**QUESTION 16/2**

*Preparation of handbooks for developing countries*

**ITU-D** STUDY GROUP 2 2nd STUDY PERIOD (1998-2002)

# *Handbook on disaster communications*

Telecommunication Development Bureau (BDT)

International Telecommunication Union

ITU

## THE STUDY GROUPS OF THE ITU-D

The ITU-D Study Groups were set up in accordance with Resolution 2 of World Telecommunication Development Conference (WTDC) held in Buenos Aires, Argentina, in 1994. For the period 1998-2002, Study Group 1 is entrusted with the study of eleven Questions in the field of telecommunication development strategies and policies. Study Group 2 is entrusted with the study of seven Questions in the field of development and management of telecommunication services and networks. For this period, in order to respond as quickly as possible to the concerns of developing countries, instead of being approved during the WTDC, the output of each Question is published as and when it is ready.

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**QUESTION 16/2**
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# *Handbook on disaster communications*

Telecommunication Development Bureau (BDT)
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# PREFACE

This first edition of the Disaster Communications Handbook, as adopted by ITU-D Study Group 2, for Developing Countries is an ITU-D publication divided into three Parts for the convenience of the reader. Part 1 is intended to provide a background framework for policy makers who have responsibilities in the area of disaster communications planning. Part 2 is designed for those who have an operational role, while Part 3 is a technical annex with useful charts tables and other information.

The Handbook material was developed for the ITU by an international team of experts recruited primarily through the UN Working Group on Emergency Telecommunications (WGET). The WGET secretariat, provided by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) in Geneva, was helpful in organising the work. Special thanks are due to them and also to two other groups, the L.M. Ericsson Company, which generously made a financial contribution to the work, and the International Amateur Radio Union (IARU), which made the initial proposal and provided the impetus for the project.

The Telecommunication Development Bureau thanks all administrations that participated and contributed to this publication.

**Hamadoun I. Touré**

*Director*
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*International Telecommunication Union*

# ITU-D Handbook on disaster communications

# PART 1

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# PART 1

## CHAPTER 1

## Telecommunications in the service of humanitarian assistance – Introduction

### 1.1 Introduction

It took 38 years for radio to reach 50 million people, 13 years for television, and even less for the Internet. The progress in telecommunications technology and applications is growing at ever increasing speed. But so is the gap, the "digital divide", which exists in the world: There are as many telephones in Tokyo as in all of Africa, and there are more computers in the United States of America than in the rest of the world combined.

Novel visions and concepts to bridge this gap have been initiated by the international community, as well as from the private sector. The recognition of the importance of technology in the United Nations Secretary-General's report to the fifty-fourth session of the General Assembly together with the initiatives from commercial entities under their corporate citizenship programmes, demonstrate the awareness for the need to bridge the gap.

In their report to the United Nations, experts expressed their hope "that by the end of 2004 a farmer in Saharan Africa should be able to get to a point of access, let's say in half a day's walk or riding a bullock cart". The experts did, however, admit that other forms of aid – such as food or health – should come first. Again, statistics confirm this caveat. According to the International Labor Organization, a quarter of the world's population of six billion people lives on an income of less than a dollar per day. Even in the country with the world's highest density of telephones, Finland, there were, in 1999, only 107 internet-connected computers per 1000 habitants – and this, too, is the highest number in the world.

We are getting used to technological visions becoming reality almost as fast as we learn about them, but overall development has its own path. It is therefore essential to give priority to the most urgent needs. In as far as telecommunications are concerned, these needs depend on what role communications play in the daily lives and the socio-cultural environment. In as far as humanitarian work, in particular disaster prevention, preparedness, and response are concerned, the differences in type and dimension of needs are as wide as the "digital divide".

Traditionally, disaster communications were centered on the provision of information from, to and at the site of the event, primarily to serve the needs of the providers of assistance. It was realized only during recent tragedies in countries where the permanent availability of local and world-wide communications links is taken for granted by everyone, that access to telecommunications has become a commodity ranging just behind food, shelter and health care.

The existence of knowledge alone is not enough – it needs to be made available through training and its application to be encouraged rather than restricted. Training should be geared not only to those who are developing and implementing appropriate technologies and applications, but also geared to the users, to allow them to make the best use of what can be made available. Limitations include regulatory restrictions based on what can only be called paranoia: Ever since communications exist, the fear that they might do harm if they were uncontrolled and in the wrong hands has prompted restrictive regulations.

Progress has been made in both the training and the regulatory fields. If this handbook, limited to the humanitarian applications of telecommunications as it is, contributes to the further development on both aspects, it will be a valuable tool in the hands of those who, directly or indirectly, serve the most noble of goals:

The prevention, and, where such is not possible, the alleviation of human suffering caused by disasters.

## 1.2 The Purpose of this Handbook

This publication attempts to combine sufficient information concerning disaster communications to permit the reader to evaluate, plan and conduct communications under the extraordinary conditions that often accompany both, natural and man made disasters, and their consequences in respect to communications. It is designed to provide an overview of the field of Disaster Communications by describing the various services and networks in telecommunications that may be useful to the planner while, at the same time providing a framework for analysis of strengths and weaknesses.

## 1.3 Why a Handbook is needed

Telecommunications is in the midst of a period of some of the most rapid change imaginable in regulations, in technology and in access. These multiple changes raise the question of what is the most effective possible application of telecommunications resources to humanitarian assistance and disaster mitigation. Telecommunications networks are becoming increasingly complex and difficult for even the expert to fully understand.

This Handbook equips the disaster communications planner, as well as the field radio operator, with the knowledge to effectively study the requirements for disaster communications, and to make the best use of existing and ad hoc networks in support of relief efforts.

## 1.4 Who should read this Handbook

The Disaster Communications Handbook should be read, studied and understood by every person who has responsibilities connected with the planning, usage, evaluation, or survey of disaster communications systems or their vulnerabilities. It is a project of the Telecommunications Development Sector of the International Telecommunication Union (ITU-D). The idea for the handbook originated in Study Group 2 of ITU-D and is an effort of a number of participants representing numerous governmental, NGO and private business enterprises.

The Handbook was written by partners in humanitarian assistance, as an aide to the wider diffusion of knowledge on the subject of disaster communications. It can be read as a stand-alone text or be used in conjunction with formal training opportunities in the field.

# CHAPTER 2

# The organizational and regulatory framework of disaster communications

## 2.1 Disaster Mitigation: Prevention and Preparedness

Disaster prevention is better than disaster response, but even the best prevention measures can not replace disaster preparedness, and even the highest level of preparedness will never cover all aspects of disaster response. Disaster communications need to concentrate on the response phase, but their effectiveness depends on preparedness.

## 2.2 Disaster Response

Disasters are generally classified as either natural or man-made. In as far as disaster relief is concerned, a classification into sudden on-set disasters and complex Emergencies is more practical, as it is less the cause of the disaster than the sequence of events which dictate the response to it: An outbreak of civil strife (example: Rwanda 1994) can be as sudden as a volcanic eruption, and so are most technological or industrial disasters (Chernobyl 1986). On the other hand, a drought in most cases develops slowly, and its consequences can be highly complex (displacement of populations, civil unrest).

In as far as disaster communications are concerned, sudden on-set disasters are of primary concern, as they create very specific needs. The general communications requirements during the typically longer-term, complex emergencies are often similar to those of developing countries in general.

## 2.3 The Levels of Disaster Response

Local response is, for reasons of time and location, the first element of relief in practically all cases. No national or international assistance can replace the response by local emergency services.

National authorities have the primary overall responsibility for disaster mitigation, preparedness and prevention, as well as for response. Whenever local resources are not sufficient, intervention on the national level is required. It is only in cases, where this second level does not have the response capacity required to cope with the situation, that international assistance is mobilised. While emergency communications on local and national levels can pose enormous problems, the need for satellite communications is most evident on this third level.

## 2.4 Telecommunications in Disaster Response

Disasters typically have a multiple, simultaneous implications on telecommunications supply and demand by creating additional temporary needs at a time of reduced availability and overload of permanent networks. For those responsible for the provision of telecommunications this means to make best use of what remains available while at the same time building up additional capacity.

### 2.4.1 The Existing Public Networks

To the extent that public networks exist and survive the impact of a disasters, they are used in relief operations. The frequent use of high technology, in particular that of satellite communication for international links, has increased the vulnerability of public networks. Their highly centralised structures can – if one vital element such as the antenna of the, possibly only, satellite earth station of a country is damaged – lead to a complete disruption of communications with the “outside world”. This actually occurred on the islands of Mauritius and Rodrigues in the Indian Ocean during cyclone “Hollanda” in February 1994, and the resulting isolation can obviously have dramatic consequences, if international assistance should be required.

The vulnerability of domestic networks has similarly increased: An increasing number of subscribers results, in case of wide-spread damage to a network, in a high number of faults, each of which is likely to add to the delays in restoration of communications even with vital establishments such as hospitals.

### 2.4.2 The Existing Specialised Networks

Local and national emergency services dispose in most cases of their own permanent networks. If properly maintained, these tend to be less vulnerable than public systems, but a lack of compatibility between technical specifications of the equipment used by different services often limits their usefulness. This specific problem is greatly enhanced in cases, where international assistance is provided by foreign services such as Search and Rescue Teams who arrive with their own communications support, generally incompatible among themselves as well as with networks in the affected location.

### 2.4.3 The Amateur Radio Service

The amateur radio service plays a double role, not only as a specialised permanent network, but as a provider of operators and technical resource persons with specific skills and experience in situations where the best use has to be made of what is available. Disaster communications have much in common with the character of amateur radio in respect to both operational procedures and technical conditions. The technical annex of this handbook is therefore largely based on work done by the international amateur radio community.

### 2.4.4 The Additional Telecommunications Requirements during a sudden on-set Disaster

For co-ordination purposes, links within and between all three levels, local, national and international, are vital. The type and structure of the networks need to correspond to the structures of the response operations within and between all levels.

- On the local level individual members of rescue teams and other services need to communicate with their team leaders, the latter with the on-site operations co-ordination centre (OSOCC), and the on-site centre with the local headquarters of the public services, police and hospitals involved in the relief operations. This traffic mostly uses voice.

- On the national level, the on-site centre needs links to the disaster management team and the national emergency operations centre, and often needs to provide links between leaders of teams at the disaster site and their respective national headquarters.

- On the international level, emergency communications via satellite are complementary to shortwave radio links. Many of the partners in international humanitarian assistance maintain and expand the networks they have built up over a long period of time, and have greatly enhanced their efficiency through the use of advanced data communication modes.

# CHAPTER 3

# The international regulatory framework

## 3.1 The International Regulatory Framework of Disaster Communications

While maritime distress and safety communications have traditionally enjoyed privileges such as absolute priority over any other traffic, the same is not the case for emergency telecommunications on land. The traditional position of telecommunications as a monopoly of a sovereign state restricts the use of any telecommunication equipment other than those registered and licensed in the country where they are to be used.

It is important to note that effective and appropriate international humanitarian assistance cannot be provided without functioning telecommunications, especially when nationally available resources often cannot cover all needs before, during and after disasters. Over the years, various concerned parties involved in both disaster relief and mitigation as well as telecommunication development have recognized the need for an international framework on the provision of telecommunication resources for disaster mitigation and relief operations. In 1991, an international Conference on Disaster Communications was convened in Tampere, Finland, and was attended by disaster and telecommunications experts. The Conference adopted the Tampere Declaration on Disaster Communications, which stresses the need to create an international legal instrument on telecommunication provision for disaster mitigation and relief. This was done with the recognition that regular communication links were often disrupted during disasters, and that regulatory barriers often crippled the use of emergency communications equipment across artificial boundaries. The Declaration requested the United Nations Emergency Relief Coordinator to cooperate with the International Telecommunication Union (ITU) and other relevant organizations, consistent with the goals and objectives of the International Decade for Natural Disaster Reduction (IDNDR). It invited them to convene an intergovernmental conference for the adoption of a convention on disaster communications.

The Tampere Declaration was annexed to the unanimously adopted Resolution No. 7 (Disaster Communications) of the first World Telecommunication Development Conference (WTDC-94, Buenos Aires, 1994). The Resolution urges all administrations to remove national regulatory barriers in order to allow the unhindered use of telecommunications in disaster mitigation and relief. It also requests the Secretary-General of the ITU to work closely with the United Nations and within the framework of IDNDR towards an international convention on disaster communications.

Within the same year, Resolution No. 7 was in turn endorsed by Resolution No. 36 (Disaster Communications) of the ITU Plenipotentiary Conference (PP-94, Kyoto, 1994). Resolution No. 36 reiterates the need for an International Convention on Disaster Communications, and echoes Resolution No. 7 in urging administrations to reduce and/or remove regulatory barriers to facilitate rapid deployment and effective use of telecommunication resources for disaster relief operations.

In the sense of these resolutions, and under a mandate given by the Inter Agency Standing Committee (IASC, the UN advisory body on humanitarian affairs), the Working Group on Emergency Telecommunications (WGET) was established. It's meetings are convened by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and its predecessors, UNDRO and DHA, and it serves as an open forum for the discussion of all emergency telecommunication related issues. The WGET includes all partners in humanitarian assistance and emergency telecommunications, United Nations entities as well as major international and national, governmental and non-governmental organizations, and experts from the academia and the private sector. Since 1995, the WGET developed and reviewed drafts of an International Convention on Emergency Telecommunications.

The ITU Secretary-General circulated a first official draft of the "Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations" to all ITU Member States in 1996. The World Radiocommunication Conference (WRC-97, Geneva, 1997) unanimously adopted Resolution No. 644, urging all administrations to give their full support to the adoption of the convention and its national implementation.

In the same way, the second World Telecommunication Development Conference (WTDC-98, Valletta) adopted Resolution No. 19. Besides endorsing all the aforementioned resolutions, this resolution invites the UN Emergency Relief Coordinator and the WGET to collaborate closely with ITU in supporting administrations and international and regional telecommunication organizations in the implementation of the Convention. The ITU Telecommunication Development Sector was invited to ensure that proper consideration be given to emergency telecommunications as an element of telecommunication development, including the encouragement for the use of decentralized means of telecommunications. This handbook is an example of the response by the ITU.

## 3.2 The Tampere Convention

The international efforts in emergency telecommunications came into fruition when from 16 to 18 June 1998, at the invitation of the Government of Finland, 76 countries and various intergovernmental and non-governmental organizations participated in the Intergovernmental Conference on Emergency Telecommunications (ICET-98) at Tampere, Finland. Thirty-three of the participating States signed the treaty, now called the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations, on 18 June 1998.

During the Plenipotentiary Conference of the ITU (Minneapolis, 1998), the national plenipotentiaries unanimously adopted Resolution 36, urging national administrations to sign and ratify the Tampere Convention as soon as practicable. The resolution also urges a speedy application of the Convention.

Furthermore, the 54th session of the United Nations General Assembly, 1999, called in its resolution 54/233 for the ratification and implementation of the Tampere Convention.

### 3.2.1 The Contents of the Tampere Convention

The structure of the Convention follows the format which is characteristic for international treaties, and its text contains, in addition to the substantive paragraphs, the stipulations required for a treaty deposited with the United Nations Secretary-General.

- The Preamble of the Convention notes the essential role of telecommunications in humanitarian assistance and the need for its facilitation, and recalls the major legal instruments, such as respective Resolutions of United Nations and of the International Telecommunications Union, which prepared the way for the Tampere Convention.
- Article 1 defines the terms used in the Convention. Of particular significance are the definitions of non-governmental organizations and non-State entities, as the Tampere Convention is the first treaty of its kind, which attributes privileges and immunities to their personnel.
- Article 2 describes the operational coordination, to be carried out by the United Nations Emergency Relief Coordinator (i.e. through the United Nations Office for the Coordination of Humanitarian (OCHA).
- Article 3 defines the overall framework for the cooperation among States Parties and all partners in international humanitarian assistance, including non-State entities.
- Article 4 describes the procedures for request and provision of telecommunications assistance, specifically recognizing the right of a State Party to direct, control and coordinate assistance provided under this Convention within its territory.

- Article 5 defines the privileges, immunities and facilities to be provided by the Requesting State Party, again emphasizing that nothing in this Article shall prejudice rights and obligations pursuant to international agreements or international law.

- Articles 6, 7 and 8 define specific elements and aspects of the provision of telecommunication assistance, such as Termination of Assistance, Payment or Reimbursement of Costs or Fees, and establishment of a Telecommunications Assistance Inventory.

- Article 9 can be considered as the core element of the Tampere Convention, as the Removal of Regulatory Barriers has been the primary aim of the work towards this treaty since 1990.

- The remaining Articles, 10 to 17, contain the standard provisions concerning the relationship between the Convention's and other international agreements, as well as dispute settlement, entry into force, amendments, reservations, and denunciation. They state that the Secretary-General of the United Nations is the depositary of the Convention and that the Arabic, Chinese, English, French, Russian and Spanish texts of the Convention are equally authentic.

### 3.2.2 Guidelines for the Signature, Ratification, Acceptance, Approval or Accession

The "Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations" is an international treaty among States. It is binding for those States who have stated their accession to it, but all or part of its content can at any time also be applied by reference to it in bi- or multi-lateral agreements governing international humanitarian assistance. The United Nations Secretary-General is the Depositary of the Convention (Art. 16). The Office of Legal Affairs, Treaty Section, United Nations Headquarters, New York, is in charge of the relevant procedures. The United Nations Emergency Relief Coordinator and Under Secretary-General for Humanitarian Affairs is the Operational Coordinator for the application of the Convention (Art. 2). The United Nations Office for the Coordination of Humanitarian Affairs (OCHA), Geneva Office, is in charge of the implementation and execution of the respective functions and works closely with the International Telecommunication Union (ITU).

The Working Group on Emergency Telecommunications (WGET), regularly convened by OCHA and including all partners in international humanitarian assistance as well as the ITU, serves as the advisory board for the work. OCHA maintains, under its project on Emergency Telecommunications with and in the Field, the secretariat of the WGET.

A State may express its consent to be bound by the convention by

- definitive signature;

- signature subject to ratification, acceptance or approval followed by deposit of an instrument of ratification, acceptance or approval;

- deposit of an instrument of ratification.

The consent of a State to be bound may be expressed at any time; in view of the urgent need for the full application of the Convention it is, however, desirable, that the procedures for this purpose be completed with the depositary as soon as possible. Procedures relating to signature should follow the instructions in the attached note by the Legal Counsel of the United Nations. On all related matter it is advised that the assistance of the Treaty Section of the United Nations be sought. The Convention will enter into force thirty days after the deposit of such instruments by thirty States.

### 3.2.3 The main Implications for Signatories

Depending on applicable national legislation, the accession to an international treaty may require consultations with and/or approval by various legislative and executive bodies. The same applies to an adjustment of national laws, rules and regulations, which might be necessary to comply with the substantive articles of the treaty. In the course of these procedures the following aspects might deserve special consideration:

- The Convention has the purpose to expedite and facilitate the use of emergency telecommunications within the framework of international humanitarian assistance. Such telecommunication assistance can be provided as a direct assistance, provided to national institutions and / or a location or region affected by a disaster, and / or as part or in support of other disaster mitigation and relief activities.

- The Convention defines the status of the personnel of the various partners in international humanitarian assistance, including that of government entities, international organizations, non-governmental organizations and other non-state entities, and defines their privileges and immunities.

- The Convention fully protects the interests of the States requesting and receiving assistance. The host government retains the right to supervise the assistance.

- The Convention foresees the establishment of bilateral agreements between the provider(s) of assistance and the State requesting/receiving such assistance. Standard frameworks for such agreements will be developed by the WGET. To avoid delay in the delivery of assistance, “best practices” will be codified into common implementing language. The use of such model agreements, which will be made available in hard copy and electronic format, will allow the immediate application of the Tampere Convention in any sudden impact disaster.

# CHAPTER 4

# The role of international organizations in disaster communications

## 4.1 The International Telecommunication Union (ITU)

The role of the ITU is a specialized agency of the United Nations System.

Article 1, Section 2 g of the ITU Constitution provides that ITU shall "promote the adoption of measures for ensuring the safety of life through the cooperation of telecommunication services".

This mandate has been further enhanced through resolutions of recent World Telecommunication and World Radiocommunication Conferences, and most recently endorsed in Resolution 36 the Plenipotentiary Conference (Minneapolis, 1998). The ITU works in close cooperation with the United Nations Emergency Coordinator and head of the Office of the Coordinator of Humanitarian Affairs (OCHA), and is a member of the Working Group on Emergency Telecommunications (WGET).

The role of the Union under the Tampere Convention and related instruments is further specified in Chapter 3 above.

## 4.2 Other International Organizations and Institutions

Initial response to any disaster is the responsibility of the local community. Only if and when the assistance required goes beyond the resources and capacities of the local response mechanisms, the mechanisms for regional, national and, ultimately, international assistance are mobilized. It is however important to note, that all such response depends on a request for or on the acceptance of an offer of assistance from the country affected by a disaster, and that all assistance from abroad must be closely coordinated with the national authorities.

A wide range of national and international, governmental and non-governmental institutions provide international humanitarian assistance. In order to carry out their tasks, they all depend on the availability of reliable communications under unpredictable and often extremely difficult conditions.

### 4.2.1 United Nations Entities

The United Nations system includes specialized agencies for the various aspects of humanitarian work, including disaster response. Their cooperation is ensured through the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), headed by the United Nations Emergency Relief Coordinator with offices in Geneva and New York, and with field offices in a number of countries. Using a permanent, 24 hours per day/365 days per year duty system, OCHA uses all available means of telecommunications to monitor events, and to immediately alert the international community to mobilize appropriate resources in cases where international assistance is likely to be required.

In the event of an emergency, OCHA dispatches United Nations Disaster Assessment and Coordination (UNDAC) teams to a country affected by a disaster. Such teams typically arrive at the site of the event within hours and support the national authorities in the coordination of international assistance.

In the affected countries, the various entities of the United Nations system work together in the Disaster Management Team (DMT). Such a team is convened by the Resident Coordinator, in most cases the Representative of the United Nations Development Programme (UNDP), which has offices in almost all member states of the United Nations. Depending on the nature of the emergency, the various agencies and institutions provide assistance in their specific field.

The United Nations entities most commonly involved in disaster response include are, in addition to OCHA, the World Food Programme (WFP) providing emergency food as well as logistics services for other relief goods, the Office of the United Nations High Commissioner for Refugees (UNHCR), providing shelter and related assistance for the affected population, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), providing health services in particular for the most vulnerable groups. Depending on the nature of assistance required, other agencies participate in their specific fields.

Throughout the monitoring, alert, mobilization and response process, telecommunications are of vital importance. All United Nations entities maintain common and own networks, and have the capacity to extent such networks in cases where other means of communication are affected by a disaster. The interaction of all networks is ensured through the mechanism of the WGET, and in the affected country a Telecommunications Coordination Officer (TCO) is responsible for the optimum use of all available networks.

### 4.2.2 International Non-Governmental Organizations (NGO)

International non-governmental organizations (NGO) play a key role in the provision of operational assistance. A well-known example for an international NGO is the International Federation of Red Cross and Red Crescent Societies (IFRC) with its national member societies worldwide. The IFRC and other NGOs maintain their own telecommunication networks and support their national counterparts when normal channels of communication are disrupted by a disaster. A new and important group among the NGOs, are commercial companies, such as Ericsson, who make the expertise resources of their headquarters and their offices in many countries available to support disaster relief operations.

### 4.2.3 National Governmental Institutions providing International Assistance

Similar to non-governmental organizations, national institutions in many countries provide disaster relief abroad. Examples are the Swedish Rescue Services Agency (SRSA), the Swiss Disaster Relief Unit (SDR), and the German "Technisches Hilfswerk". They often provide services in specific fields they may provide their assistance under bilateral arrangements with the receiving country or as implementing partners in United Nations relief operations. National organizations for international assistance usually provide telecommunications for their own needs, and are, in some cases, also able to support other institutions, such as the United Nations, NGOs and national rescue services, with telecommunication support.

### 4.2.4 The International Committee of the Red Cross (ICRC)

The ICRC has a specific status in international law, which differentiates this body from NGOs. While the ICRC is in many cases a provider of operational humanitarian assistance, its primary function is the implementation of the Geneva Conventions, which govern humanitarian law in case of conflict. The ICRC delegations in many countries worldwide are linked by their telecommunication network, which can be reinforced in case of need created by the impact of a disaster.

### 4.2.5 Regional Organizations

In both, the humanitarian and the telecommunications sector, the importance of regional organizations of governmental or non-governmental character is increasing. Examples are the Caribbean Disaster Emergency Response Agency (CDERA) and the Caribbean Telecommunication Union (CTU, telecommunications authorities) and the Caribbean Association of National telecommunications Operators (CANTO, network operators). Regional cooperation, in fields like training for emergency response between the sectors can best be ensured through these mechanisms.

# CHAPTER 5

# National frameworks

## 5.1 National Disaster Management Structures

The attribution of disaster-related functions differs from country to country. In most cases, the attribution of functions follows the country's administrative structures, with a disaster coordinator for each district, state, county or similar geographical division. The "horizontal" cooperation among specialized services on each level is as essential as the vertical "lines of command"; for disaster communication this requires established links between disaster coordinators and telecommunication authorities and service providers on each level.

This need for coordination throughout the national structures applies also for international humanitarian assistance, where the national government is the primary counterpart of the foreign providers of assistance, while their operational activities must be fully integrated with those under the responsibility of the respective levels. A "Disaster Management Team", normally convened by the United Nations Resident Representative and consisting of all international organizations present in the affected country is established in the capital. It's counterpart is the entity or official which has the function of a national disaster manager. On the local level, an on-site operational coordination center (OSOCC), usually established by a United Nations Disaster Assessment and Coordination (UNDAC) team, ensures the integration of international assistance with the national and local partners at the site of the event. Reliable communications are a prerequisite for the function of each of these mechanisms and for their interaction.

## 5.2 The National Regulatory Framework for Disaster Communications

The laws and regulations governing telecommunications in any country are often complex the legislative mechanisms cannot always follow rapid advances in technology. Among the national telecommunication and related legal restrictions with particular importance to disaster communications are the requirements for radio licenses, type approval for telecommunication equipment, frequency allocations and import restrictions or customs duties.

When an international search-and-rescue team with its own telecommunication equipment arrives at a disaster-stricken country, the equipment may face assessment by custom officials. The same equipment may have to be type-approved before being used. Foreign providers of assistance as well as national public network operators have to fulfill the licensing requirements. Some or all of these processes may take a long period, and precious time may be lost in activities such as search and rescue may be lost. The Tampere Convention therefore recommends the removal or reduction of regulatory barriers for the provision of telecommunication resources for disaster mitigation and relief operations. In the spirit of the Tampere Convention, States Parties are furthermore requested to provide for the privileges and immunities of disaster communications personnel, including immigration formalities, and should maintain a national telecommunication assistance information inventory.

## 5.3 The Development of a National Disaster Communications Concept

As part of the implementation of the Tampere Convention, pilot projects in several countries were carried out in developing countries to assess the strengths, weaknesses, opportunities and threats of the disaster communications networks. These projects usually attempt to learn about and evaluate the background information on prevalent disasters in a country, the problems and constraints of disaster communications, the existing disaster-response operational structure and the equipment and personnel involved. Based on such information, recommendations – institutional, regulatory, technical and financial – are presented for consideration by the appropriate national authorities for improving or building up a national disaster communications concept.

### 5.3.1 The overall Concept of a National Disaster Communications Review and Plan

The specific situation in each country will have to determine the structure of the study and the resulting report and plans, the studies listed in the annex to this publication, and possible further studies, which will be available from the Secretariat of the WGET may serve as guidelines. The WGET secretariat can furthermore assist in the identification of experts with experience in the assessment of national disaster communications structures and the development of concepts.

## 5.4 The Methods and Scope of a Study

The involvement of both the disaster managers and the telecommunication entities on each level and throughout the study is essential for applicability of the results. The following paragraphs list some key elements of such work, each of which may be of higher or lower importance in each particular case. All available communications networks need to be analyzed; the following considerations refer to public networks, which are commonly most complex. With the necessary changes they apply, however, equally to private networks such as those of public safety institutions, other specialized networks, links to maritime and aeronautical networks and to the emergency preparedness concepts of the Amateur Radio Service.

### 5.4.1 Confidentiality Considerations

Experience shows that gathering information on network vulnerability may not be possible without the approval of senior management and governmental officers. The vulnerability of National Telecommunications systems might be of great interest to would-be-saboteurs. Therefore accurate information about the exact layout of networks is at best in ‘Commercial Confidence’ and may be classified as a national secret, with all that that implies. Consequently, telecommunication staff may be reluctant to give information, when questions are asked for the purpose of disaster preparation. Network operators may not agree to give information unless the results are available only to a specified group on a ‘Need to Know’ basis.

Authority for a study of the vulnerability of systems will usually have to come from the highest levels of the authorities and entities concerned. A ‘Non Disclosure Agreement’, ‘Non Disclosure Forum’ or ‘Memorandum of Understanding’ may need to be entered into with their legal departments before a study can be undertaken.

### 5.4.2 Telecommunications Operators

In many countries a de-regulation and privatization of telecommunications has taken place, and any operator might be in competition with other enterprises. Information about the capacity of a network may be of commercial interest to a competitor and result in reluctance to answer capacity related questions. An instruction to release such information must come from the most senior level of management. The operating company may have ‘Business Continuity Manager’, often reporting directly to the Chief Executive Officer (CEO). This person is responsible for the rapid restoration of business capacity for the company and likely to have a good knowledge of the vulnerabilities of the system. Many companies have a ‘business continuity. Such a plan details the position of spares and the logistical plans for rapid restoration of services, and restoration of data.

### 5.4.3 Results

The results of the study, supplied by the network operator, may be difficult to interpret. It will likely refer to ‘Erlang’ values and high-level PCM capacities but may avoid mention of transmission methods or back up power systems. Businessmen may tend to emphasize the strengths and play down the weaknesses of their networks, and an independent researcher will have to keep this in mind when performing the evaluation.

