introduction

The first step in any sharing study is to characterize the environment, configuration, and conditions of the systems being analysed.

Two types of conditions need to be considered: in-band analysis, where the systems share the same band and adjacent band analysis where the unwanted emissions of one system may impact the radio receivers in an adjacent band.

Section 2 describes methodologies that can be used for sharing analyses involving the land mobile service and § 3 describes mitigation techniques that can be used in some conditions in order to improve the ability to share the spectrum by the systems.

2 Methodologies for sharing studies

There are two basic methodologies for sharing studies in the land mobile service: the link budget methodology and the Monte Carlo methodology.

2.1 Link budget methodology

The maximum permitted equivalent isotropic radiated power (e.i.r.p.) level of an interfering signal may be determined by using the following simple equation:

$$EIRP_{MAX} = I_{MAX} - G_R(\theta) + L_P + L_R$$

where:

$EIRP_{MAX}$: the maximum permitted e.i.r.p. density of the interfering device (dBm/B_{REF}), where a suitable reference bandwidth B_{REF} needs to be chosen

I_{MAX}: the maximum permissible interference power level at the receiver input, normalized (dBm/B_{REF})

$G_R(\theta)$: the victim receiver's antenna gain in the direction of the interfering signal (dBi)

L_P: the propagation loss between transmitting and receiving antennas (dB), which may be a complex term depending upon environmental factors, some of which may be time-variant (e.g. fading)

L_R: the insertion loss (loss between the receiver antenna and receiver input) (dB). A zero dB may be assumed if no value is available.

2.2 Monte Carlo methodology

The Monte Carlo methodology is capable of providing any desired level of mathematical accuracy and statistical validity and confidence to calculations of the probability of interference for any kind of radiocommunication system. Accuracy and statistical validity and confidence are limited by:

a) how closely the mathematical model(s) describe the interference scenarios in consideration, and

b) the number of trials done to calculate whether or not interference is present.

The Monte Carlo methodology uses randomly generated values for uncertain variables, based on probability distributions applicable to these variables. The methodology combines a large number of cases of independent variables and generates statistical results. A particular advantage of using a Monte Carlo simulation is its ability to develop a statistical distribution of the predicted aggregate interference level (i.e. a cumulative distribution function) that takes into account the uncertainties of significant elements of the aggregate interference model, such as deployment densities of interfering devices/systems, activity factors, etc. This methodology is therefore particularly useful when an estimate is desired of the probability that a certain aggregate interference power level is exceeded.

The ITU-R has developed the Monte Carlo simulation methodology as a statistical tool for compatibility studies between radiocommunication services. An overview of this methodology is provided in Report ITU-R SM.2028-1. In addition, Recommendation ITU-R M.1634 describes the use of the Monte Carlo methodology for compatibility with the mobile service.

For land mobile services the Monte Carlo simulation methodology assumes a victim receiver operating amongst a population of uniformly random distributed interferers.

The desired signal level at the victim receiver can be calculated from the transmit power, antenna gains, and path loss. The effect of each interferer on the victim receiver is determined using the transmit power, antenna gains, path loss, transmitter unwanted emission characteristic, receiver blocking and frequency separation.

For some services, interference is considered to take place when the resultant *C*/*I* is less than the protection ratio.

3 Mitigation techniques

Pressure to make efficient use of the radio spectrum often means that radio systems are operated as close together in radio space as possible. To do this without reducing the reliability of these radio systems, interference mitigation techniques can be used.

Mitigation reduces interference and thereby the impact on an intended communication. Therefore, if used properly, mitigation helps different equipment and users to share the same frequency space.

The possible mitigation techniques can be classified into four main types:

– SPEC: Methods related to specifications
– PERF: Equipment performance (supplier improving the equipment performance)
– SESS: Site engineering on single site
– DEPL: Deployment relationship between sites.

The following is a list of various existing interference mitigation techniques. Not all techniques are applicable to all types of systems, for example site shielding can be helpful for fixed systems, but can not be used for mobile terminals. Similarly, some of these techniques are useful at both ends of an interfering link, while other techniques can only be applied to the interfering transmitter or to the victim receiver.

Site selection – Choosing a site to minimize potential interference. (SESS, DEPL)

Physical shielding – Using natural terrain, buildings, special purpose fencing to block signal in undesired directions. (SESS)

Antenna separation – Coupling between two antennas located in the same site can be reduced by separating the antennas vertically, horizontally or back-to-back by a few metres. (SESS)

Antenna orientation – Orienting the antenna of a directional, fixed system away from other radio systems. Physical constraints of system geometry often limit flexibility in antenna orientation. (SESS, DEPL)

Antenna tilting – A special case of antenna orientation where the vertical antenna pattern and antenna down-tilt may be used to tailor coverage and hence reduce interference outside of the served area. Especially applicable to system base stations, but the effects on coverage may make this technique undesirable in many cases. (SESS, DEPL)

Diversity combining – A technique of coherently combining the signals from multiple antennas to produce a gain. (SESS)

NOTE 1 – Diversity combining uses all antenna elements at all times for each user, creating an antenna pattern that dynamically adjusts to the propagation environment.

