REPORT ITU-R F.2087

# Requirements for high frequency (HF) radiocommunication systems in the fixed service

(2006)

## 1 Increased requirements in the HF fixed service

### 1.1 Introduction

Increasing requirements in the HF fixed and mobile services are driven by two factors. Firstly, other technologies do not meet all requirements. This is especially true in public protection and disaster relief operations. Ease of deployment and comparatively lower costs continue to make HF fixed and mobile applications desirable during the development of a crisis situation. The second factor is the emergence of HF advanced technologies which allow development of applications to exchange more information at higher data rates.

### 1.2 Disaster relief support by HF radiocommunication systems

HF radiocommunication systems and networks play a vital role in the support of relief efforts during disasters. Disasters may be local, regional, or, worst case, global in nature. Basic HF systems are vital during disasters, and, as shown in this Report, have recently supported a multitude of events. The categorization of global relief support provided by the optimal use of radio-frequency systems includes, in particular HF.

#### 1.2.1 Background

Disaster relief operations using the HF spectrum provide emergency radiocommunications when the telecommunications infrastructure has been disrupted or destroyed for the exchange of critical and lifesaving information between administrations, private voluntary organizations (PVOs), non-governmental organizations (NGOs) and local public safety activities during crisis situations. Normally, HF channels supporting disaster relief activities are global in nature. The propagation characteristics of the HF portion of the radio spectrum make it most suitable for this type of operation. It offers a propagation medium in which reliable, long range and geographically expansive networks can be established, without the use of satellites, using inexpensive and easy-to-deploy equipment, which operate over a range of frequencies.

When a disaster occurs, personnel from surrounding areas, other administrations and international agencies provide first-responder support to local disaster agencies. HF radiocommunication offers radiocommunication supporting safety and security during these humanitarian relief operations, especially long-range communications when the telecommunications infrastructure is destroyed or disabled.

HF mobile radios provide both short- and long-range support for a variety of activities including various land, maritime and aeronautical radiocommunications while serving as an integral component in an extensive fixed and mobile network capability. Due to the unique characteristics of HF radio propagation, mobile radio use is able to support a wide variety of critical needs specific to these public protection and disaster relief responses.

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Modern radiocommunications in the HF band have specific attributes that make it a viable and irreplaceable solution for many emergency response requirements:

– HF radiocommunication allows transmissions across national borders;

– HF radiocommunication can, and is often the only means to provide both local and beyond line-of-sight communications;

– in mountainous areas, it may be the only terrestrial radiocommunication technology that will overcome line-of-sight obstructions by way of near vertical incidence sky-wave (NVIS);

– it is capable of supporting low and medium transmission data rates and different modes of radiocommunication operation (e.g. voice/data/electronic messaging/e-mail);

– it is not dependent upon a relay (e.g. aircraft or satellite);

– its operational cost per bit of information transmitted is considerably less than alternative radiocommunication systems;

– it is generally readily available and easily deployable;

– it can be integrated or used in conjunction with many commercial hardware products;

– it is highly interoperable due to open standards.

Humanitarian relief operations that rely on the use of HF radiocommunication operation modes are evolving to encompass multinational organizations and treaties, responding to needs on a worldwide basis. This trend demonstrates the incalculable value and support HF radiocommunication use provides on a global basis for humanitarian purposes.

### 1.2.2 A case study in requirements surge: 2004 Indian Ocean Tsunami

A recent example of disaster relief operations was the multinational administration response to the Indian Ocean Tsunami. Extensive infrastructure damage combined with the need to rapidly provide relief supplies from many administrations provided a classic scenario for HF radiocommunications. Landline telecommunications were destroyed, and severe damage was done to all other forms of telecommunications. The only long-range communication means available were provided via satellite and HF radio. The up-front expense and lack of availability of satellite communications equipment and infrastructure limited their use.

HF radiocommunication was a ready solution. Administrations that sent governments and private organizations to the disaster areas to provide relief supplies and support possessed sufficient HF radiocommunication equipment to establish telecommunications under extremely austere conditions. The emergent need for HF spectrum in this situation drove up spectrum demand. The following chart shows the increase in requirements for HF radiocommunications as administrations established organizations for the delivery of disaster relief supplies in several locations in the Indian and Pacific Oceans. The chart demonstrates how the demand for HF increases dramatically in a very short period of time to accommodate the need to maintain order and organization for the disaster relief effort as well as provide critical communications for those administrations struck by the disaster.

Each bar on Fig. 1 represents assignments for a single day.