The study should consider three related but different issues,

- Capacity
- Vulnerability.
- Rapid recovery

### 5.4.4 Network Capacity

Very few telecom systems are designed to carry all the traffic that the users could possibly generate. That would be hopelessly uneconomical, so the designers make various assumptions about what the highest load on a busy working day is likely to be.

A typical residential area switch design assumes that about 5% of the users will be using it at any one time. In business districts, this figure may be closer to 10%. For example, a typical 10,000 line exchange in a residential area may be able to carry only 500 phone calls at one time. The 501st person to make a call will get a 'congestion tone', or no 'dial tone'.

On any network remaining functional after the impact of a disaster, traffic is likely to increase dramatically. It is therefore important to study how systems behave during acute overload situations. In some systems, a public switch will respond to an overload situation by sending a signal to surrounding switches advising them that the incoming routes to the switch are closed. In this case it will not be possible to reach any subscriber on that switch from outside, but it will still be possible for users of that switch to make calls to the outside. Planners should reflect this when designing information flows within their organizations.

Priority can be offered to some users of the network, but the details of how this is done and how priority users can be identified are potentially sensitive issues. In the case of 'wireline' systems, it may be on the basis of prioritizing individual lines. In mobile systems this may take the form of a 'classmark' for the phone, or a "Preemptive capability indication" feature on the account, which allows certain users to jump the queue. In data systems it may take the form of differentiating the 'sub-net' grade of service. In all cases where competition between operators exists, mandatory application of the same determination criteria for all providers of public network services is indispensable.

### 5.4.5 Additional Vulnerabilities

The impact of natural disasters can further reduce the capacity of a telecommunications network by damaging elements on which it depends, such as power stations and the related distribution infrastructure, cable networks, switches and transmission stations. The resulting loss of power can be detrimental to a telecommunication system. Such damage will be discussed below.

### 5.4.6 Recovery

When equipment is damaged or destroyed, it needs to be replaced or repaired quickly. The operator will need rapid assistance from the supplier of the systems, which may be from outside the country. Since their contribution to the rapid restoration of communications is in the national interest, diplomatic assistance, perhaps on the basis of the Tampere Convention may be in order to expedite equipment import. The extreme urgency of the situation means that international law allows for the 'reduction or removal' of normal importation restrictions in order to expedite such vital work.

## 5.5 The Implementation of the National Disaster Communications Plan

A plan, which is developed in close cooperation with all those national entities that are concerned with disaster management or with telecommunications, has the best prospects of being fully implemented. Experience shows that the awareness for the need for any disaster plan is always highest in the aftermath of a disaster and diminishes quickly when time goes by without the occurrence of a major emergency. It is therefore essential to establish, as part of the plan itself, a mechanism for the periodic review of all measures taken in the implementation of a disaster communications plan.

## Bibliography

The documents listed in this bibliography appear in the Annexes.

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# ANNEX 1

## Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations

## THE STATES PARTIES TO THIS CONVENTION,

*recognizing*

that the magnitude, complexity, frequency and impact of disasters are increasing at a dramatic rate, with particularly severe consequences in developing countries,

*recalling*

that humanitarian relief and assistance agencies require reliable, flexible telecommunication resources to perform their vital tasks,

*further recalling*

the essential role of telecommunication resources in facilitating the safety of humanitarian relief and assistance personnel,

*further recalling*

the vital role of broadcasting in disseminating accurate disaster information to at-risk populations,

*convinced*

that the effective, timely deployment of telecommunication resources and that rapid, efficient, accurate and truthful information flows are essential to reducing loss of life, human suffering and damage to property and the environment caused by disasters,

*concerned*

about the impact of disasters on communication facilities and information flows,

*aware*

of the special needs of the disaster-prone least developed countries for technical assistance to develop telecommunication resources for disaster mitigation and relief operations,

*reaffirming*

the absolute priority accorded emergency life-saving communications in more than fifty international regulatory instruments, including the Constitution of the International Telecommunication Union,

*noting*

the history of international cooperation and coordination in disaster mitigation and relief, including the demonstrated life-saving role played by the timely deployment and use of telecommunication resources,

*further noting*

the Proceedings of the International Conference on Disaster Communications (Geneva, 1990), addressing the power of telecommunication systems in disaster recovery and response,

*further noting*

the urgent call found in the Tampere Declaration on Disaster Communications (Tampere, 1991) for reliable telecommunication systems for disaster mitigation and disaster relief operations, and for an international Convention on Disaster Communications to facilitate such systems, *further noting*

United Nations General Assembly Resolution 44/236, designating 1990-2000 the International Decade for Natural Disaster Reduction, and Resolution 46/182, calling for strengthened international coordination of humanitarian emergency assistance,

*further noting*

the prominent role given to communication resources in the Yokohama Strategy and Plan of Action for a Safer World, adopted by the World Conference on Natural Disaster Reduction (Yokohama, 1994),

*further noting*

Resolution 7 of the World Telecommunication Development Conference (Buenos Aires, 1994), endorsed by Resolution 36 of the Plenipotentiary Conference of the International Telecommunication Union (Kyoto, 1994), urging governments to take all practical steps for facilitating the rapid deployment and the effective use of telecommunication equipment for disaster mitigation and relief operations by reducing and, where possible, removing regulatory barriers and strengthening cooperation among States,

*further noting*

Resolution 644 of the World Radiocommunication Conference (Geneva, 1997), urging governments to give their full support to the adoption of this Convention and to its national implementation,

*further noting*

Resolution 19 of the World Telecommunication Development Conference (Valletta, 1998), urging governments to continue their examination of this Convention with a view to considering giving their full support to its adoption,

*further noting*

United Nations General Assembly Resolution 51/194, encouraging the development of a transparent and timely procedure for implementing effective disaster relief coordination arrangements, and of ReliefWeb as the global information system for the dissemination of reliable and timely information on emergencies and natural disasters,

*with reference*

to the conclusions of the Working Group on Emergency Telecommunications regarding the critical role of telecommunications in disaster mitigation and relief,

*supported*

by the work of many States, United Nations entities, governmental, intergovernmental, and non-governmental organizations, humanitarian agencies, telecommunication equipment and service providers, media, universities and communication- and disaster-related organizations to improve and facilitate disaster-related communications,

*desiring*

to ensure the reliable, rapid availability of telecommunication resources for disaster mitigation and relief operations, and

*further desiring*

to facilitate international cooperation to mitigate the impact of disasters, *have agreed as follows:*

## Article 1

Definitions

Unless otherwise indicated by the context in which they are used, the terms set out below shall have the following meanings for the purposes of this Convention:

1. “State Party” means a State which has agreed to be bound by this Convention.

2. “Assisting State Party” means a State Party to this Convention providing telecommunication assistance pursuant hereto.

3. “Requesting State Party” means a State Party to this Convention requesting telecommunication assistance pursuant hereto.

4. “This Convention” means the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations.

5. “The depositary” means the depositary for this Convention, as set forth in Article 16.

6. “Disaster” means a serious disruption of the functioning of society, posing a significant, widespread threat to human life, health, property or the environment, whether caused by accident, nature or human activity, and whether developing suddenly or as the result of complex, long-term processes.

7. “Disaster mitigation” means measures designed to prevent, predict, prepare for, respond to, monitor and/or mitigate the impact of, disasters.

8. “Health hazard” means a sudden outbreak of infectious disease, such as an epidemic or pandemic, or other event posing a significant threat to human life or health, which has the potential for triggering a disaster.

9. “Natural hazard” means an event or process, such as an earthquake, fire, flood, wind, landslide, avalanche, cyclone, tsunami, insect infestation, drought or volcanic eruption, which has the potential for triggering a disaster.

10. “Non-governmental organization” means any organization, including private and corporate entities, other than a State or governmental or intergovernmental organization, concerned with disaster mitigation and relief and/or the provision of telecommunication resources for disaster mitigation and relief.

11. “Non-State entity” means any entity, other than a State, including non-governmental organizations and the Red Cross and Red Crescent Movement, concerned with disaster mitigation and relief and/or the provision of telecommunication resources for disaster mitigation and relief.

12. “Relief operations” means those activities designed to reduce loss of life, human suffering and damage to property and/or the environment caused by a disaster.

13. “Telecommunication assistance” means the provision of telecommunication resources or other resources or support intended to facilitate the use of telecommunication resources.

14. “Telecommunication resources” means personnel, equipment, materials, information, training, radio-frequency spectrum, network or transmission capacity or other resources necessary to telecommunications.

15. “Telecommunications” means any transmission, emission, or reception of signs, signals, writing, images, sounds or intelligence of any nature, by wire, radio, optical fibre or other electromagnetic system.

## Article 2

Coordination

1. The United Nations Emergency Relief Coordinator shall be the operational coordinator for this Convention and shall execute the responsibilities of the operational coordinator identified in Articles 3, 4, 6, 7, 8, and 9.

2. The operational coordinator shall seek the cooperation of other appropriate United Nations agencies, particularly the International Telecommunication Union, to assist it in fulfilling the objectives of this Convention, and, in particular, those responsibilities identified in Articles 8 and 9, and to provide necessary technical support, consistent with the purposes of those agencies.

3. The responsibilities of the operational coordinator under this Convention shall be limited to coordination activities of an international nature.

## Article 3

General Provisions

1. The States Parties shall cooperate among themselves and with non-State entities and intergovernmental organizations, in accordance with the provisions of this Convention, to facilitate the use of telecommunication resources for disaster mitigation and relief.

2. Such use may include, but is not limited to:

a) the deployment of terrestrial and satellite telecommunication equipment to predict, monitor and provide information concerning natural hazards, health hazards and disasters;

b) the sharing of information about natural hazards, health hazards and disasters among the States Parties and with other States, non-State entities and intergovernmental organizations, and the dissemination of such information to the public, particularly to at-risk communities;

c) the provision of prompt telecommunication assistance to mitigate the impact of a disaster; and

d) the installation and operation of reliable, flexible telecommunication resources to be used by humanitarian relief and assistance organizations.

3. To facilitate such use, the States Parties may conclude additional multinational or bilateral agreements or arrangements.

4. The States Parties request the operational coordinator, in consultation with the International Telecommunication Union, the depositary, and other relevant United Nations entities and intergovernmental and non-governmental organizations, to use its best efforts, in accordance with the provisions of this Convention, to:

a) develop, in consultation with the States Parties, model agreements that may be used to provide a foundation for multinational or bilateral agreements facilitating the provision of telecommunication resources for disaster mitigation and relief;

b) make available model agreements, best practices and other relevant information to States Parties, other States, non-State entities and intergovernmental organizations concerning the provision of telecommunication resources for disaster mitigation and relief, by electronic means and other appropriate mechanisms;

c) develop, operate, and maintain information collection and dissemination procedures and systems necessary for the implementation of the Convention; and

d) inform States of the terms of this Convention, and to facilitate and support the cooperation among States Parties provided for herein.

5. The States Parties shall cooperate among themselves to improve the ability of governmental organizations, non-State entities and intergovernmental organizations to establish mechanisms for training in the handling and operation of equipment, and instruction courses in the development, design and construction of emergency telecommunication facilities for disaster prevention, monitoring and mitigation.

## Article 4

Provision of Telecommunication Assistance

1. A State Party requiring telecommunication assistance for disaster mitigation and relief may request such assistance from any other State Party, either directly or through the operational coordinator. If the request is made through the operational coordinator, the operational coordinator shall immediately disseminate this information to all other appropriate States Parties. If the request is made directly to another State Party, the requesting State Party shall inform the operational coordinator as soon as possible.

2. A State Party requesting telecommunication assistance shall specify the scope and type of assistance required and those measures taken pursuant to Articles 5 and 9 of this Convention, and, when practicable, provide the State Party to which the request is directed and/or the operational coordinator with any other information necessary to determine the extent to which such State Party is able to meet the request.

3. Each State Party to which a request for telecommunication assistance is directed, either directly or through the operational coordinator, shall promptly determine and notify the requesting State Party whether it will render the assistance requested, directly or otherwise, and the scope of, and terms, conditions, restrictions and cost, if any, applicable to such assistance.

4. Each State Party determining to provide telecommunication assistance shall so inform the operational coordinator as soon as possible.

5. No telecommunication assistance shall be provided pursuant to this Convention without the consent of the requesting State Party. The requesting State Party shall retain the authority to reject all or part of any telecommunication assistance offered pursuant to this Convention in accordance with the requesting State Party's existing national law and policy.

6. The States Parties recognize the right of requesting States Parties to request telecommunication assistance directly from non-State entities and intergovernmental organizations, and the right of non-State entities and intergovernmental organizations, pursuant to the laws to which they are subject, to provide telecommunication assistance to requesting States Parties pursuant to this Article.

7. A non-State entity or intergovernmental organization may not be a “requesting State Party” and may not request telecommunication assistance under this Convention.

8. Nothing in this Convention shall interfere with the right of a State Party, under its national law, to direct, control, coordinate and supervise telecommunication assistance provided under this Convention within its territory.

## Article 5

Privileges, Immunities, and Facilities

1. The requesting State Party shall, to the extent permitted by its national law, afford to persons, other than its nationals, and to organizations, other than those headquartered or domiciled within its territory, who act pursuant to this Convention to provide telecommunication assistance and who have

been notified to, and accepted by, the requesting State Party, the necessary privileges, immunities, and facilities for the performance of their proper functions, including, but not limited to:

a) immunity from arrest, detention and legal process, including criminal, civil and administrative jurisdiction of the requesting State Party, in respect of acts or omissions specifically and directly related to the provision of telecommunication assistance;

b) exemption from taxation, duties or other charges, except for those which are normally incorporated in the price of goods or services, in respect of the performance of their assistance functions or on the equipment, materials and other property brought into or purchased in the territory of the requesting State Party for the purpose of providing telecommunication assistance under this Convention; and

c) immunity from seizure, attachment or requisition of such equipment, materials and property.

2. The requesting State Party shall provide, to the extent of its capabilities, local facilities and services for the proper and effective administration of the telecommunication assistance, including ensuring that telecommunication equipment brought into its territory pursuant to this Convention shall be expeditiously licensed or shall be exempt from licensing in accordance with its domestic laws and regulations.

3. The requesting State Party shall ensure the protection of personnel, equipment and materials brought into its territory pursuant to this Convention.

4. Ownership of equipment and materials provided pursuant to this Convention shall be unaffected by their use under the terms of this Convention. The requesting State Party shall ensure the prompt return of such equipment, material and property to the proper assisting State Party.

5. The requesting State Party shall not direct the deployment or use of any telecommunication resources provided pursuant to this Convention for purposes not directly related to predicting, preparing for, responding to, monitoring, mitigating the impact of or providing relief during and following disasters.

6. Nothing in this Article shall require any requesting State Party to provide its nationals or permanent residents, or organizations headquartered or domiciled within its territory, with privileges and immunities.

7. Without prejudice to their privileges and immunities in accordance with this Article, all persons entering the territory of a State Party for the purpose of providing telecommunication assistance or otherwise facilitating the use of telecommunication resources pursuant to this Convention, and all organizations providing telecommunication assistance or otherwise facilitating the use of telecommunication resources pursuant to this Convention, have a duty to respect the laws and regulations of that State Party. Such persons and organizations also shall have a duty not to interfere in the domestic affairs of the State Party into whose territory they have entered.

8. Nothing in this Article shall prejudice the rights and obligations with respect to privileges and immunities afforded to persons and organizations participating directly or indirectly in telecommunication assistance, pursuant to other international agreements (including the Convention on the Privileges and Immunities of the United Nations, adopted by the General Assembly on 13 February 1946, and the Convention on the Privileges and Immunities of the Specialized Agencies, adopted by the General Assembly on 21 November 1947) or international law.

## Article 6

Termination of Assistance

1. The requesting State Party or the assisting State Party may, at any time, terminate telecommunication assistance received or provided under Article 4 by providing notification in writing. Upon such notification, the States Parties involved shall consult with each other to provide for the proper and expeditious conclusion of the assistance, bearing in mind the impact of such termination on the risk to human life and ongoing disaster relief operations.

2. States Parties engaged in providing or receiving telecommunication assistance pursuant to this Convention shall remain subject to the terms of this Convention following the termination of such assistance.

3. Any State Party requesting termination of telecommunication assistance shall notify the operational coordinator of such request. The operational coordinator shall provide such assistance as is requested and necessary to facilitate the conclusion of the telecommunication assistance.

## Article 7

Payment or Reimbursement of Costs or Fees

1. The States Parties may condition the provision of telecommunication assistance for disaster mitigation and relief upon agreement to pay or reimburse specified costs or fees, always bearing in mind the contents of paragraph 8 of this Article.

2. When such condition exists, the States Parties shall set forth in writing, prior to the provision of telecommunication assistance:

a) the requirement for payment or reimbursement;

b) the amount of such payment or reimbursement or terms under which it shall be calculated; and

c) any other terms, conditions or restrictions applicable to such payment or reimbursement, including, but not limited to, the currency in which such payment or reimbursement shall be made.

3. The requirements of paragraphs 2 b) and 2 c) of this Article may be satisfied by reference to published tariffs, rates or prices.

4. In order that the negotiation of payment and reimbursement agreements does not unduly delay the provision of telecommunication assistance, the operational coordinator shall develop, in consultation with the States Parties, a model payment and reimbursement agreement that may provide a foundation for the negotiation of payment and reimbursement obligations under this Article.

5. No State Party shall be obligated to make payment or reimbursement of costs or fees under this Convention without having first expressed its consent to the terms provided by an assisting State Party pursuant to paragraph 2 of this Article.

6. When the provision of telecommunication assistance is properly conditioned upon payment or reimbursement of costs or fees under this Article, such payment or reimbursement shall be provided promptly after the assisting State Party has presented its request for payment or reimbursement.

7. Funds paid or reimbursed by a requesting State Party in association with the provision of telecommunication assistance shall be freely transferable out of the jurisdiction of the requesting State Party and shall not be delayed or withheld.

8. In determining whether to condition the provision of telecommunication assistance upon an agreement to pay or reimburse specified costs or fees, the amount of such costs or fees, and the terms, conditions and restrictions associated with their payment or reimbursement, the States Parties shall take into account, among other relevant factors:

a) United Nations principles concerning humanitarian assistance;

b) the nature of the disaster, natural hazard or health hazard;

c) the impact, or potential impact, of the disaster;

d) the place of origin of the disaster;

e) the area affected, or potentially affected, by the disaster;

f) the occurrence of previous disasters and the likelihood of future disasters in the affected area;

g) the capacity of each State affected by the disaster, natural hazard or health hazard to prepare for, or respond to, such event; and

h) the needs of developing countries.

9. This Article shall also apply to those situations in which telecommunication assistance is provided by a non-State entity or intergovernmental organization, provided that:

a) the requesting State Party has consented to, and has not terminated, such provision of telecommunication assistance for disaster mitigation and relief;

b) the non-State entity or intergovernmental organization providing such telecommunication assistance has notified to the requesting State Party its adherence to this Article and Articles 4 and 5; and

c) the application of this Article is not inconsistent with any other agreement concerning the relations between the requesting State Party and the non-State entity or intergovernmental organization providing such telecommunication assistance.

## Article 8

### Telecommunication Assistance Information Inventory

1. Each State Party shall notify the operational coordinator of its authority(ies):

a) responsible for matters arising under the terms of this Convention and authorized to request, offer, accept and terminate telecommunication assistance; and

b) competent to identify the governmental, intergovernmental and/or non-governmental resources which could be made available to facilitate the use of telecommunication resources for disaster mitigation and relief, including the provision of telecommunication assistance.

2. Each State Party shall endeavour to inform the operational coordinator promptly of any changes in the information provided pursuant to this Article.

3. The operational coordinator may accept notification from a non-State entity or intergovernmental organization of its procedures for authorization to offer and terminate telecommunication assistance as provided in this Article.

4. A State Party, non-State entity or intergovernmental organization may, at its discretion, include in the material it deposits with the operational coordinator information about specific telecommunication resources and about plans for the use those resources to respond to a request for telecommunication assistance from a requesting State Party.

5. The operational coordinator shall maintain copies of all lists of authorities, and shall expeditiously disseminate such material to the States Parties, to other States, and to appropriate non-State entities and intergovernmental organizations, unless a State Party, non-State entity or intergovernmental organization has previously specified, in writing, that distribution of its material be restricted.

6. The operational coordinator shall treat material deposited by non-State entities and intergovernmental organizations in a similar manner to material deposited by States Parties.

## Article 9

### Regulatory Barriers

1. The States Parties shall, when possible, and in conformity with their national law, reduce or remove regulatory barriers to the use of telecommunication resources for disaster mitigation and relief, including to the provision of telecommunication assistance.

2. Regulatory barriers may include, but are not limited to:

a) regulations restricting the import or export of telecommunication equipment;

b) regulations restricting the use of telecommunication equipment or of radio-frequency spectrum;

c) regulations restricting the movement of personnel who operate telecommunication equipment or who are essential to its effective use;

d) regulations restricting the transit of telecommunication resources into, out of and through the territory of a State Party; and

e) delays in the administration of such regulations.

3. Reduction of regulatory barriers may take the form of, but shall not be limited to:

a) revising regulations;

b) exempting specified telecommunication resources from the application of those regulations during the use of such resources for disaster mitigation and relief;

c) pre-clearance of telecommunication resources for use in disaster mitigation and relief, in compliance with those regulations;

d) recognition of foreign type-approval of telecommunication equipment and/or operating licenses;

e) expedited review of telecommunication resources for use in disaster mitigation and relief, in compliance with those regulations; and

f) temporary waiver of those regulations for the use of telecommunication resources for disaster mitigation and relief.

4. Each State Party shall, at the request of any other State Party, and to the extent permitted by its national law, facilitate the transit into, out of and through its territory of personnel, equipment, materials and information involved in the use of telecommunication resources for disaster mitigation and relief.

5. Each State Party shall notify the operational coordinator and the other States Parties, directly or through the operational coordinator, of:

a) measures taken, pursuant to this Convention, for reducing or removing such regulatory barriers;

b) procedures available, pursuant to this Convention, to States Parties, other States, non-State entities and/or intergovernmental organizations for the exemption of specified telecommunication resources used for disaster mitigation and relief from the application of such regulations, pre-clearance or expedited review of such resources in compliance with applicable regulations, acceptance of foreign type-approval of such resources, or temporary waiver of regulations otherwise applicable to such resources; and

c) the terms, conditions and restrictions, if any, associated with the use of such procedures.

6. The operational coordinator shall regularly and expeditiously make available to the States Parties, to other States, to non-State entities and to intergovernmental organizations an up-to-date listing of such measures, their scope, and the terms, conditions and restrictions, if any, associated with their use.

7 Nothing in this Article shall permit the violation or abrogation of obligations and responsibilities imposed by national law, international law, or multilateral or bilateral agreements, including obligations and responsibilities concerning customs and export controls.

## Article 10

Relationship to Other International Agreements

This Convention shall not affect the rights and obligations of States Parties deriving from other international agreements or international law.

## Article 11

Dispute Settlement

1. In the event of a dispute between States Parties concerning the interpretation or application of this Convention, the States Parties to the dispute shall consult each other for the purpose of settling the dispute. Such consultation shall begin promptly upon the written declaration, delivered by one State Party to another State Party, of the existence of a dispute under this Convention. The State Party making such a written declaration of the existence of a dispute shall promptly deliver a copy of such declaration to the depositary.

2. If a dispute between States Parties cannot be settled within six (6) months of the date of delivery of the written declaration to a State Party to the dispute, the States Parties to the dispute may request any other State Party, State, non-State entity or intergovernmental organization to use its good offices to facilitate settlement of the dispute.

3. If neither State Party seeks the good offices of another State Party, State, non-State entity or intergovernmental organization, or if the exercise of good offices fails to facilitate a settlement of the dispute within six (6) months of the request for such good offices being made, then either State Party to the dispute may:

a) request that the dispute be submitted to binding arbitration; or

b) submit the dispute to the International Court of Justice for decision, provided that both States Parties to the dispute have, at the time of signing, ratifying or acceding to this Convention, or at any time thereafter, accepted the jurisdiction of the International Court of Justice in respect of such disputes.

4. In the event that the respective States Parties to the dispute request that the dispute be submitted to binding arbitration and submit the dispute to the International Court of Justice for decision, the submission to the International Court of Justice shall have priority.

5. In the case of a dispute between a State Party requesting telecommunication assistance and a non-State entity or intergovernmental organization headquartered or domiciled outside of the territory of that State Party concerning the provision of telecommunication assistance under Article 4, the claim of the non-State entity or intergovernmental organization may be espoused directly by the State Party in which the non-State entity or intergovernmental organization is headquartered or domiciled as a State-to-State claim under this Article, provided that such espousal is not inconsistent with any other agreement between the State Party and the non-State entity or intergovernmental organization involved in the dispute.

6. When signing, ratifying, accepting, approving or acceding to this Convention, a State may declare that it does not consider itself bound by either or both of the dispute settlement procedures provided for in paragraph 3 above. The other States Parties shall not be bound by a dispute settlement procedure provided for in paragraph 3 with respect to a State Party for which such a declaration is in force.

## Article 12

Entry into Force

1. This Convention shall be open for signature by all States which are members of the United Nations or of the International Telecommunication Union at the Intergovernmental Conference on Emergency Telecommunications in Tampere on 18 June 1998, and thereafter at the headquarters of the United Nations, New York, from 22 June 1998 to 21 June 2003.

2. A State may express its consent to be bound by this Convention:

a) by signature (definitive signature);

b) by signature subject to ratification, acceptance or approval followed by deposit of an instrument of ratification, acceptance or approval; or

c) by deposit of an instrument of accession.

3. The Convention shall enter into force thirty (30) days after the deposit of instruments of ratification, acceptance, approval or accession or definitive signature of thirty (30) States.

4. For each State which signs definitively or deposits an instrument of ratification, acceptance, approval or accession, after the requirement set out in paragraph 3 of this Article has been fulfilled, this Convention shall enter into force thirty (30) days after the date of the definitive signature or consent to be bound.

## Article 13

Amendments

1. A State Party may propose amendments to this Convention by submitting such amendments to the depositary, which shall circulate them to the other States Parties for approval.

2. The States Parties shall notify the depositary of their approval or disapproval of such proposed amendments within one hundred and eighty (180) days of their receipt.

3. Any amendment approved by two-thirds of all States Parties shall be laid down in a Protocol which is open for signature at the depositary by all States Parties.

4. The Protocol shall enter into force in the same manner as this Convention. For each State which signs the Protocol definitively or deposits an instrument of ratification, acceptance, approval or accession, after the requirements for the entry into force of the Protocol have been fulfilled, the Protocol shall enter into force for such State thirty (30) days after the date of the definitive signature or consent to be bound.

## Article 14

Reservations

1. When definitively signing, ratifying or acceding to this Convention or any amendment hereto, a State Party may make reservations.

2. A State Party may at any time withdraw its prior reservation by written notification to the depositary. Such withdrawal of a reservation becomes effective immediately upon notification to the depositary.

## Article 15
Denunciation

1. A State Party may denounce this Convention by written notification to the depositary.

2. Denunciation shall take effect ninety (90) days following the date of deposit of the written notification.

3. At the request of the denouncing State Party, all copies of the lists of authorities and of measures adopted and procedures available for reducing regulatory measures provided by any State Party denouncing this Convention shall be removed from use by the effective date of such denunciation.

## Article 16
Depositary

The Secretary-General of the United Nations shall be the depositary of this Convention.

## Article 17
Authentic Texts

The original of this Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the depositary. Only the English, French and Spanish authentic texts will be made available for signature at Tampere on 18 June 1998. The depositary shall prepare the authentic texts in Arabic, Chinese and Russian as soon as possible thereafter.

# ANNEX 2

## RESOLUTION 7

### First World Telecommunication Development Conference (WTDC)

of the International Telecommunication Union (ITU),

Buenos Aires, April 1994

**Disaster Communications**

The World Telecommunication Development Conference (Buenos Aires 1994),

*nothing*

the Tampere Declaration on Disaster Communications, issued by the group of experts in communications and disaster management, participating in the Conference on Disaster Communications help in Tampere, Finland, on 20-22 May 1991, annexed to this resolution,

*and noting further*

*a)* the support which the Tampere Declaration has received from numerous national, regional and international organizations,

*b)* Resolution No. 209 (Mob-87) Study and Implementation of a Global Land and Maritime Distress Safety System by the World Administrative Radio Conference on Mobile Services, 1987,

*c)* the studies carried out by the Study Group of ITU-R in response to Resolution No. 209 (Mob.87),

*d)* the scope to studies in study group of ITU-T, relevant to disaster communications, and in particular in ITU-T SG II, SG III and SG IV,

*recognizing*

a) that disasters have caused and are likely to continue to cause severe human suffering, loss of human lives and damage to property and environment,

b) that disasters may have particularly devastating consequences in developing countries,

c) that disaster preparedness requires the existence of de-central means of communications such as, but not limited to, those provided by mobile and portable Satellite Terminals and by the Amateur Radio Services, to supplement the possibly vulnerable elements of the national, regional and global communications networks,

*convinced*

a) that the fast and efficient flow of information is essential for disaster mitigation, prevention and preparedness, as well as for disaster relief.

b) that telecommunications can play a vital role in restoring the continuity of the development progress, *concerned*

a) that the development process is disrupted in the events of a disaster,

b) that disaster situations, as they occur, often affect or destroy existing telecommunications facilities,

*resolves*

to invite the ITU-R

a) to continue studying, as a matter of priority, the technical, operational and regulatory of radio communications for disaster mitigation and relief,

b) to consider recommending the inclusion, in the agenda of competent World Radio Communication Conference, of the consideration of Radio Regulations concerning Disaster Communications,

to invite the ITU-R to study, as a matter of priority,

a) the means of facilitating efficient communications for disaster mitigation and relief,

b) charging and accounting in domestic and international disaster communications, including waiver of charges and an appropriate tariff structure where appropriate,

*instructs*

the Director of the BDT to help developing countries, particularly the LDCs, to prepare their telecommunications services for the event of a disaster and to restore that in case of disruption by such an event,

*further instructs*

the Director of the BDT to help, within the framework of the International Decade for Natural Disaster Reduction, those developing countries which are particularly prone to nature disasters, in the development of early warning systems, using telecommunications, including broadcast services, through the special voluntary programme for technical co-operation,

*requests*

the Secretary General to work closely with the United Nations Department of Humanitarian Affairs, with a view to increase the Union's involvement in Disaster Communications,

*further requests*

the Secretary General, to communicate this resolution to the relevant international organizations,

*invites*

the United Nations Department of Humanitarian Affairs, to actively contribute, in close collaboration with the IRU and in particular with the BDT, to the further development and strengthening of the disaster communications capabilities of developing countries,

*urges*

administration, to take all practicable steps for facilitating the rapid deployment equipment for disaster relief by reducing and, where possible, removing regulatory barriers and strengthening transboundary co-operation between states.