Cross polarization – The use of cross polarization can be used to introduce as much as 25-30 dB of discrimination. (DEPL)

Frequency coordination – Coordination of frequency selection between neighbouring systems so as to reduce the potential for interference. (DEPL)

Synchronized time division – The mitigation brought by ensuring adjacent band systems synchronize their transmission and reception to avoid situations where a system is transmits during the time interval when the adjacent band system is receiving. (DEPL)

Transmitter and receiver filtering – Filtering is the ideal technique for avoiding, causing, or receiving adjacent channel interference. (PERF)

Smart antennas – A smart antenna system combines multiple antenna elements with a signal-processing capability to optimize its radiation and/or reception pattern automatically in response to the signal environment. The benefit from the use of smart antennas on sharing is due to the fact that the RF energy radiated by antenna arrays is both lower than that from conventional antennas for the same e.i.r.p. and focused in limited, specific regions of a cell rather than wide sectors. (SPEC, PERF)

NOTE 1 – The two major categories of smart antennas, based on the choice of transmit strategy, are adaptive antennas and switched-beam antennas.

Dynamic channel selection techniques – The radio system can potentially use one of a number of channels within a band for each transmission. The radio system listens on all of those channels to determine which ones are occupied and dynamically chooses the channel to be used accordingly. Such techniques include for example Dynamic Frequency Selection, or Detect and Avoid mechanisms. (SPEC)

Static channel selection techniques – Before transmitting, the radio system listens on predetermined sub-channel(s) to determine whether a channel is appropriate for transmission. Such techniques include, for example, listen before talk or other static detect and avoid mechanisms. (SPEC)

Frequency hopping – The use of frequency hopping means that a radio system will only be using a particular frequency a small portion of the time and thus interference will only be caused or received for a brief moment and be unlikely to interfere with system operation. Dynamic frequency hopping goes a step further by eliminating channels from the hop sequence if they are being used by another system. (SPEC)

Spread spectrum techniques – As defined in Recommendation ITU-R SM.1055, the average energy of the transmitted signal is spread over a bandwidth which is much wider than the information bandwidth. This includes, for example, techniques such as Frequency Hopping spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS). (SPEC)

Adaptive power control – Systems using adaptive power control transmit using just enough power for a signal to go through. This minimizes the total amount of radio power that could potentially interfere with other systems and allows systems to adapt to poor conditions by temporarily increasing the transmitted power level. (SPEC)

Adaptive modulation – Changing to a lower-order modulation scheme can allow a radio system to continue to operate in the presence of interference, although at some loss in system capacity. (SPEC)

Frequency diversity **–** Diversity reception in which several radio channels are used with appropriate frequency separations. (SPEC)

Duty cycle, time division – The mitigation is brought by a division of time such that various transmitters do not transmit simultaneously. (SPEC)

Different technical solutions for mitigation may offer a different level of mitigation to devices of the same kind as compared to devices of a different kind. The level of mitigation may depend on the technology used and often on a combination of technical requirements.

Annex 3

References

1 Introduction

This Annex contains a list of references relevant for sharing studies in the land mobile service.

2 Examples of ITU-R Recommendations and Reports containing characteristics and protection criteria for systems in the mobile services

The following ITU-R Recommendations and Reports provide land mobile system characteristics to be used in sharing studies. Other Recommendations and Reports may also be applicable.

– Recommendation ITU-R M.1808 – Technical and operational characteristics of conventional and trunked land mobile systems operating in the mobile service allocations below 869 MHz to be used in sharing studies.

– Recommendation ITU-R M.1823 – Technical and operational characteristics of digital cellular land mobile systems for use in sharing studies.

– Report ITU-R M.2116 – Characteristics of broadband wireless access systems operating in the land mobile service for use in sharing studies.

– Recommendation ITU-R M.1801 – Radio interface standards for broadband wireless access systems, including mobile and nomadic applications, in the mobile service operating below 6 GHz.

– Report ITU-R M.2039 – Characteristics of terrestrial IMT-2000 systems for frequency sharing/interference analyses.

3 Protection criteria

– Recommendation ITU-R M.1739 – Protection criteria for wireless access systems, including radio local area networks, operating in the mobile service in accordance with Resolution 229 (WRC-03) in the bands 5 150-5 250 MHz, 5 250-5 350 MHz and 5 470-5 725 MHz.

– Recommendation ITU-R M.1767 – Protection of land mobile systems from terrestrial digital video and audio broadcasting systems in the VHF and UHF shared bands allocated on a primary basis.

4 Propagation

P-Series Recommendations ITU-R P.452, ITU-R P.1238, ITU-R P.1406, ITU-R P.1407, ITU-R P.1411, ITU-R P.1546, etc., and the ITU-R Handbook – Terrestrial land mobile radiowave propagation in the VHF/UHF bands.

5 Sharing methodologies/studies

– Recommendation ITU-R M.1634 – Interference protection of terrestrial mobile service systems using Monte Carlo simulation with application to frequency sharing.

– Report ITU-R SM.2028-1 **–** Monte Carlo simulation methodology for the use in sharing and compatibility studies between different radio services or systems.

6 Mitigation techniques

– Report ITU-R M.2045 **–** Mitigating techniques to address coexistence between IMT-2000 time division duplex and frequency division duplex radio interface technologies within the frequency range 2 500-2 690 MHz operating in adjacent bands and in the same geographical area.

– Recommendation ITU-R M.1652 – Dynamic frequency selection (DFS) in wireless access systems including radio local area networks for the purpose of protecting the radiodetermination service in the 5 GHz band.

– Report ITU-R M.2040 – Adaptive antennas concepts and key technical aspects.

7 Other Recommendations

– Recommendation ITU-R M.1797 – Vocabulary of terms for the land mobile service.