The disaster relief operation for the December 2004 Tsunami utilized extensive radiocommunications, primarily HF in the early stages, although satellite communications became available for long distance communications as the work progressed. Two administrations involved in the disaster relief work made use of over 1 000 HF frequency channels between 2 MHz and 29.7 MHz for fixed and mobile communications for relief work in the disaster affected areas. Similar requirements may have been needed by other administrations involved in the relief work.

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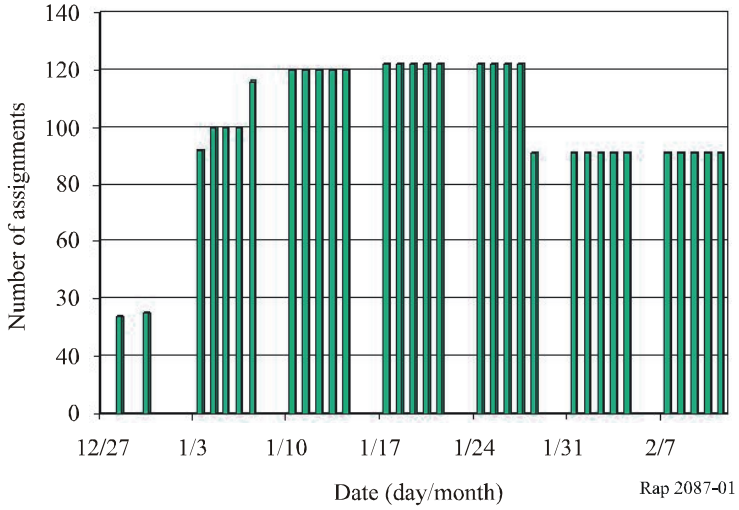
FIGURE 1

**Assignments for Pacific Tsunami**




Because of existing extensive usage of the HF bands in the disaster areas, it was not possible to provide all these channels in accordance with the provisions of the Table of Allocations in the Radio Regulations (RR), although in most cases this was achieved. For example the maritime mobile bands were primarily used for maritime mobile purposes; fixed/mobile bands were primarily used for fixed and mobile purposes, etc. Those frequency assignments that were made in derogation of the regulations, e.g. those in the amateur and broadcasting bands, were made under the provisions of RR No. 4.4.

Frequencies below 10 MHz can generally be used 24-h a day. Because of this 24-h availability they are preferred for use in disaster relief work for local communications, using single side band voice communications. Existing HF usage in the affected areas meant that some of the frequencies used for local communications had to be above 10 MHz, as there was insufficient spectrum available below 10 MHz to meet these requirements.

Frequencies generally above 10 MHz experience ionospheric propagation over long distances during daylight hours. Using these frequencies during daylight for groundwave communications in the disaster area carries with it the risk of causing interference to others or (of far more importance to those involved in the relief work) suffering from interference which may disrupt essential communications. For this reason, frequencies below 10 MHz are preferred for this type of work.

Frequencies in the higher bands were mainly used for long-distance digital communications to the home countries of these two administrations, although a portion was also used to supplement the lower bands to provide local voice communications in the disaster area as well. Initially, these HF circuits were the primary means of communications to the headquarters of the organizations undertaking relief work. As the work progressed, satellite communications became available, however the HF circuits continued to be used to carry a portion of the long distance traffic, as well as being retained as an essential back-up facility to the satellite circuits. Essential back up is required in areas where satellite communications can be interrupted by other factors such as by monsoonal weather conditions causing loss of communications through attenuation of signals caused by heavy rainfall.

Because some HF frequencies could be used simultaneously in the different countries affected by the disaster, a reuse factor of three was achieved, giving rise to an overall usage of around 1 000 kHz of HF for the disaster relief work.

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### 1.2.3 Effect of bands identified in Resolution 544 (WRC-03)

The HF spectrum usage for Tsunami disaster relief work in different bands is shown in Annex 1.

Table 1 summarizes the number of frequency channels that would not have been available for fixed service usage (except under the provisions of RR No. 4.4) if the bands identified in Resolution 544 (WRC-03) were allocated to the broadcasting service on an exclusive basis. The broadcasting service usage would result in strong interfering signals in broadcasting bands. Some use of individual channels could be available for disaster relief work under RR No. 4.4, however, as interference free channels are needed for safety-of-life situations in disaster relief, this usage may not be compatible with sharing spectrum with the broadcasting service.