# ANNEX 3

# RESOLUTION 19

## Telecommunication resources for disaster mitigation and relief operations

The World Telecommunication Development Conference (Valletta, 1998),

*considering*

a) that the World Telecommunication Development Conference (Buenos Aires, 1994) (WTDC-94), adopted Resolution 7 on telecommunications for disaster mitigation and disaster relief operations, thereby reactivating a process initiated by the Conference on Disaster Communications, (Tampere, 1991);

b) that the Plenipotentiary Conference (Kyoto, 1994), endorsed that resolution in its Resolution 36 on telecommunications for disaster mitigation and disaster relief operations;

c) the report of the Secretary-General on the progress made in the implementation of WTDC-94 Resolution 7;

d) that the World Radiocommunication Conference (Geneva, 1997), in its Resolution 644, urged administrations to give their full support to the adoption and national implementation of a Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations,

*recognizing*

a) the potential of modern telecommunication technologies as an essential tool for disaster mitigation and relief operations and the vital role of telecommunications for the safety and security of relief workers in the field;

b) the particular needs of developing countries and the special requirements of the inhabitants of remote areas,

*noting with appreciation*

the invitation by the Government of Finland to hold the Intergovernmental Conference on Emergency Telecommunications (ICET-98) from 16 to 18 June 1998 in Tampere, Finland, which is expected to adopt the Convention referred to in *considering* d) above,

*resolves*

to invite the ITU Telecommunication Development Sector to ensure that proper consideration be given to emergency telecommunications as an element of telecommunication development, including, in close coordination and collaboration with the ITU Radiocommunication Sector, by facilitating and encouraging the use of decentralized means of communications that are appropriate and generally available, including those provided by the amateur radio service and GMPCS services,

*instructs the Director of BDT*

a) to support administrations in their work towards the implementation of this Resolution and of the Convention;

b) to report to the next world telecommunication development conference on the status of implementation of the Convention, *instructs the Secretary-General*

to work closely with the United Nations Emergency Relief Coordinator with a view to further increasing the Union's involvement in, and support to, emergency communications, and to report on the outcome of ICET-98 to the 1998 Plenipotentiary Conference so that the Plenipotentiary Conference or the ITU Council may take any action that it deems necessary,

*invites*

the United Nations Emergency Relief Coordinator and the Working Group on Emergency Telecommunications to collaborate closely with ITU in work towards implementing this Resolution, adopting the Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations, and supporting administrations and international and regional telecommunication organizations in the implementation of the Convention,

*urges administrations*

to continue their examination of the draft Convention, with a view to considering giving their full support to the adoption of the said Convention,

*encourages administrations*

to participate in the forthcoming Intergovernmental Conference on Emergency Telecommunications (ICET-98) hosted by the Government of Finland in Tampere from 16 to 18 June 1998.

## ANNEX 4

## RESOLUTION 644 (WRC-97)

### Telecommunication resources for disaster mitigation and relief operations

The World Radiocommunication Conference (Geneva, 1997),

*considering*

*a)* that ITU, in the same spirit as reflected in Articles 40 and 46 of its Constitution and in Resolution **209 (Mob-87)**, has specifically recognized the importance of the international use of radiocommunications in the event of natural disasters, epidemics, famines and similar emergencies;

*b)* that the Plenipotentiary Conference (Kyoto, 1994), in endorsing Resolution 7 of the World Telecommunication Development Conference (Buenos Aires, 1994), adopted Resolution 36 on telecommunications for disaster mitigation and disaster relief operations;

*c)* that administrations have been urged to take all practical steps to facilitate the rapid deployment and effective use of telecommunication resources for disaster mitigation and disaster relief operations by reducing and, where possible, removing regulatory barriers and strengthening transborder cooperation between States,

*recognizing*

*a)* the potential of modern telecommunication technologies as an essential tool for disaster mitigation and relief operations and the vital role of telecommunications for the safety and security of relief workers in the field;

*b)* the particular needs of developing countries and the special requirements of the inhabitants of remote areas;

*c)* the progress made in the implementation of Resolution 36 with respect to the preparation of the Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations,

*noting*

with appreciation the scheduling of the Intergovernmental Conference on Emergency Telecommunications (ICET-98) from 16 to 18 June 1998 in Tampere, Finland, which is expected to adopt the Convention referred to in *recognizing c)* above,

*resolves*

to invite ITU-R to continue to study, as a matter of urgency, those aspects of radiocommunications that are relevant to disaster mitigation and relief operations, such as decentralized means of communications that are appropriate and generally available, including amateur radio facilities and mobile and portable satellite terminals,

*requests the Director of the Radiocommunication Bureau*

to support administrations in their work towards the implementation of Resolution 36, *instructs the Secretary-General*

to work closely with the United Nations Emergency Relief Coordinator with a view to further increasing the Union’s involvement in, and support to, disaster communications, and to report on the outcome of the Tampere Conference to the 1998 Plenipotentiary Conference so that that Conference or the Council may take any action that it deems necessary,

*invites*

the United Nations Emergency Relief Coordinator and the Working Group on Emergency Telecommunications to collaborate closely with ITU in further work towards the implementation of Resolution 36, and in particular the adoption of the Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations,

*urges administrations*

to give their full support to the adoption of the said Convention and its national implementation.

# ANNEX 5

## RESOLUTION 36 (Rev. Minneapolis, 1998)

## Telecommunications in the service of humanitarian assistance

The Plenipotentiary Conference of the International Telecommunication Union

(Minneapolis, 1998),

*endorsing*

*a)* Resolution 644 of the World Radiocommunication Conference (Geneva, 1997) on telecommunication resources for disaster mitigation and relief operations;

*b)* Resolution 19 of the World Telecommunication Development Conference (Valletta, 1998) on telecommunication resources for disaster mitigation and relief operations;

*c)* the Valletta Declaration adopted by the World Telecommunication Development Conference (Valletta, 1998), drawing the attention of ITU Member States and Sector Members to the importance of emergency telecommunications and the need for an international convention on this subject,

*considering*

that the Intergovernmental Conference on Emergency Telecommunications (Tampere, 1998) has adopted the Tampere Convention on the provision of telecommunication resources for disaster mitigation and relief operations,

*noting*

*a)* the Final Act of the Intergovernmental Conference on Emergency Telecommunications (Tampere, 1998), which reflects the recognition by the conference of the significant impact of disasters on societies and the environment and of the need for providing timely, effective telecommunication assistance and resources for disaster mitigation and relief;

*b)* the report of the Secretary-General on the implementation of, *inter ali*a, Resolution 36 (Kyoto, 1994),

*noting with appreciation*

*a)* the efforts deployed by the ITU Secretary-General towards the adoption of the Tampere Convention;

*b)* the close cooperation between the United Nations Office for the Coordination of Humanitarian Affairs and ITU during the past four years,

*recognizing*

the seriousness and magnitude of potential disasters that may cause dramatic human suffering,

*convinced*

that the unhindered use of telecommunication equipment and services is indispensable for the provision of effective and appropriate humanitarian assistance, *further convinced*

that the Tampere Convention provides the necessary framework for such use of telecommunication resources,

*resolves to instruct the Secretary-General*

to work closely with the United Nations Emergency Relief Coordinator on the development of practical arrangements for the implementation of the Tampere Convention,

*urges Member States*

to work towards the earliest possible ratification, acceptance, approval or final signature of the Tampere Convention by the appropriate national authorities,

*further urges Member States Parties to the Tampere Convention*

to take all practical steps for the application of the Tampere Convention and to work closely with the operational coordinator as provided for therein.

# ANNEX 6

## RESOLUTION ADOPTED BY THE GENERAL ASSEMBLY

### 54/233. International cooperation on humanitarian assistance in the field of natural disasters from relief to development

The General Assembly,

*reaffirming*

its resolution 46/182 of 19 December 1991, which contains in its annex the guiding principles for the strengthening of the coordination of emergency humanitarian assistance of the United Nations system, and its resolutions 52/12 B of 19 December 1997 and 54/219 of 22 December 1999, and recalling Economic and Social Council agreed conclusions 1999/1,[1] which addressed the theme "International cooperation and coordinated responses to the humanitarian emergencies, in particular in the transition from relief to rehabilitation, reconstruction and development", and Council resolution 1999/63 of 30 July 1999,

*noting with appreciation,*

the report of the Secretary-General on strengthening of the coordination of emergency humanitarian assistance of the United Nations,[2] in particular in the context of the transition from relief to rehabilitation, reconstruction and development,

*recognizing*

the importance of the principles of neutrality, humanity and impartiality for the provision of humanitarian assistance,

*emphasizing*

that the affected State has the primary responsibility in the initiation, organization, coordination and implementation of humanitarian assistance within its territory and in the facilitation of the work of the humanitarian organizations in mitigating the consequences of natural disasters,

1. *Expresses deep concern* at the increasing number and scale of natural disasters, resulting in massive losses of life and property worldwide, in particular in vulnerable societies lacking adequate capacity to mitigate effectively long-term negative social, economic and environmental consequences of natural disasters;

2. *Stresses* that humanitarian assistance for natural disasters should be provided in accordance with and with due respect for the guiding principles contained in the annex to resolution 46/182 and should be determined on the basis of the human dimension and needs arising out of the particular natural disaster;

3. *Calls upon* States to adopt, where required, and to continue to implement effectively necessary legislative and other appropriate measures to mitigate the effects of natural disasters, *inter alia*, by disaster prevention, including building regulations, as well as disaster preparedness and capacity-building in disaster response, and requests the international community in this context to continue to assist developing countries, where appropriate;

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[1] A/54/3, chap. VI, para. 5. For the final text, see *Official Records of the General Assembly, Fifty-fourth Session, Supplement No. 3* (A/54/3/Rev.1).

[2] A/54/154–E/1999/94 and Add.1.

4. *Stresses* the need to strengthen efforts at all levels, *inter alia*, at the domestic level, to improve natural disaster awareness, prevention, preparedness and early warning systems, as well as international cooperation, in response to emergencies from relief to rehabilitation, reconstruction and development, bearing in mind the overall negative impact of natural disasters, the resulting humanitarian needs and requests from affected countries, as appropriate;

5. *Encourages* further efforts by the Under-Secretary-General for Humanitarian Affairs and Emergency Relief Coordinator, Inter-Agency Standing Committee members and other members of the United Nations system in promoting preparedness for response at the international, regional and national levels and strengthening the mobilization and coordination of humanitarian assistance of the United Nations system in the field of natural disasters, *inter alia*, through the effective deployment in all regions of the world and expansion of the United Nations Disaster Assessment and Coordination roster appropriately to include more representatives from countries of Africa, Asia and the Pacific and Latin America and the Caribbean, bearing in mind that these representatives are funded by the participating countries;

6. *Also encourages* further efforts by the United Nations Development Programme to strengthen operational activities and capacity-building in natural disaster mitigation, prevention and preparedness, taking due account of the evolving comprehensive strategy to maximize international cooperation in the field of natural disasters;

7. *Invites* the Office for the Coordination of Humanitarian Affairs of the Secretariat and concerned organizations, taking due account of the evolving comprehensive strategy to maximize international cooperation in the field of natural disasters, to strengthen their support to the United Nations disaster management teams which are dispatched upon request by host Governments and steered by the United Nations resident coordinator;

8. *Recalls* the consideration of natural disasters contained in the report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space,[3] held in Vienna from 19 to 30 July 1999, and encourages further use of space-based technologies for the prevention, mitigation and management of natural disasters, noting in this regard, the establishment of the Global Disaster Information Network;

9. *Takes note* of the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations, adopted at Tampere, Finland, on 18 June 1998, and encourages States that have not signed the Convention to consider doing so;

10. *Welcomes* innovative efforts to link various phases of international assistance from relief to rehabilitation, such as the joint Office for the Coordination of Humanitarian Affairs, United Nations Development Programme, United Nations Children's Fund and World Health Organization and Pan American Health Organization Disaster Response and Recovery Mission undertaken in all countries affected by hurricane Mitch, and stresses the need to ensure adequate assessment of and follow-up to these approaches with a view to further developing and applying them in other disasters;

11. *Encourages* Governments, in particular through their disaster response agencies, relevant organizations of the United Nations system and non-governmental organizations, to continue to cooperate appropriately with the Secretary-General and the Under-Secretary-General for Humanitarian Affairs and Emergency Relief Coordinator to maximize the effectiveness of the international response to natural disasters, based, *inter alia*, on humanitarian need, from relief to development;

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[3] A/CONF.184/6.

12. *Recall*s, in this regard, its request to the Secretary-General to solicit the required input further to optimize and disseminate listings of organizations of civil protection and emergency response at all levels with updated inventories of available resources to help in natural disasters, as well as information, including handbooks, that guide the international cooperation in responding to natural disasters;

13. *Stresses* that particular international cooperation efforts should be undertaken to enhance and broaden further the utilization of national and local capacities and, where appropriate, regional and subregional capacities of developing countries for disaster preparedness and response, which may be made available in closer proximity to the site of a disaster, more efficiently and at lower cost;

14. *Notes* that the transition phase after natural disasters is often excessively long and characterized by a number of gaps, and that Governments, in cooperation with relief agencies, as appropriate, when planning for meeting immediate needs, should place these needs in the perspective of sustainable development whenever such an approach is possible;

15. *Stresses* the need to continue to provide adequate funds and to release funds quickly for natural disasters in order to contribute to a comprehensive recovery in the shortest time possible;

16. *Also stresses,* in this regard, that contributions for humanitarian assistance for natural disasters should be provided in a way that is not to the detriment of resources made available for international cooperation for development or complex humanitarian emergencies;

17. *Reiterates its request* to the Secretary-General, contained in resolution 54/95 of 8 December 1999, to submit to the General Assembly, early in 2000, concrete proposals in order to enhance the functioning and utilization of the Central Emergency Revolving Fund, and, in this regard, invites the Secretary-General to consider more active use of the Fund for timely and adequate natural disaster response;

18. *Invites* the Secretary-General further to consider innovative means for timely and adequate natural disaster response, *inter alia*, through mobilization of additional resources from the private sector;

19. *Invites* the Economic and Social Council, at its substantive session of 2000, in the context of the follow-up to its agreed conclusions 1999/1, to consider ways to enhance further the effectiveness of international cooperation and coordination in respect of the provision of timely and adequate humanitarian assistance in response to natural disasters;

20. *Invites* the Secretary-General to continue to consider innovative mechanisms to improve the international response to natural disasters and other emergencies, *inter alia*, through addressing any geographical and sectoral imbalances in such a response where they exists, as well as more effective use of national emergency response agencies, taking into account their comparative advantages and specialization, as well as existing arrangements, and to report thereon to the General Assembly at its fifty-fifth session under the item entitled “Strengthening of the coordination of humanitarian and disaster relief assistance of the United Nations, including special economic assistance” with a view, *inter alia*, to contributing towards the comprehensive report on the implementation of the international strategy for disaster reduction to be submitted to the Assembly at its fifty-sixth session under the item entitled “Environment and sustainable development”.

87th Plenary Meeting
22 December 1999

# ITU-D Handbook on disaster communications

# PART 2

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# PART 2

# CHAPTER 1

## The operational aspects of disaster communications

### 1.1 Introduction

The operational aspects of disaster communications should be understood by users of communications as well as by the providers. Disaster managers are often confronted with the task of defining requirements, and they can do so best if they know what is available and feasible under the specific circumstances of an emergency situation. Telecommunication service providers include those providing services to the public on a commercial basis, those providing services to specific users, as well as the operators of specialized networks, in particular the amateur radio service.

This Handbook divides operational matters into two groups, first describing the communication modes and the networks using these modes. The discussion of each mode starts with a user-oriented description of their applications in disaster communications. This is followed by information addressed to the provider of the respective service about when the mode or network is to be applied for disaster communications. In a technical annex to this Handbook, practical technical information is provided for telecommunication officers, technicians and operators of humanitarian organizations and institutions, and for the technical staff of service providers.

### 1.2 Tactical and Strategic Communications

Emergency operations and military operations share a number of characteristics, such as the rapidly and often unpredictably changing physical and social environment in which they take place, and the need for rapid decision making on all levels. Their communications requirements are therefore comparable. The military terms of tactical and strategic communications best describe what has to be provided for a coordinated response to any emergency with more than strictly local implications.

### 1.3 Standardization and Gateways

Standardization is the ideal solution to ensure compatibility and interaction among all communication networks, at least within each of the two groups, i.e. the tactical and the strategic communications. However, emergency response, is a temporary activity, and those involved are not necessarily participants in a continuous routine function.

Gateways are not ideal but are so far the only realistic solution. In tactical communications, this function is mostly carried out by a human interface – the operator or the disaster manager who uses more than one network at the same time. For this, they need a solid knowledge of the structures and the procedures of the networks involved. In strategic communications, automatic gateways between different systems have been developed. To apply these the technical staff must be familiar with the technology and how it may be utilized.

# CHAPTER 2

# Communication modes

Practically all modes of communications on public and private networks, have their role in disaster communications. The following sections give an overview of available modes and networks, which will be described in more detail in the technical annex to this Handbook.

## 2.1 Voice Communications

Voice is the most common and most suitable mode of communication for the real-time transmission of short messages and with minimal equipment requirements. Its applications in disaster communications range from point-to-point wired field telephone links and VHF and UHF hand-held or mobile transceivers to satellite phones, and also include public address systems as well as broadcasts via radio. However for the transmission of more complex information, the lack of a permanent documentation is an important shortcoming of voice.

### 2.2 Data Communications

The earliest forms of electronic communication were in fact data links: The telegraph was in use long before the telephone, and wireless telegraphy preceded radiotelephony. It was, however, only the development of electronic interfaces and peripheral equipment – replacing the human operator translating between Morse code and written text – which made data communications for many applications superior to voice.

The first such interface with practical applications in disaster communications was the teleprinter or teletype machine, commonly known in commercial usage as “Telex”. Initially used on wired networks, it was soon on radio links. While very reliable and with a very low error rate on wired circuits, efficient use over radio required strong signals and interference-free channels. The requirement of considerable technical resources for a reliable radio teletype (RTTY) link limited their usefulness in emergency situations.

The coming of advanced digital technology allowed the development of new data communication modes, which eliminate the shortcomings of RTTY. The key to error-free links is the splitting of the messages into “packets”, and the automatic transmission of an acknowledgement of correct reception or a request for re-transmission.

The earliest general application of automatic error correction is the ARQ concept, standing for “automatic repeat request”, with communication protocols known as TOR, SITOR and AMTOR. In ARQ mode, an automatic acknowledgement or request for re-transmission takes place after every third letter of the message.

Different from RTTY, where the number of stations receiving a transmission is not limited, ARQ signals can only be exchanged between two partners at any given time. To allow broadcasting, a somewhat less reliable version, forward error correction: (FEC) mode was introduced. In FEC, every “packet” of three letters is transmitted twice; the receiving station automatically compares the two transmissions and, if they differ, identifies the most likely correct content of the “packet”.

Further development led to more efficient methods of data communications on both wired and radio links. The most important example of this is the Internet Protocol (IP), which has also been adopted as the common standard of communications among all major partners in international humanitarian assistance. The "Packet Radio" is most commonly used on VHF and UHF. Its derivative "Pactor" and various other proprietary modes allow, through suitable gateways, the use of HF radio links for practically all functions of the Internet.

Fax was the first mode allowing the transmission of images in graphic hard-copy format over wired and, to a limited extent, wireless networks. In its original form, fax images are carried as analog signals over voice circuits such as the telephone network. As with the data modes, the development in digital technology has led to new forms of image transfer, including the applications on the World Wide Web.

# CHAPTER 3

# Public communication networks

Networks are structured according to the needs of the users, and according to the technology, such as the mode in use. They range from the most basic, two-point link all the way to world-wide structures, and they can be centralized, with each user connected to a form of exchange, or use an almost infinite variety of options to connect from one terminal to another. The public telephone system is an example for the first option, the Internet for the second.

## 3.1 The Public Switched Telephone Network (PSTN)

The Public Switched Telephone Network (PSTN) has undergone both political and technical changes in recent years. Until recently, in many countries, they were owned and operated by large government monopolies such as the post office. Today individual members of the public and businesses are often free to choose between the telephone services offered by several local service providers. However, if the service offered is fully interconnected to all other telephones, then the system is part of the PSTN, sometimes also referred to as the Plain Old Telephone System (POTS). In many cases, centralization of critical functions has resulted in potentially high vulnerabilities. The main parts of a PSTN are as follows:

### 3.1.1 Local Distribution

Local distribution systems connect the end users to the switches. Typically, switches will be in the order of 10-20 km away. The local cable system is a network of one unscreened twisted pair cable per telephone line. One separate pair, all the way from the customer to the nearest switch, is permanently provided for each line.

In many places, telephone lines are open wires or cables with numerous pairs of wires, suspended from poles. Such pole routes are vulnerable to disasters involving high winds or earthquakes. In many cases, however, the cables are buried all or some of the way, either directly in the ground, or in ductway systems, reducing their vulnerability.

One factor is that the local cable system is such a large capital investment that the operators of competing systems may well use the same local cable system for access. Therefore damage to the local cable system may affect all operators to the same degree.

The local loop used on the PSTN has the advantage that the telephone at the user's premises is powered from a battery at the telephone exchange. If power at the user's premises is disrupted, the phone will still work as long as the lines are not damaged. However, this does not apply to cordless phones, which will have a home base station powered by the domestic power. Every home and business should be urged to have at least one normal type, central battery powered phone.

### 3.1.2 Wireless Local Loop (WLL)

Some operators offer access to their switches via “wireless local loop” (WLL) solutions. WLL relies on local Radio Base Stations (RBS). These provide a radio link to fixed radio units in the home, which in turn connect to telephones in the home or business. The user may be unaware of the details of such arrangement.

One problem with WLL is that if the power in the building is lost, the radio unit will be inoperable unless reliable alternative power is provided. The RBS stations do have backup power, but are connected to the switch via the local cable system, or by leased lines also carrying other services, but along the same route as the local cables. In other cases the base station is connected by dedicated microwave link. Nevertheless, wireless access may in some cases be less vulnerable to physical damage than pole routes, provided backup power is part of the configuration.

"Private wires" used by enterprise systems are often routed through the local cable system of public networks. In such cases, damage to the latter is likely to affect any wire telecom system in the area, public or private.

### 3.1.3 Switches

Switches are the center of a telephone system and they also present the most serious risk because of their tendency to overload. In a residential area, a switch is dimensioned to accommodate simultaneous calls by about 5% of the subscribers. In a business area this figure may be up to 10 %. When the load is greater than the switch is designed to handle, a switch is “blocked”. Disasters, and even quite trivial local events, can cause a very high traffic volume within as well as from and to an affected area, mostly as subscribers seek information about friends and relatives. This traffic alone is likely to block a switch in the aftermath of a disaster.

Modern switches are often of the computerized digital type. However, no matter how the switch is built, it needs power, an enclosure such as a building and often also air conditioning. Any disruption or damage affecting supporting elements will cause the switch to fail.

### 3.1.4 The Trunk and Signalling System

Trunk lines are links between switches. Trunks are often multiplexed and therefore of carrying hundreds or thousands of calls. They may be implemented by microwave radio links, copper cables, or optical fiber, depending on the expected capacity of the link. The trend is for large-scale operators to use optical fiber systems. If the cables are buried, as they often are, they will be less vulnerable.

Operators normally link the switches through their own trunking system. Having accounts with several different operators may increase the survival capability of a system in an emergency. Sometimes the competing operators have built their own trunk system, but sometimes they have merely bought capacity on other systems. Even commercially competing systems may therefore share their physical infrastructures.

One way to carry trunks is by microwave. These are radio links between relay stations, usually mounted on hills or high buildings. Microwave relay stations are therefore often in exposed locations, and may sometimes difficult to reach. After a disaster, some sites may in fact only be accessible only by helicopter and, given the importance of communications, money spent on regular checking of remote installations is a good investment by the system operator.

A special case is the “Signalling system No. 7”. Under its structure, the switches need to “talk” to each other in order to set up calls. To do this there is a separate dedicated service called the SS7 or CCITT7 system, which is similar to a private Internet system for use exclusively by switches. Though logically separate, the SS7 channels are often multiplexed into the trunk circuits and are carried by the same transmission as the trunk circuits. In the event of SS7 failure, calls between switches can no longer be made. Generally, local calls on the same switch are not affected.

### 3.1.5 Integrated Services Digital Network (ISDN)

Integrated Services Digital Network (ISDN) is a circuit switched, transparent data service at high speeds, which can be increased in 64 kbit/s steps. A typical use is video conferencing for scientific and technical applications. Generally, the same switch carrying telephony is also switching the ISDN, and the trunk network is the same. ISDN is neither more nor less reliable than telephony, because it shares the same infrastructure.

### 3.1.6 Telex

The importance of Telex is diminishing as text messages are increasingly handled by e-mail. Nevertheless, Telex remains an important tool. The Telex system consists of teleprinters or specially programmed computer terminals, connected to each other by means of the International Telex network. Telex messages consist of only upper case letters of the Roman alphabet and some punctuation symbols, using the Baudot code ITU-ITA2.

Telex has two distinct advantages over other systems. The most important one is that Telex is switched through a different switch than used for telephone calls. This is relevant in the case of a disaster, when the telephone switch may be overloaded. Access to the Internet is achieved by modems, which dial the service provider's local point of presence over the telephone system, and here, too, Telex can serve as an alternative. Any teleprinter machine does of course require local power.

Telex exchanges are designed to handle high levels of traffic, and will not usually be overloaded by private calls. Telex also features an optional store-and-forward mode that will forward messages as soon as possible, if it can not be done in real time. Thus there is a very good chance of getting through with Telex. This store-and-forward mode is also applied for Telex connections with Inmarsat Standard C terminals, which have an important role in disaster communications.

One weakness of Telex is that nowadays signals are often sent over the same transmission systems as most of the other services. Therefore a total loss of transmission may cause loss of Telex. On the other hand, Telex circuits are defined on the trunks on a permanent basis, so they will have capacity permanently reserved and they are less likely to be affected by congestion on the trunk system.

Telex is a "narrow band" system, meaning that it requires very little system resources to operate. It is easy and inexpensive to provide alternative wireless connectivity for Telex terminals. In theory disaster proof Telex service is possible, but in practice this will depend on the instructions to the network planner, as to whether reliability or economy is the major factor.

Telex terminals should be connected directly to the Telex network and not via an intermediate service provider, otherwise they may be using dial up modem service via the PSTN, thus losing their major advantage. Telex machines allow a real-time dialogue between two users. This does not apply to the transmission and reception of Telex messages through a computer terminal, possible through some service providers; such a connection is always in the form of a storage-and-forward system. It therefore does not allow such dialogue and actual teleprinter machines may be preferable for emergency purposes.

In many parts of the world Telex is being removed from service in favor of more "modern" systems that are faster but by far not as robust in serving disaster communication needs.

### 3.1.7 Facsimile (Fax)

A facsimile machine consists of a scanner, a computer, a modem and a printer in one unit. This combination allows the transmission and reception of graphic images, independently of their contents. A document in the hands of one user can therefore be made available to another user in real time. In disaster communications this has applications in respect to drawings and maps, as well as to manually compiled lists or tables or documents written by a third party, in a language not necessarily comprehensible to the sender, and/or using an alphabet not available on existing text communication links. In disaster communications this might, however, be an advantage as well as a disadvantage – a Fax connection may also tempt emergency managers to forward information "as is" rather than communicating the concise results of their assessment of the situation.

A general weakness of fax is that it is usually carried over normal telephone circuits. It is therefore subject to all their shortcomings. Furthermore all fax machines depend on external power and – unless they are connected directly to the public network – on the functioning of related equipment at the user's premises.

### 3.1.8 The Public Land Mobile Network (PLMN)

The Public Land Mobile Network, (PLMN) includes the cellular telephone networks, Personal Communications Systems (PCS) and the so-called 3rd Generation wireless data systems. PLMNs are composed of fixed radio base stations, which provide network of so called cells, and mobile terminals, which are increasingly of the hand-held type. Users can move within the area covered by the cells of a service provider, and links are automatically handed over from one cell to another. Depending on common features of various systems in use, and on commercial arrangements among service providers, subscribers can "roam" within the areas covered by other providers than the one with which the terminal is registered.

PLMNs offer connectivity to any phone or data network anywhere in the world. PLMN coverage is limited to densely populated areas, mostly in developed countries; a global coverage would not be economically feasible at present.

Many types of terminals also offer slow speed data, typically at the rate of 9.6 kbit/s. "Third generation" high-speed packet data services are becoming available, enabling data speeds comparable to those on wired networks. 3G systems are designed to give connection to Internet services such as e-mail and the World Wide Web (WWW). With such services, terminals remain logged on to the Internet all the time, thus having very rapid access to data. Depending on the arrangement with the service provider, the user might pay for data actually sent to or from the Internet, as opposed to the time charges in normal telephone connections.

Services such as Wireless Access Protocol (WAP) are carried over the PLMN networks. WAP is a protocol for the transmission of special forms of web pages, over low capacity wireless links, and for display on small telephone screens. A bonus of these systems is that the subscriber does not need to install additional infrastructure.

