Aeronautical Mobile Communications Panel

Working Group F : Second Meeting

Bangkok 5-14 May 1999

Agenda item 5a. Revisions to the ICAO R/F policy handbook

new Annex on interference
(presented by the Secretariat)

1. Introduction

1.1 The **Handbook on Radio Frequency spectrum Requirements Doc. 9718 – AN/957** has been published by ICAO. It has been agreed that an Annex dealing with the protection of aviation radio services would be opportune and beneficial.

1.2 The subject of the protection of aeronautical radio services has been discussed over the past 15 years in relation to other radio services, particularly the FM broadcast service, and various industrial, scientific and medical equipment. A considerable amount of agreement has been made containing data and other material, which is scattered, over many different places. The purpose of this Annex is to provide a readily accessible source of the main conclusions of these past discussions, together with a selection of the important details, so that it is available as a work of reference.

1.3 The Annex deals only with the protection of aviation radio services from sources external to aviation itself, and does not address any frequency planning criteria, which are contained in Annex 10 and other ICAO documents.

2 Draft Annex 1

2.1 The collection of material is thought to be reasonably complete in terms of the work of the past 15 years. Nevertheless the list is not an exhaustive treatment, and further additions, either now or later, would be normal.

3 Action Proposed

3.1 The WG is requested to provide comment on the attached. Suggestions for improvement, or additions, would be welcomed.

Attachment : Draft Annex 1 to RF Handbook

HANDBOOK ON RADIO FREQUENCY SPECTRUM

REQUIREMENTS FOR CIVIL AVIATION

INCLUDING STATEMENT OF APPROVED ICAO POLICY

ANNEX 1 : PROTECTION OF AERONAUTICAL RADIO SERVICES

PROTECTION OF AERONAUTICAL RADIO SERVICES

Contents

PART A GENERAL BACKGROUND

1 FOREWORD

This Annex 1 to the Handbook of Radio Frequency Requirements for Civil Aviation ICAO Doc. 9718 – AN/957 supplements and extends the spectrum and frequency management material contained in that main document. It is intended to be informative in nature and has been drawn from a variety of sources , e.g. ITU and ITU_R documents, ICAO Annexes and Guidance Material, and others. These more explicit sources should be referred to for the full context in any situation where the discussion requires it, or where precise texts are necessary as part of a negotiation process.

The material provides a readily accessible collection of data, criteria and agreements relating to the protection of aviation radio services from **interfering sources outside aviation** , and includes also those sources employing radio waves for purposes other than the transmission of information, e.g. Industrial Scientific and Medical (ISM) equipment. The text is organised in the following way.

Part A : General Background Material (3 Chapters)

Part B : Particular Cases of Interference and Sharing (8 Chapters)

Part C : Supplementary Data (3 Chapters)

Criteria for the planning of assignments within the aeronautical mobile and radionavigation services is not treated in this Annex. This material is referenced in the technical material at Section 7 of the Handbook for each of the frequency bands used by aeronautical radio services.

This protection subject is an ongoing one creating amendment, and additions from time to time. These will be added at the same point in the amendment cycle as those for the Handbook. (see Attachment E- Review and Update)

Action by Contracting States and ICAO

The material may be used by Contracting States as is found necessary in national discussions on the protection of aviation radio services, or in international fora where the subject arises. ICAO observers attending international meetings may use the texts in this Annex in the circumstances where definitive texts are not available, with the condition that corroboration from the relevant source is advisable where accuracy of reporting is essential.

SECTION 2

The Basis of Protection for Aviation Radio Services

Note : References in this Annex to the Handbook are to the **Handbook on Radio Frequency Spectrum Requirements for Civil Aviation : ICAO Doc.9718 – AN/957.**

2.1 The Definitions of Interference and Harmful Interference

The international framework of agreements for dealing with interference to radio services is contained in the International Telecommunications Union (ITU) document entitled The Radio Regulations. The provisions in this document govern the circumstances, and the procedures for seeking clearance action from other ITU Administrations when interference is suffered. The basic qualification for claiming protection is "conformity with the Radio Regulations " which implies that the Seville is operating in an agreed frequency band, and with any characteristics, which are specified in the Regulations, including its Annexes.

The basic definition for interference in the Radio Regulations is: -

S1.166 ***Interference***

The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radiocommunication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy.

It is to be noted that interference is defined by the way in which the interfered system operation is affected. Thus any performance degradation, misinterpretation, or loss of information, which would not occur in its absence, constitutes interference. The definition does not imply that it is measurable in a quantitative sense, although it may well be in certain instances, but that there has been an adverse change of some detectable character. The change may be detectable by primary means aurally (voice signals), visually (radar or TV), or by measurement (loss of data, inaccurate information etc.). In some cases it may be easier, or preferable to instrument and record, or use the changed condition to give warning or to apply corrective measures. It is assumed also that interference in the sense employed in the Radio Regulations arises in all cases from sources outside the receiving system itself.

This basic definition of interference as stated in the Regulations makes no reference as to whether it is acceptable, or otherwise, merely to the condition of its existence, and its recognition. It is the category of interference classed as **Harmful Interference,** where the concept of unacceptibility appears as a qualification or condition. This is clearly stated in the Radio Regulation which defines the unacceptibity parameter.. Thus :

S1.169 Harmful Interference

Interference that endangers the functioning of a radionavigation service or other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunications service operating in accordance with these Regulations .

This regulation introduces the concept of unacceptability and defines criteria on which to make the decision. It is notable that the definition has two quite separate elements, one for radio navigation and safety services, and one for all other radio services. The former requires only proof of endangerment of the functioning, but the latter must demonstrate that a serious degradation or disruption has occurred which is at a higher level of disturbance. Again as in the case of interference above, the means of assessment is not prescribed, and could be either subjective, or quantitative. It is important to observe that for interference to be harmful, it must be to a service that <u>is operating in accordance with the Regulations.</u> In this respect , accordance with the Regulations means the totality of the Regulations, including Appendices. A service which is not can not claim protection as a right under the Regulations, although administrations may well respond in many cases which are outside this scope**. It is to be noted that all aviation services are operating on frequencies taken from**

allocations to the service concerned, either Aeronautical Mobile (R) Service, or Aeronautical Radionavigation Service, and to agreed characteristics, and are operating in accordance with the Regulations , as normally specified in Annex 10.

This framework recognises that interference in its general sense is a condition where a parameter of a received signal is affected in some way, but not necessarily to the extent of being damaging to the reception. It is the special situation of harmful interference, which is the condition where the operator of a service decides that the service can not be used for the purpose for which it is intended, which then creates the situation where the interfering service must cease the interference. The action to be taken is very wide, from switch off at one end, to reduction of power at the other, the requirement being to cease the interference by any means.

2.2 Harmful Interference

Harmful Interference is the condition recognised throughout the Radio Regulations as establishing a case for complaint, and for the removal of the sources causing the problem. The procedures , obligations, and rules are given detailed attention in **Chapter S IV.**. The reporting and clearance of harmful interference to a radio service is one of the rights established by a registration in the Master International Frequency Register, and is a right conferred in general terms in **S8.1**, and **S8.3**. In international terms it creates an obligation on the country operating the interfering service to take action. The Regulations however do not enjoy mandatory force, and negotiation is the only course of action to resolve difficulties. Within countries harmful interference is also the criteria for action and resolution. and radio regulatory authorities respond to cases of interference to aviation radio services in particular with special care.

Safety services, such as a Radionavigation Service, or an Aeronautical Mobile (R) , or in certain cases the Aeronautical Mobile Satellite (R) Service, being safety services as defined in :-

S1.59 Safety Service

Any radiocommunication service used permanently or temporarily for the safeguarding of human life and property.

Harmful interference to a safety service requires the most urgent attention at all times and is recognised as such by all ITU administrations. Safety services include not only the aeronautical services, but also maritime and land mobile services when the messages have a safety of life content.

Of particular interest to aeronautical services in this context are the provisions mentioned at Section 7-III-3.4 of the Handbook. Also the permission to operate without an identification for the testing of navaids is to be noted as at **RR S15.16.** These measures provide a framework of regulatory actions, which ensure that interference judged as harmful is cleared in an effective, and expeditious, manner.

2.3 Emission, radiation and induction

These three terms receive mention in the definition of interference and it is important to understand their ITU interpretations since their existence and influence will appear at some time in any discussion on interference and its effects. Reference to **RR S1.137** indicates that a ***radiation*** is the generic category for any radio wave energy that is propagated either deliberately or inadvertently. As a sub -set, **RR S1.138** states that an ***emission*** is the case of a radiation produced by a *radio transmitting station,* and only by that source. Thus a *radiation* could either be the radio wave energy coming from a local oscillator in a receiver, or an instrument or machine used in medical or industrial purposes, whilst an *emission* is exclusively the radio energy from a transmitting antenna.

2.4 Unwanted Emissions

Most generation of radio energy for transmission purposes produces products than those required for the efficient transmission and reception of the necessary information. When radiated these have the potential to interfere. In the Radio Regulations these unwanted emissions are defined as :

S1.146 Unwanted Emissions
Consist of spurious emissions and out-of-band emissions.

The definitions for these two elements are given below.

S1.145 Spurious Emission
Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which can be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency products, but exclude out-of-band emissions.

S1.144 Out-of-band Emission
Emission on a frequency or frequency immediately outside the necessary bandwidth which result from the modulation process, but exclude spurious emissions.