TABLE 1

**Number of frequency channels affected if the bands identified in Resolution 544 (WRC-03) were allocated to the broadcasting service on an exclusive basis**

| Frequency range (kHz) | Number of affected frequency channels |
|---|---|
| 4 500-4 650 | 1 |
| 5 060-5 250 | 13 |
| 5 840-5 900 | 1 |
| 7 350-7 650 | 25 |
| 9 290-9 400 | 7 |
| 9 900-9 940 | 1 |
| TOTAL | 48 |

Two hundred and seventy-four frequency channels (around 25% of the total) used were between 4 and 10 MHz during the disaster relief operation. Therefore, approximately 17% of the frequencies below 10 MHz used in the Tsunami relief work may have been unavailable depending upon the level of broadcasting usage at the time.

What cannot be estimated is the flow on effect on emergency communications a reallocation of some of these bands to the broadcasting service would have had on communications during the relief work for this disaster, or could have on relief work for future major disasters. If many of the domestic and international circuits presently using the bands identified in Resolution 544 (WRC-03) had been moved to other bands below 10 MHz, congestion in those bands would be greater than at present.

Additionally, if a similar response is required for a future disaster after 2009, the effect of the reallocations to the broadcasting service by WARC-92 and WRC-03 (with dates of effect in 2007 and 2009 respectively) would have to be taken into account in making frequency assignments for use in relief work.

Consequently, it may be much more difficult in future to find spectrum below 10 MHz for all the channels required for similar relief work communications. This will result in a higher percentage of circuits used in the disaster relief work being placed in bands above 10 MHz, which are not the preferred bands for this type of operation.

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### 1.3 Emergence of advanced HF technologies

The lower parts of the HF spectrum represent an essential element of adequate frequency management and constitute an important basis for the reuse of HF resources. But already the spectrum available today does not support the full range of HF radiocommunication requirements and the great variety of capabilities of the equipment available. Because all fixed and mobile users want to increasingly take advantage of new HF technology available on the market. Propagation concerns make it essential that the frequency channels or sub-bands of an HF pool are evenly spaced in order to adapt to the daily and seasonal changes in the ionosphere.

#### 1.3.1 Background

There has been a steady evolution of technology related to HF fixed systems driven by the growth of fixed service use of the HF bands as noted in Table 2. The data capabilities of HF modems has progressively advanced over the past 30-40 years and will continue its growth as new HF fixed applications are developed.

TABLE 2

**The data capabilities of HF modems**

| Decade | 1970 | 1980 | 1990 | 2000+ |
|---|---|---|---|---|
| Data rate (bit/s) | 50 | 2 400 | 9 600 | 19 200-64 000 |

Adaptive systems have not been adopted by all operators; however, second generation adaptive systems were developed in the 1980s and development of third generation systems in the 1990s provide faster link establishment, more robust algorithms and higher data rates.

HF adaptive systems must only be operated on frequency hopsets/frequency pools in order to ensure sufficiently interference-free conditions.

On the other hand, the number of frequencies in a hopset or in an adaptively used frequency pool is directly interrelated to the frequency re-visitation rate, the potential interference level, the interference tolerance of the potential victim (a co-channel or adjacent channel user) and to the operational performance of the own system.

As an example, for the operation of a standard medium hopper with 100-130 hops/ s, an ideal hopset should be composed of about 120 coordinated frequencies. The minimum size would be around 16-20 frequencies to allow hopping at all.

It is obvious that to fully exploit all these chances offered by modern technology, the availability of sufficient spectrum resources is crucial, and even more bandwidth beyond the present standard 3 kHz-channels must be available.

Based on recent developments, there are two HF very high data rate technologies identified which could be considered as technological protagonists:

The channel banding approach is based on the use of several 3 kHz channels. The advent of the first HF 64 kbit/s modem using this technology on the international market was appreciated as a technological highlight.

The wideband channel approach is based on the family of modulation schemes of the Digital Radio Mondiale (DRM) standard offering data rates up to 72 kbit/s for a 20 kHz wideband HF channel. The European Telecommunications Standards Institute (ETSI) has published this option in its “Data Applications Directory”.

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A modern state-of-the-art HF radiocommunication system can be a reliable bearer for many data, fax, messaging, imagery and voice services. It has been demonstrated that HF e-mail is ideally suited for HF channels.

### 1.3.2 Establishing fixed and mobile usage considering advanced technologies

Statistical analysis of fixed and mobile HF usage is problematic after the Radiocommunication Bureau (BR) discontinued assessments of interference potential prior to documenting new frequency assignments.