Cells in urban areas are designed for a capacity of about 30 simultaneous phone calls each, cells in rural areas with lower population density often have a capacity of only 6 or 7 traffic channels. The planners of cellular networks measure the traffic generated by each type of area, rural or urban, and match the capacity accordingly. Cell sizes can vary from 35 km in a rural area with very low traffic density, to 100 meters or less in a high capacity urban area. A typical figure is for a serving station to be within 5 km from the subscriber.

Radio Base Stations (RBS) are expensive, and the commercial operators provide enough capacity for their present need, but not for the kind of peak traffic required in disasters communication usage. Despite its convenience, the PLMN is therefore unsuitable for disaster. This is why services such as Fire/ Rescue and Police have private radio systems and do not rely only on cellular services.

Radio base stations at or near the disaster scene are vulnerable to damage in the same way as any other structure. Floods may damage equipment in cabinets at ground, earthquakes and storms may affect antennas on the towers and other structures.

A serious problem is that each station is connected to local power systems, which may be damaged in the disaster. The typical RBS has a capacity to continue on battery back up for about 8 hours. Many have capability to be connected to a mobile generator, but this has to be brought to the scene. Very few RBS have permanently mounted generators. A further problem is that base stations may not be able to operate standing alone, and must be connected to a Base Station controller (BSC), or a Mobile Switching Center (MSC). This link is provided either by an underground line, or a microwave link

Like any cell or RBS, Mobile Switching Centers (MSCs) have a limited capacity. They, too, are designed for the average traffic load expected in the area, but not for additional requirements such as typically experienced in the aftermath of a disaster. To offset this problem, advanced software in some switches can optionally identify certain high priority users and allocate a channel to them at the expense of those with lower priorities. In the GSM system for example, subscribers can be marked as having "Pre-emptive capability". Calls from lower priority users will be dropped in favor of calls from a user with pre-emptive vulnerability status. An actual application of such priority schemes is less depending on the technical possibilities than on the regulatory environment.

In a highly competitive market, a subscriber who is told that in case of emergency he or she might have less chances to make calls is likely to give preference to a service provider who has not implemented a priority mechanism. Only a mandatory application, using identical criteria for priority subscribers in all networks operating in a given area can ensure the application of this highly desirable network feature.

### 3.1.9 Cells on Wheels (COW)

The capacity of the PLMN can be boosted in an ad-hoc manner by the addition of temporary cell stations, known as "Cells On Wheels" (COW). These may replace a failed RBS, boost the capacity of the system or provide service in a not normally covered area. The primary problem with their deployment is the need to link the calls to an appropriate switch. It goes without saying that the COW needs to be of the same system as the one used by the mobile stations in the area and to operate in the same frequency band. The COW also needs to be connected to a switch which is compatible with the COW, this usually means made by the same manufacturer. In extreme situations, COW can be connected to remote switches in another country through VSAT links.

## 3.2 Mobile Satellite Systems

The most widely used mobile satellite system at the time of writing is the Inmarsat system. Originally created under the auspices of the International Maritime Organization (IMO) in the late 1970s, to serve the international shipping community, Inmarsat is now a privatized enterprise offering service to maritime, aeronautical and land mobile customers.

The Inmarsat system consists of Geo-stationary satellites, which connect mobile terminals through Land Earth Stations (LES) to the PSTN and other networks. Four satellites cover the surface of the earth with the exception of the Polar Regions. LES are located in various countries and within the range of one or more satellites. A communication link includes in any case at least one LES, which is the actual service provider. Below are listed the types or "Standards" of interest for land based disaster communications.

### 3.2.1 Standard M and mini-M

Standard M and mini-M are the most popular for highly mobile applications. Mini-M terminals are about the size and weight of a laptop computer, Standard M terminals the size of a briefcase. They enable connections with any PSTN subscriber worldwide, including other mobile satellite terminals. Most M and mini-M terminals have a port for connection to a Fax machine, and an RS-232 data port for the relatively slow rate of 2.4 kbit/s. Many subscribers use this type of terminal for email by means of a Post Office Protocol (POP) connection.

In common with other Inmarsat terminals, the portable versions have to be unpacked and set up so that the antenna can "see" the satellite. Most terminals have provisions to remotely locate the antenna outdoors. They can not be used in a vehicle when in motion unless equipped with special antennas compensating for the movement of the vehicle.

While Standard M terminals can operate anywhere within the coverage of the Inmarsat satellites, the use of mini-M terminals is limited to the coverage provided by spot beams of these satellites. Such spot beams, which allow the use of terminals with lower power and smaller antennas, cover most landmasses but not the oceans and many of the smaller or more isolated islands. Further developments, including a mobile ISDN service, may be expected as extensions of Standard M.

### 3.2.2 Standard C

Standard C is a store-and-forward text system, used extensively at sea for distress messages. It will transmit e-mail as well as Telex. It can be used for short emails, but is not suitable for carrying large files of data, such as attachments. Terminals are typically briefcase sized, but require terminal equipment such as a laptop computer to handle the text. Some service providers forward messages from Standard C terminals to Fax machines (but not in the opposite direction). There is no voice capability on this system.

### 3.2.3 Standard B

Standard B service offers ISDN Data at 64 kbit/s. Standard B equipment is considerably larger and heavier than Standard M terminals and intended primarily for stationary use, where it can provide connectivity for multiple, simultaneous users or high-speed data applications.

### 3.2.4 Standard A

Standard A was the first generation of Inmarsat mobile satellite terminals, offering voice, data and Telex connections using an analogue mode. Standard A units are typically much larger and heavier than the later terminals.

## 3.3 Global Mobile Personal Communications by Satellite (GMPCS)

The distinguishing feature of Global Mobile Personal Communications by Satellite (GMPCS) versus other mobile satellite systems is that the terminals are very small and lightweight, about the size and weight of a normal cell phone. The GMPCS systems include Globalstar and ICO. Because of the use of low efficiency antennas on the terminals, strong signals from the satellites are required. This is achieved either by using large high gain antennas on satellites in geostationary orbit, or by using low earth orbiting satellites (LEOs).

Terminals will be of the so called dual mode type are able to connect to either satellite or terrestrial service. Normally, users program the terminal to connect to a cellular system when that is available, but automatically connect to the satellite system when cellular coverage does not exist. Typically this may happen when operating outside of the coverage area of the terrestrial service or if the terrestrial system is disrupted or overloaded such as in the aftermath of a disaster.

An important market segment for GMPCS is fixed terminal operations, for example public telephone boxes located in places without wireline infrastructure. Another application is the “backhauling” of PBX voice circuits, for which the subscriber needs an account either with a terrestrial service provider, or with a service provider who in turn has agreements with both a space segment provider and terrestrial providers. For this to work, roaming arrangements such as described for PLMN are required. All this is done automatically, so the users need take no actions when changing form space to cellular and back again. The dual mode space/cellular phones, which automatically use the satellite links wherever cellular coverage is not available, overcome the need to either locate the terminal or phone outdoors or to use a remote antenna. They also allow savings by communicating, whenever possible, via terrestrial services rather than via satellite systems which are usually more expensive.

## 3.4 Mobile Satellite Systems with Regional Coverage

Whereas the systems described above offer global coverage, regional systems typically cover a region such as the USA or the Asian subcontinent. No service will be possible outside the coverage or "footprint" of the satellite. Current systems are such as Motient (formerly American Mobile Satellite Corporation AMSC) for the USA, Thuraya for the Middle East, northern Africa and southwestern Asia, and ACeS for Asia. Terminal types vary, with laptop computer sized terminals used for AMSC and hand held personal types used for Thuraya and ACeS. Other features, such as the possibility to make use of terrestrial cellular systems where and when available, are similar to those of the GMPCS systems.

## 3.5 The Internet

The Internet increasingly provides support for major operations and functions of organizations, including those with significant distances between headquarters and field offices. For governmental disaster workers, access to the Internet permits continuous updates of disaster information, accounts of human and material resources available for response, and state-of-the-art technical advice. As an important feature, messages can also be disseminated to groups of pre-selected recipients, thus allowing a form of targeted broadcasts.

### 3.5.1 Structure of the Internet

The Internet is a global network of networks. Communication among these networks is facilitated by common, open standards, the so-called "TCP/IP" protocols. The first and still indispensable application of the Internet is e-mail, the ability of any connected user to exchange messages with any other connected user.

In the early 1990s, a major shift in the nature and use of the Internet occurred with the emergence of the worldwide web (www) or "web", first developed in Geneva at the European Nuclear Research Center (CERN). The web is a network of servers providing hypermedia information – not only text, but graphics, sound, video and animation, with links among different content areas. A system of embedded instructions known as Hypertext Markup Language (HTML) is used to display the documents locally. The prevailing way for structuring web information is the "page". By clicking on pre-programmed hyperlinks, the user can navigate among pages that make up a single web site and switch to other sites. The display and navigation procedures are consistent among sites, so that the actual geographical location and configuration of the computer on which the information is stored is transparent to the user.

A consequence of the emergence of the web as the principal Internet application is that it requires higher speed (generally at least 28.8 kbit/s) for on-line access. Useful Internet functionality is however still available at lower connect speeds without using web-enabled browser software. One has the impression that the web has overwhelmed and incorporated all other Internet utilities and capabilities. While true in a practical sense, older utilities such as the file transfer protocol (ftp), remote login (telnet) and e-mail are independent of the web and can be fully adequate for many purposes.

In fact, all three important Internet information applications can work satisfactorily also on computers running older operating systems. Users should be aware of the potential usefulness of computers such as those with a central processor of the "386" type. Following a disaster, it may not be possible to access direct, high bandwidth connectivity. Even when no disaster has occurred, there are many locations where modern high-speed direct Internet connectivity (such as DSL or ISDN) is either unavailable or too costly. Useful Internet information exchange using ftp, telnet and email can still be accomplished through low speed (e.g. 9.6 kbit/s or less) modem dial-up to host computer accounts. Such services still exist and hosts typically connect to Internet at specific times only, i.e. connections are not continuous. There are even "web mail" servers available, permitting the retrieval of the textual content of web sites via email. Store-and-forward messaging low earth orbiting satellite systems can make email-based information available in isolated areas. A future possibility is incorporating the Wireless Access Protocol (WAP), designed for PLMN cellular systems, into low-bandwidth email systems for transmission of graphic and hypermedia content of web sites. Such systems are expected to be operative in a few areas in the near future, at least in Europe and North America, not later than in the year 2002.

### 3.5.2 Strengths and Weaknesses of the Internet

The power of the Internet, specifically that of web-based information services, continues to grow and evolve. The integration of wireless (including satellite-based) technologies and of high-speed capability on wire connections will provide disaster managers with access to far more information resources that they are likely to use. In the context of disaster communications it is essential to always keep in mind that personnel at the site of an event has, first and foremost, the task to save lives. Specific information might greatly enhance the efficient and effective use of available resources, and disaster managers are managers, not reporters. On-site relief personnel can not be expected to conduct information searches. They neither dispose of the time, nor, in most cases, of the peripheral equipment necessary to process such information in a format directly applicable to field operations. The same is valid for the provision of information from a disaster-affected location and the observations in respect to the use of facsimile apply to other graphic communication modes as well. A careful selection from potentially available options always remain necessary, but the following could be included:

– Sending and receiving e-mail and using web-based directories to locate colleagues, suppliers, governmental and non-governmental organizations who can provide assistance,
– Tracking news and weather information from a variety of government, academic and commercial providers,
– Finding up-to-date geopolitical information, geographical maps, travel warnings, bulletins and situation reports for areas of interest,
– Accessing medical databases to gather information on everything from parasitic infestations to serious injuries,
– Participating in worldwide discussion lists to exchange lessons learned and coordinate activities,
– Reading and commenting on content at various governmental, and non-governmental web sites to maintain an awareness of the large picture and how others are portraying the disaster,
– Registering refugees and displaced persons to facilitate reunification with relatives and friends,
– Reporting other than disaster related news, such as sports results, as a morale builder.

There are also certain disadvantages to an Internet-based information resource strategy. Mentioned in the previous section is the identification of the web, with high bandwidth and costly connectivity, as the only useful Internet-based information creation and retrieval resource. The possibility of maintaining older legacy systems (non-Windows, non-high bandwidth connectivity) as a redundancy option in the event of a systems failure should always be considered. The fact that equipment is not of the latest technology does not mean that it has no use, and in critical situations the opposite may apply. The high vulnerability of solid-state circuitry to static electricity and electromagnetic pulses has been overcome in some cases by the re-introduction of vacuum tube technology in critical applications.

Other possible disadvantages of Internet-based information exchange are reviewed in the following section.

### 3.5.2.1 Privacy

The openness and global reach of the Internet – the same characteristics that make it attractive for users in a disaster situation - threaten the security of data transferred via the Internet. Some institutions use secure data networks that bypass the Internet entirely except as a last resort. Given the sensitivity of information especially in a complex emergency, data tampering may be an issue. The unsuspecting and sometimes accidental wide dissemination of debilitating computer viruses could seriously affect computer systems at crucial points just when they are needed most.

### 3.5.2.2 Availability

There are limits to the robustness and flexibility of the network. As more and more important traffic migrates to the Internet, it becomes an attractive target for disruption by extremist groups. In addition to deliberate and malicious actions, denial of service can be a result of excessive demand. There have already been examples in the USA, where servers providing storm information from the National Hurricane Center and the National Oceanographic and Atmospheric Administration were overwhelmed by demand during the approach of a storm. During a crisis, the most valuable information source will often be found to be the most difficult to reach.

#### 3.5.2.3 Accuracy

The quality of information to be found on the Internet is probably no better or no worse than of information available through more traditional channels. The Internet decreases the time lag between events and the posting of information about them, and it empowers its users to contribute and publish their expertise and observations practically without any delay. However, this free market of information gives equal play to valuable information and to material that is out of date, slanted, misleading, or just plain wrong. Therefore, the user of information provided by Internet resources must in each case verify the source of an information before forwarding or applying it."

#### 3.5.2.4 Maintainability

One of the key paradigm shifts realized by the Internet is user-initiated, demand-driven access to information. While this change can increase the effectiveness of an organization and lower the costs of information dissemination, information needs to be processed. Web planners need to carefully define the scope of information to be hosted, verify its reliability, structure it in a logical way that allows easy access, and ensure continuous and prompt updating. The availability of the human resources for these tasks is as important as the acquisition of information itself.

# CHAPTER 4

# Private networks

The term “private network” is used here to describe communications facilities available to specialized users. They serve disaster communications in two ways:

1) The regular users of the network may be involved in disaster response activities, and
2) The network may temporarily carry information from and to users, which are not part of the specialized user group for which the specific network has been designed.

In the following section, both options are considered for those services most likely to be involved in disaster communications. Private networks other than those mentioned below may offer similar possibilities.

## 4.1 Maritime Radio Service

The Maritime Radio Service uses frequencies on defined channels within the frequency bands allocated to this service. It is unlikely that a station of another service will need to communicate directly with a ship at sea, but the maritime radio service has, nevertheless, applications in disaster communications. As its own emergency communication system, the maritime service uses the Global Maritime Distress and Safety System (GMDSS). This service is however of use only to ships and Marine Rescue centers for the purpose of safety of life at sea (SOLAS).

### 4.1.1 Maritime Networks

For short-range communications, typically within 20 km, the VHF band is used. The standard Distress Urgency and Safety frequency in the maritime VHF band is 156.8 MHz. By law, every ship is required to monitor this frequency 24 hours a day. In an emergency, it is recommended to first call the vessel on that frequency before moving to another channel for the communication.

Ships may have an automatic selective call system called DSC (Digital selective calling), on VHF channel 70. To use this facility, the Maritime Mobile Service Indicator (MMSI) code of the ship is required. If this code is not known, the ship's name can be used in voice on VHF channel 16. In addition, coast stations must also have a MMSI. This code is assigned together with the station's callsign.

Another way to contact a ship if the MMSI code is not known is the use of an “all ships” code. This causes a text message to appear on the communications terminals' screens on ships in range of the calling station. The originator will then state for what ship the call is intended, and both stations will switch to a voice channel.

While in port, a ship or boat may monitor a port operations channel. Once contact on a port frequency is established, the port radio station may assign a working channel.

A ship at sea may also be contacted through the shipping agent responsible for its cargo. This enterprise will be able to contact the shipping company operating the voyage, which will in turn have a reliable way of communication with the ship. The shipping line is likely to know the communications means available on board the specific vessel, and can assist with arrangements for direct contact.

### 4.1.2 Maritime Public Correspondence Stations

Ships at sea maintain contact with the shipping line by means of satellite telephone services such as Inmarsat, or through coastal radio stations. If the vessel is equipped with a satellite Telex terminal, then it may be possible to communicate directly with the ship by Telex. Ships also often have an e-mail address, usually through a storage and forward system including a mailbox on shore.

On HF Radio, many coast radio stations are set up for the purpose of public correspondence, offering phone patch service to PSTN phones. For long-range communications, HF radio frequencies are used.

Maritime Coast Stations traditionally accept disaster and emergency related traffic, even though the disaster relief station may be land rather than sea based. As with all radio systems, a license will be required from the country where the land station is operating. In an emergency situation, there has been flexibility on these issues, and a coast station might well accept to handle traffic from a station, which does not have an account with the respective service.

## 4.2 The Aeronautical Radio Service

The Aeronautical radio service has frequency bands allocated for communication with and among aircraft, and additional bands are allocated for Radio Navigation equipment such as used during instrument flight. A station intending to communicate with aircraft in flight needs "air band" radio equipment. Land Mobile Service equipment is technically incompatible with that used in the aeronautical band; this is not only due to the different frequency allocations, but because the aeronautical service on VHF uses amplitude modulation (AM), whereas FM is the standard on VHF in the Land Mobile Service.

### 4.2.1 Aeronautical Networks

Civil aircraft are usually fitted with VHF radios operating between 118-136 MHz, using the AM modulation system. This is the standard for air to ground and air to air communication. In addition, some long-range aircraft, (but not all), may be fitted with HF radio equipment using the Upper Side Band (USB) modulation system. By far most communication is performed using a single frequency in Simplex mode, without repeaters. The heights of aircraft mean that they are easy to communicate with, even at very great ranges.

The international standard emergency frequency is 121.5 MHz AM. Many high-flying aircraft monitor this frequency when they are en route. This frequency is also monitored by satellites, which can determine the position of a radio calling on this frequency. For this reason, 121.5 should only be used in the case of genuine life threatening emergency. To contact an aircraft in flight without prior arrangement with the aircraft, calling on 121.5 MHz may get a reply, but this should be considered only as a last resort. Once contact has been made, both stations must immediately change to another working frequency.

Whenever possible, prior arrangements should be made when a need for communication with aircraft is expected. The local civil aviation authority should be asked for the allocation of a channel for such traffic, and respective information should be included in the agreement with the air carrier and in the briefings to the crew.

In disaster response operations, HF radio can play a key role in the airlift management. In such cases, the contract with the air carrier should specify that the aircraft is to be equipped for this type of communication. HF radios in the aeronautical service often feature a selective calling system (SELCAL). This works somewhat like a paging system and allows the crew to ignore calls not transmitted specifically to them. If a ground station does not have this capability, the flight crew needs to be instructed not to engage their SELCAL.

If no specific frequency for contact with disaster operations has been defined, 123.45 MHz is an option. Though not officially allocated to any purpose, it has come to be an unofficial “pilots’ chat frequency”. A pilot may not, however, be monitoring 121.5 MHz or 123.45 MHz, but rather a local or regional flight information frequency. Information about such channels can best be obtained from air traffic control centers in the region.

### 4.2.2 Aeronautical Public Correspondence Stations

The aeronautical service includes public correspondence stations, similar to those of the marine radio station previously described. All over the world, HF radio stations are established for the purpose of relaying flight operational information between pilots and their bases, and of position reports to the respective control authorities. In addition, however, they also make phone patches to landline telephones for personal calls, home to family members for example. This service is charged against a credit card or an account.

For disaster communications, aeronautical public correspondence stations can be contacted for phone patch traffic in the same way as maritime correspondence stations. To facilitate this, relief organizations may wish to open an account with such stations in advance and they will then also receive information such as a frequency guide. In all cases frequencies in use for flight operations are to be avoided by other than aeronautical users.

### 4.2.3 NOTAM

When filing a flight plan, pilots are provided with any Notices to Airmen (NOTAM), safety related messages, referring to the path of their intended flight. Such notices include updates on the navigational and other relevant information provided in charts and manuals. In the case of major disaster response activities with involvement of air operations, details about air drop sites, temporary airstrips and related communications arrangements may be published in a NOTAM.

### 4.2.4 Private Radio on Board Aircraft

Experience has shown that it is not a good solution to expect pilots to use a radio of the land mobile service. Land mobile FM radio equipment operates on other frequency bands than aeronautical AM radio equipment, and additional equipment would have to be installed on board. This would be time consuming and would have implications in respect to air safety regulations.

A hand-held transceiver is hard to use in an aircraft, given the high noise levels in most light aircraft and even in some of the larger planes commonly used in airdrop operations. If such a link to the operations on the ground is inevitable, one crewmember should monitor this radio, independently of aeronautical radio traffic and using headphones. A skilled operator may then even use the extended range provided a station at high altitude to relay emergency traffic.

### 4.2.5 Special Considerations involving Communications with Aircraft

A station of the land mobile service must never, even accidentally, give the impression that the operator is a qualified air traffic controller, as this might be misleading. A ground station which is not providing official air traffic control needs to make this fact clear at all times. Pilots must know when they are in uncontrolled airspace, and apply the respective rules.

Communication with aircraft should preferably be conducted with the captain, who may also be called the pilot in command. Only captain is authorized to make decisions such as whether an aircraft will take off or land, and the captain's decision can in no case be overruled.

## 4.3 Radionavigation Services

Radionavigation systems have a complementary role in disaster communications. Hand-held equipment for personal use is available at low cost, and subscriptions or licenses are not normally required. The system most commonly used at the time of writing is the Global Positioning System (GPS), operated by the US Government. Available is also GLONASS, run by the Russian government, and an additional system, Gallileo, has been proposed by the European Union.

The above-mentioned systems provide global coverage, and commercially available hand-held receivers have a position accuracy of about 50 meters. Their indication of altitude above mean sea level is somewhat less accurate. For special applications, equipment with higher accuracy is available at higher cost. In many emergency applications, however affordability and simplified use may well be more important than highest accuracy. In disaster situations, position finding serves the three main purposes outlined below.

### 4.3.1 Safety and Security Applications

Humanitarian personnel in the field are exposed to high safety and security risks. The provision of reliable communication links in combination with position information is therefore vital. Assistance to personnel in danger includes two separate elements: search, and rescue. The search is the more time consuming and often more costly part of such response, and if the distressed person is able to report his or her position, this will enhance the speed and appropriateness of the response.

### 4.3.2 Reporting Applications

Periodic position reporting facilitates the provision of assistance and may at the same time provide essential information about potential hazards encountered by personnel at a disaster site. Positions can be read off from hand held units in two ways, either in coordinates, i.e. as Latitude and Longitude, or as a relative position. The use of coordinates requires that maps with respective grids be available, and that the operators be familiar with the use of the system.

Relative positions, the indication of direction and distance from or to pre-defined, fixed points, can be obtained from most hand held GPS receivers. If an easily identifiable landmark is chosen as the reference point, this information can be more useful than coordinates, as it may be easier to interpret and allows the use even of a tourist or other less accurate map without coordinates.

Combinations of communications equipment and navigation systems, allow the automatic tracking of vehicles on a map displayed on a monitor screen in a dispatcher's office. Similar equipment in hand-held form is expected to become available for the tracking of individual users.

### 4.3.3 Logistics Applications

Moving relief goods, supplies and equipment, is particularly difficult if drivers are not familiar with an area where road signs may not exist and language problems may furthermore hinder the acquisition of information. Knowing the coordinates of the destination, or its location in respect to a fixed reference point or landmark rather than just its name, can help to overcome these problems. Place names may be hard to write or pronounce, and are often duplicated within a close distance. Whenever possible, vehicles should be equipped with position locating equipment and drivers should receive training in its use.

### 4.3.4 Waypoints

Position finders may have a feature allowing the user to record his or her position. The unit will then allow the user to define this position as a waypoint. Storing such information along the route facilitates the return to any point passed previously. Others travelling the same route later can copy the waypoints to their equipment and follow the identified route. This will however require a systematic assignment of names to the waypoints.

### 4.3.5 Personal Locator Beacons (PLB)

A Personal Locator Beacon (PLB) is a body worn small radio transmitter designed to transmit position, plus some information about the user, to a rescue center. PLBs are intended primarily for the personal use of mountain climbers and yachtsmen. PLBs are more expensive than Emergency Location Transmitters (ELTs), but since ELTs are associated with aircraft and have limited accuracy, the PLB is recommended as personal equipment for field personnel.

When a specific button is pressed on the PLB, the position and the identity of the PLB is sent to the rescue center via satellite. The voyage plan file is then associated with the PLB identity, and the contact details of the user's office can be recalled. The center alerts the base of the PLB user or a rescue agency. It is the responsibility of the owner of the PLB to up-date the voyage plan regularly with the rescue center. Such devices are valuable in cases of extreme isolation or when working in areas with high security risks.

## 4.4 Enterprise Systems (Private Systems)

Enterprise systems are small-scale systems intended for use by businesses and organizations. Except for smaller size, their structures are similar to those of the corresponding public systems. Larger institutions involved in disaster management often maintain their own enterprise systems. These form the most important command and control tool for the management, and understanding their strengths and weaknesses is therefore essential.

The Private Branch Exchange (PBX) is one typical example of an enterprise system. It consists of a telephone switch on the owner's premises, usually connected to PSTN lines. Internal cabling connects the switch to extensions throughout the premises. Initially connections used to be established by an operator, and connections among the extensions of the PBX were therefore independent of any external network infrastructures.

The Direct Dial-In (DDI) systems commonly used today reduce the need for switchboard operators by associating each extension with an external number. Thus a caller from outside may be unaware that the called party is on an extension. At the same time, however, the functioning of the PBX even for internal connections may be affected by a disruption of the public network.

One significant advantage of PBX systems is that the owners can keep control of the grade of service. Since they are paying for the capacity of the switch, they can decide to allow for the much greater traffic that a disaster can generate. Since their circuits will not be allocated for public use, they will not be contending for capacity.

A PBX will work only if it has power. Switches commonly have battery backup power for a few hours. If the regular power remains disrupted for a longer period, a generator backup will be required. A PBX may take some time to reboot after any interruption of the power.

If a PBX becomes inoperable due to a power failure, a “fallback service” comes into play. With this system, certain pre-defined extensions are connected directly to incoming lines. In fallback mode, only these fallback phones will work, while all others will be inoperable. Fallback phones have often plain designs. As a result they often get hidden or disconnected; in an emergency situation it is essential that their locations be known. Only these fallback phones will ring on incoming calls during power outages. Power outages also mean loss of lighting and air conditioning, a fact that needs to be considered when deciding on the location of fallback phones. It should also be noted that fallback service is only possible if the connection is provided by a 2-wire POTS connection, and not by a digital connection.

Permanent private links to other parts of the organization do not necessarily ensure immunity from failures of the public system. Very likely the private cables providing circuits to other premises, are carried down the local cable system, via repeaters and over the public trunk system. If any part of the public system is affected by a power failure of switches, private lines may be disrupted as well. Connection by direct cable-connection, without passing through elements of other networks, may overcome this problem.

A common solution to improve disaster resistance is to use microwave links for up to 20 km and satellite links for longer distances. Microwave link systems should be considered if there is line-of-sight connection between premises.

### 4.4.1 Data Networks, Local and Wide Area Networks, Intranets

Many medium and large organizations operate their own electronic mail service, using computers with e-mail server software. The server is connected to the workstations by means of a Local Area Network LAN, and in some cases may cover various premises of an enterprise. Such an arrangement is known as a Wide Area Network (WAN).

LANs and WANs have switches similar to a PBX. These are called “routers”. Their function is to send traffic not intended for a local server over a long-range link to another router on different premises. A router can have more than one link to more than one off site router. This adds redundancy, as alternative links may replace disrupted connections.

### 4.4.2 Diverse Routing

Whenever possible, the PSTN and the private lines of a router or a PBX should be connected to different exchanges via different routes. This arrangement is called diverse routing. Local telephone companies can usually provide such a service upon request, but the cost might be considerable.

### 4.4.3 Software Defined Radios (SDR)

Software Defined Radios (SDR), also called software radios or soft radios, are digital computers connected to an antenna and controlled by software. This is a relatively new development. Most software receivers use an analogue front end, consisting of band-pass filtering, a low-noise RF amplifier to set a low system noise level, and local oscillator and mixer stages to heterodyne the signal to an intermediate frequency (IF). On the IF an analogue-to-digital (A/D) conversion and digital filtering and demodulation take place. Some software receivers perform A/D conversion immediately after the antenna. It is important to note that software radios are distinct from computer-controlled radios. The latter are conventional analogue designs, but include features such as digital signal processing (DSP) and software-driven control.

Future SDRs should accommodate any protocol and/or frequency band and/or feature package in the subscriber unit, plus the ability to effect changes dynamically. Some of the more obvious multi-protocol/multi-frequency combinations can be accommodated by advanced designs, but their scope is still limited and units are not necessarily "future proof". SDR designs have the ability to store required protocols and to allow rapid changes to both hardware and software. For system operators this ultimately eliminates protocol and frequency issues for worldwide service, and a uniformity of systems might no longer be a requirement to ensure connectivity.

Another SDR feature is the ability to deliver software upgrades and new features to users. SDR terminals accept downloaded data to effect the installation of new software, speeding implementation of new features. Introducing software “updates” in this manner avoids a mass recall of units or the necessity for users to replace their older terminals.

SDR applications for civil use are so far primarily in public safety and for state and local government agencies to communicate during civil emergencies. Civil SDR applications include portable command station for crisis management, inter-agency communications, and instant routing of emergency information.