The understanding of these definitions is completed by the definition given to the term necessary bandwidth :

S1.152 Necessary Bandwidth
For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

With increased congestion in spectrum utilisation this set of interlinking Regulations have become the highly important starting point for dealing with interactions between adjacent services, between services sharing the same frequency band, and in any other situation of frequency use conflict.. A display of the relationship is at Fig 1 below

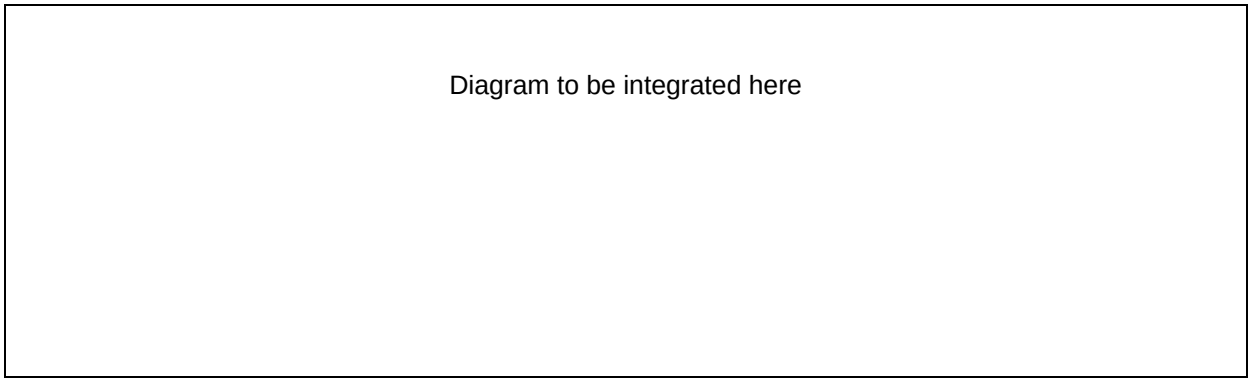

Fig 2- 1 Unwanted emissions

The Regulations in Appendix S3 specify **a Table of Maximum Permitted Spurious Emission Power Levels.** These are referenced to the power supplied to the antenna transmission line from the transmitter and are “never to be exceeded values”. It is recognised that more stringent levels may be laid down by Conference agreement, or by special agreement between administrations. ICAO SARPs often, for system performance reasons, specify more stringent levels - in effect meeting the spirit of the “ special agreement” requirements of the Regulations.

2.5 Permissible Interference and Accepted Interference

The Regulations specify these two further classes of interference.

S1.167 Permissible Interference
Observed or predicted interference which complies with quantitative interference and sharing criteria contained in these Regulations or in ITU-R Recommendations or in special agreements as provided for in these Regulations.

S1.67.1 The terms "permissible interference " and " acceptable interference " are used in the coordination of frequency assignments between administrations.

S1.168 Accepted Interference
Interference at a higher level than that defined as permissible interference and which has been agreed upon between two or more administrations without prejudice to other administrations.

These two definitions are fully in line with the basic definitions for interference, and for harmful interference, and highlight the distinction between them, as outlined at 2.1 and 2.2 above. The important element is that of quantification, that is the agreement is linked to stated and measurable values of signal level.
This concept of acceptability based on quantitative criteria can only be a conditional one, since it can not negate the freedom to state a complaint of harmful interference by a service suffering harmful interference, although such a complaint would be harder to sustain and prove than in the circumstances where a planning basis had not been agreed. It would provide nevertheless be a basis for review, and adjustment of the criteria as a condition for agreement to continue. In such a situation it would be an assumption that aeronautical safety services would be permitted to continue in operation, with the prime obligation being on the interfering service to adjust, close down, or to take other immediate action to resolve the situation.

2.6 Frequency Sharing / Frequency Planning

Assignment planning within a service is the most notable example of the concept of Permissible Interference, and is the application of an agreed protection criteria to ensure that the strength of the unwanted signal from a like facility, or a similar facility in the same service (e.g. voice and data in the VHF Comms Band) is the agreed number of decibels below that of the wanted signal. In these cases the acceptable performance change is normally minimal, and quite often is a change in the noise floor, or the received signal to noise ratio. This is highly important for systems, such as VOR or ILS, or navigation systems in general, where the changes to the received signal are not easily detectable by the user. All of these quantitative criteria for in-service planning are developed by ICAO for harmonised world wide application.

Frequency sharing has recently developed a new context in the addition of services other than aeronautical services to previously exclusive aeronautical bands. The criteria for acceptability in these cases are normally developed by the Study Groups of ITU-R and embodied in their Recommendations. Bands where this procedure have already been applied are the Aero Radio Nav bands at 5000 to 5250 MHz, and 15.4 – 15.7 GHz. As the spectrum becomes more extensively exploited and greater demands appear for further uses, the principle of sharing of allocations between two compatible services is likely to become more extensive. In these discussions, the aviation service must justify its protection requirement to the satisfaction of the other interests wishing to use the same frequency. Final decisions are made at ITU Conferences, sometimes against the best advice from the aviation community.

Sharing an allocation between two services normally places constraints on the future expansion capabilities of both services, and can ultimately work to the detriment of aeronautical services whose expansion rate is slower than other, more commercially based, services, in effect resulting in a first come-first served situation. As mentioned above, the application of sharing criteria, whether covered by an ITU-R Recommendation or not, can not negate the right to claim protection from harmful interference and where the service interfered with has a safety of life function. would normally require immediate closure, or reduction of power of the interfering service until a permanent resolution has been found.

2.7 The Aggregation of Interference Inputs

Assessments of interference effects and acceptable levels tend to be conducted in isolation one from another. In any given practical situation the net effect of many potentially interfering sources must be considered. and due allowance made. An extra margin of perhaps 3 dB is recommended for the general case, with higher values in particular cases where a number of interferes are known to exist.

2.8 Aviation Safety Factor

Some aeronautical applications, for example precision approach and landing, are regarded as having high criticality in safety terms, thereby meriting an additional safety factor. In its application the analysis would consider the probabilities applying in the total operational situation, which is then narrowed down to the element involving unacceptable interference. From there an additional protection factor, often 6 dB , is applied to increase the operational assurances to the required level.

2.9 Electromagnetic Compatibility (EMC)

EMC is defined as the ability of a system to function satisfactorily in an electromagnetic environment, without introducing intolerable electromagnetic disturbance to any other system in that environment.

Two elements, basically receiver rejection, and transmitter unwanted emissions, are fundamental design centres in the specification and engineering of radio systems to operate in their typical operating environment. They are normally addressed by national legislation, such as FCC Rules in the United States, or in ETSI Standards as in Europe. Within many national legislations they are a prerequisite to the approval of any equipment which generates radio frequency energy as a main functional source. This includes not only communications and navigation equipment, but also computing equipment, industrial equipment, etc. The limiting values chosen are normally selected on the basis of best judgement and on the practical and economic factors applying in particular systems.

A good example of the essential need for EMC is in the case of the multiple radio systems, (and more recently the digital control systems), used on board aircraft. In a modern transport aircraft these can amount to systems operating in 18 different frequency bands, with up to possibly 24 antenna. Great care in the placement of antenna, in the internal cabling, and severe limitation of both output power, and spurious products, is necessary to maintain all installed systems within performance limits. Provisions addressing this point may be found in the specifications for airborne equipment produced by RTCA and ARINC.

2.10Other Important Radio Regulations

Radio Regulations Chapter S1V : Interferences , Article 15 is the Article which lays down procedures and priorities for the actions to be taken in identifying, reporting, and clearing interference. Reference to this material should be made for the detailed rules governing the circumstances , the scope for reporting, and the actions to be taken. Important Regulations are :

S15.16 Makes provision in the Aeronautical Radionavigation for the removal of identification signals when tests or adjustments are being carried out.

S15.36 When the service being interfered with is a safety service, provides for direct communication to the administration having jurisdiction over the transmitting station causing the interference.

S15.40 Where there is a specialised agency (such as ICAO) reports of interference may be copied to that agency coincident with notifying the administration responsible for the station causing the interference.

S15.41 to 46 Describes the procedure for the reference of disputes to the Radiocommunications Bureau. It should be noted that the Bureau has no powers, and their action is solely that of investigation, reporting, and arbitration.

2.11 The Registration of Frequencies

The Master International Frequency Register (MIFR) is held at the Headquarters of the ITU in Geneva, and is the document in which administrations may register their national frequency use. Following their request to the the Radiocommunications Bureau, who are charged with the recording process, the assignment will be checked against the requirements of the Radio Regulations, and if in compliance , the frequency is recorded with the date of request. Later requests must protect any assignment with an earlier date. If a request is not in accordance with the Regulations an entry may still be made provided it does not interfere with a registered service, but the assignment will enjoy no protection from later registrations meeting the requirements. This is the so called Non-Interference Basis. In the Radio Regulations, the status of recorded assignments is defined in **Article S8,** and the notification procedure followed in the recording process is laid down in **Article S11.**

Recorded assignments are the highest category of assignment and must always be protected. However administrations normally accept an interference complaint provided the service is operating in accordance with the Regulations.

Apart from frequencies used for NDB, or HF Communications, aviation assignments are not registered with ITU on a systematic basis, although administrations may do so if they wish. The ICAO coordination, or the bi-lateral coordination in some world areas, has traditionally been accepted as a quasi registration process. In these cases the ICAO regional Plan assumes the same role as the MIFR.

2.12 The Management and Control of Interference

2.12.1 Interferences of all kinds are an ever present feature of all radio frequency bands, arising from the transmissions from a multiplicity of different radio services, increasing in quantity and in power almost daily. The higher power services such as broadcasting, radar, and some specialised defence systems, have a potential to cause considerable disruption and must be carefully controlled. In addition to radio services, there are many other sources of interfering radio energy, such as industrial and medical machinery, motor vehicles, power transmission lines, and many other electrical and electronic sources. Over cities and industrial areas particularly, the ambient radio noise can attain quite high levels making the detection of weak signals difficult, and on occasions impossible, affecting in particular the reception of radio in aircraft.

2.12.2 The **management and control** of the interference present in the radio environment is a highly important supplementary activity to that of the management of the radio spectrum itself. As with spectrum management the overall process is a layered activity with international agreement on fundamentals in the upper layer, followed by national legislation and enforcing machinery. Good management and minimisation of harmful products also increases the effective utilisation of frequencies.