Until 1995, international agreements for frequency regulation and assignment for the HF fixed services were based on long-standing procedures. Proposals for new assignments were submitted to ITU BR (before 1993 to the IFRB). BR examined the proposal and submitted it to a technical examination for compatibility with existing assignments. If the result of the technical examination showed that the proposed use would not cause harmful interference to an existing assignment, the assignment was included in the Master International Frequency Register (MIFR). The administration then proceeded to authorize the assignment.

For several reasons including time constraints, associated costs of registering frequencies as well as the growth of HF fixed systems, the MIFR has not been steadily updated since 1995 and the entries do not represent actual usage. It is well known that many fixed assignments have not been included in the MIFR and individual administrations keep track of their own assignments and coordinate with other administrations as necessary.

Most users are expected to experience the impact of a complete realignment of the fixed and mobile bands to include the users displaced by the assignments already made internationally to the broadcasting service for 2007 and 2009. This additional congestion will make it difficult for many users to successfully meet their required missions without encountering interference from other fixed and mobile users. Increased usage of adaptive technologies and advanced HF systems will ease this impact, but will unlikely solve it completely.

With the development and introduction of frequency adaptive systems, the MIFR no longer contains accurate information related to fixed service use and therefore the licensing and usage statistics in each administration provides the basis for demonstrating supply and demand of allocated spectrum. In addition to the information maintained by administrations, the evolution of HF fixed system technology is also a very good indicator of the growth of the HF fixed service demonstrating a demand for faster more robust systems.

Given the nature of HF propagation, the use of frequencies across the entire 3-30 MHz band is a requirement for most fixed and mobile users. At a given time of day, season, sun spot cycle, etc. only specific sub-sets of the HF spectrum will successfully propagate a signal through ionosphere refraction. These characteristics impact how the demands by the users are satisfied.

The benefits of advanced technologies are diligently being applied to maximize the use made by fixed and mobile users within the existing allocations under 30 MHz and, in particular between 4 and 10 MHz. This is essential to ensure that the general increased demands placed on the limited spectrum resources are satisfied effectively and efficiently within the existing allocations.

## 2 General information on HF usage

### 2.1 Introduction

This section addresses specific features and technical aspects related to the spectrum support for fixed and mobile service operating in the lower part of the HF range.

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*Typical technical parameters*

**Land mobile**

| | |
|---|---|
| Frequency range: | 1.5-30 MHz |
| Power: | 10-30 dBW |
| Emission designator: | 3k00J3E (98%), 3k00J3A |
| Antenna height: | Maximum 2-15 m |
| Antenna gain: | Minus 10-2 dBi |

**Fixed stations**

| | |
|---|---|
| Frequency range: | 1.5-30 MHz |
| Power: | 30-40 dBW |
| Emission designator: | 2k70J2B, 3k00J3E (98%), 3k00J3A |
| Antenna height: | 10-60 m |
| Antenna gain: | 5-10 dBi |

## 2.2 Background

Ionospheric effects have a severe impact on the use of the HF range, constraining essential operations to the lower bands, i.e. below 10 MHz.

The next World Radiocommunication Conference planned for 2007 (WRC-07), will review the HF bands between 4 and 10 MHz in respect of their allocation to services, taking account of new techniques and, in particular, the spectrum requirements of the broadcasting service. In view of numerous exemptions from this review process, any expansion of the broadcasting bands may – again – have to be made at the expense of the fixed and mobile services.

## 2.3 Specific features of the HF range

The specific HF features have been well known for many decades. Typical types of propagation paths are:

### 2.3.1 Groundwave

In the case of groundwave, the path is up to line-of-sight (LoS) and beyond. This mode is normally used for path lengths up to 50-200 km. The frequencies required are not time dependent but the longer ranges (200 km) require lower frequencies. Therefore, many HF groundwave radiocommunications can only be operated if frequencies are taken from the lower part of the HF band, i.e. below 10 MHz.

### 2.3.2 Skywave

In the case of skywave, the path is not LoS but is affected via reflection at the ionosphere, 100-350 km above the Earth. Ranges of several thousands of kilometres are common. The majority of HF skywave paths also require frequencies taken from the lower part of the HF band, i.e. below 10 MHz.

Evidently, selecting frequencies for the HF skywave is difficult. Whether a frequency will propagate depends on the time of the day, season, the length of the link, etc. For the determination of suitable frequencies it is necessary to use programmes that take all the various factors into account and predict the range of usable frequencies for an HF skywave link.

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