A common commercial application of SDR is to solve logistical/service problems in cellular, PCS and dispatch networks. SDR offers the wireless user the ability to use a single terminal to access a wide range of wireless services and features – and to reconfigure dynamically. These designs also facilitate “future proofing” of subscriber terminals, an important consideration in a high capacity system. In the future, SDR is expected to provide true international roaming with a single unit, freedom of choice (types of service, level of features), Internet inter-operability, and the creation of virtual networks.

## 4.5 Very Small Aperture Terminal (VSAT) Networks

One way to improve the chances that an enterprise system will remain operational during a disaster, is to connect via satellite. This will make it free from both a failure of terrestrial infrastructure and a congestion of the PSTN.

The acronym VSAT stands for “very small aperture terminals”. The antennas determining the aperture typically range in size from less than one meter to 5 meters, depending on the frequency band used. VSAT terminals cost from USD 3000 – USD 5000 at year 2000 prices. They are mostly designed for fixed installation, but so-called "flyaway" systems are available for disaster recovery purposes. Further developments are expected to enhance their applications in disaster communications.

In general, subscribing to a VSAT service means the purchase of a group of channels for a fixed period. No other user will be sharing these channels, and the subscriber is guaranteed the use of these channels even when systems such as PSTN and mobile satellite may be congested. This is a preferred alternative, but the cost is high and it may be economical only as part of a larger enterprise system. VSAT service is available from a number of commercial operators offering global or regional coverage.

Alternatively, a demand assigned multiple access system (DAMA) can be used in case it should not be desirable to use a regular VSAT service as part of an enterprise system. DAMA permits access to bandwidth on a demand basis. The cost is likely to be lower, but there is a risk of not getting service when the demand on capacity is high.

If one is serious about reliable long-range communications, VSAT is a superior system. The terminal equipment needs of course be protected from physical damage. The dish in particular should be placed where it is not exposed to flying debris during storms, while still maintaining its aim at the satellite. Following a storm or an earthquake an adjustment the position of the antenna may be necessary, and special equipment in addition to the actual VSAT terminal is required for this.

VSAT systems connect the PBX directly to one at another location by satellite link. This means immunity from failure of the ground services, as long as the earth station remains operational and has independent power. However, but both the capital cost of the equipment and air-time charges are high. Another strategy is to use either satellite mobile phones, or fixed cellular terminals, as one of the outside lines. The terminal must have a standard 2-wire POTS interface in order to do this. When the terrestrial lines fail, the satphone can be used to make and receive calls.

Some institutions use private data networks for workstations. This is done so users can share file servers and printers. By far the most useful service provided is electronic mail (e-mail). A short-range system covering one building is called a Local Area Network (LAN). A network connecting different premises of the same institution is usually called a Wide Area Network (WAN).

## 4.6 Training Exercises to ensure Rapid Response

The high turnover of staff in many organizations requires continuous training activities. In as far as routine operations are concerned, new staff members are often expected to learn “on the job” from predecessors or peers, but in respect to disaster communications this approach is not sufficient. Periodic training also ensures a continuous awareness of the additional demands which each individual might be confronted with in case of a disaster.

Disaster response depends on teamwork. Training exercises including all potential partners are therefore important. In addition to a familiarization with the roles of all sectors and individuals within the own organization, an understanding of the mandate and the working modalities of others involved in emergency operations is indispensable in particular for those in charge of communications.

Training exercises rarely go perfectly, but this is a good thing. The trainers need to make the exercise realistic enough to expose weaknesses in procedures or equipment, but at the same time simple enough for newcomers to learn how operations are supposed to work. After the exercise, time should be spent reviewing shortcomings encountered and mistakes made, so that lessons learned can be applied in the future. Since the environment in disaster response is highly dynamic, training exercises are one of the most effective tools in the development of operating procedures and contingency planning.

Technical equipment rarely takes well to long term storage. One reason for this is the deterioration and self-discharge of batteries, but equally common are other factors, including the loss of instruction manuals or of auxiliary parts. Taking equipment out of storage and testeing them during training exercises are major contributions to maintaining a readiness state.

# CHAPTER 5

# The amateur radio service

A word of explanation is needed in the introduction of this subject. Amateur Radio is a radiocommunication service defined in the Radio Regulations (RR, S1.56, Geneva, 1998) of the ITU. It is not a "hobby" or "citizens band" radio. It is a regulated and licensed service made up of operators who have successfully passed a technical examination given by an Administration prior to the issuance of an individual operator's license.

Therefore, while Amateur Radio is a specialized radio communication service in the meaning of this text, it is somewhat different in character from the other services described. Amateur Radio operators can take on a public service role when and if requested, and they frequently do so in times of disaster. Many of the characteristics of the amateur radio service are such that they can assist to respond to requests for disaster communications services. These characteristics include the operation of highly independent and flexible networks while often using very limited resources.

This permits amateur radio to be of service in disaster communications in several ways. Firstly, it provides a cadre of trained operators, many with superior technical and operational skills. These operators are able to use radios under field conditions and, most important, to make them work. Secondly, amateurs already have in place, in many parts of the world, an existing core of stations loosely configured for local, regional and inter-continental radio communications.

For the amateur service, Administrations do not assign stations to specific frequencies; instead they allot frequency bands within which amateurs may dynamically select channels. This results in amateurs having a high degree of skill and knowledge about such topics as radio wave propagation, antenna design and installation and interference mitigation techniques. Because amateur radio is normally conducted with personally owned equipment, the operators are also familiar with cost effective means of prolonging equipment and battery life through care and maintenance procedures.

Therefore, to benefit fully from the potential contributions of Amateur Radio operators and stations in disaster communications, Administrations should encourage amateur activity by establishing rules, regulations and organizational structures promoting and facilitating this service.

## 5.1 Communication Range

The Amateur Radio Service operates networks in all ranges of concern for disaster communications, from local VHF networks to long distance HF and satellite links. Most of the considerations in the following section apply in principle to all disaster communications radio networks.

### 5.1.1 At the Disaster Site

Local communications utilizing hand-held or vehicular VHF and UHF radios provide immediate, real-time, flexible, highly mobile and reliable communications. Such networks can be most useful for the co-ordination between emergency response providers if their own communications are not interoperable, overloaded or disrupted.

### 5.1.2 To and from the Disaster Site

Communication from the area affected by the disaster to stations outside the area can be established over shorter distances by VHF/UHF, and over longer distances by HF radio or amateur radio satellite links. Unless special arrangements have been made, a station in the disaster area will usually make a general call (CQ) to other amateur radio stations, indicating the type of communication requested. Once an initial contact is established, the station outside the disaster-affected area may then also alert other stations that might be in a better position and ask stations to be on stand-by on an emergency frequency.

At present, there is no permanently established and structured global amateur radio disaster network. In some areas however nets are scheduled on a regular basis, providing training opportunity and, if and when required, immediate disaster communications.

## 5.2 Distance Considerations

The distance of communication is an important factor in the election of frequencies, radio equipment and antennas. The following overview refers to the frequency bands allocated to the amateur radio service, but the characteristics of the various bands also apply to bands of other services below and above each amateur band. Note: Amateur allocations may differ by ITU Region and by Administration. In some places, a regionally allocated frequency band may be less wide than the frequency ranges shown below.

### 5.2.1 Short Range (0-100 km)

For short distance communications of 0-100 km VHF and UHF frequencies are the primary choice. The respective amateur radio service allocations are the following:

50-54 MHz (6 meter band)

This band provides good propagation beyond line-of-sight up to about 100 km but is subject to long-distance interference from sky wave signals at distances up to about 1500 km.

144-148 MHz (2 meter band, in some regions only 144-146 MHz)

This band is the best choice for local communication between hand-held transceivers up to about 10 km or up to about 30 km with directional antennas. Radio amateurs are most likely to have fixed, mobile and hand-held transceivers for this band. Communication over a wider area is possible using a repeater installed in a favorable location with sufficient height over average terrain. Repeaters can furthermore be equipped with telephone interconnection devices (known as autopatch).

420-450 MHz (70 centimeter band, in some regions only 430-440 MHz)

This band covers ranges shorter than those for the 2 meter band but has otherwise similar characteristics, including the possibility to use repeaters.

### 5.2.2 Medium Range (0-500 km) Near-Vertical-Incidence HF Sky Wave

Communication at medium distances of 100-500 km may be accomplished by near-vertical-incidence sky wave (NVIS) propagation at the lower HF frequencies up to about 7 MHz. The band characteristics are as follows:

1800-2000 kHz (160 meter band)

This band is most useful at nighttime and during low solar activity. Under field conditions, the dimensions of antennas may restrict the use of this band, which is also frequently affected by atmospheric noise, particularly in the tropical zone.

3500-4000 kHz (80 meter band, in some regions only 3500-3800 kHz)

This is an excellent nighttime band. Like all frequency ranges below about 5 MHz it can be subject to high atmospheric noise.

7000-7300 kHz (40 meter band, in some regions only 7000-7100 kHz)

This is an excellent daytime band for near-vertical-incidence sky wave paths. At the higher latitudes, especially during periods of low sunspot activity, lower frequencies may be preferable.

### 5.2.3 Long range (beyond 500 km) Oblique-Incidence HF Sky Wave

Amateur stations can communicate over long distances, typically beyond 500 km, using oblique-incidence sky wave propagation at HF. The characteristics of the respective bands are as follows:

3500-4000 kHz (80 meter band, in some regions only 3500-3800 kHz)

This is an excellent night-time band, particularly during low sunspot activity. However communications may affected by high atmospheric noise, particularly at low latitudes.

7000-7300 kHz (40 meter band, in some regions only 7000-7100 kHz)

This band is a good choice for around 500 km during the daytime and for long distances, including intercontinental paths, at nighttime.

10100-10150 kHz (30 meter band)

The 30-m band has good day and night propagation and can be used for data communication. It is not currently used for voice because of its limited width.

14000-14350 kHz (20 meter band)

The 20-m band is the common choice for the daytime communication over long distances.

Propagation on the following bands is suitable for longer distances during daytime and high sunspot activity:

18068-18168 kHz (17 meter band)
21000-21450 kHz (15 meter band)
24890-24990 kHz (12 meter band)
28000-29700 MHz (10 meter band)

### 5.2.4 Medium and Long Ranges via Amateur Radio Satellites

Amateur radio satellites can serve as an alternative to HF sky wave links. They do not provide a continuous global coverage, but some satellites have a storage-and-forward capability, allowing the forwarding of messages between stations without simultaneous access to the respective satellite. Further developments in the Amateur Radio Satellite service can be expected to increase its applications in disaster communications.

## 5.3 Selection of Operating Frequencies

Amateur radio operators are free to make real-time selection of operating frequencies within the bands allocated to the service. The choice of a band depends primarily on the range to be covered, and changes might be necessary depending on the propagation conditions at a given location and time. Calculation tables and computer software are available for the prediction of optimum frequencies for any given path. Due to the rapid changes of the conditions affecting the propagation of radio waves such information is, like terrestrial weather forecasts not fully reliable.

### 5.3.1 Band Plans

Each of the three IARU Regions has its own band plans, which serve as guidelines for the sub-bands to be used for communications in various modes. Typically, band plans designate sub-bands used for telegraphy, digital data, voice, and image communications. While not mandatory under the Radio Regulations, sub-bands need to be strictly respected in order to avoid interference among users operating in different modes.

### 5.3.2 Emergency Frequencies

Frequencies for emergency calls have been defined in some countries. In the event of a disaster, Administrations may assign specific frequencies for use only by stations providing emergency communications. In some cases, Administrations have assigned frequencies adjacent to the amateur band allocations to relief organizations such as the Red Cross movement, thus facilitating their communications with stations of the Amateur Radio Stations and allowing the use of ready available amateur radio equipment and antennas.

## 5.4 Communication Modes

Amateur stations can use any type of emission for which the allocated frequency bands, the band plans and national radio regulations provide the appropriate bandwidth.

### 5.4.1 Radio Telegraphy

Radio Telegraphy using the international Morse code is still in widespread use throughout the amateur services and can play an important role in disaster communications, particularly when simple equipment or low transmitter power must be employed. The use of Morse code also helps to overcome language barriers in international communication. Its effective use requires operators with skills greater than the minimum licensing requirements.

### 5.4.2 Amateur Radio Data Communication

Data communications have the advantage of accuracy and of creating records for later reference. Messages can be stored in computer memory or on paper. Amateur digital data communication is accomplished by a desktop or laptop personal computer as the base-band device and a communication processor, sometimes referred to as a terminal node controller (TNC). The communication processor performs encoding and decoding, breaks the data into transmission blocks and restores the data into a stream. It also compensates for transmission impairments, compresses and decompresses data, and handles analogue-to-digital and digital-to-analogue conversions.

#### 5.4.2.1 HF Data

On HF, the Amateur Radio Service uses a variety of data communications protocols. PACTOR II is one of the proprietary modes available for amateur disaster communications and is also used on several emergency networks of the United Nations and other organizations. Depending on the specific requirements of a network, other data modes might be preferable, among them PSK-31 as a real-time data communications mode, replacing mostly radioteletype (RTTY) links.

#### 5.4.2.2 Packet Radio

Packet radio can be a powerful tool for traffic handling. Text messages can be prepared and edited off line and then transmitted in shortest time, thus reducing congestion on busy traffic channels. Packet radio can be used by fixed as well as mobile or portable stations.

Packet radio is an error-correcting mode, and uses the radio spectrum efficiently. It allows multiple communications on the same frequency at the same time and provides time-shifting communication. By storing messages on packet bulletin boards (PBBS) or mailboxes, stations can communicate with other stations not on the air at the time. Packet radio operates over permanently established or temporary networks, and any station with access to such networks can by this means expand its communication capability. With all these features, radio amateurs are using packet for numerous diverse applications including traffic handling, satellite contacts, long distance communications and disaster communications.

#### 5.4.2.3 VHF/UHF Data

On the VHF and UHF bands, the AX.25 packet radio protocol is a reliable and efficient method of data communications at rates of 1 200-9 600 bit/s, depending on the equipment used.

### 5.4.3 Single-Sideband Radiotelephony

Suppressed-Carrier Single-Sideband (SCSSB or SSB) radiotelephony with 300-2 700 Hz audio passband is the most commonly used voice mode in the amateur as well as in other HF radio voice services.

## 5.5 Image Communication

Although not in widespread use for disaster communication, suitably equipped amateur stations can transmit and receive facsimile or television images. For image communications, amateurs employ basically three techniques: fast-scan amateur television (FSTV) also referred to as amateur television (ATV), slow-scan amateur television (SSTV) and facsimile (fax). In addition, some data modes allow the transmission of files containing images.

## 5.6 Amateur Radio Satellites

The amateur radio service over satellites is an extension of the terrestrial amateur radio networks. Due to the very nature of the service, communications through such satellites require skilled operators and, at least in the case of some amateur radio satellites, equipment which may not be suitable for use without specific technical knowledge. In the hands of experienced operators these satellites can nevertheless provide useful services in disaster communications, and further developments will increase the possibilities for such applications.

### 5.6.1 Analog Transponders

Repeater stations retransmit signals to provide wider coverage. This is essentially also the function of any telecommunication satellite, including those operated by radio amateur organizations. While a repeater antenna may be ten or hundred meters above the surrounding terrain, the satellite is hundreds or thousands of kilometers above the surface of the Earth. The area that the satellite signals can reach is therefore much larger than the coverage area of even the best positioned terrestrial repeaters. It is this characteristic of satellites that makes them attractive for communications. Amateur radio satellites usually act as either an analog repeater, re-transmitting signals simultaneously and exactly as they are received, or as packet store-and-forward systems, receiving messages from ground stations and re-transmitting them at a later time and from another position on their orbit.

In the case of amateur-satellites, the difference between transmit and receive frequencies, called the frequency split, is in most cases considerably larger than that of typical terrestrial repeaters. Transmission from the satellite (the downlink) often takes place in another frequency band than the transmission to the satellite (the uplink). A transmission received by the satellite in the 2-meter band might thus be retransmitted on a frequency in the 10-meter band. Such cross-band operation allows the use of less complex filters in the satellite as well as at the terrestrial stations. Stations operating via a satellite in this cross-band mode can furthermore use full duplex mode, simultaneously transmitting and receiving.

Unlike most commercial communication satellites, amateur radio satellites are not always immediately accessible. They mostly use elliptic Low Earth Orbits (LEO about 1000 km above the surface of the Earth, causing the satellite to complete an orbit in about 100 minutes. The combined movements of the satellite and the Earth result in the periodic coverage of various regions.

From the perspective of an observer on the ground a LEO satellite rises above the horizon, travels across the sky in an arc, and then sets again. It may do so six to eight times a day. For “passes” in which the satellite goes nearly overhead, this rise and set cycle takes 15 or 20 minutes. On some orbits the satellite path is such that it rises only to a low angle above the horizon, much like the winter sun near the Arctic Circle. The time the satellite is within range of a specific station is then much shorter. The total amount of time during which any particular LEO satellite of the Amateur Radio Service is available at a given location is in most cases in the dimension an hour.

### 5.6.2 Digital Transponders

A fundamental change in amateur radio in recent years has been the use of packet radio over satellites. The combination of the two has resulted in the PACSAT, a type of satellite carrying a packet radio transponder. PACSATs operate in a fundamentally different way from satellites with analog transponders.

When a ground station transmits a digital message, the satellite stores the message in its onboard computer memory; only once it passes over the ground station for which the message is intended, it retransmits the message. This store-and-forward operation allows worldwide communications using a low-Earth orbit satellite without the need for a traffic link to a terrestrial control station. Each PACSAT can store a large amount of data, and because these satellites are optimized for data rather than voice mode they furthermore are a highly effective bulletin transmission system.

## 5.7 The Amateur Radio Emergency Service (ARES)

Amateur Radio Emergency Service Groups, in several countries known as ARES, consist of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public interest when disaster strikes. All licensed amateurs are eligible for membership in the ARES. Members of ARES groups either use their own personal emergency-powered equipment, or operate equipment that the group has acquired and maintains specifically for disaster communications. The outline of standard ARES procedures given in the following section may also serve as a guideline for disaster communications support teams in general.

### 5.7.1 Pre-Departure Functions

Team leaders should provide ARES members with notification of activation and assignment. Credentials should be provided for recognition by local authorities. An operational and a technical briefing should take place, based on information from the requesting authority and supplemented by reports from amateur radio, commercial radio, and other sources. The briefing has to include an overview of identified equipment and manpower requirements, ARES contacts, and conditions in the disaster area.

### 5.7.2 In-Travel Functions

The time spent on travel to the disaster-affected location should be used to review the situation with the team. The review can include can include task assignments, checklists, affected area profile, mission disaster relief plan, strengths and weaknesses of previous and current responses, maps, technical documents, contact lists, tactical operation procedures, and response team requirements.

### 5.7.3 Arrival Functions

Upon arrival, team leaders should check with local ARES officials and obtain information about frequencies in use, current actions, available personnel, communication and computer equipment, and support facilities. The ARES plan in effect for the specific disaster should be obtained. A priority should be the establishment of an initial intra-team communication network and HF or VHF links to the home location. Team leaders should meet with served agencies, amateur radio clubs' communications staff, local communications authorities and others as needed to obtain information and coordinate the use of frequencies. Communication site selections should take into account team requirements and local constraints.

### 5.7.4 In-situ Functions

Team leaders should make an initial assessment of functioning regular communication facilities and networks of other response teams, to coordinate operations and reduce duplication of effort. Proper safety practices and procedures must be followed. Periodic critiques of communication effectiveness should be conducted with served units and communication personnel.

### 5.7.5 Demobilization Functions

An extraction procedure for amateur communicators should be negotiated with served agencies and host officials before it is needed. To get volunteers' commitment to travel and participate, they must be assured that there will be an end to their commitment. Open-ended commitments of volunteers are undesirable, partly because they make potential volunteers hesitate to become involved. Leaders must coordinate with served agencies, to determine when equipment and personnel are no longer needed. A demobilization plan should be in effect. A team critique, begun on the trip home, should be conducted, and individual performance evaluations should be prepared. Problems stemming from personality conflicts should be addressed and/or resolved outside of formal reports, as they only provide distractions to the reports. Equipment should be accounted for. A post-event evaluation meeting should be conducted, and a final report prepared.

### 5.7.6 Standard Procedures

The size of a disaster affects the size of the response, but not the procedures. Standard procedures exist on issues such as the use of repeaters and an autopatch, check in on a net frequency and the format of messages. In disaster communications, following such standard principles of operations is always preferable to the introduction of new and possibly not previously exercised procedures.

Amateurs need training in operating procedures and communication skills. In an emergency, radios don't communicate – people do. Proper disaster training needs to prepare the participants for systematic and accurate work in even the most chaotic environment.

## 5.8 Training Activities

Training should cover the basic subjects: emergency communications, traffic handling, net or repeater operation and technical knowledge. Practical on-the-air activities, such as a Field Day or a Simulated Emergency Test (SET) offer training opportunities on a nationwide basis for individuals and groups and reveal weak areas in which more training or improvements to equipment are needed. In addition, drills and tests can be designed specifically to check the readiness and the reliability of emergency equipment that is not permanently in use.

### 5.8.1 Practice, Drills and Tests

A drill or test that includes interest and practical value makes a group glad to participate because it seems worthy of their efforts. In order to present a realistic scenario, training should be centered on a simulated disaster situation and, if possible, in combination with training exercises of other partners in emergency assistance.

Training should include the activation of emergency networks, the dispatch of mobile stations to served agencies, the originating and processing of messages and the use of emergency-powered repeaters. As warranted by traffic loads, liaison stations may need to be assigned to receiving traffic on a local net and relay it to outside destinations. To a large degree, the value of any exercise depends on its careful evaluation and on the application of lessons learned.

### 5.8.2 Field-Day-Type Event

A Field Day (FD) event encourages amateurs to operate under simulated emergency conditions. A premium is placed on operating skills and adapting equipment to meet the challenges of emergency conditions and related logistics. Amateurs are used to operate stations capable of long-range communications at almost any place and under difficult conditions. They are also familiar with the alternatives to commercial power such as the use of generators, batteries, wind and solar power.

### 5.8.3 Simulated Emergency Tests

A Simulated Emergency Test (SET) builds emergency-communications skills. The purposes of SET are to

– help operators gain experience in communicating using standard procedures under simulated emergency conditions, and to experiment with some new concepts,

– determine strong points, capabilities and limitations in providing emergency communications to improve the response to a real emergency, and

– provide a demonstration, to served agencies and the public through the news media, of the value of Amateur radio, particularly in time of need.

SET will furthermore serve to

– exercise VHF-to-HF interfaces at the local level,

– encourage an increased use of digital modes for handling high-volume traffic and point-to-point welfare messages,

– strengthen the cooperation between amateur radio operators, users and disaster response organizations,

– focus energies on ARES communications at the local level, on the use and recognition of tactical communications, and on the procedures for formal message traffic.

## 5.9 Amateur Radio Service Traffic Networks

Traffic handling includes the forwarding of messages from and to others than amateur radio operators. Where national regulations allow this, amateurs radio stations can handle such third party traffic both in routine situations and in times of disaster. Such public-service communications make amateur radio a valuable public resource and provide the best training for disaster communications. The traffic network structures differ in the various countries, but the outline given in the following section may serve as an example.

### 5.9.1 Tactical Nets

The Tactical Net is the front line net activated during an incident. Such a net is often used by a single government agency to coordinate with amateur radio operations within their jurisdiction. There may be several tactical nets in operation for a single incident depending on the volume of traffic and number of agencies involved. Communications typically include both traffic handling and resource mobilization.

### 5.9.2 Resource Net

For larger-scale incidents, a Resource Net is used to recruit operators and equipment in support of operations on the Tactical Nets. As an incident requires more operators or equipment, the Resource Net evolves as a check-in place for volunteers to register and to receive their assignments.

### 5.9.3 Command Net

As the dimension of a disaster response operation increases and more partners become involved in the incident, a command net may become necessary. This net allows incident managers to communicate with each other to resolve inter- or intra-agency problems, particularly between cities, or within larger operational areas. It is conceivable, that such a net becomes overloaded by a high traffic volume. It may consequently be necessary to create multiple command nets to cover all requirements.

### 5.9.4 Open and Closed Nets

A net may operate as an open net or a closed net with a net control station controlling the flow of communications. When the amount of traffic is low or sporadic, a net control will not be required, and an open net is the appropriate form. The stations participating in the net announce their presence and remain on standby. If they have traffic, they directly call another station after checking that the channel is not presently occupied. In a closed net, any station wishing to establish a contact calls the net control station, who might then either authorize direct communication on the calling channel or assign a working channel to the respective stations. Upon completion of their communication, the participating stations report to the net control station on the main frequency. For this type of operation it is essential that the net control station keep a record of the activities of all stations and of working channels assigned. This will ensure that all stations remain continuously available for urgent messages.

### 5.9.5 Net Operator Training

Network discipline and message-handling procedures are fundamental concepts of amateur radio net operation. Training should involve as many different operators as possible in net control station and other functions; it is less useful to have the same operator performing the same functions in all training sessions.

## 5.10 Information Handling

The basically informal character of amateur radio operations makes it necessary to pay particular attention to the procedures for handling messages within and among the different networks and between the amateur radio service and other networks. Permanently established traffic networks are ideal means to ensure efficient message handling during an emergency.

### 5.10.1 Emergency Operations Center

Amateur radio emergency communications frequently use the combined concepts of a Command Post (CP) and an Emergency Operations Center (EOC). The CP primarily controls the initial activities in emergency and disaster situations, and is typically a self-starting, spontaneously established entity. The initial functions of the CP are to assess the situation, to report to a dispatcher and to identify and request appropriate resources. The Emergency Operations Center (EOC) responds requests from a CP by dispatching equipment and personnel, anticipating needs to provide further support and assistance and pre-positioning additional resources in a staging area. If the situation at the site of the event changes, the CP provides the EOC with an update and maintains control until the arrival of additional or specialized resources. By being located outside the perimeter of potential danger, the EOC can use any appropriate type of communications, concentrate on gathering data from all partners involved, and mobilize and dispatch the requested means of response.

### 5.10.2 Information Exchange

Whether traffic is tactical or by formal messages, by packet radio or amateur television, success depends on the knowledge of the possibilities and limitations of the telecommunications resources available. Tactical traffic supports the initial response operations in an emergency situation, typically involving few operators within a limited area. Tactical traffic, even though unformatted and seldom written, is particularly important when different organizational entities are getting involved in the operations. The use of one VHF or UHF calling frequency, including possibly the use of repeaters and net frequencies, most typical for tactical communications.

One way to make tactical net operation transparent is to use tactical call signs, i.e. words that describe a function, location or agency, rather than callsigns of the Amateur Radio Service. When operators change shifts or locations, the set of tactical calls remains the same. Call signs like “Event Headquarters”, “Net Control” or “Weather Center” promote efficiency and coordination in public-service communication activities. Amateur radio stations must however identify their stations at regular intervals with the assigned call signs.

The operations of a tactical net require discipline, and following instructions to operators may serve as an example:

– Report to the Net Control Station (NCS) promptly as soon as you arrive at your station,

– Ask the NCS for permission before you use the frequency,

– Use the frequency exclusively for essential traffic,

– Answer promptly when called by the NCS,

– Use tactical call signs,

– Follow the net procedures established by the NCS.

In some relief activities, tactical nets become resource or command nets. A resource net is used for an event which goes beyond the boundaries of a single jurisdiction and when mutual aid is needed. A command net is used for communications between EOC and ARES leaders. Yet with all the variety of nets, sometimes the act of putting the parties directly on the radio, rather of trying to interpret their words, is the most practical approach.

### 5.10.3 Formal Message Traffic

Formal message traffic is handled in a standard message format and primarily on permanently or temporarily established HF and VHF nets. There may be links between local, regional and international nets. When accuracy is more important than speed, formatting a message before it is transmitted increases the accuracy of the information transmitted.

### 5.10.4 Operation during Disasters

When an emergency occurs, the mobilization of the local ARES organization does not depend on instructions of higher headquarters. Each group responds spontaneously to the needs of local rescue agencies.

### 5.10.5 Message Handling by Packet Radio

Packet radio is a preferred mode for the handling of formal messages It also allows the forwarding of traffic between various nets with a minimum of re-formatting, thus ensuring accuracy.

## 5.11 Amateur Radio Emergency Groups

In many places, radio amateurs wishing to put their skills and resources at the disposal of the community have established local groups. Trained operators are thus ready to provide disaster communications when other services fail entirely or can not cover the requirements. Amateur radio emergency groups often recruit members from existing clubs, and may include amateurs outside the specific club area since disaster response operations may involve a wider area.

### 5.11.1 Natural Disasters and Calamities

Despite the wide spectrum of requirements in a disaster situation radio amateurs should neither seek nor accept any duties other than radio communications. Volunteer communicators do not, for example, make major decisions, act as rescuers, or rent generators, tents or lights to the public. Radio amateurs handle radio communications in support of those who provide the emergency response such as described in the following section.

### 5.11.2 Health and Welfare Traffic

There can be a tremendous amount of radio traffic to handle during a disaster, partly because phone lines remaining operational should be reserved for operational use. Shortly after a major disaster, emergency messages within the disaster area often have life-and-death urgency. Of course, they receive primary emphasis. Much of their local traffic will be on VHF or UHF. Secondary to such priority traffic, messages of an emergency-related nature but not of the utmost urgency, can be handled. Finally, welfare traffic originating from evacuees at shelters or at hospitals can relayed by amateur radio.

Incoming health-and-welfare traffic should be handled only after all emergency and priority traffic is cleared. Welfare inquiries into a disaster area can take time to obtain answers to questions might have already been answered through restored circuits.

Stations at shelters, acting as net control stations, may exchange information on the HF bands directly with destination areas as propagation permits. They may also handle formal traffic through outside operators.

### 5.11.3 Property damage survey

Officials near the disaster area need communications to communicate damage reports to the appropriate agencies. Amateur radio operators may offer to help but may need proper identification to gain access into restricted areas. While traffic may often be informal, operators should keep a log and notes for later reference.