The basic elements in the process are :

- **International agreement on the regulatory basis.**

The elements of the basic regulatory framework are contained in the Radio Regulations and have been described above. These define a set of principles, and actions, which are designed to provide administrations with agreed understandings for use with other administrations, and internally within their own countries This activity is international in character and is centred on the ITU in the first instance. ITU Regulations are treaty obligations and in respect of interference clearance are conscientiously followed. Where normal negotiation fails to resolve an issue, there is scope for reference of problems to the ITU IFRB. However this is not a compulsory arbitration procedure and in the unlikely event that this fails, the service suffering the interference may have to take independent action.

- **System and Equipment Standards**

Standards and specifications for systems and equipment's is the second layer in the process. These must contain essential performance requirements relating to the maximum permitted levels of

unwanted emissions. Internationally developed standards such as those in aviation agreed by ICAO and RTCA , or in ITU-R Recommendations, and in Europe those of Eureka and ETSI, have to incorporate clauses addressing these aspects. The Spurious Products Limit at Appendix S3 are " never to be exceeded" limits, and negotiations are often necessary to analysis individual situations and specify levels below those in the Regulations. Most Annex 10 SARPs for adjacent channel frequency planning specify levels which are lower that Appendix 3. A recent example of individual negotiation may be found in the case of mobile satellite equipment operating in bands adjacent to that of GNSS with the potential to interference with approach and landing of aircraft. In this case it was necessary to have agreement in both ITU-R and in ETSI.

- **Licensing of Radio Services**

Within national territory legislation is necessary to provide the enforcement powers to manage and control the processes at the operating level. National telecommunications authorities hold this responsibility for the licensing of all radio services within their jurisdiction. In this process the authority must ensure that the radio system is approved to agreed standards, that its EMC performance is adequate, and that it operates with characteristics which are in accordance with international agreements. The national telecommunications authority remains as the regulating body for its operation in regard to interference with other radio services. The most important international obligation is the Radio Regulations and ITU-R Recommendations; others may be regional standards such as those developed in Europe by ETSI. In the case of radio for civil aviation safety purposes, both ground and airborne, other requirements may be applied emanating from ICAO SARPs, RTCA and Eurocae specifications, and for Airworthiness purposes the TSO laid down by FAA in the US, and the JAA in Europe.

- **Control and Clearance of Interference**

As with radio licensing the responsibility for these aspects will normally rest with the national telecommunications authority under the same national legislation, whose task it is to introduce a framework for the detection, resolving, and if necessary the closing down of sources of interference. This will include, in addition to radio stations, licensed or unlicensed, any equipment or system capable of radiating and causing interference. Many industrial, scientific, computer, and line transmission systems have the potential for interference. If the service is a safety service, action must be taken on an urgent basis Identification of interference source is a difficult and often time consuming activity. Some aviation authorities have found it beneficial in effecting a speedy clearance, to assist the national telecommunications organisation by local detection actions in which local knowledge is used to good advantage.

2.13 Summary of Regulatory Aspects of Protection

2.13.1 The protection of aeronautical radio services is an end to end process, covered at all points by agreed technical protection criteria, and by regulatory provisions, all of which are embodied in ITU Regulations, in ITU-R Recommendations, and in aviation documents. Considerable attention is given in these to the needs of safety services, of which aeronautical services are examples. Exercise of the regulatory functions is the responsibility of national telecommunications administrations who have the necessary powers to license equipment which conforms to agreed specifications, and to take action within their own jurisdiction, and with other administrations to clear harmful interference. Important elements in these processes are :-

- the existence of national and international agreements on safe planning criteria and practices ;
- agreed mandatory equipment specifications which embody the necessary control of unwanted emissions and radiations ;
- an assignment planning process which is safely applied, and which is co-ordinated to the extent necessary with other services and administrations ;
- the efficient and effective monitoring and reporting of interference ;

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- immediate attention to clearing cases of harmful interference to aeronautical radio services

2.13.2 The material in this Annex relates mainly to the first three elements in the above, and covers the more important of the agreements and actions having effect at the present time.

SECTION 3

The Assessment of Protection for Aeronautical Radio Services

3.1 The Nature of Interference and its Detection

Inteference from any source, or of any type, is recognizeable by a change in the reciever output signal. Quantification is not necessary for it to be harmful (see Section 2), and many interferences, e.g pulse, are not easily quantified but nevertheless are undisputably harmful. In this regard, particular care is necessary with systems in which the output is neither aural or visual, such as modern digital systems or systems where the output is used to operte control systems, and detection may go unnoticed for some time. The task of assessment of the threat offered by other signals so as to make a decision of acceptibility, for example in allocation sharing, must however have a basis which is logical and amenable to analysis.

For the theoretical assessment of compatible sharng with other radio services (a situation becoming more common), or where the threat is unwanted emissions from a known non aviation system, a quantitative criteria has to be stated and used as a reference for decision making. For this purpose a maximum interference threshold limit is normally chosen which has been selected on the basis of acceptable degradation, taking in to account all other environmental conditions. In the absence of other data, the usual planning ratio for wanted to unwanted signals within the aviation service, should be enhanced to give a margin for uncertainties which can not be quantified. An increase not less than 6 dB is often taken to be appropriate for this safety factor.

At higher frequencies in the GHz ranges, and for wide band low signal services, a more appropriate criteria is the acceptible increase in the noise floor, or the noise temperature, of the receiving system. Antenna gains, or losses, are a necessary inclusion to replicate real life conditions. The approach to land operation is accepted as of the highest and most importance of the safety critical services. The model displayed at Attachment C, approved by the ICAO AWO and GNSS Panels, is recommended for these analysis.

3.2 The Concept of a Generalized Assessment Method

Many interference predictions have to be assessed on the basis of theoretical analysis. In this a standard model and methodology is of assistance in comparing the results of separate analysis, and in formulating a conclusion on acceptability. The need will arise in many different situations, and particularly in the case where a decision on acceptable sharing of an allocation by two services is the issue. Real life conditions are not accurately predictable, and theoretical analysis will invariably have to be verified under actual operational conditions before a full acceptance is given to any proposal for sharing.

The effects of interference and the particular form of the signal degradation that it causes are usually dependent on the characteristics of the interfering signal. Pulsed and continuous type signals often produce different results, with one or the other having more objectionable effects, or with more invasion of the demodulating process. Whenever data relating to the effects of specific modulations is available these should be used to provide near realistic analysis of the interference situation. Tests and experiments should carefully replicate the actual interference situation as closely as possible, and quantitative analysis should clearly indicate the relevance of the criteria to the case in question.

The Variables

In the minimisation of the effects of interference there are three main areas on which to concentrate to make improvements.

(i) ***The Source of the Interfering Signals***

Control of the source is often the only practical means of protecting aviation radio services. This can take many forms depending on the nature of the potentially interfering signal. For radio transmitters close control of unwanted emissions is essential, and the use of only necessary transmitting power to meet the requirements stated in **RR S15.2** is also a discipline for operators of stations. Control at source is dependant on effective measures at a national licensing level, which themselves should be aligned on standards agreed internationally , either globally and regionally.

A particular example is that of Industrial, Scientific and Medical (ISM) equipment using the heating effect of radio wave energy, which are a potential source and are required to operate only in designated bands, and to exercise control and monitoring in accordance with **RR S15.13**
Another recent example is that of Mobile Satellite terminals operating in bands close to GNSS services, for which ITU-R and ETSI standards have been developed.

(ii) ***Distance Separation between the interference Source and the Aviation Receiver***

Distance separation to reduce the energy of the potentially interfering signal to an acceptable level is a standard method of establishing the protection necessary in many practical applications. It is the method normally employed in assignment planning, for which purpose agreed protection and propagation path criteria are used in the calculation. In co-ordination between two services, a limiting value of separation, based on worst case evaluation beyond which no co-ordination is required, is often employed. Another notable example is the analysis of final approach situations where a typical minimum separation distance between source and receiver may be chosen and used in calculations to establish the acceptability of proposed maximum spurious levels. (An ITU-R standard model for approach and landing has been developed - see Appendix C to this Handbook)

(ii) ***The Aviation Receiver***

Receivers having a good interference rejection performance are now, in an ever increasingly crowded spectrum, an essential requirement. No service user can claim protection until the receiving equipment employed in that service has been designed and built having full regard to this requirement. The Radio Regulations in **S3.3** makes mention of this obligation to take all measures which are economically and technically justifiable to minimise the effects of transmissions, particularly in adjacent bands., and **S3.12** and **S3.13** requires that radio receivers should have adequate performance to minimise the effects of signals outside the occupied bandwidth. The principle that is applied is based on the joint responsibility of both the service that is vulnerable, and the potential interferer, to share equally the burden of compatibility. Where the affected service is a safety service, such as aeronautical radionavigation, or communications, the same general considerations apply and receivers are expected to be resistant to expected interferences. An example of this is the case of VOR and ILS receivers operating adjacent to FM Broadcasting. (see Section 6)

Consideration of the above three elements leads to the concept of a **Standard Model** for use as a tool in theoretical assessments. This is described below.

3.3 The Standard Model

The above leads to a convenient three element simulation of actual conditions, the source-path-receiver model. This model is commonly used for assessing on a quantitative basis the acceptability of specific limits on the production of interfering products. The analysis may be single evaluation, or iterative simulation depending on the data and facilities available. simulation The model in its application to the analysis of aeronautical radio services protection is deterministic. That is, the receiver susceptibility mask, the antenna losses or gains, the propagation path and its variabilities, are all considered at their worst case limits. From these considerations the ideal RFI source mask may be

estimated and tested for practical realism A process of adjustment of the variables, particularly distance separation , would follow to arrive at agreed standards, which if necessary may then be embodied in regulatory material.

Important points in the analysis are :-

Service Volume :

The aeronautical protection point and the service volume chosen must take account of agreed and specified .service volumes as stated in ICAO Annexes , or in other defining documentation. Normally this will be the nearest service volume extremity to the interfering source This is the case where the source is outside the service volume. Where the source is close to the receiver, such as during a landing operation, a carefully prepared scenario should be used. That Recommended in ITU-R Recommendation { } has been prepared by ICAO Panels and may be used in many cases. (ITU-R Recommendation is at Appendix)

Receiver Susceptibility : The receiver criteria for acceptable degradation has to be carefully chosen, related as appropriate to a detected change in a measurable parameter, or in perceived aural or visual reference, or in increase in error rate, or other relevant characteristic, depending on the form and content of the receiver output. The receiver must under all conditions, with and without normal signal input, operate within its standard performance envelope , including measurement error limits, taking account also of the real life environment and other known interfering sources, in arriving at the limits for receiver susceptibility. Unacceptable change to the noise floor may be used as the datum for systems in the higher frequency bands , for example in assessing interference to radar.