### 5.11.4 Local Accidents and Hazards

Using features found on modern VHF hand-held and mobile radios, the operator might activate a repeater autopatch by sending a code. The repeater connects to a telephone line and routes the incoming and outgoing audio accordingly. By dialling an emergency number, the operator has direct access to law-enforcement agencies. The ability to call assistance without depending on another station to monitoring the channel saves time.

### 5.11.5 Working with Public Safety Agencies

Amateur radio can provide public-safety agencies, such as local police and fire officials, with an valuable additional resource in times of emergency. In order for the Amateur Radio Service to be useful as a public-service lifeline in an emergency situation, its possibilities need to be fully understood by the public-safety agencies, and the establishment of continuous contacts between the two sides is a must.

### 5.11.6 Search and Rescue

Amateur radio can assist search and rescue teams during and after disasters, especially following severe storms and earthquakes. In some cases, their technical skills might furthermore be valuable in respect to other electronic equipment such as increasingly used in search operations.

### 5.11.7 Hospital Communications

Hospitals and similar establishments might in the aftermath of a disaster be without communications. This affects in particular the coordination among various providers of health services. Inside a hospital, ARES operators might temporarily serve to replace a paging system and to maintain critical interdepartmental communications. Local amateur radio emergency groups should prepare in advance for hospital communications.

### 5.11.8 Toxic-Chemical Spills

Amateur communications have helped in situations involving toxic-chemical and contamination of water supplies. Following directions from the command post, amateurs provide communications in support of the evacuation of residents the coordination between the disaster site and the evacuation sites or shelters. As indicated below, amateur radio operators may also provide communications related to the identification of the materials involved and appropriate response.

### 5.11.9 Hazmat Incidents

The term "hazardous materials" (HAZMAT) refers to substances or materials which, if released in an uncontrolled manner, are harmful to people, animals, crops, water systems, or other elements of the environment. The list includes explosive, flammable and combustible gases, liquids and solid material, oxidizing, poisonous and infectious substances, radioactive materials, and corrosives. The initial problem in an incident with such materials is the determination of the nature and quantity of the chemicals involved. Various institutions maintain registers of hazardous materials in order to provide rapid indications of the hazards associated with potentially dangerous substances, but this most essential information will not be available unless communications can be established immediately. ARES operators may be asked to establish communications with such institutions. Information on information sources and on the standard markings of hazardous goods should included in the briefing material of ARES groups.

## 5.12 Third Party Communications in the Amateur Radio Service

An amateur radio communication link normally has two parties – the operators. However, in addition to communicating with each other, they might be requested to pass a message on behalf of a third party, a person or organization that is not necessarily present at the radio station

From the regulatory point of view, two cases need to be distinguished: If both sides of the radio link are within a single country, third party traffic is subject to national regulations. If the message originates by amateur radio in one country but is destined for a third party in another country, the Radio Regulations of the ITU concerning international third party traffic need to be respected in addition. They provide that in the Amateur Radio Service such traffic is not allowed unless a bilateral agreement exists between the national Administrations concerned, specifically allowing such messages. Some Administrations may tolerate third party traffic or enter into temporary agreements if this type of traffic is in public interest, such as when other communication channels have been disrupted.

Operators should also be aware that there is a general rule for radio communications that states that, when Safety of Life and Property is at stake, administrative regulations can be temporarily waived. A revision of Article S-25 of the Radio Regulations, relevant to these issues, is on the agenda of the World Radiocommunication Conference scheduled for 2003.

# CHAPTER 6

# Broadcasting

Broadcasting is actually a semi-private system, with an unlimited number of receivers but a defined number of transmitters. In addition to being subject to regulations governing radio services, broadcasting is normally also subject to regulations concerning the media in general, and any applications to disaster communications need to take this into account. The verification of the reliability of information before its dissemination to a large audience is in any case of prime importance and the related responsibilities have to be to be clearly defined.

## 6.1 Emergency Broadcasts over Radio, Television and Cable networks

Radio, television, and local cable systems are primary means to alert the public in cases of potentially dangerous conditions such as heavy rain or snow storms, hurricanes, tornadoes, floods and other disasters that can be anticipated at least shortly before their impact. Once a disaster has occurred, the same means are, if they remain operational, invaluable tools to inform the affected population about measures being or to be taken. In many locations with a high risk of severe weather, permanent networks have been established. In addition to and in support of such official networks run by national or local authorities, amateur radio groups have established networks such as "Tornado Watches", who in turn, notify local authorities and broadcasting stations on impending danger.

National weather services usually forward weather information to broadcasters. This may include the activation of Emergency Broadcasting Systems (EBS) where established. In this case, the designated authority or official activates the EBS, notifying control points of the radio, television, and cable networks.

Television may provide helpful information in the form of maps and images, but radio broadcasts remain, due to the low technological requirements on the receiver side, the best means for the dissemination of emergency information in the aftermath of a disaster. Television receivers mostly depend on the availability of line power and fixed antennas or cable network connections, all of which might be affected by the event. Portable transistor radios are inexpensive. Together with spare batteries, or if powered by solar cells or other independent power sources, they will serve throughout the acute phase of most disasters.

## 6.2 Mobile Emergency Broadcasting

On the transmitter side, portable, low-power FM stations can provide broadcasting service when permanent installations are affected. They can be operated from a vehicle or a temporary shelter of some kind. Digital satellite broadcast systems are likely to play an increasing role. The development of low-cost receivers for these services will be a prerequisite for their extensive application in disaster communications.

# CHAPTER 7

# Telecommunications coordination

Telecommunications are primary tools of coordination, but they can fulfil this task only when they are well coordinated themselves. Experience shows that, in cases of a major event, requiring cooperation between various public and rescue services, the connectivity between units from different districts is often lacking. This applies even more in cases of international assistance, where partners who are not normally operating in a common location need to communicate on all levels. In such cases, the Secretariat of the Working Group on Emergency Telecommunications, maintained by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) in Geneva, has the mandate to facilitate arrangements among all partners concerned.

## 7.1 The Role of the Telecommunications Coordination Officer

As part of the framework of cooperation in international humanitarian assistance, the Inter-Agency Standing Committee (IASC) as the coordinating body for international humanitarian assistance has adopted the concept of the Telecommunication Coordination Officer (TCO) as the basic principle for a joint approach to emergency telecommunications. In case of major disasters with international response, either the telecommunications expert of an UNDAC team or the senior telecommunications officer of one of the institutions participating in the relief efforts is being nominated as the TCO.

The TCO supports the Disaster Management Team (DMT) in all matters relating to telecommunications and reports to the head of this team. He or she facilitates cooperation among the telecommunications officers of all participating agencies and, on behalf of all users of emergency telecommunications, ensures the liaison with the national telecommunication authorities. The functions of the TCO are of operational, technical and regulatory nature. They include the compatibility of networks or at least their interaction through common, the mutual support using technical and human resources of all. The TCO needs to be thoroughly familiar with the international regulatory instruments, in particular the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations and their application.

## 7.2 The Lead Entity Concept

Similar to a structure which, in international humanitarian response mechanisms, is know as the "lead agency concept", it might in some cases be appropriate that a single operator, service provider or organization accepts the overall responsibility for the provision of emergency telecommunication services. Such an option depends on two main issues: First on the availability of the necessary resources to one entity, and second the acceptability of this entity in respect to commercial or political implications of its overall activities. Agreement on the appointment of a "lead-entity" is likely to take time, and the concept is therefore primarily applicable to operations of longer duration.

# ITU-D Handbook on disaster communications

# PART 3

## TECHNICAL ANNEX

## SOME TECHNICAL ASPECTS OF DISASTER COMMUNICATIONS

## Table of contents

# PART 3

## TECHNICAL ANNEX

## SOME TECHNICAL ASPECTS OF DISASTER COMMUNICATIONS

## 1 Introduction to Part 3 of this Handbook

In Part 1 of this handbook, the reader was presented with definitions and overall policy considerations regarding disaster communications. Following this general discussion, the reader was invited to consider the more specific guidance required to operate a disaster communications network as presented in Part 2 designed for operational personnel.

In order to improve the flow of thought in Parts 1 and 2, technical details and formulas are consolidated in Part 3. This permitted the previous two parts to be written in a narrative style. Further, it made the text more readable for planners and policy makers who require an overview of the problems, solutions and techniques related to disaster communications.

Part 3 is organised into the following sections:

- The selection of the appropriate technology for disaster communications
- Methods of radiocommunication
- Antennas as an essential part of any radio station
- Use of relay stations (repeaters) and trunking systems
- Power sources (including batteries)

In addition, there is a bibliography listing a number of references that will guide the reader to an extensive historical source listing. Also, it will provide information about useful sources of additional information from which it is possible to expand on the subjects raised in briefer form in this Handbook.

At the conclusion, there is an Appendix of a number of useful documents from a number of diverse original sources.

No introduction would be complete without acknowledgement of a number of participating organisations that made this work possible. Especially noteworthy is the contribution of persons associated with two specific organisations having strong interest in the field of disaster communications. These are the United Nations Office of the Coordination for Humanitarian Affairs (UN-OCHA), Geneva, and the International Amateur Radio Union (IARU), especially its Technical Office in Washington, DC. Other contributors to this part are L. M. Ericsson and Volunteers in Technical Assistance (VITA).

## 2 The selection of appropriate technologies for disaster communications

### 2.1 Simplicity vs. new technologies

Generally, the simpler time-tested forms of radiocommunication work best in disaster situations. These include single-sideband (SSB) voice and Morse code (CW) telegraphy at HF and FM voice at VHF/UHF. The equipment has been perfected over time, and its installation, maintenance and operation are widely understood. There are robust versions of equipment designed to meet the rigours of transportation and operation in the field.

Nevertheless, some newer technologies offer features that may facilitate disaster communications. Those include cellular telephones, digital dispatch radios, facsimile, data communications, television and satellites. Each has their advantages and disadvantages, which should be weighed carefully in the planning process.

Emerging technologies such as 3rd generation cellular (IMT-2000), software-defined radio (SDR), broadband and multimedia systems should be evaluated in terms of their ability to function during emergency conditions.

Training of radiocommunication personnel is an important aspect of the selection of appropriate technologies. It is fruitless to plan on an HF Morse telegraphy capability without trained and experienced operators. Use of SSB voice to avoid training Morse operators is not necessarily a solution unless the operators are trained in installation, maintenance and operation of an SSB radio station. It is also inappropriate to introduce new technologies without a continuing supply of personnel adequately trained in system planning, installation, maintenance and operation.

The ideal disaster communications system is one in routine daily use that has the capability of functioning in disaster and other emergency conditions. Second best is a capability exercised periodically, such as weekly or monthly, under simulated emergency conditions.

## 2.2 Reliability of the infrastructure

HF communications, whether by SSB voice and Morse telegraphy, normally do not require any infrastructure for relaying or processing, i.e., communications can be direct from the originating station to the destination. When long distances are involved, such as beyond 2 000 km, or when propagation conditions are poor, base stations or relay stations can facilitate communication but may not be required.

## 2.3 Transportation and mobility considerations

New technology includes such telecommunication systems as portable satellite earth stations, mobile and portable cellular telephone base stations, and telemedicine video base and remote stations. There are circumstances where it would be desirable to use these the new technologies at a disaster area. However, transportation and mobility should be taken into account before using such systems. For example, a satellite earth station that is mounted on pallets might require special handling equipment for loading and unloading an aircraft may be available at the point of origin, but not at the point of debarkation.

Further, once the communications system is unloaded at the nearest available airport, ground transportation will be needed to transport it to the disaster area. Trucks and loading equipment are generally in full use at the disaster site and may not be available at an airport.

A third consideration is the condition of roads leading to the disaster area. In many cases, it may not be possible to move the communications equipment to a location where it is most desired because of obstructions.

## 2.4 Interoperability

The capability to communicate with the local public protection organisations such as police, fire and medical, the local military, international disaster relief organisations and neighbouring countries is an important consideration.

There may be circumstances where it should be possible for any station to be able to communicate with any other station in the disaster area. Such a feature can cut across the formal structure and get communications specifically to the intended party without delays and the possibility of misinterpretation by intermediaries. Unfortunately, there are other circumstances where separate channels are needed for different groups of stations and it would be difficult if not impractical for everyone to be on one channel.

## 2.5 Comparison of satellite systems for disaster communications

### 2.5.1 Low Earth orbit satellites

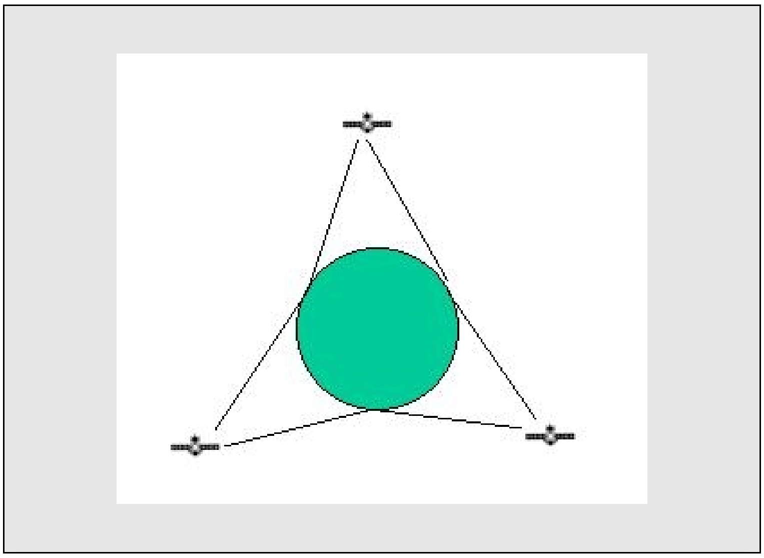
Low Earth orbit (LEO) satellites may be used to relay radio signals far beyond line-of-sight. Depending on altitude, a single LEO satellite could be used to relay signals over paths up to about 5 000 km when the two earth stations are both visible to the satellite. Such visibility lasts only for a few minutes at such extreme distances. Stations closer together can have mutual visibility to the satellite for longer periods, perhaps up to 20 minutes on a favourable pass. Owing to their orbits, single LEO satellite have the disadvantage that they can provide real time communication only for a few times each day.

LEO constellations can be used for continuous real time relay. This requires a sufficient number of satellites to assure that at least one is visible to a point on Earth at all times. Also, there must be a means of networking the satellites, either through inter-satellite (satellite-to-satellite) links or via earth stations located throughout the world.

### 2.5.2 Geostationary satellites

Each geostationary (GSO) satellite located 35 784 km above the Earth can communicate with earth stations over about one third of the globe. Thus, three GSO satellites can cover the entire Earth.

**Figure 1 – Three satellites in geostationary orbit can cover the entire Earth**



#### 2.5.2.1 INMARSAT vs. VSAT and USAT

Common telephone and data services are available from land-based satellite terminal systems using the portable International Maritime Satellite (INMARSAT) or the semi-fixed Very Small Aperture Terminal (VSAT) satellite network. These services include voice, facsimile and electronic mail communications. Any device that works with a common telephone device may be used with these satellite systems. In addition to the above-mentioned services, some satellite terminals offer transfer of digital photographs or live video conferencing.

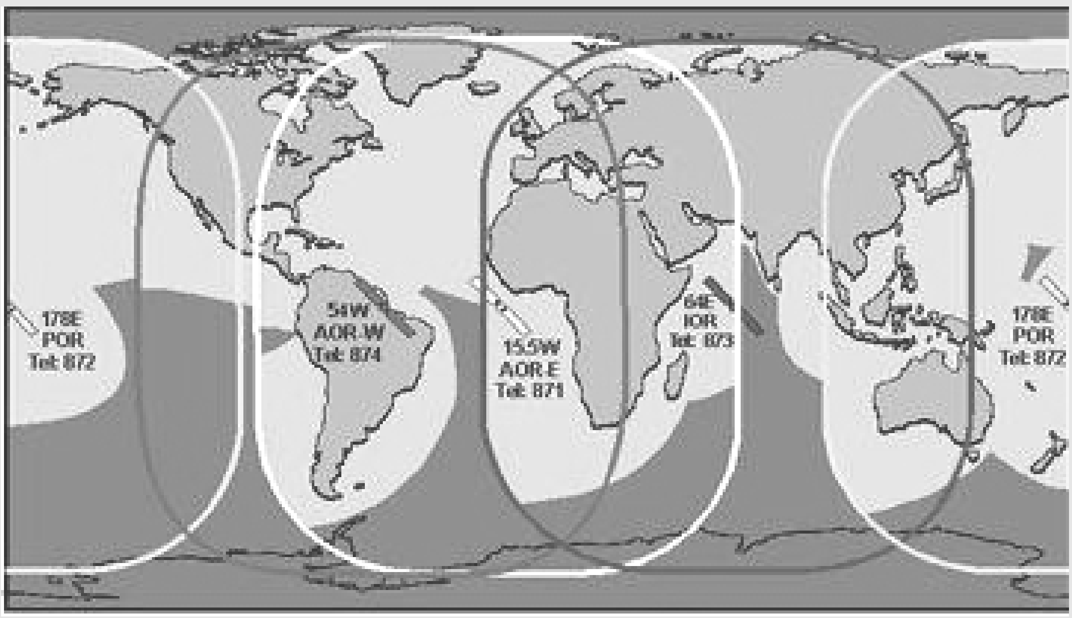
The choice of whether to use INMARSAT or VSAT is dependent upon the particular telecommunications requirements for the system. Many variable factors will influence the choice of one over the other: cost, mobility, need for high volume use. Also, the ability of the system to support various modes of communication, such as: standard voice, computer data (networked or stand-alone e-mail connections), facsimile, text-only messages and videoconferencing.

### 2.5.2.2 INMARSAT

The INMARSAT system consists of nine satellites in geostationary orbit. Four of these satellites, the latest INMARSAT-3 generation, provide overlapping operational coverage of the globe. Each satellite covers up to one third of the Earth's surface and is strategically positioned above one of the four ocean regions to form seamless coverage. Each region is covered by an active satellite and an operational spare. The others are used as in-orbit spares or for leased capacity. Only the Earth's extreme poles are without coverage**.** Land earth stations (LES) connect the INMARSAT system to the global fixed communication networks. Most INMARSAT phone calls are made from land. One advantage of the INMARSAT-3 satellites is their ability to concentrate power on particular areas of high traffic within the footprint. Each satellite utilises a maximum of seven spot beams and one global beam. The number of spot beams will be chosen according to traffic demands. In addition, these satellites can re-use portions of the L-band frequency for non-adjacent spot beams, effectively doubling the capacity of the satellite. Roaming users communicate direct via INMARSAT satellites. Airtime services are available worldwide through a network of about 100 service providers.

Some service providers also operate INMARSAT land earth stations. There are about 40 such stations in 31 countries. These stations receive and transmit communications through the INMARSAT satellites and provide the connection between the satellite system and the fixed communications networks.

**Figure 2 – INMARSAT coverage areas: Atlantic Ocean Region-East, Atlantic Ocean Region-West, Pacific Ocean Region and Indian Ocean Region**



INMARSAT provides a global mobile satellite communications capability with several advantages to support disaster preparedness and relief operations. INMARSAT terminals are self-sufficient and can be operational within 10 to 15 minutes of arriving at the disaster scene. They are independent from local telecommunications infrastructures, and can be operated with batteries or generator power supplies. INMARSAT can be configured to provide communications between two independent relief teams working in the same locality or to provide direct links to relief agencies and materials suppliers worldwide. INMARSAT equipment is simple to operate, and can be set up and operated by untrained personnel using instructions provided with the units. The equipment is compact and lightweight. Some models can be hand carried.

INMARSAT terminals can be used worldwide, subject to local regulations. For calling from a fixed network to an INMARSAT terminal, the caller simply dials the desired terminal ID preceded by a special 3-digit "ocean region" code. From a mobile, the user dials the desired fixed or mobile network number preceded by the 3-digit code for the selected LES.

Many commercial and military ships have INMARSAT-A ship earth station (SES) satellite terminals. Through these it is possible to contact a ship anywhere in the world. There are now some transportable INMARSAT-A terminals that can be moved in two suitcase-size containers. Typically the parabolic antenna is 1 meter across or larger. Accessories are in a separate box that weighs approximately 27 kg. It provides telephone, facsimile and electronic mail capability. INMARSAT-A terminals are no longer manufactured. Typical airtime cost: USD 5-7 per minute.

The INMARSAT-B terminal is an improved, digital version, of the IMARSAT-A terminal. The size and weight are similar to an INMARSAT-A terminal. Both A and B type terminals require that the antenna be pointing at the satellite. For mobile service a tracking antenna must be used. The INMARSAT-B terminal can provide 9.6 kbit/s facsimile and good quality voice service at 16 kbit/s. It provides telephone, facsimile and e-mail capability. Some models provide high-speed data links and multiple phone/facsimile lines (with field public exchange). The major difference is that data can be transmitted at 9.6 kbit/s as standard or at 64 kbit/s in the High Speed Data facility. Although airtime charges are higher, the faster data throughput means that the service is used for shorter periods and will offset this. Typical stand-alone unit cost: Standard B: USD 23 000); B+ High Speed Data: USD 27 000. Typical airtime cost: Standard B: USD 4-7 per minute; B+ High Speed Data: USD 10 per minute.

A Standard C is a satellite terminal that can fit into one suitcase, which includes a laptop computer, printer, and omni-directional antenna. The antenna is a hemispherical design which does not require accurate pointing and tracking. These small terminals provide text based services such as electronic mail, telex and low rate data messages (no phone capability). It includes a built-in battery (4-hours standby). Typical unit cost: USD 5 000. Typical airtime cost: USD 0.01 per character.

Standard M is a satellite terminal in an attaché case with a flat antenna in its lid. It requires a separate laptop computer or fax machine. It provides phone, fax, or electronic mail capabilities. It is designed to provide more capability than an INMARSAT-C terminal but less than an INMARSAT-B terminal. The M terminal provides a 4.8 kbit/s voice service and a facsimile rate of 2.4 kbit/s.

Mini-M terminals are less expensive than those required for the other services yet can provide voice, facsimile, data and electronic mail at 2.4 kbit/s. Unlike the other services outlined above, Mini-M users communicate via powerful spot beams that project from the satellite onto the landmass below. This system has the advantage that smaller, lower powered units and antenna can be used. These are much more portable and can be contained within a package the size of a small suitcase. The coverage of the spot beams includes considerable expanses of water for maritime applications. Typical unit cost: USD 6 000; typical airtime cost: USD 2-3 per minute

#### 2.5.2.3 VSAT

Very Small Aperture Terminal (VSAT) is a satellite communications technology using small earth antenna, usually 0.9 and 1.8 meters in diameter, for reliable voice, data, audio, video, multimedia, and wide-band service transmission. VSAT services constitute a network composed of a series of remote points connected to a main control center, which in turn is connected through space with a data center or central processor: the central station and a large number of geographically disbursed sites. One of the many applications of this technology is Internet via satellite.

VSAT communication networks are comprised of a space and a land segment. The space segment is comprised of a geostationary satellite, which amplifies and changes frequencies. The land component consists of a central station or *hub* and remote VSAT stations. VSAT networks can be configured in star-like or mesh shapes, based on the normal flow of communications through the hub or can be sent directly between the VSAT stations (with no need for double hopping).

Changes in technology have led to a reduction in antenna size and have decreased the cost and size of electronics, increased bandwidths and permitted better management capabilities.

When the communication requirement is to provide a long distance link between two or more nodes of a fixed network, a user may select VSAT for such full time, guaranteed bandwidth. For example, some Internet service providers in South America and Africa connect their router to the main Internet by a VSAT full time high-speed link.

VSAT can provide a single communications platform capable of providing service to an entire country or region. For semi-permanent or permanent applications with a large volume of traffic, VSAT may prove to be the best option for telecommunications service.

For VSAT terminals, set-up time varies from 30 minutes to 3 hours, depending on system complexity.

#### 2.5.2.4 USAT Networks

The diffusion of VSAT networks in fixed-satellite service (FSS) with small-antenna earth stations at distant locations – such as the terraces of office buildings, hotels, shopping centres and other useful locations – has stimulated the development of antennas that are even smaller than VSATs, generally with an effective aperture of less than 1 m. In general, they are known as ultra small aperture terminals (USATs). Antenna discrimination naturally deteriorates as its size decreases.

Satellite service provides wide-band and direct access to the backbone of the Internet for reception and/or reception-transmission of Internet information. Point-to-multipoint connections using high-speed frame relay technology are used. Standard Single Channel Per Carrier (SCPC) satellite connections can also be used. Or both systems can be used for the purposes of redundancy.

# 3 Methods of radiocommunication

## 3.1 Frequencies

Radio frequencies should be selected according to propagation requirements, allocation to the service for which they are used and in accordance with licensing regulations of the country in which the station is operating.

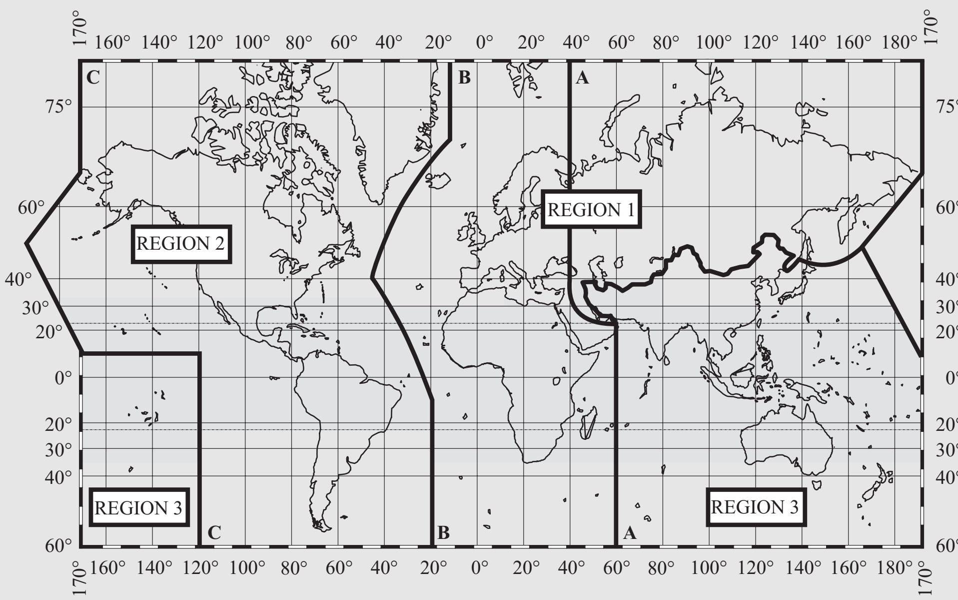
Example 1: An amateur station licensed to operate in the country may use a frequency of 7 050 kHz to communicate via sky wave with a station 300 km away, as this frequency is within the 7 MHz amateur allocation.

Example 2: A land mobile station licensed to operate in a country and assigned an operating frequency of 151.25 MHz may use this frequency to communicate up to about 60 km with other authorised stations.

### 3.1.1 International frequency allocations

The radio frequency spectrum is divided into bands of frequencies by means of international treaty conferences of the International Telecommunication Union (ITU). These bands are allocated to specific radio services and are listed in Article S5 of the international Radio Regulations. Some bands are allocated to the same service(s) worldwide, while others are allocated to different services on a regional basis. The three Regions are shown in the following map.

**Figure 3 – ITU radio regions**




The shaded part represents the Tropical Zones as defined in Nos. **S5.16** to **S5.20** and **S5.21.**

S5-01

A simplified table of frequencies allocated to the amateur, fixed and mobile services is shown in Table 1.