Propagation Data : The best available propagation data, usually that documented in CCIR and ITU-R Reports, should be used. Account must be taken of the variability which applies to all propagation modes , and particularly where the separation distances are at the limits, near or beyond the radio horizon, or where seasonal phenomena, such as night effect at LF/MF, ducting at VHF, or ionosphere conditions at HF etc., exists. Natural features , or shielding, such as that provided by terrain, or the aircraft body may be included if it is a permanent feature present in all cases of interest. In many cases free space attenuation may be used as the reference level in calculations, especially above 1 GHz and where the distance separation exceeds 20 KMs.

Installation Conditions : Variables such as antenna system losses, antenna gain in particular directions, terrain shielding., or in the case of aircraft installations the effects of the aircraft body, may be included as variations from standard scenarios to produce more refined results in particular cases. Similarly the interfering source conditions may be treated in the same way as a means to arrive at practical results.

3.4 The Institutional Processes for Protection Discussions and Agreements

The International Telecommunications Radiocommunications Assembly adopts Recommendations dealing with all aspects of radio. This includes the interference aspects, and sharing between services. Increasing congestion and sharing of two services on the same frequencies has caused this activity to increase in intensity, and in depth. As spectrum congestion spreads,this activity is likely to increase further. Adjacent band services with a high differential in power levels, such as FM Broadcast, and mobile satellite terminals, are typical real lifeproblem areas encountered by aviation services. The strategic siting of services in the allocation table to minimize adjacent band problems is no longer practicable because of the pressures to meet requirements wherever they can be fitted in.

ITU-R Recommendations, resulting from studies by the Study Groups, are the normal means of documenting the conclusions and agreements on technical bases. Whilst these are generally only voluntary in their application, they are nevertheless applied conscientiously by administrations, and by industry. The exception are a few special category subjects – NDB signal levels is one – where a linking reference placed in the Radio Regulations gives a Recommendation the same treaty status as the Regyulations.

Study Group 8 is the most important for aviation, and deals with all mobile services, terrestrial and satellite, and with radionavigation of all kinds. WP8B and WP8D are the principal sub components. Exceptionally, Study Group 4, which deals with Fixed Satellite Services, has dealt with an MLS/FSS problem in the 5 Ghz band. (see Section 9)

In Europe the ETSI body develops standards for radio in the European region. These include standards for the unwanted emissions from systems, and for the EMC between systems. Some ETSI standards are processed through a consultative stage and then become mandatory in the 15 member states of the European Union. The other European countries normally follow and apply the standards also. ETSI is an important component in the interference processes because of its multi national (42 countries) participation.

The following external sources are some of the man made interference emissions and radiations that are either known, or have the potential, to cause harmful interference to aeronautical radio services, and have been the subject of discussion in international bodies dealing with the subject.

- Sharing between NDB and Maritime Services
- Broadcasting services, LF/MF AM, VHF FM, VHF TV
- Cable distribution systems
- Power line carrier systems
- Industrial, scientific, and medical equipment (ISM)
- Local oscillator radiations from radio receivers
- Satellite terminals, hand held and vehicle

3.5 Specific Interference Areas

Reports and recommendations dealing with individual subjects are treated in Part B of this Annex.

PART B

SPECIFIC SYSTEM CONSIDERATIONS

SECTION 4 General Protection Levels for Aeronautical Radio Services

4.1 General

The limits displayed in this section are intended to give general guidance. For individual analysis reference should be made to the complete definitive texts in the authoritative documents.

	Service	Freq Band	Min Sig dB(uV/m)	Planning Protection Ratio DB	Suggested Max Level of Interfering Signal DB(uV/m)		
1	Omega	10 – 14 KHz					
2	NDB	190-850 KHz	37 (1)	15	16		
3	HF Comms	2.8 – 22 MHz		15			
4	ILS Mkr Beacon	74.8-75.2 MHz	46 (1)	20	20		
5	ILS Localizer	108 –112 MHz	40 (1)	20	14		
6	VOR	108 –118 MHz	39 (1)	20	13		
7	VHF Comms	118 – 137MHz	37 (1)	14	17		
8	ILS Glide Path	328.6-335.4MH	52 (1)	20	26		
9	ELT	406 MHz					
10	DME	960-1215 MHz	71 (1)	8	57		
11	SSR	1030/1090 MHz					
12	Primary Radar (23cm)	1215-1350 MHz					
13	Satcom (S to E)	1545-1555MHz					
14	GPS	1559 to 1610 MHz	-160 dBW (3)		-137 (2)		
15	GLONASS	1559 to 1610 MHz	-160dBW (3)		-137 (2)		
16	Satcom (E to S)	1645.5/1655.5					
17	PSR (10cm)	2700-3300MHz					
18	Radio Altimeter	4200-4400MHz					
19	MLS	5030-5150MHz	58	20	32		
20	Air Weather Radar	5350-5460MHz					
21	Air Weather Radar	9345/9375MHz					
22	Primary Radar (3cm)	9000-9500MHz					
23	Air Doppler Nav	13.25-13.4GHz					
24	ASDE	15.4-15.7GHz					
25	RSMS	15.4-15.7GHz					

Notes : 1. Signal levels specified in Annex
2. –137/dBW/m2/MHz (Wide band signals) -147 dBW/m2/MHz (narrow band signals) (Source :GNSSP)
3. At receiver terminals

5 Sharing between Maritime Mobile Service and Non Directional Beacons

5.1 General

In a number of LF and MF frequency bands, for example between 415 and 495 kHz, and in all 3 ITU Regions, there are shared allocations between the Aeronautical Radionavigation Service and the Maritime Mobile Service. In some cases the sharing is on a joint Primary basis, in other cases one or other of the services is Secondary. With careful planning and co-ordination an acceptable environment can be achieved, a process which is assisted by the geographically different areas of operation of the two services.

A special situation exists in the Western European area of Region 1 where an ITU Plan was created in 1984 to allow entry by the Maritime Mobile Service, which at that time was a Permitted Service. This category of service was deleted from Article 5 in the Radio Regulations by WRC-95., and the Maritime Mobile Service was changed to a Primary status.

The establishment of protection to aeronautical beacons from the transmissions of coast and ship stations of the Maritime Mobile Service can be assured by the application of the criteria contained in the Radio Regulations, together with the Guidance Material contained in Annex 10. Additionally some ICAO Regions, notably the European Region, have also agreed supplementary criteria to be applied to the NDB in their area. An overview of these provisions follows below.

5.2 ITU Radio Regulations

The protection requirements for Aeronautical Beacons (NDB) as contained in the Radio Regulations may be found in :

Appendix S12 Special Rules Applicable to Radiobeacons
Section 1 Aeronautical Radiobeacons

(1) The assignment of frequencies to aeronautical radiobeacons operating in the bands between 160 kHz and 535 kHz shall be based on a protection ratio against interference of at least 15 dB for each beacon throughout its service area.

(2) The radiated power should be kept to the minimum value necessary to give the desired field strength at the service range .

(3) the daylight service range of radiobeacons referred to in (1) above shall be based on the following field strengths :

(4) *Regions 1 and 2*

- 70 microvolts per metre for radiobeacons North of 30 N ;
- 120 microvolts per metre for radiobeacons between 30 N and 30 S ;
- 70 microvolts per metre for radiobeacons south of 30 S ;

(5) *Region 3*

- 70 microvolts per met for radiobeacons North of 40 N ;
- 120 microvolts per metre for radiobeacons between 40 N and 50 N ;
- 70 microvolts per metre for radiobeacons south of 50 S.

The provisions above have the status of Regulations through the linked reference at Article 28 , S28.23 and S28.24, which specifies the above as special rules requirements which must be complied with.

5.3 ICAO Annex 10

Important planning material may be found at

Annex 10, Vol 1, Part 1, Para 3.4 - Specification for NDB, and

Attachment B to Part II - Considerations affecting the Deployment of LF/MF Frequencies and the Avoidance of Harmful Interference

The planning guidance in the second reference relating to the rejection characteristics of ADF receivers in aircraft, is particularly applicable to establish the required separation distance in the case where the NDB and Maritime Service frequencies are not coincidental.

5.4 Propagation Model

Daytime transmissions at LF and MF propagate in a ground wave mode. Night time transmissions from NDB using sky wave do not generally provide a reliable service, and are not recommended. The appropriate ground wave transmission model is that contained in :

CCIR Recommendation (368)

This Recommendation provides ground wave propagation data for frequencies from 10 kHz up to 30 MHz. In the range of interest for NDB there are separate curves for the frequencies of 200, 300, 400, and 500 kHz. Separate families are provided for sea and for 8 different values of ground conductivity and permitivity, which must be ascertained from local knowledge to enable accurate application.
Typical values extracted from these curves to indicate the order of attenuation variation with earth constants and with frequency are given below (Field strength in dB/uV/m at 100 Kms for 1 KW radiated power) :-

Freq (kHz).	Sea Path	Land (High attentn.)
200	68	30
700	69	20

5.5 CCIR Report 910-1 Sharing between MMS and NDB in Band 415 – 526.5 kHz

Parts of the frequency band 415 to 526.5 kHz are allocated to both the Maritime Mobile Service and the aeronautical radionavigation service. Because of differences in operational use, frequency planning,radiated power, etc., the co-existence of these two radio services in the same bands may present problems. Particular attention is required with respect to the problems which have their origin in the power levels used. In general the MMS coast station operates at considerably higher levels of power than short and medium range NDB, perhaps 20 to 30 dB higher. For example coast station operation at e.r.p of 10 to 50 Watts is typical and ship stations at 40 Watts e.r.p., whereas an NDB with a range of 50 NM would have an e.r.p of less than 1 Watt. (taking in to account the relative antenna efficiencies which may be as low as 10 to 30 per cent)

This Report examines in detail some of the important parameters to be addressed in any analysis of these situations. The required protection to both maritime (NAVTEX services on 518 kHz) and NDB is examined for the full range of conditions of propagation. Two Annexes provide detailed analysis for particular cases, Annex 1 for protection to NAVTEX services and Annex II for protection of NDB services.

The examination is restricted to : -

(i) geographical separation (co – channel)
(ii) frequency separation (co-location)

(iii) a combination of (I) and (ii) with variable geographical distance and frequency separation.

Four sets of curves are displayed (see Figs 5-1 to 5-4) for the following sets of parameters :-

(i) aircraft ADF selectivity with 2 curves from Annex 10 and 1 improved version
(ii) distance separation for a coast station at 500 watts e.r.p and NDB at 25,45, and 75 kms range
(iii) distance separation for coast stations at 2 kW, 1 kW, 0.5 kW, 100 W, 10 W e.r.p., and an NDB of range 75 kms.
(iv) Distance separation for a coast station at 1 kW e.r.p, an NDB at 75 kms range, and the 3 selectivity curves displayed at (I)

Table V from Annex II of the Report (reproduced below) indicates the distance separations at various frequency differences for the ground wave situation. Sky wave conditions are also examined. However NDB planning within the aeronautical service is normally made on the basis of protection from ground wave only.

[Insert here Table V of Annex II of CCIR Report 910-1]

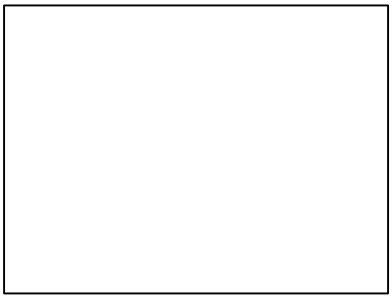


Table 5-1 Distance between NAVTEX station and edge of NDB cover (ground wave)

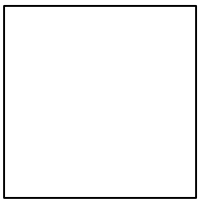
5.6 Co-ordination

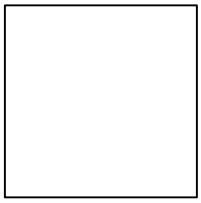
Where the services to be co-ordinated are both covered by a single radio regulatory authority the necessary co-ordination would be carried out, and agreement established, on a national basis without any other involvement.

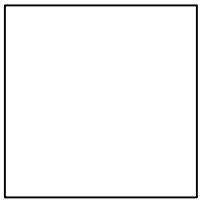
Where the services affect more than one country the method of bi-lateral, and multi-lateral, co-ordination is necessary. Areas of high density facilities, such as is the case in the European Region, may use the facilities of appropriate Regional Groupings to affect the two levels of co-ordination, firstly between aeronautical assignments, and secondly that with respect to maritime assignments. The latter would be undertaken by radio regulatory administrations.

Figures 5-1 to 5-4

[insert here the Figs 1,2,3, and 4 from CCIR Report 910-1]
Report 910-1]







6 Compatibility between FM Broadcasting and Aeronautical Radio Services in the VHF Bands between 88 MHz and 137 MHz

6.1 General

The ITU WARC in 1979 allocated the band at 87 to 108 to Broadcasting Services throughout the world, having previously been allocated in that way only to Regions II and III. The band is adjacent to the VOR/ILS band at 108 to 118 MHz and band edge problems can not be avoided, particularly if high power broadcast stations are operated on frequencies close to the band edge, and in high density aircraft environments. In many countries FM Sound Broadcasting services, of both low and high power are operated in this band, in others the Broadcast services are those for analogue Television Services . Compatibility problems due to intermodulation,and overloading of the front end of aircraft receivers became apparent when broadcast stations commenced to use the frequencies in the top 4 or 5 MHz of the band, in the mid seventies. This was particularly the case with ILS/VOR receivers. Studies on a suitable planning methodology initiated by the CCIR in a joint SG4/SG8 group has documented a viable methodology for planning broadcast and aeronautical frequencies to produce a safe situation for air operations.

The problem is a difficult one and any resolution through planning automatically restricts both services. In high density areas such as Western Europe and North America the full potential of the frequency band for either service can not be realised. Since both services tend to be at their greatest density in areas of high population , this places a severe constraint on the full utilisation of the potential of the 40 channels agreed for use by ILS (see Annex 10, Vol. I, Part I, Para. 3.1.6.). VOR services are also affected but not to the same critical degree, whilst VHF Communications because of their greater frequency separation are even less so.

6.2 CCIR Studies

The Joint Study Group SG4/SG8 with members from the two services have established a methodology for the co-ordination of Sound Broadcast services in the Bands from 87 to 108 MHz, and Aeronautical Services in the Band 108 - 137 MHz. CCIR Reports 927-2, 929-2, and 1198 produced by this group have been consolidated in to an approved Recommendation

ITU-R Rec. IS.1009 Geneva April 1994

The 3 Annexes of this Recommendation deal comprehensively with the subject and are :

Annex 1 : Types of Interference and criteria to be used in compatibility assessments
Annex 2 : Methodology for predicting potential incompatibilities
Annex 3 : Techniques for case by case analysis

The Report covers comprehensively the treatment of conflict situations for the 4 interference modes :-

Type A : Interference products falling within the ILS/VOR bands. With two sub types :

Type A1 Spurious or Harmonic intermodulations from in band components,
Type A2 Band edge overflow at 108 MHz band edge (affecting only 108 MHz Band edge)

Type B : Interference generated by broadcast frequencies outside the ILS/VOR band. With two sub types :-

Type B1 Interference due to high power effects on receiver resulting in non linearity and intermodulation products.
Type B2 Performance degradation due to high power overload and desensitization without any frequency relationship

This Recommendation, with its 3 detailed Annexes, provides the essential requirements for the identification, and analysis of conflict situations ; and for the coordination between broadcasting and aeronautical interests within any country, or between countries. The criteria and methods have been developed and reviewed by a group of experts and represents the best available information on the subject. Furthermore the document is recognised by aviation experts, radio administrations, and civil aviation authorities as the definitive guidance for planning and coordination purposes.

6,3 ICAO Studies

ICAO : Handbook for Evaluation of Electromagnetic Compatibility (EMC) between ILS and FM Broadcasting Stations using Flight Tests (1997) ICAO Doc.

This ICAO Handbook is the result of considerable flight testing programmes provides detailed guidance on this activity. It addresses the methods of flight testing for analyzing and resolving cases of FM interference to aircraft ILS Localizer receivers. It describes test equipment, test procedures and interference assessment criteria. The material is also generally applicable to VOR, or Communications systems. The areas covered in the Handbook are :-

- Description and Operation of Airborne Equipment ;
- Interference Assessment Methodology ;
- Flight Test Procedures ;

with 5 Explanatory Appendices.

6.4 Amendment of Annex 10

As part of the compatibility agreement, Annex 10 was amended to incorporate provisions covering the rejection performance of airborne receivers. The following SARPS were hence incorporated to standardise the rejection performance of receivers to FM Broadcast signals. Whilst the SARPS were incorporated in the Annex with Amendment No 65 in 1984, giving 14 years before it became effective. At that time MLS was expected to replace ILS around the year 1998. After 1998 the agreement is that all broadcast assignment planning would be made on the assumption that all aircraft concerned would be equipped with up to date receivers meeting the new immunity performance.

ILS : **Annex 10 Vol I Pt. I Para. 3.1.4 Interference Immunity Performance for ILS Localizer Receiving System**

and : **Annex 10 Vol. 1 Pt 1 Att C Para. 2.2.10 Guidance Material on above**

VOR : Annex 10 Vol 1 Pt 1 Para. 3.3.8. Interference Immunity Performance for VOR Receiving System.

VHF Com : Annex 10 Vol 1 Pt 1 Para. 4.7.3. Interference Immunity Performance

6.5 LEGBAG Consultative Arrangements

In Europe the L E G B A C

6.6 Modification of Airborne Equipment

The Annex requirements for aircraft immunity performance specified the year 1998 as the date when Airborne equipment was expected to meet the new immunity performance requirements. Essentially the modifications were only necessary for aircraft operating in areas where a conflict was predicted using the methodology specified in ITU- R Recommendation IS.1009. The responsibility rests with member states of ICAO to assess all such situations within their territory, and promulgate conflict areas when they exist. Mandatory carriage requirements for aircraft on a states register is also a state responsibility.

7 Protection of Global Navigation Satellite System (GNSS) in the band 1559 to 1610 MHz

7.1 Band 1559 to 1610 MHz

The 51 MHz Radio Navigation Satellite band at 1559 to 1610 MHz supports the operation of the GNSS which is expected to become the future all - purpose radio navigation system for aviation operations. GPS and GLONASS as systems presently in operation have been identified as the initial components of systems that will be used, possibly with ground augmentation. Both systems are also available for all purposes where a position fixing facility is required. This includes all mobile navigation needs for land, sea, or air, survey, mineral exploitation, search and rescue, etc.

For the aviation requirement very stringent integrity and reliability standards, and other performance standards, have been developed by the ICAO GNSS Panel**. (for example see Draft SARPS for GNSS, and ICAO Circular 267-AN/159 - Guidelines for the Introduction and Operational Use of GNSS)** Chapter 4 of the last named document gives a GNSS System Overview and describes the two current candidate systems, Global Positioning (GPS) and Global Orbiting Navigation Satellite System (GLONASS). Chapter 5 deals with interference in a general manner. Both systems operate using multiple orbiting satellites (up to 24 in number) at around 20,000 Kms above the surface of the earth. Each satellite transmits exact orbital parameters (ephemeris data) with its corresponding highly accurate (atomic source) timing signal. Ground receivers solve four simultaneous equations for at least three sets of position data using the receivers integral accurate time source to obtain a two dimensional position. A minimum of four satellites is required to provide a three dimensional position. The two systems use different methods of modulation and transmission, GPS with pseudo-random coding transmitted on the same frequency, and GLONASS with frequency division on discrete frequency for individual satellites.