**Table 1 – Allocation to amateur, fixed and mobile services (simplified, footnotes omitted)**

<table>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>1 810-1 850 AMATEUR</td><td>1 800-1 850 AMATEUR</td><td rowspan="2">1 800-2 000 AMATEUR FIXED<br>MOBILE except aeronautical mobile</td></tr>
<tr><td>1 850-2 000 FIXED<br>MOBILE except aeronautical mobile</td><td>1 850-2 000 AMATEUR FIXED<br>MOBILE except aeronautical mobile</td></tr>
<tr><td>2 000-2 045 FIXED<br>MOBILE except aeronautical mobile (R)</td><td colspan="2" rowspan="2">2 000-2 065 FIXED MOBILE</td></tr>
<tr><td>2 045-2 160 FIXED MOBILE</td></tr>
<tr><td></td><td colspan="2">2 107-2 170 FIXED MOBILE</td></tr>
<tr><td>2 194-2 300 FIXED<br>MOBILE except aeronautical mobile (R)</td><td colspan="2">2 194-2 300 FIXED MOBILE</td></tr>
</table>

**Table 1 – Allocation to amateur, fixed and mobile services (simplified, footnotes omitted)** *(cont.)*

<table>
<tr><th>Region 1</th><th>Region 2</th><th>Region 3</th></tr>
<tr><td>2 502-2 625 FIXED<br>MOBILE except aeronautical mobile (R)</td><td colspan="2" rowspan="2">2 505-2 850 FIXED MOBILE</td></tr>
<tr><td>2 650-2 850 FIXED<br>MOBILE except aeronautical mobile (R)</td></tr>
<tr><td>3 155-3 400</td><td colspan="2">FIXED MOBILE except aeronautical mobile (R)</td></tr>
<tr><td>3 500-3 800 AMATEUR FIXED<br>MOBILE except aeronautical mobile</td><td>3 500-3 750<br>AMATEUR</td><td rowspan="3">3 500-3 900<br>AMATEUR FIXED MOBILE</td></tr>
<tr><td rowspan="2">3 800-3 900 FIXED LAND MOBILE</td><td rowspan="3">3 750-4 000<br>AMATEUR FIXED<br>MOBILE except aeronautical mobile (R)</td></tr>
<tr></tr>
<tr><td>3 950-4 000 FIXED</td><td>3 950-4 000 FIXED</td></tr>
<tr><td>4 000-4 063</td><td colspan="2">FIXED</td></tr>
<tr><td colspan="2">4 438-4 650 FIXED MOBILE except aeronautical mobile (R)</td><td>4 438-4 650 FIXED<br>MOBILE except aeronautical mobile</td></tr>
<tr><td>4 750-4 850 FIXED LAND MOBILE</td><td>4 750-4 850 FIXED<br>MOBILE except aeronautical mobile (R)</td><td>4 750-4 850 FIXED Land mobile</td></tr>
<tr><td>4 850-4 995</td><td colspan="2">FIXED LAND MOBILE</td></tr>
<tr><td>5 005-5 060</td><td colspan="2">FIXED</td></tr>
<tr><td>5 060-5 450</td><td colspan="2">FIXED Mobile except aeronautical mobile</td></tr>
<tr><td>5 450-5 480 FIXED LAND MOBILE</td><td></td><td>5 450-5 480 FIXED LAND MOBILE</td></tr>
<tr><td>5 730-5 900 FIXED<br>MOBILE except aeronautical mobile (R)</td><td>5 730-5 900 FIXED<br>MOBILE except aeronautical mobile (R)</td><td>5 730-5 900 FIXED<br>Mobile except aeronautical mobile (R)</td></tr>
<tr><td>6 765-7 000</td><td colspan="2">FIXED Land mobile</td></tr>
<tr><td>7 000-7 100</td><td colspan="2">AMATEUR AMATEUR-SATELLITE</td></tr>
<tr><td></td><td>7 100-7 300 AMATEUR</td><td></td></tr>
<tr><td>7 350-8 100</td><td colspan="2">FIXED Land mobile</td></tr>
<tr><td>8 100-8 195</td><td colspan="2">FIXED</td></tr>
<tr><td>9 040-9 400</td><td colspan="2">FIXED</td></tr>
<tr><td>9 900-9 995</td><td colspan="2">FIXED</td></tr>
<tr><td>10 100-10 150</td><td colspan="2">FIXED Amateur</td></tr>
<tr><td>10 150-11 175</td><td colspan="2">FIXED Mobile except aeronautical mobile (R)</td></tr>
<tr><td>11 400-11 600</td><td colspan="2">FIXED</td></tr>
<tr><td>12 100-12 230</td><td colspan="2">FIXED</td></tr>
<tr><td>13 360-13 410</td><td colspan="2">FIXED</td></tr>
<tr><td>13 410-13 570</td><td colspan="2">FIXED Mobile except aeronautical mobile (R)</td></tr>
<tr><td>13 870-14 000</td><td colspan="2">FIXED Mobile except aeronautical mobile (R)</td></tr>
<tr><td>14 000-14 250</td><td colspan="2">AMATEUR AMATEUR-SATELLITE</td></tr>
<tr><td>14 250-14 350</td><td colspan="2">AMATEUR</td></tr>
<tr><td>14 350-14 990</td><td colspan="2">FIXED Mobile except aeronautical mobile (R)</td></tr>
<tr><td>15 800-16 360</td><td colspan="2">FIXED</td></tr>
<tr><td>17 410-17 480</td><td colspan="2">FIXED</td></tr>
<tr><td>18 030-18 068</td><td colspan="2">FIXED</td></tr>
<tr><td>18 068-18 168</td><td colspan="2">AMATEUR AMATEUR-SATELLITE</td></tr>
<tr><td>18 168-18 780</td><td colspan="2">FIXED Mobile except aeronautical mobile</td></tr>
<tr><td>19 020-19 680</td><td colspan="2">FIXED</td></tr>
<tr><td>19 800-19 990</td><td colspan="2">FIXED</td></tr>
<tr><td>20 010-21 000</td><td colspan="2">FIXED Mobile</td></tr>
</table>

**Table 1 – Allocation to amateur, fixed and mobile services (simplified, footnotes omitted)** *(end)*

| Region 1 | Region 2 | Region 3 |
|---|---|---|
| **21 000-21 450** | AMATEUR AMATEUR-SATELLITE | |
| **21 850-21 924** | FIXED | |
| **22 855-23 000** | FIXED | |
| **23 000-23 200** | FIXED Mobile except aeronautical mobile (R) | |
| **23 200-23 350** | FIXED | |
| **23 350-24 000** | FIXED MOBILE except aeronautical mobile | |
| **24 000-24 890** | FIXED LAND MOBILE | |
| **24 890-24 990** | AMATEUR AMATEUR-SATELLITE | |
| **25 010-25 070** | FIXED MOBILE except aeronautical mobile | |
| **25 210-25 550** | FIXED MOBILE except aeronautical mobile | |
| **26 175-27 500** | FIXED MOBILE except aeronautical mobile | |
| **27.5-28** | FIXED MOBILE | |
| **28-29.7** | AMATEUR AMATEUR-SATELLITE | |
| **29.7-47** | FIXED MOBILE | |
| | **47-50** FIXED MOBILE | **47-50** FIXED MOBILE |
| | **50-54** AMATEUR | |
| | **54-68** Fixed Mobile | **54-68** FIXED MOBILE |
| **68-74.8** FIXED<br>MOBILE except aeronautical mobile | **68-72** Fixed Mobile | **68-74.8** FIXED MOBILE |
| | **72-73** FIXED MOBILE | |
| | **74.6-74.8** FIXED MOBILE | |
| **75.2-87.5** FIXED<br>MOBILE except aeronautical mobile | **75.2-75.4** FIXED MOBILE | |
| | **75.4-76** FIXED MOBILE | **75.4-87** FIXED MOBILE |
| | **76-88** Fixed Mobile | |
| | | **87-100** FIXED MOB ILE |
| **137-138** | Fixed Mobile except aeronautical mobile (R) | |
| | **138-144** FIXED MOBILE | **138-144** FIXED MOBILE |
| **144-146** | AMATEUR AMATEUR-SATELLITE | |
| **146-148** FIXED<br>MOBILE except aeronautical mobile (R) | **146-148** AMATEUR | **146-148** AMATEUR<br>FIXED MOBILE |
| **148-149.9** FIXED<br>MOBILE except aeronautical mobile (R) | **148-149.9** FIXED MOBILE | |
| **150.05-174** FIXED<br>MOBILE except aeronautical mobile | **150.05-174** FIXED MOBILE | |
| | **174-216** Fixed Mobile | **174-223** FIXED MOBILE |
| | **216-220** FIXED | |
| | **220-225** AMATEUR | |
| **223-230** Fixed Mobile | FIXED MOBILE | **223-230** FIXED MOBILE |
| **401-406** | Fixed Mobile except aeronautical mobile | |
| **406.1-430** | FIXED MOBILE except aeronautical mobile | |
| **430-440** AMATEUR | **430-440** Amateur | |
| **440-450** | FIXED MOBILE except aeronautical mobile | |
| **450-470** | FIXED MOBILE | |

## 3.1.2 National frequency allocations

The frequency allocation tables of most countries closely follow the international table of allocations. There are exceptions and it is necessary to be aware of, and adhere to, national radio regulations concerning frequencies and their use.

### 3.1.3 Frequency assignments

Assignment of specific radio frequencies to radio stations is made by national administrations. This is the case for the fixed and mobile services. Amateur stations do not normally have frequency assignments and are free to select a specific operating frequency dynamically within an allocated band.

In some cases, administrations may assign frequencies to services not allocated to those services in the international table of allocations on a non-interference basis. This is provided for in the Radio Regulations, as follows:

**S4.4** Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with the provisions of the Constitution, the Convention and these Regulations.

In times of emergency, administrations may use the following provision of the Radio Regulations:

**S4.9** No provision of these Regulations prevents the use by a station in distress, or by a station providing assistance to it, of any means of radiocommunication at its disposal to attract attention, make known the condition and location of the station in distress, and obtain or provide assistance.

Stations in the fixed and mobile services having emergency communications missions should have a family of frequencies from which to select according to propagation for specific paths.

## 3.2 Propagation

Radio signals are electromagnetic waves that travel through the Earth's atmosphere and into space. These waves propagate by means of difference mechanisms, such as surface wave, direct or space wave (line-of-sight), diffraction (knife-edge propagation), ionospheric refraction (sky wave), tropospheric refraction and tropospheric ducting. Ionospheric propagation varies according to time of day, season of the year, solar activity (sunspot number), path distance, and location of the transmitters and receivers. Tropospheric propagation is somewhat related to weather conditions.

Recommendation ITU-R P.1144, the guide to the propagation methods of Radiocommunication Study Group 3, may be used to determine which propagation methods should be used for different applications. Computer programmes are also available and are available from ITU-R.

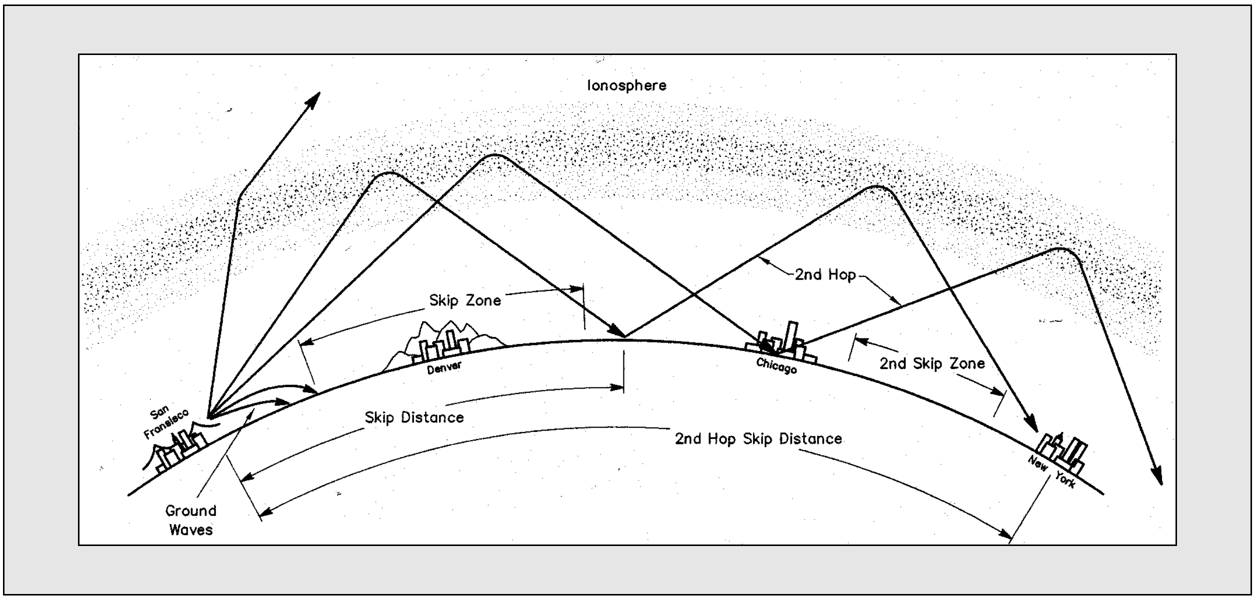
### 3.2.1 Ground wave

Ground waves are those confined to the Earth's lower atmosphere. Distances are dependent on transmitter power, antenna efficiency, ground conductivity and atmospheric noise levels. Ground-wave propagation curves for frequencies between 10 kHz and 30 MHz are given in Recommendation ITU-R P.368. For practical emergency communications, ground waves are useful only at lower high frequencies (near 3 MHz) and for relatively short distances of a few kilometers.

### 3.2.2 Sky wave propagation

Sky waves use the Earth's ionosphere to refract the signal. The ionosphere is formed by several layers, which are identified by letters of the alphabet. The *D layer* lies between about 60 and 92 km above the Earth. The *E layer* is about 100 to 115 km above the Earth. The D layer is used for medium frequency sky wave propagation. The D and E layers absorb signals at frequencies in the lower part of the HF band around 3 MHz. The *F layer* (about 160 to 500 km) may split into two layers, $F_1$ and $F_2$ and can support frequencies over the entire HF band at long distances. Frequencies and distances vary according to the specific path, time of day, season and solar activity. Sky wave propagation for the frequency range 2-30 MHz may be predicted using Recommendation ITU-R P.533.

**Figure 4 – Illustration of how HF radio signals travel through the ionosphere. Frequencies above the maximum usable frequency (MUF) penetrate the ionosphere and go into space. Frequencies below the MUF are refracted back to the Earth. Ground waves, skip zones and multiple hop paths are shown**




### 3.2.2.1 Near-vertical-incidence sky wave

Near-vertical-incidence sky wave (NVIS) is a term describing high angle ionospheric paths covering short distances. It is particularly useful for distances just beyond those practical for VHF or UHF. To be successful, it is necessary to select frequencies below the critical frequency, which means that frequencies will be in the 2-6 MHz range, the higher end during the daytime and the lower part of the range at night. Antenna take-off angle is essentially straight overhead so a practical antenna is horizontally polarised and just a few meters above ground.

### 3.2.3 VHF/UHF propagation

Radio signals travel somewhat beyond the optical line-of-sight, as though the Earth were 4/3 its size. The radio horizon for VHF/UHF signals can be approximated by:

$$D = 4.124\ h^{-2}$$

where:

D: distance in kilometers

$h^{-2}$: square root of the antenna height above ground in meters

Free-space propagation loss may be calculated using Recommendation ITU-R P.525.

**Figure 5 – The ionosphere consists of several regions of ionised particles at different heights above Earth. At night, the D and E regions disappear. The $F_1$ and $F_2$ regions combine to form a single F region at night**

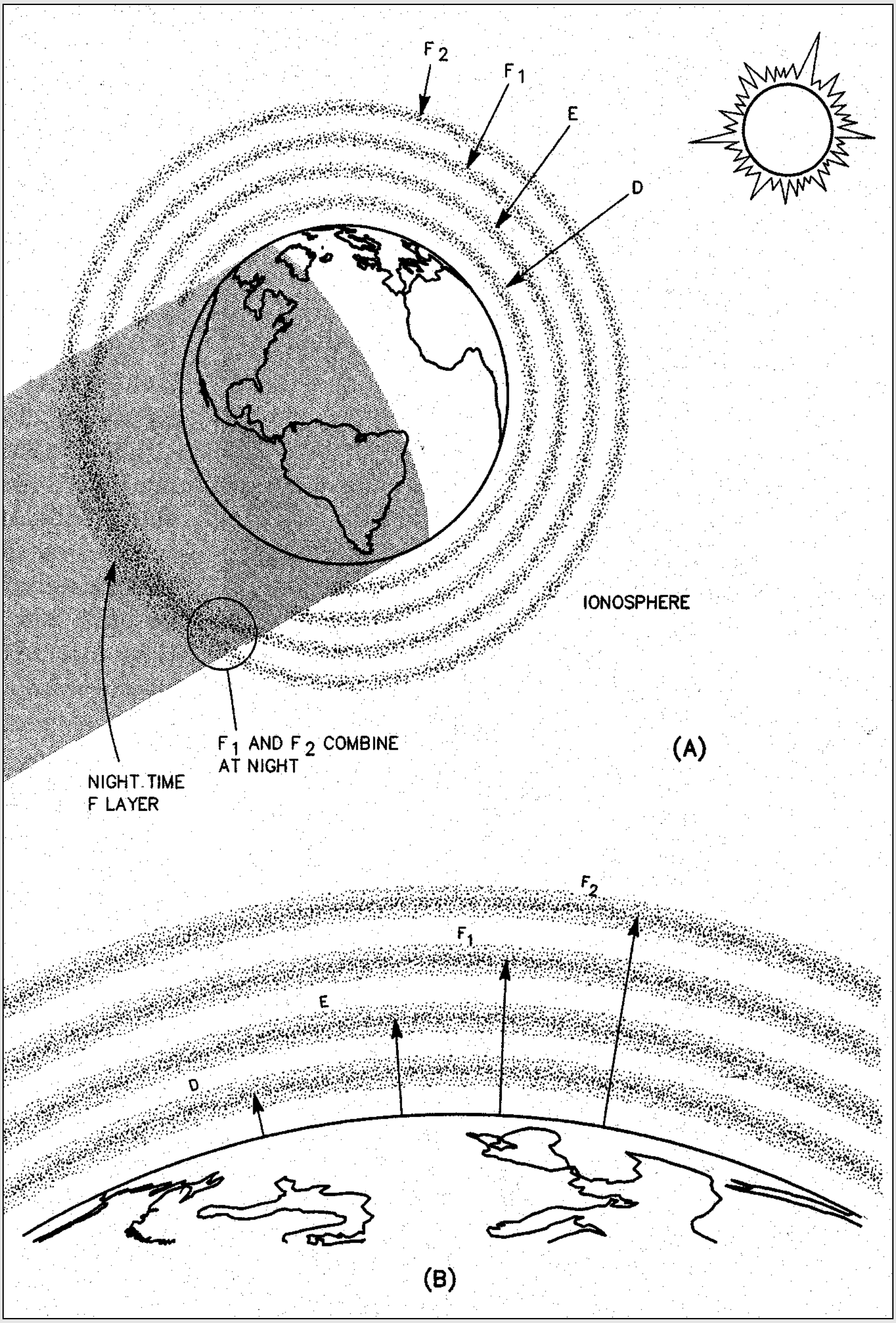
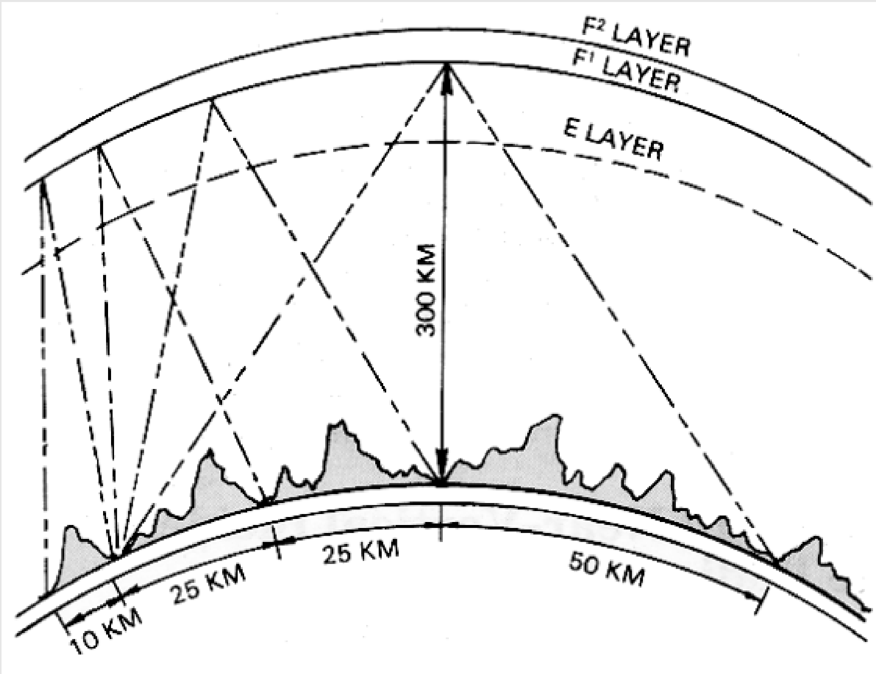


**Figure 6 – Near-vertical incidence sky wave paths**




### 3.2.3.1 Point-to-area links

If there is a transmitter serving several randomly distributed receivers (for example in the mobile service), the field is calculated at a point located at some appropriate distance from the transmitter by the expression:

$$e = \frac{\sqrt{30p}}{d}$$

where:

$e$ : r.m.s. field strength (V/m) (see Note 1)

$p$ : equivalent isotropically radiated power (e.i.r.p.) of the transmitter in the direction of the point in question (W)

$d$ : distance from the transmitter to the point in question (m).

Land mobile point-to-area propagation for the VHF (10-600 km) and UHF (1-100 km) may be predicted using Recommendation ITU-R P.529.

### 3.2.3.2 Point-to-point links

With a point-to-point link it is preferable to calculate the free-space attenuation between isotropic antennas, also known as the free-space basic transmission loss (symbols: $L_{bf}$ or $A_0$), as follows:

$$L_{bf} = 20 \log \left( \frac{4\pi\, d}{\lambda} \right) \quad \text{dB}$$

where:

$L_{bf}$ : free-space basic transmission loss (dB)

$d$ : distance

$\lambda$ : wavelength, and

$d$ and $\lambda$ are expressed in the same unit.

The above equation can also be written using the frequency instead of the wavelength.

$$L_{bf} = 32.4 + 20 \log f + 20 \log d \quad \text{dB}$$

where:

$f$ : frequency (MHz)

$d$ : distance (km).

Point-to-area propagation for 150 MHz – 40 GHz for distances up to 200 km may be predicted using Recommendation ITU-R P.530

### 3.2.3.3 Conversion formulas

On the basis of free-space propagation, the following conversion formulas may be used.

Field strength for a given isotropically transmitted power:

$$E = P_t - 20 \log d + 74.8$$

Isotropically received power for a given field strength:

$$P_r = E - 20 \log f - 167.2$$

Free-space basic transmission loss for a given isotropically transmitted power and field strength:

$$L_{bf} = P_t - E + 20 \log f + 167.2$$

Power flux-density for a given field strength:

$$S = E - 145.8$$

where:

$P_t$ : isotropically transmitted power (dB(W))

$r$ : isotropically received power (dB(W))

$E$ : electric field strength (dB(μV/m))

$f$ : frequency (GHz)

$d$ : radio path length (km)

$L_{bf}$ : free-space basic transmission loss (dB)

$S$ : power flux-density (dB(W/m$^2$)).

For further information on point-to-point line-of-sight propagation refer to Recommendation ITU-R P.530.

# 4 Antennas as an essential part of any radio station

## 4.1 Choosing an antenna

Communicators quickly learn two antenna truths:

- Any antenna is better than no antenna.
- Time, effort and money invested in the antenna system generally will provide more improvement to communications than an equal investment to any other part of the station.

The antenna converts electrical energy to radio waves and radio waves to electrical energy, which makes two-way radio communication possible with just one antenna.

Success in communicating depends heavily on an antenna. A good antenna can make a fair receiver perform well. It can also make a few watts sound like much more. Since the same antenna is used to transmit and receive, any improvements to the antenna make the signal stronger at the desired reception points. Some antennas work better than others. It is useful to experiment with different antenna types.

## 4.2 Antenna system considerations

### 4.2.1 Safety

Safety should be the first consideration in installing an antenna system.

An antenna or transmission line should never be installed on top of electrical power lines. A vertical antenna should never be located where it could fall against the electrical power lines. Electrocution could result if power lines ever come into contact with the antenna.

Antennas should be high enough above the ground to ensure that no one can touch them. When the transmitter is active, the high voltages present at the ends of an antenna could kill or at least cause a serious RF burn.

A lightning arrester should be placed on the transmission line at the entrance point to the building housing the transmitting and receiving equipment. For safety, an Earth ground connection is necessary and the wire used for that purpose should be of conductor size equivalent to at least 2.75 mm diameter wire. The heavy aluminium wire used for TV-antenna Earth grounds is satisfactory. Copper braid 20 mm wide is also suitable. Ground connection may be made to a metal water pipe system, the grounded metal frame of a building, or to one or more 15 mm diameter ground rods driven to a depth of at least 2.5 meters.

Antenna work sometimes requires that someone climb up on a tower, into a tree, or onto the roof. It is not safe to work alone. Each move should be planned beforehand. The person on a ladder, tower, tree or rooftop should always wear a safety belt and keep it securely anchored. Before each use, the safety belt should be inspected carefully for damage such as cuts or worn areas. The belt will make it much easier to work on the antenna and will also prevent an accidental fall. A hard hat and safety glasses are also important safety equipment.

Tools should not be carried by hand when climbing. They should be placed on a tool belt. A long rope leading back to the ground should be secured to the belt and can be used to pull up other needed objects. It is helpful (and safe) to tie strings or lightweight ropes to all tools. This will save time in retrieving dropped tools and reduce the chances of injuring a helper on the ground.

Helpers on the ground should never stand directly under the work being done. All ground helpers should wear hard hats and safety glasses for protection. Even a small tool can cause an injury if it falls from 15 or 20 meters. A helper should always observe the tower work carefully. If possible, an observer with no other duties other than to watch for potential hazards should be positioned with a good view of the work area.

### 4.2.2 Antenna location

After assembling the antenna components, select a good place for it to be installed. Avoid running the antenna parallel close to power lines or telephone lines. Otherwise unwanted electrical coupling may occur, which could result in either power line noise in the station receiver or the transmitted signal appearing on the power or telephone lines. Avoid running the antenna close to metal objects, such as rain gutters, metal beams, metal siding, or even electrical wiring in the attic of a building. Metal objects may shield the antenna or modify its radiation pattern.

### 4.2.3 Antenna polarisation

Polarisation refers to the electrical-field characteristic of a radio wave. An antenna that is parallel to the earth's surface produces horizontally polarised radio waves. One that is perpendicular (at a 90° angle) to the Earth's surface produces vertically polarised waves.

Polarisation is most important when installing antennas for VHF or UHF. The polarisation of a terrestrial VHF or UHF signal tends not to change from transmitting antenna to receiving antenna. Both transmitting and receiving stations should use the same polarisation. Vertical polarisation is commonly used for VHF and UHF mobile operation including hand-held transceivers, in vehicles and base stations.

For HF sky-wave communications, radio signals tend to rotate through the ionosphere, thus horizontally or vertically polarised antennas can be used with almost equal results. Horizontally polarised antennas are preferred for receiving as they tend to reject local manmade noise, which is usually vertically polarised.

Vertical antennas provide low-angle radiation but have a null (radiate no energy) upward. This makes them suitable for longer sky-wave paths requiring a low take-off angle and they are not recommended for near-vertical-incidence sky-wave (NVIS) paths of about 0-500 km.

### 4.2.4 Tuning the antenna

The antenna length given by an equation is just an approximation. Nearby trees, buildings or large metal objects and height above ground all affect the resonant frequency of an antenna. An SWR meter can help to determine if the antenna should be shortened or lengthened. The correct length provides the best impedance match for the transmitter.

After cutting the wire to the length given by the equation, the tuning of the antenna should be adjusted for the best operation. With the antenna in its final location, the SWR should be observed at various frequencies within the desired band. If the SWR is much higher at the low-frequency end of the band the antenna is too short. If the antenna is too short, an extra length of wire can be attached to each end with an alligator clip. Then the extra length can be shortened a little at a time until the correct length is reached. If the SWR is much higher at the high-frequency end of the band, the antenna is too long. When the antenna is properly tuned, the lowest SWR values should be around the preferred operating frequency

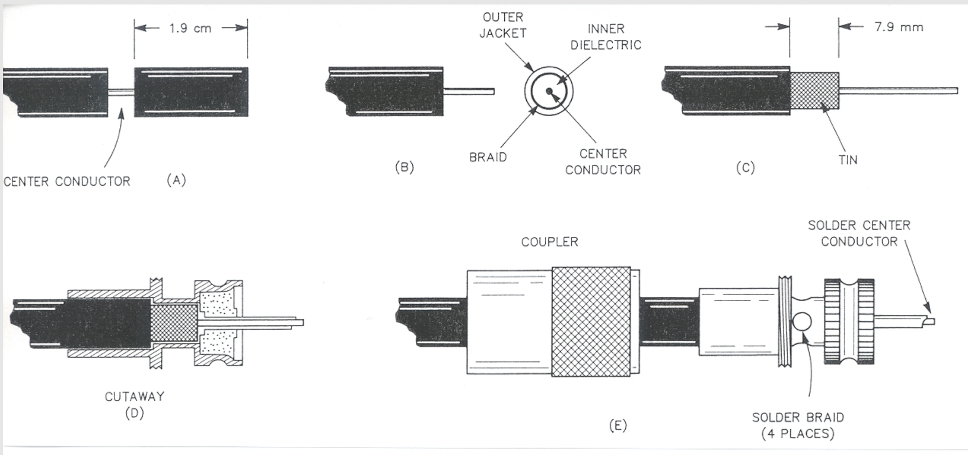
### 4.2.5 Transmission lines

The most commonly used type of antenna system transmission line is the coaxial cable ("coax"), where one conductor is inside the other. Coaxial cable has several advantages: It is readily available and resistant to weather. It can be buried in the ground if necessary, bent, coiled and run adjacent to metal with little effect.

Most common HF antennas are designed for use with transmission lines having characteristic impedances of about 50 ohms. RG-8, RG-58, RG-174 and RG-213 are commonly used coaxial cables. RG-8 and RG-213 are similar cables, and they have the least loss of the types listed here. The larger coax types (RG-8, RG-213, RG-11) have less signal loss than the smaller types. If the feed line is less than 30 meters long, the small additional signal loss on the HF bands is negligible. On VHF/UHF bands losses are more noticeable, especially when the feed line is long. On these bands, higher-quality RG-213 coax or even lower-loss rigid or semi-rigid coaxial cables minimise losses for transmission lines exceeding 30 meters.

Coaxial cable connectors are an important part of a coaxial feed line. It is prudent to check the coaxial connectors periodically to see that they are clean and tight to minimise any loses. If a bad solder connection is suspected, the joints should be cleaned and re-soldered. The choice of connectors normally depends on matching connectors on the radios. Many HF radios and many VHF radios use SO-239 connectors. The mating connector is a PL-259 (Figure 7). The PL-259 is sometimes called a UHF connector, although constant impedance connectors such as Type-N the best choice for the UHF bands. PL-259 connectors are designed for use with RG-8 or RG-213 cables. When using coax to connect the transmission line, an SO-239 connector should terminate the line at the centre insulator and a PL-259 should be used at the end connecting to the radio.

**Figure 7 – PL-259 coaxial connector**




### 4.2.6 Matching impedances within the antenna system

If an antenna system does not match the characteristic impedance of the transmitter, some of the power is reflected back from the antenna to the transmitter. When this happens, the RF voltage and current are not uniform along the line. The power travelling from the transmitter to the antenna is called forward power and is radiated from the antenna. The standing-wave ratio (SWR) is the ratio of the maximum voltage on the line to the minimum voltage. An SWR meter measures the relative impedance match between an antenna and its feed line. Lower SWR values mean a better impedance match exists between the transmitter and the antenna system. If a perfect match exists, the SWR is 1:1. The SWR defines the quality of an antenna as seen from the transmitter, but a low SWR does not guarantee that the antenna will radiate the RF energy supplied to it by the transmitter. An SWR measurement of 2:1 indicates a fairly good impedance match.