Brief spectrum details of the occupation of the 1559-1610 MHz frequency band, present and expected, are shown on Fig 7-1. The details of the two systems presently in operation are :-

Global Positioning System : The centre frequency is 1575.42 MHz. The occupied bandwidth is dependant on the type of receiver and its tracking process C/A code requires plus or minus [4 MHz] and P code around plus or minus [12 MHz].

GLONASS : In its final configuration (expected in 2005) GLONASS will operate on 12 frequencies spaced at 0.5625 MHz. After 2005 no frequency will be above 1610 MHz. (see Handbook Section 7-II-93) Bandwidth of protection of plus or minus 4 MHz around each frequency is required.

GNSS Augmentation : Proposals have been made for augmentation systems to improve GNSS integrity , which may operate in the lower end of the 1559 to 1610 MHz band. Protection requirements are tentative but early indications are that they would be similar to the systems already in use.

7.2 Aircraft Receiving System Protection

The performance requirements for the aircraft receiving system in regard to the projection from interference are contained in

RTCA - DO 229 Min Operational Performance Standards for GPS/ WAAS Airborne Equipment (Jan.1996)

RTCA- DO228 Min Operational performance Standards for GPS/WAAS Airborne Antenna Equipment (Jan 1996)

The document

RTCA DO-235 Assessment of Radio Frequency Interference Relevant to GNSS (1977)

addresses the specifics of the interference situation. These documents may be taken to be the definitive texts produced by aviation experts and should be used as basic material in all protection calculations.

The protection requirements for aircraft receivers as contained in **RTCA DO-229 Appendix C** are

Wide band signals : minus 115 dBm/MHz

Narrow band signals : minus 120.5 dBm/MHz

Wide band signals are 1MHz and wider, and narrow band are nominally less than 700 kHz

7.3 Sharing and Protection from other Radio Services

The situation in regard to sharing with other services, and protection from adjacent bands services, is

7.3.1 Fixed Links

No published characteristics are available for the Fixed Links operated under footnotes S5.335 and S5.339 operated by the countries (74) included in the footnotes. (Appendix B7-1). Information from other work in connection with these fixed links indicates typical systems with characteristics as follows :

Frequency	:	Anywhere in Band 1400 to 1660 MHz at bandwidth of 600 kHz
Output Power	:	1.2 W
Antenna Gain	:	up to 22dB
Front/Back	:	16 dB
Side Lobe Att.	:	9 dB min

With these characteristics unacceptable interference to GNSS services could exist at distances of 400 Kms and greater to an aircraft receiver in the main lobe of the fixed link transmitter.. Ground station GNSS monitors used for augmentation may be affected within 80 Kms. The numbers, locations, and operating frequencies of these equipments are only known to the licensing national administrations. National co-ordination with authorities in the countries concerned is necessary to establish the sharing possibilities on an individual site basis.

These links have the potential to inhibit GNSS operations over a wide area. The problem has been recognized internationally and WRC2000 is expected to discuss solutions. ICAO Policy (Section 7-73 et seq in RF Handbook) supports the removal of the GNSS band at 1559 to 1610 MHz from both footnotes.

7.3.2 Sharing with Mobile Satellite Service in band 1559 to 1610 MHz

Proposals have been made to ITU WRC-97 to operate Mobile Satellite Services in the Space to Earth direction to Mobile Earth Stations (on vehicles, ships, or aircraft). Geostationary satellites only have been included in the present proposal. The present aviation position opposes this sharing as an unacceptable practice, which could jeopardise the future aviation use of GNSS for high criticality navigation applications. This would include higher Category precision approach and some sole means en-route functions.

Resolution COM 5-31 (WRC-97) has called for studies of the subject (see below) with a report to be made to WRC-2000. ITU-R WP8D has documented and continues to study the following :'

- **PNDR ITU-R M (RNSS CHAR) : Technical Assessment of the Sharing Possibilities between MSS (Space to Earth) and RNSS (Space to Earth)/ARNS in a portion of the Band 1559 – 1610 MHz**

A Report prepared by WP8D to CPM 2000 should indicate that this sharing is not feasible

7.4 Other ITU-R Documentation

- **Recommendation ITU-R M.1088 : Considerations for Sharing with Systems of services operating in the bands allocated to the radionavigation satellite service**

- **Recommendation ITU-R M.1317 : Considerations for sharing between systems of other services operating in bands allocated to the radionavigation satellite service and aeronautical radionavigation services and the global navigation satellite system GLONASS**

- **Recommendation ITU-R M.1318 : Interference protection evaluation model for the radionavigation –satellite service in the 1559 to 1610 MHz band.**

- **Recommendation ITU-R M.1343 : Essential Technical requirements of mobile earth stations for global non-geostationary mobile satellite service systems in the bands 1 – 3 GHz.**

7.5 ICAO Studies

The ICAO GNSS Panel has prepared material on the protection of GNSS, to be used as ICAO input documentation to ITU-R and other discussions on this subject. These have assessed the protection requirements for all GNSS and support systems that are expected to be utilized for aviation purposes

The protection requirements for GNSS systems as stated by the GNSS Panel are :-

- Minus 137 dBW/m2/MHz (wide band signals)
- Minus 148 dBW/m2/Hz (narrow band signals)

Appendix B6-
Fixed Service Footnotes in GNSS Band

The information below has been abstracted from Article 5 of the Radio Regulations.

Underlined entries are those countries whose names have been added to the footnotes since the RNavSat service was allocated the band 1559 to 1610 MHz in 1959. In some instances the move was from Secondary to Primary status.

Primary Status (45 countries)

S5.359 *Additional Allocation :*

Germany	Saudi Arabia	Armenia	Austria	Azerbijan	Belarus
Benin	Bulgaria	Cameroon	Spain	France	
Gabon	Georgia	Greece	Guinea	Guinea-Bassau	
Hungary	Jordan	Kazakstan	Kuwait	Latvia	

Libya Mali Maurtania Moldova Mongolia

Nigeria Ugan Uzebekistan Pakistan Poland

Syria Krgyzstan Korea Romania Russia

Senegal Swaziland Tajikistan Tanzania Turkmenistan

Ukraine Zambia Zimbabwe

the bands 1540 - 1645.5 MHz and 1646.5 - 1660 MHz are also allocated to the fixed service on a primary basis.

Secondary Status (27 countries)

S5.355 Additional allocation :

Saudi Arabia Bahrain Bangladesh Congo Egypt

UAE Eritrea Ethiopia Iran Iraq

Israel Jordan Kuwait Lebanon Malta

Morroco Niger Oma Qatar Sytia Somalia

Sudan Sri Lanka Chad Togo Yemen Zambia

Notes 1. In the secondary list Afghanistan and Thailand have removed their names
2. Saudi Arabia and Zambia appear in both footnotes

8 Protection of GNSS from MES Unwanted Emissions

8.1 Mobile Satellite Terminals in the Bands from 1 to 3 GHz

The band 1610 to 1626.5 MHz is allocated for use by the Mobile Satellite Service for transmissions from mobile devices in the Earth to Space direction,to satellites in Non Geostationary Orbits. (NGSO). The mobile terminals may either be fixed to a vehicle or other mobile unit, or be hand held. The systems presently proposed may be either of CDMA (wideband), or of FDMA (narrow band)type. These systems generate unwanted emissions which can interfere with GNSS services in the band 1559 to 1610 MHz.

GSO mobile satellite systems operating in other bands between 1 and 3 GHz, and particularly the Earth to Space band at 1660.5 to 1660.5 MHz, also have potential for interference. The latter band is that also used by AMS(R)S for transmissions from the aircraft (i.e. from an AES) to the satellite. For this situation, special measures have to be applied by aircraft systems designers to maintain the AMS(R)S signal level at the GNSS antenna below the agreed protection value.

Any of these mobile terminals may be used in the vicinity of airports, which creates the need for an international agreement to control the manufacture, the use, and the cross border controls relating to such terminals. The importance of this international aspect is caused by the global nature of these systems. The Global Mobile Personal Communications by Satellite (GMPCS) MOU, developed jointly by ITU and the World Telecommunications Policy Forum 1996, has been raised for signature by all participating countries, as an agreement addressing the import and control of mobile satellite equipment.

8.2 ITU-R Recommendations

These ITU-R Recommendations have been based on studies made by the ICAO GNSS Panel, using a model similar to that at Attachment C, and presented to the ITU-R WP8D for use in their discussions.

8.2.1 NGSO MES Terminals

Recommendation ITU-R M.1343 : Essential Technical Requirements of Mobile Earth Stations for Global Non Geostationary Mobile Satellite systems in the bands 1 to 3 GHz.

The purpose of this Recommendation, approved in 1997, is to provide a common technical basis for the following purposes (as stated in Recommends 1) :-

a) establishing type approval requirements for MES terminals ;
b) facilitating the licensing of MES terminal operations ;
c) facilitating the development of mutual recognition arrangements of type approvals of MES terminals
d) facilitating the development of mutual recognition arrangements to facilitate the the circulation and use of MES terminals.

Two Annexes deal respectively with TDMA systems (Annex 1), and CDMA systems (Annex 2)

The following data has been extracted from these Annexes and is reproduced for guidance on the general scheme of levels that have been adopted. However, it is stressed that the subject is complex and reference to the ITU-R document is necessary wherever there is a need for definitive information. The figures quoted are for the maximum levels of unwanted emissions from an MES measured in a bandwidth of 1 MHz – except where stated otherwise. The data is for the carrier-on condition only.

Frequency (MHz)	TDMA MES e.i.r.p (dBW)	CDMA MES e.i.r.p. (dBW)
1559-1573.42	- 70	- 70
1573.42-1580.42	- 70	- 70 (1)
1580.42-1590	- 70	(2)
1590-1605	- 70	(2)
1605-1610	(4)	(2)(3)

Notes

1 Averaged over 20ms.
2 Further study required.
3 The value at1605 MHz (-70 dBW/MHz), linearly interpolated in dB/MHz, to –10 dBW/MHz at 1610 MHz. For the special conditions for the protection of GLONASS, refer to the ITU-R Recommendation.
4 –70 dBW at 1605 MHz, linearly interpolated in dB/MHz, to – 10 dBW/MHz at 1610 MHz. For special conditions relating to the protection of GLONASS, refer to the ITU-R Recommendation.

8.2.2 GSO MES Terminals

Draft New ITU-R Recommendation : Essential Technical Requirements of Land Mobile Earth Stations for Global GSO MSS systems providing voice and /or data communications in the bands 1 to 3 GHz.

This Recommendation has been developed from an initiative by the European ETSI organization, who have developed and agreed a European Standard for application in that area. There may be

differences between this Standard and that finally agreed in ITU-R. Approval by the ITU-R Radiocommunications Bureau is anticipated in late 1999.

The data for the carrier on condition only has been extracted. For the carrier off condition and all other relevant data reference to the Recommendation should be made. The subject is complex and the information presented here is for general guidance only

The limits relate to the level of unwanted emissions at the output of the MES in the frequency bands quoted. The first column is for terminals with antenna gain less than 8 dBi and eirp less than 15 dBW. The measurement bandwidth is 1 MHz unless indicated otherwise.

Frequency Range (MHz)	EIRP limit (dBW)	EIRP limit (dBW)
1559-1600	-70	-70
1600-1605	-70	-70
1605-1612.5	-70 to –58.5(1)	(2)

Notes
1 Linear interpolation in dBW versus frequency
2 Linearly interpreted from –70 dBW in 1 MHz at1605 MHz to –46dBW at 1610 at 1610 MHz.
Special conditions are applicable to GLONASS protection.(see Recommendation)

9 Protection requirements for MLS (Co-ordination with MSS Earth Stations)

9.1 General

The band 5000 to 5250 MHz is allocated to the Aeronautical Radionavigation Service (ARNS). Footnote S5.444 gives precedence in the section 5000 to 5150 MHz to the international standard system (microwave landing system) for precision approach and landing. Footnote S5.444A allocates on a joint primary basis the band 5091 to 5150 MHz to the Fixed Satellite Service (for Mobile Satellite Feeder Links) in the Earth to Space direction, until the year 2010. This addition was made by ITU WRC 95. A Conference Resolution No 114 was agreed calling for studies of the compatibility of the two services. (see Handbook Section 7-11 et seq)

The compatibility .studies were carried out by ITU-R SG4A. This Group is one dealing with Fixed Satellite systems, and it was found appropriate for the results to be examined by the ICAO AWO Panel. This was done at their 16th meeting held in 1997.

9.2 ITU-R Recommendations

The method for the determination of co-ordination distances between Earth Stations in the Mobile Satellite Service (Feeder Links) in the band 5091 to 5150 MHz and MLS in the band 5030 to 5090 MHz which has been agreed in ITU-R is contained in :-

> **ITU-R Rec. No. [-] : Method for determining co-ordination distances between the International Standard Microwave Landing System (MLS) operating in the Aeronautical Radionavigation Service (ARNS) Band 5030 to 5090 MHz and Stations of the Fixed Satellite Service (Earth to Space) operating in the Band 5091 to 5250 MHz**

.

This Recommendation addresses only the protection of MLS in the band 5030 to 5090 MHz. This band is the one displayed at Table ! of Annex 10 Vol 1 from which the 200 channels for present MLS installations will be made. The Recommendation recognizes that the sharing between MLS in the band 5091 to 5150 MHz and the FSS in the band 5091 to 5250 MHz, and other new ARNS in the band 5030 and 5250 MHz and FSS in the band 5091 and 5250 MHz remain to be studied.

Annex 1 of the Recommendation contains the details of the method to be used. Important points are :-

(i) If the distance separation between the MLS site and the Earth Station site exceeds 450 Kms no co-ordination between the two services is necessary. [The figure of 450 Kms is based on a radio line of sight where the MLS site and the FSS site are at the same height above sea level. Where this is not the case an additional 3 Kms per 100 metres (330 feet) distance separation may be necessary.

(i) The definitions used for "in-band" and "out-of-band" are referenced to the MLS tuned frequency. The " in –band " is specified as a band 150 KHz wide centred on the MLS frequency. "Out of band " are frequencies outside this band.

(ii) Free space propagation is used as the propagation model. Height difference allowance between MLS and FSS sites is included where appropriate.

(iii) If the distance separation between the MLS site and the Earth Station site exceeds 450 Kms no co-ordination between the two services is necessary. [The figure of 450 Kms is based on a radio line of sight where the MLS site and the FSS site are at the same height above sea level. Where this is not the case an additional 3 Kms per 100 metres (330 feet) distance separation may be necessary}.

(iv) for separations less than 450 Kms coordination is necessary in accordance with the following :-

<u>In Band Case</u>

Interference threshold is taken to be –130 dBm interference level at the MLS receiver terminals. The coordination distance separation between the MLS transmitter site and the FSS station is then :-

$$R_{in}\,(kms) = (4.775 \times 10^{-6})\,(10^{((P\ 160)//20))} + 43$$

where P = FSS peak eirp dBW(150 KHz in the band 5030-5091 MHz

This relationship is displayed in Fig 9-1 below :

[Integrate Fig 2 on
Page A-5 of AWOP 16
Item 5 in Report]

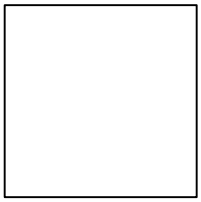


Fig 9-1 Co-ordination Distance for In Band Case

Out of Band Case

The interference threshold is taken to be –61 dBm that includes a 6 dB margin. With this value the coordination distance separation between the MLS transmitting site and the FSS station is then :-

$$R_{oob}\,(kms) = (4.775 \times 10^{-6})\,(10^{(P\ 91)/20}) + 43$$

Where P = FSS peak eirp dBW in the band 5091 to 5250 MHz.

This relationship is depicted in Fig 9-2 below :

[Integrate here Fig 1 on
Page A-4 of AWOP 16
Item 5 Report]

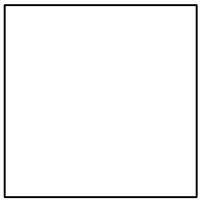


Fig 9-2 Co-ordination Distance for Out of Band Case

9.3 Mitigation Factors

Annex 3 of the ITU-R Recommemendation quotes a number of additional factors and possible mitigation techniques that may be employed as refinements in any individual case. The more important of these are :-

- The gain of the MSS antenna in the direction of the MLS service volume
- Site specific signal attenuation factors such as terrain blocking
- Alternative locations for the FSS station providing a better path loss
- Optionally, at the discretion of the affected aviation authority, taking in to account the frequency separation where the MLS frequency is in the lower part of the MLS band.

9.4 Interference clearing

It may be noted that any co-ordination effected by the application of the methods in Recommendation (- - -) does not prevent or remove the requirement for the reporting and clearance of interference to aeronautical services if it takes place. The provisions of the Radio Regulations in regard to the removal of interference to a safety service apply irrespective of the coordination agreement affected using the methodology in this Recommendation. Where the interference persists a case would exist for a review and modification of any agreement.

10 Protection of Radio Altimeters in Band 4200 to 4400 MHz

10.1 General

The frequency band at 4200 to 4400 MHz has been allocated to the Aeronautical Radionavigation Service, and is reserved exclusively for radio altimeters by footnote S5.438. The radio altimeter, in one of its main applications, performs the highly important task of providing flare guidance in the last stages of automated approach to land. Equally critical is its use as an input to Ground Proximity Warning Systems in aircraft.

For these applications a good interference rejection performance is essential. Integrity standards of the order of one failure in 10^{19} operations are not uncommon. The use of band width is an essential feature in effective designs to achieve high orders of interference rejection, and freedom from disruptive effects due to the high levels of pollution of the radio environment which exists around most big cities.

Studies have determined the necessity for the retention of the existing 200 MHz of spectrum to meet the exacting requirements of high accuracy with good all round performance.

10.2 CCIR Studies

CCIR Report 1186 discusses the technical background to meeting the operational performance required for modern conditions. It concludes that :-

" The whole of the band 4200 to 4400 MHz currently allocated is required up to at least the year 2015 "

In coming to this conclusion Report 1186, and its support paper (ref 4) review the accuracy requirements and the design features to meet those requirements as laid down in specification documents. The relationship between frequency excursion and accuracy are particularly noted. Typical performance requirements are the following

AIRINC 707-1 Section 3.7

- Accuracy : Within 1.5 ft., or 2 per cent if greater, in the range 20 to 2500 feet
- Output noise : 0.25 ft.
- Output Resolution : 0.125 ft

The referenced document (Ref 4) discusses the relationship between accuracy and bandwidth for a range of altimeters, using FMCW (the most common type used in low height, high accuracy roles), pulse, and spread spectrum.

11 Sharing in the Aeronautical Radionavigation Band 15.4 to 15.7 GHz

11.1 General

The part of the band at 15.43 to 15.63 GHz of the Aeronautical Radionavigation Band 15.4 to 15.7 GHz is shared with the Fixed Satellite Service , an allocation which was made by WRC-95, and later amended by WRC-97.(see **RR S5.511 A**). The FSS use is restricted to Feeder links for Non Geostationary satellites in the Mobile Satellite Service. The conditions of use are covered by the footnotes S5 511A and S5.511C, which place restrictions on both services as part of the protection requirements.

11.2 Aeronautical Utilization of Band

The band is utilised by the ARNS for a variety of systems :-

- Airport Surface Detection Equipment (ASDE) : Radar systems used at civil airports for the control of surface movement.
- Radar Sensing and Measurement System(RSMS) : Sensing system used in small aircraft and helicopters for height and other low range measurement.
- Airfield Landing System (ALS) : A transportable landing system used for temporary airfields
- Multi Purpose Radar (MPR) : An airborne surveillance radar.

Descriptions of these systems are given in Annex A of the ITU-R Recommendations S.1340 and S.1341 (see below)

11.2 ITU-R Recommendations

Considerable study by ITU-R SG4 of the protection requirements to ensure safe sharing by these two services has produced the following:-

(i) Rec. ITU-R S.1340 : Sharing between the ARNS and MSS Feeder Links in the Earth to Space direction

This Recommendation contains the following limitations :

- Limits the emissions from ALS and MPR at graded angles of shoot (Para 2.1)
- Limits horizontal emission by Earth Stations to 54 dB(W/MHz)
- Restricts RSMS to band 15.43 to 15.63 GHz
- Establishes co-ordination distances for the protection of ALS and MPR.
- Urges the limit of 42 dBW on all ARNS stations.

(ii) Rec. ITU-R S.1341 : Sharing between Feeder Links for MSS and the ARNS and the RAS in the Space to Earth direction

This Recommendations contains the following limitations :

- Limits the PFD of the FSS at the earth's surface for various angles of arrival (Para 2.1)
- Establishes co-ordination distances for ALS and MPR.(Para 5)
- Limits Earth Stations to operate above 5 degrees
- Makes provision for the protection of the Radio Astronomy Service in the band 15.35 to 15.4 GHz.

A diagrammatic representation of the situation in this band is at Fig 11.1

Following discussion by WRC-97 on the difficulties in designing a practical Space system to operate within the restrictions required for the protection of the systems already in use in this and the adjacent band below , the WRC-97 agreed Resolution 123(WRC-97) for study of the feasibility of making use of the band for these systems. Depending on the results of this study, which is focussed primarily on the protection of the radio astronomy services in the band below, it would be an anticipation that modifications, including deletion, could be made to the FSS allocation

12 Industrial, Scientific and Medical Equipment (ISM)

12.1 Definition and Description

The definition for ISM Applications appears at Radio Regulation S1.15 and is :

Industrial Scientific and Medical (ISM) Applications (**of radio frequency energy) : Operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic, or similar purposes, excluding applications in the field of *telecommunications.***

This definition is intended to include a wide range of equipments in which the heating effect of R.F. energy is utilised to perform industrial and medical processes. High powers can be generated especially for such processes as metal hardening (e.g. car engine crankshafts), but the application area is local to the R.F. head. Measurement standards are often difficult to define, and this is particularly in the case of large equipments assembled on site. Electromagnetic screening measures must be efficient in constraining the escape of energy, and effective in maintaining that level of protection.

12.2 Radio Regulations

In the Radio Regulations ISM does not fall within the definition of a radio service and is hence not subject to any of the provisions of the Regulations. Nevertheless frequencies are designated for ISM use with the condition that radio services must accept interference if they are operated on the same frequencies. The text of the Regulation concerned is :-

S5.150 The following bands

13553 - 13567 kHz	**(centre frequency 13560 kHz)**	
26957 - 27283 kHz	**(centre frequency 27120 kHz)**	
40.66 - 40.70 MHz	**(centre frequency 40.68 MHz)**	
902 - 928 MHz	**(centre frequency 915 MHz)**	**in Region 2 only**
2400 - 2500 MHz	**(centre frequency 2450 MHz)**	
5725 - 5875 MHz	**(centre frequency 5800 MHz)**	
24 - 24.25 GHz	**(centre frequency 24.125 GHz)**	

are also designated for industrial, scientific, and medical (ISM) applications.
Radio communications services operating within these bands must accept harmful interference, which may be caused by these applications. ISM equipment operating in these bands is subject to the provisions of No. S15.13.

The text of No **S15.13** is :-

Administrations shall take all necessary and practicable steps to ensure that radiation from equipment used for industrial, scientific and medical applications is minimal and that, outside the bands designated for use by this equipment ,radiation from such equipment is at a level that does not cause harmful interference to a radiocommunication service and, in particular, to a radionavigation , or any other safety service operating in accordance with the provisions of these Regulations.

Particular attention has to be given to the frequencies in the above list in the 13 MHz and 27 MHz bands, since harmonics of these fall into both the ILS/VOR, and the VHF COM, bands with the potential in each case to affect a number of assignment points within each harmonic spread (as indicated below) Thus

- 13 MHz band -

13,553.0 kHz	8th	108.424 MHz	9th	121.977 MHz	10 th	135.530 MHz
13,567.0 kHz	8th	108.536 MHz	9th	122.109 MHz	10 th	135.670 MHz

- 27 MHz band -

26,957.0 kHz	4th	107.828 MHz	5th	134.785 MHz
27,283.0 kHz	4th	109.132 MHz	5th	136.415 MHz

affecting potentially the frequencies below

ILS/VOR Freqs	**VHF Frequencies**
108.00	122.00 MHz and all up to 122.1083 (15 freqs)
108.05	
108.10	134.7833, 143. 7917 (2 freqs)
109.00	135 -136 All 80 frequencies
109.05	136- 137 All 43 frequencies up to
109.10	136.4083 MHz

12.3 Control of ISM equipment

International action to agree standards and conditions for the radio frequency radiations from ISM equipment takes place under the aegis of the Committee Internationale Special Perturbation Radio (CISPR), which is a component of the International Technical Commission (IEC). These standards are voluntary and it is the responsibility of national authorities to decide the extent and the nature of their national legislation required for the control of interference from these systems

12.4 ITU-R Recommendations and CISPR Publications

Recommendation ITU-R SM-1056 recommends the use of CISPR Publication 11 as a guide for the application of limits and methods of measurement for ISM equipment.

PART C

SUPPLEMENTARY INFORMATION

12 Useful Data

12.1 Propagation

Note : The data below together with other useful information may be found in the Annexes to CCIR Report 525

- **Radio Horizon**

  $1.23\ (\sqrt{h_1} + \sqrt{h_2})$ NM h in feet above ground

  $1.41\ (\sqrt{h_1} + \sqrt{h_2})$ Km h in metres above ground

- **Free Space Field Strength**

  Basic equation : $E = \sqrt{30p / d}$ E = r.m.s field in Volts/metre
  p = e.i.r.p in watts
  d = distance in metres

  Practical form : $E = 173\sqrt{p / d}$ E = r.m.s field in mVolts/metre
  p = e.i.r.p in Kw
  d = distance in Kms

- **Free Space Loss (between isotropic antenna)**

  Basic equation $L = 20 \log (4 \Pi d / \ddot{Y})$ L = transmission loss in dB
  d and Ÿ are distance and wavelength in the same units

  Alternative form $L = 32.5 + 20\log f + 20 \log d$
  L is loss in dB
  f in MHz
  d in Kms

- Impedance of free space = 377 ohms

- PFD at a point $S = E^2/120\Pi$ S = p.f.d. in watts per sq. metre
  $= 4\Pi p / \lambda^2$ E = r.m.s. field strength in V/m
  λ = wavelength in metres
  p = power from isotropic antenna in watts

  Alternative form p = 30 + 10 log (50 ohm) p is power from antenna in dBm
  V is field strength in Volts/metre

- Effective Area (of an antenna) $A = \lambda^2 G / 4\Pi$

12.2 Field Intensity and Power Intensity Relationships

[Table (full page) to be provided and integrated here]

13 Bodies and Organisations concerned with Radio Standards or Interference Matters

- **CISPR** Committee International Special Perturbation Radio,

- **ITU / ITU-R** International Telecommunications Union,
  Place des Nations
  CH-1211 Geneva 20, Switzerland.

- **IEC**

- **RTCA** Radio Technical Committee for Aeronautics

- **ETSI** European Telecommunications Standards Institute
  06921 Sophia Antipolis, Cedex, France.

- **CE**

Attachment A

Glossary of Terms

A main Glossary of Terms is at Attachment B to the Handbook. The following acronyms appear in this Annex and are supplementary to those in the main document.

AEEC	Airlines Electronic Engineering Committee (US)
AES	Aircraft Earth Station (Satellite Comms station on aircraft)(RR S1.184)
AES	Aeronautical Earth Station (AMS(R)S ground Feeder station)(RRS1.182)
ARINC	Aeronautical Radio Incorporated (US)
ASDE	Airfield Surface Detection Equipment
CEN	Committee European Normalisation (Europe)
CISPR	Committee International Special Perturbations Radio
ED	EUROCAE document
ERP	Equivalent Radiated Power
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ETS	European Telecommunications Standard
ETSI	European Telecommunications Standards Institute
EUROCAE	European Organisation for Civil Aviation Equipment
FMBC	Frequency Modulation (Broadcasting)
GMPCS	Global Mobile Personal Communications by Satellite
GNSS	Global Navigation Satellite System
IEC	International Electrotechnical Committee
IMT2000	International Mobile Telecommunications System
ISO	International Standards Organisation
ITU-R	International Telecommunications Union - Radiocommunications Bureau
MASPS	Minimum Aviation System Performance Specification
MES	Mobile Earth Station
MLS	Microwave Landing System
MMS	Maritime Mobile Service
MOPR	Minimum Operational Performance Requirement
MPS	Minimum Performance Specification
NDB	Non-Directional Beacon
NGSO	Non Geostationary Orbit (Satellite systems)
PR	Protection Ratio
RB	Radiocommunications Bureau (ITU)
RSMS	Radar Sensing and Measurement System
RTCA	Radio Technical Commission for Aeronautics
UMTS	Universal Mobile Telecommunications System
WARC	World Administrative Radio Conference
WRC	World Radio Conference
WTPF	World Telecommunications Policy Forum

Attachment B

References

1 Handbook of Radio Frequency Spectrum Requirements for Civil Aviation : ICAO Doc 9718

2 ITU Radio regulations

3

4 Ingless. R.M. Report on the feasibility of reducing the radio altimeter band 4200 to 4400 MHz (1989).

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Attachment C

Model for Touchdown Analysis

C1 Touchdown Model

The model displayed and described below has been used in the analysis of interference conflicts between hand held satellite and mobile satellite equipments when used in the vicinity of airports, and aircraft approach using GNSS. It has been accepted by the ICAO GNSS Panel as representative, and accurate, for these purposes.