### 4.2.7 SWR meters

The most common SWR meter application is tuning an antenna to resonate on a given frequency. An SWR reading of 2:1 or less is quite acceptable. A reading of 4:1 or more is unacceptable. This means there is a serious impedance mismatch between the transmitter, the antenna or the feed line.

How the SWR is measured depends on the type of meter. Some SWR meters have a SENSITIVITY control and a FORWARD-REFLECTED switch. If so, the meter scale usually provides a direct SWR reading. To use the meter, first put the switch in the FORWARD position. Then adjust the SENSITIVITY control and the transmitter power output until the meter reads full scale. Some meters have a mark on the meter face labelled SET or CAL. The meter pointer should rest on this mark. Next, set the selector switch to the REFLECTED position. This should be done without readjusting the transmitter power or the meter SENSITIVITY control. Now the meter pointer displays the SWR value. Find the resonant frequency of an antenna by connecting the meter between the feed line and your antenna. This technique will measure the relative impedance match between the antenna and its feed line. The settings that provide the lowest SWR at the operating frequency are preferred.

### 4.2.8 Antenna impedance matching networks

Another useful accessory is an impedance matching network. It is also called an antenna matching network, antenna tuner, antenna tuning unit (ATU), or simply a tuner. The network compensates for any impedance mismatch between the transmitter, the transmission line and the antenna. A tuner makes it possible to use one antenna on several frequency bands. The tuner is connected between the antenna and SWR meter, if used. The SWR meter is used to indicate the minimum reflected power as the tuner is adjusted.

Just one more step and the antenna installation is complete. After routing the coaxial cable to your station, cut it to length and install the proper connector for the transmitter. Usually this connector will be a PL-259, sometimes called a UHF connector. Figure 7 shows how to attach one of these fittings to RG-8 or RG-11 cable. It is important to place the coupling ring on the cable *before* installing the connector body. If using RG-58 or RG-59 cable, use an adapter to fit the cable to the connector. The SO-239 female connector is standard on many transmitters and receivers.

If the SWR is very high, a problem may exist that cannot be cured by simple tuning. A very high SWR may mean that the feed line is open or shorted. If the SWR is very high the cause may be an improper connection or insufficient space between the antenna and surrounding objects.

## 4.3 Practical antennas

### 4.3.1 The half-wave dipole antenna

Probably the most common HF antenna is a wire cut to a half wavelength (½ λ) at the operating frequency. The transmission line attaches across an insulator at the centre of the wire. This is the half-wave dipole. This is often referred to as a dipole antenna. (*Di* means two, so a dipole has two equal parts. A dipole could be a length other than ½ λ.) The total length of a half-wavelength dipole is ½ λ. The feed line connects to the centre. This means that each side of this dipole is ¼ λ long.

Wavelength in space can be determined by dividing the constant 300 by the frequency in megahertz (MHz). For example, at 15 MHz, the wavelength is 300/15 = 20 meters.

Radio signals travel slower in wire than in air, thus the following equation may be used to find the total length of a ½ λ dipole for a specific frequency. Notice that the frequency is given in megahertz and the antenna length is in meters for this equation.

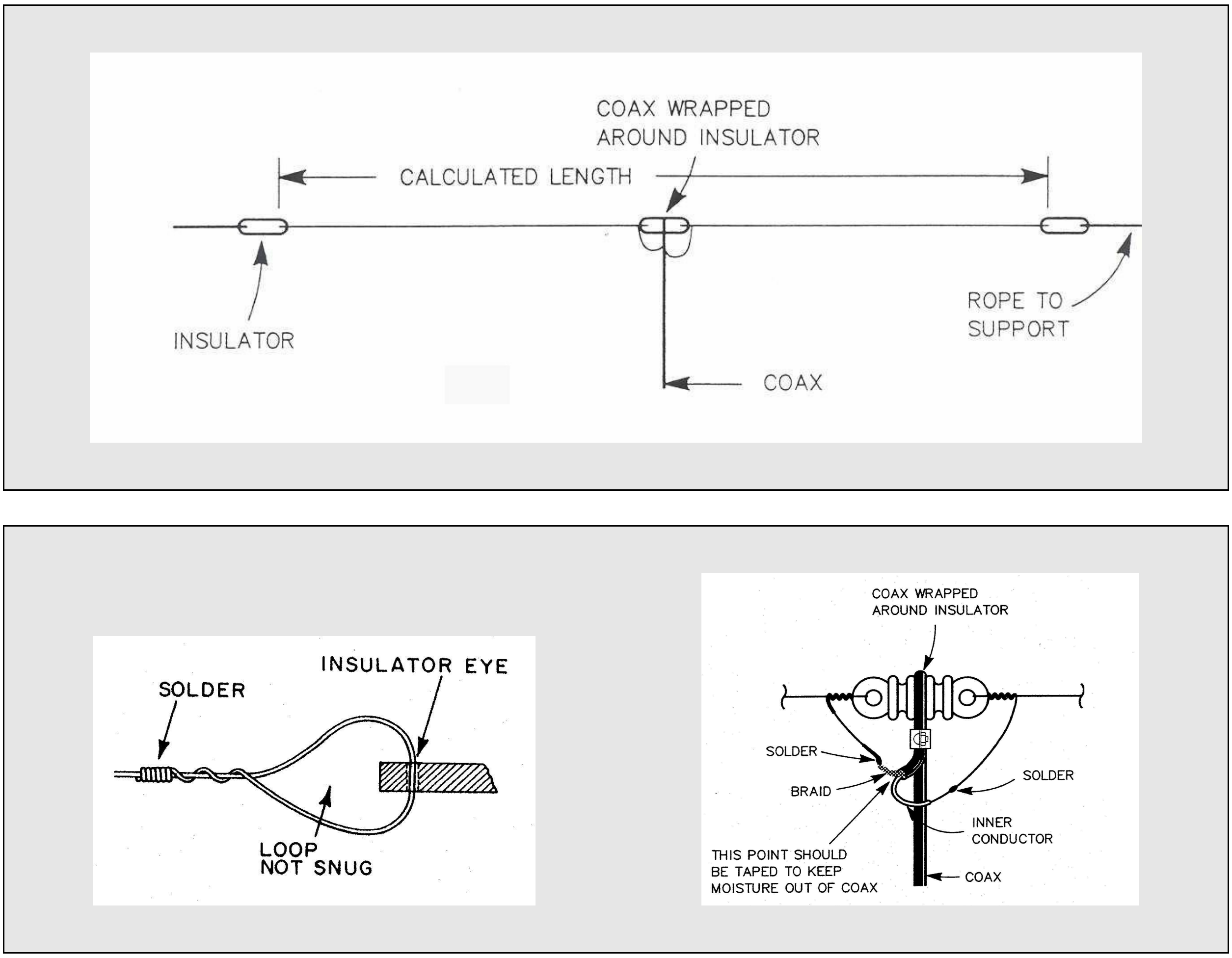
$$L \text{ (in meters)} = \frac{143}{f_{\text{MHz}}}$$

This equation also takes into account other factors, often called *antenna effects*. It gives the approximate length of wire for an HF dipole antenna. The equation will not be as accurate for VHF/UHF antennas. The element diameter is a larger percentage of the wavelength at VHF and higher frequencies. Other effects, such as *end effects* also make the equation less accurate at VHF and UHF.

**Table 2 – Approximate lengths for ½ λ dipoles suitable for fixed, mobile and amateur bands**

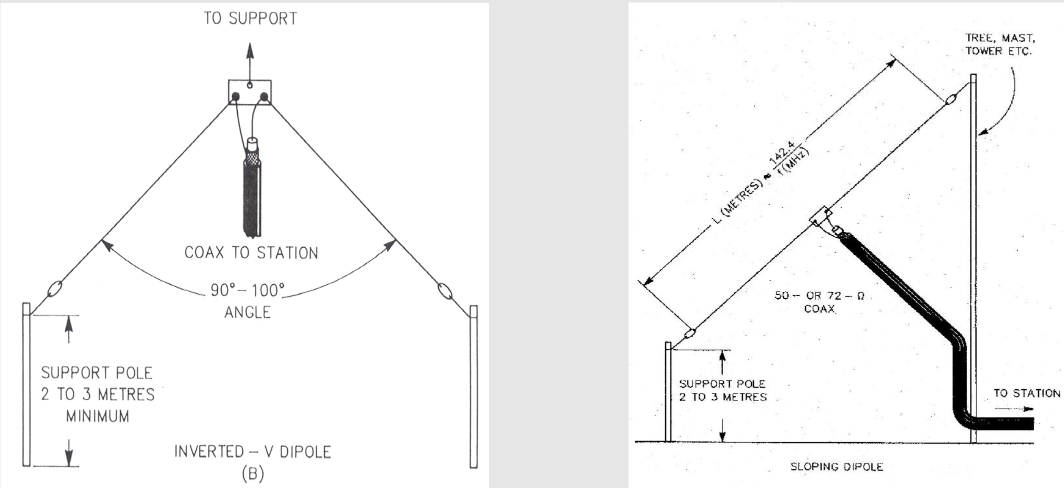
| Frequency (MHz) | Length (m) | Frequency (MHz) | Length (m) | Frequency (MHz) | Length (m) |
|---|---|---|---|---|---|
| 3.3 | 43.3 | 12.2 | 11.7 | 30 | 4.8 |
| 3.5 | 40.8 | 13.4 | 10.7 | 35 | 4.1 |
| 3.8 | 37.6 | 13.9 | 10.3 | 40 | 3.6 |
| 4.5 | 31.8 | 14.2 | 10.0 | 50 | 2.86 |
| 4.9 | 29.2 | 14.6 | 9.8 | 145 | 99 cm |
| 5.2 | 27.5 | 16.0 | 8.8 | 150 | 95 |
| 5.8 | 24.6 | 17.4 | 8.2 | 155 | 92 |
| 6.8 | 21.0 | 18.1 | 7.9 | 160 | 89 |
| 7.1 | 20.1 | 20.0 | 7.1 | 165 | 87 |
| 7.7 | 18.6 | 21.2 | 6.7 | 170 | 84 |
| 9.2 | 15.5 | 21.8 | 6.5 | 435 | 33 |
| 9.9 | 14.4 | 23.8 | 6.0 | 450 | 32 |
| 10.1 | 14.1 | 24.9 | 5.7 | 455 | 31.4 |
| 10.6 | 13.5 | 25.3 | 5.6 | 460 | 31 |
| 11.5 | 12.4 | 29.0 | 4.9 | 465 | 30.7 |

**Figure 8 – Construction of a simple half-wave dipole antenna. At top is the basic dipole assembly. Bottom left shows how to connect wire ends to insulators. Bottom right illustrates connection of the transmission line to the centre of the dipole**



Household electrical wire and stranded wire will stretch with time; a heavy gauge copper-clad steel wire does not stretch as much. The dipole should be cut according to the dimension found by the equation above (total length of a ½ λ dipole), but a little extra length should be provided to wrap the ends around the insulators. A coaxial or parallel transmission line is needed to connect the antenna to the transmitter. Three insulators are also needed. If supporting the antenna in the middle, both ends will droop toward the ground. This antenna, known as an inverted-V dipole, is almost omni-directional and works best when the angle between the wires is equal to or greater than 90°. A dipole can also be supported only at one end, in which case it is known as a sloping dipole.

**Figure 9 – Alternative ways of installing a dipole. The configuration on the left is an Inverted-V dipole. A sloping dipole is shown at right. A balun (not shown) may be used at the feed point, as this is a balanced antenna**

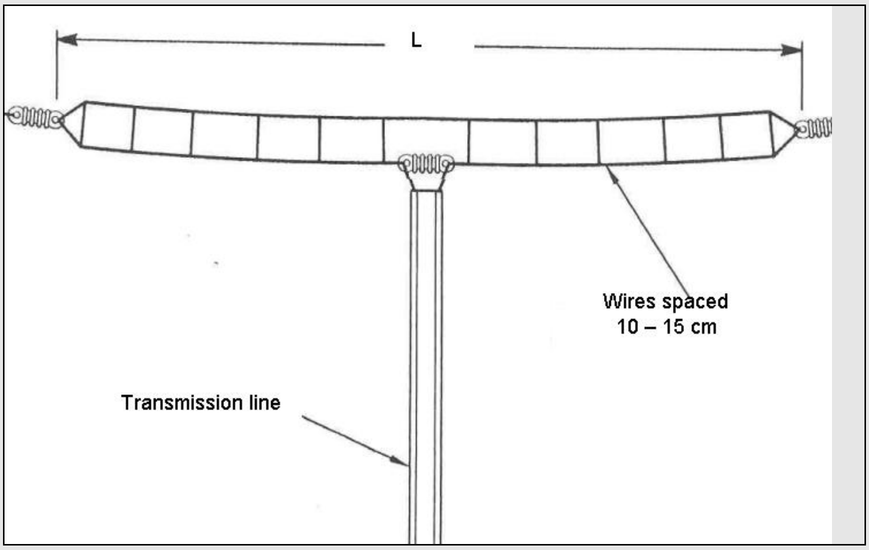



Dipole antennas radiate best in a direction that is 90° to the antenna wire. For example, suppose a dipole antenna is installed so the ends of the wire run in an east/west direction. Assuming it was sufficiently above the ground (for example, ½ λ high), this antenna would send stronger signals in north and south directions. A dipole also sends radio energy straight up and straight down. Of course, the dipole also emits some energy in directions off the ends of the wire, but these signals will be attenuated. Though it is possible to contact stations to the east and west with this antenna, signals are stronger with stations to the north and south.

### 4.3.2 Broadband folded dipole

A broadband version of the dipole, the folded dipole (Figure 10), has an impedance of about 300 ohms and can be fed directly with any length of 300 ohm feed line. This variation of the dipole is termed *broadband* because it offers a better match to the feeder over a somewhat wider range of frequencies. When a folded dipole is installed as an inverted "V" it is essentially omni-directional. There are several broadband folded dipoles available commercially that provide acceptable HF performance, even when operating without a tuner.

**Figure 10 – Broadband folded dipole antenna. L = 143/$f_{MHz}$**




### 4.3.3 Quarter-wavelength vertical antenna

The quarter-wavelength vertical antenna is effective and easy to build. It requires only one element and one support. On the HF bands it is often used for long distance communications. Vertical antennas are referred to as non-directional or omni-directional antennas because they send radio energy equally well in all compass directions. They also tend to concentrate the signals toward the horizon as they have a low-angle radiation pattern and do not generally radiate strong signals upward.

Figure 11 shows how to construct a simple vertical antenna. This vertical antenna has a radiator that is ¼ λ long. Use the following equation to find the approximate length for the radiator. The frequency is given in megahertz and the length is in meters in this equation.

$$L \text{ (in meters)} = \frac{71}{f_{\text{MHz}}}$$

**Figure 11 – Simple quarter-wave vertical antenna**

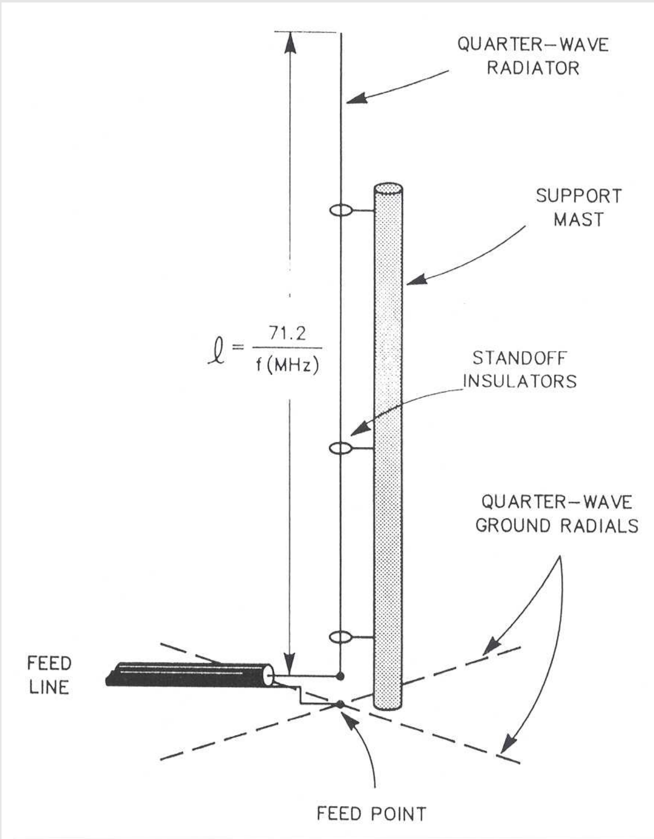


**Table 3 – Approximate lengths for ¼ λ monopoles and ground radials suitable for fixed, mobile and amateur bands**

| Frequency (MHz) | Length (m) |
|---|---|
| 3.3 | 21.6 |
| 3.5 | 20.4 |
| 3.8 | 18.8 |
| 4.5 | 15.9 |
| 4.9 | 14.6 |
| 5.2 | 13.7 |
| 5.8 | 12.3 |
| 6.8 | 10.5 |
| 7.1 | 10.0 |
| 7.7 | 9.3 |
| 9.2 | 7.7 |
| 9.9 | 7.2 |
| 10.1 | 7.1 |
| 10.6 | 6.7 |
| 11.5 | 6.2 |

| Frequency (MHz) | Length (m) |
|---|---|
| 12.2 | 5.9 |
| 13.4 | 5.3 |
| 13.9 | 5.1 |
| 14.2 | 5.0 |
| 14.6 | 4.9 |
| 16.0 | 4.5 |
| 17.4 | 4.1 |
| 18.1 | 3.9 |
| 20.0 | 3.5 |
| 21.2 | 3.3 |
| 21.8 | 3.2 |
| 23.8 | 3.0 |
| 24.9 | 2.9 |
| 25.3 | 2.8 |
| 29.0 | 2.5 |

| Frequency (MHz) | Length (m) |
|---|---|
| 30 | 2.4 |
| 35 | 2.1 |
| 40 | 1.8 |
| 50 | 1.43 |
| 145 | 50 cm |
| 150 | 48 |
| 155 | 46 |
| 160 | 44 |
| 165 | 43 |
| 170 | 42 |
| 435 | 117 |
| 450 | 16 |
| 455 | 16 |
| 460 | 16 |
| 465 | 15 |

For successful results, the ¼ λ vertical should have a radial system to reduce Earth losses and to act as a ground plane. For operation on high frequencies, the vertical may be at ground level and the radials placed on the ground. At least 3 radials should be used and out like the spokes of a wheel, with the vertical at the centre. Radials should be at least ¼ λ long or more at the lowest operating frequency.

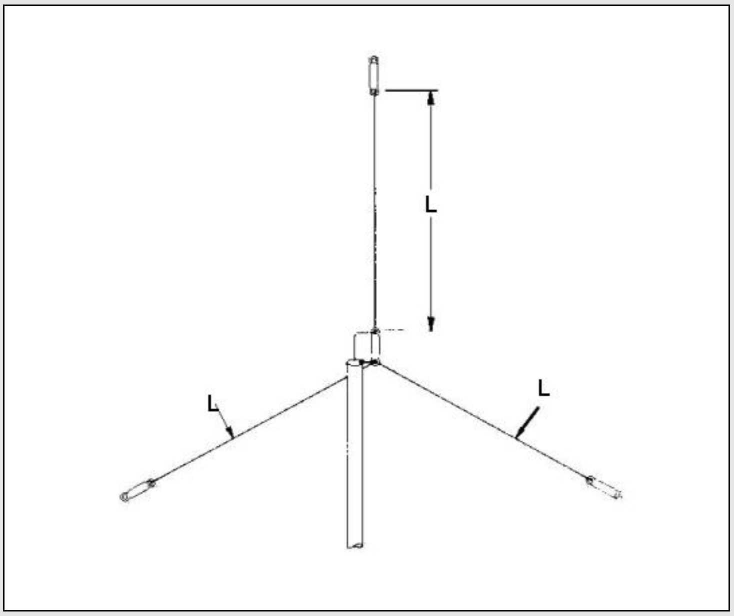
Most vertical antennas used at HF are ¼ λ long or shorter with appropriate loading networks. For VHF and UHF, antennas are physically short enough that longer verticals may be used. A popular mobile antenna is a 5/8 λ vertical, often called a "five-eighths whip". This antenna is popular because it concentrates more of the radio energy toward the horizon than a ¼ λ vertical.

Commercially available vertical antennas need a coax feed line, usually with a PL-259 connector. Just as with the dipole antenna, RG-8, RG-11 or RG-58 coax can be used.

Some manufacturers offer multi-band vertical antennas that use series-tuned circuits (traps) to make the antenna resonant at different frequencies.

To fabricate a tree-mounted HF ground plane antenna (Figure 12), a length of RG-58 cable is connected to the feed point of the antenna and is attached to an insulator. The radial wires are soldered to the coax-line braid at this point. The top of the radiator section is suspended from a tree limb or other convenient support, and in turn supports the rest of the antenna.

**Figure 12 – Construction of tree-mounted ground plane antenna. $L = 143/f_{MHz}$**




The dimensions for the antenna are the same as for a ¼ λ vertical antenna. All three wires of the antenna are ¼ λ long. This generally limits the usefulness of the antenna to 7 MHz and higher bands, as temporary supports higher than 10 or 15 meters may not be available.

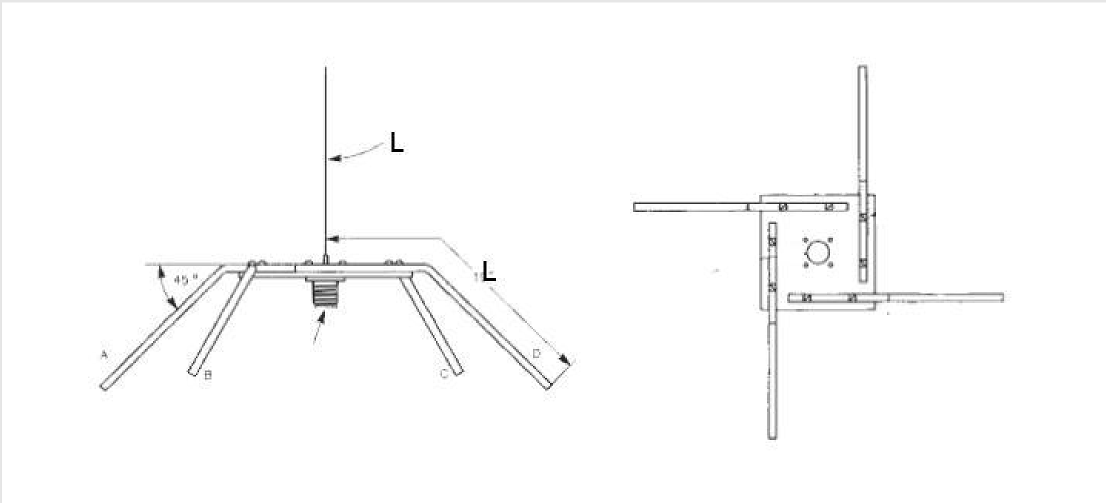
### 4.3.4 Antennas for hand-held transceivers

VHF and UHF hand-held transceivers normally use shortened flexible antennas that are inexpensive, small, lightweight and robust. On the other hand, they have some disadvantages: It is a compromise design that is inefficient and thus does not perform as well as larger antennas. Two better-performing antennas are the ¼ λ and the 5/8 λ telescoping types that are available as separate accessories.

### 4.3.5 Vertical antennas for VHF and UHF

For operation of stations at fixed locations, the ¼ λ vertical is an ideal choice. The 145 MHz model shown in Figure 13 uses a flat piece of sheet aluminium, to which radials are connected with machine screws. A 45° bend is made in each of the radials. This bend can be made with an ordinary bench vise. An SO-239 chassis connector is mounted at the centre of the aluminium plate with the threaded part of the connector facing down. The vertical portion of the antenna is made of 10 mm copper wire soldered directly to the centre pin of the SO-239 connector.

**Figure 13 – A VHF or UHF ground plane antenna with 4 drooping radials. L = 143/$f_{MHz}$**

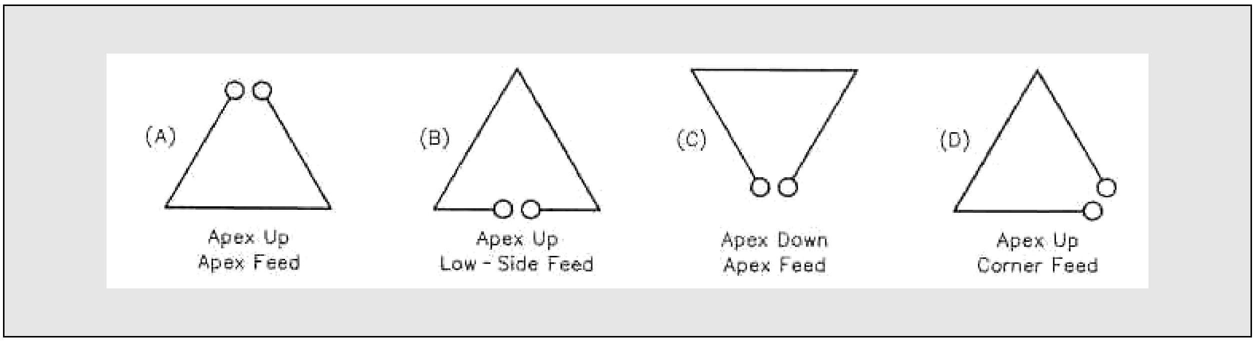



Construction is simple as it requires nothing more than an SO-239 connector and some common hardware. A small loop formed at the inside end of each radial is used to attach the radial directly to the mounting holes of the coaxial connector. After the radial is fastened to the SO-239 with hardware, a large soldering iron or propane torch is used to solder the radial and the mounting hardware to the coaxial connector. The radials are bent to a 45° angle and the vertical portion is soldered to the centre pin to complete the antenna. It is prudent to apply a small amount of sealant around the areas of the centre pin of the connector to prevent the entry of water into the connector and coax line.

### 4.3.6 Delta loop

The Delta loop is another field expedient wire antenna used by disaster relief organisations. There are three key advantages to a Delta loop antenna: 1) a ground plane is unnecessary; 2) a full-wave loop (depending on the shape) has some gain over a dipole; and 3) a closed loop is a "quieter" (improved signal-to-noise ratio) receiving antenna than are most vertical and some horizontal antennas. Feed point selection will permit the choice of vertical or horizontal polarisation. Various angles of radiation will result from assorted feed-point selections. The system is rather flexible and is capable of maximising close in or long distance communications (high angle versus low angle). Figure 14 illustrates various configurations that can be used. The bandwidth at resonance is similar to a dipole. An antenna-tuning unit (ATU) is recommended for matching the system to the transmitter in parts of the band where the SWR is high. There is no rule that dictates the shape of a full wave loop. It may be convenient to use a triangular shape with the apex is at the top in which case only one high support is needed. Circular, square or rectangular shapes have been used.

**Figure 14 – Various configurations for a full-wavelength Delta loop antenna. Overall length of the antenna wire is approximately 286/$f_{MHz}$**




| Configuration | A | B | C | D |
|---|---|---|---|---|
| Polarisation | Horizontal | Horizontal | Horizontal | Vertical |
| Radiation angle | Moderately high | High | Moderately high | Low |

### 4.3.7 Directional antennas

Directional antennas have two important advantages over simpler omni-directional antennas such as dipoles and vertical monopoles. As transmitting antennas, they concentrate most of the radiation in one direction. For receiving, directional antennas can be pointed toward the desired direction or away from a source of noise.

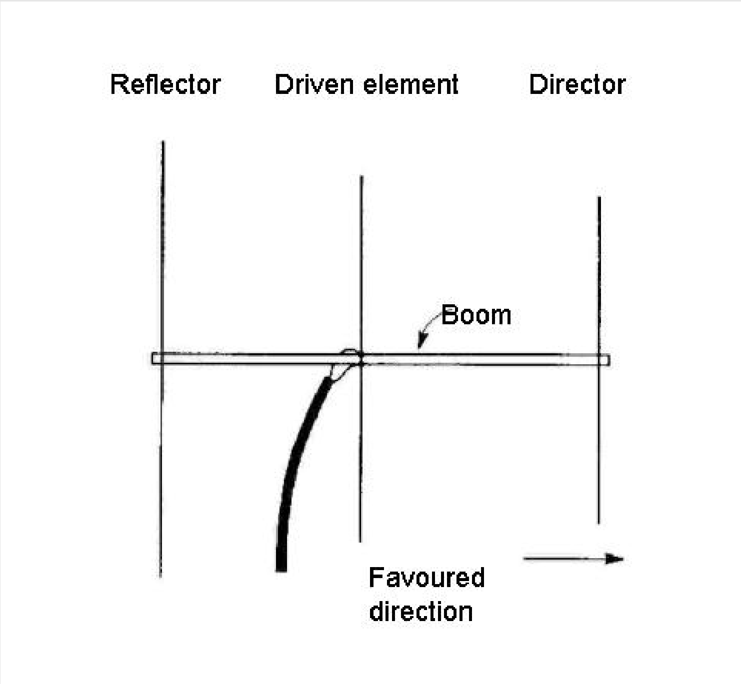
Although generally large and expensive below about 10 MHz, directional antennas often are used on the upper high frequency bands, such as from 10 MHz to 30 MHz. Directional antennas commonly used at VHF and UHF owing to their reasonably small size. The most common directional antenna is the *Yagi* antenna, but there are other types, as well.

A Yagi antenna has several elements attached to a central *boom*, as Figure 15 shows. The elements are parallel to each other and are placed in a straight line along the boom. Although several factors affect the amount of gain of a Yagi antenna, *boom length* has the largest effect: The longer the boom, the higher the gain.

The transmission line connects only to one element called the *driven element*. On a three-element Yagi like the one shown in Figure 15, the driven element is in the middle. The element at the front of the antenna (toward the favoured direction) is a director. Behind the driven element is the reflector element. The driven element is about ½ $\lambda$ long at the antenna design frequency. The director is a bit shorter than ½ $\lambda$, and the reflector a bit longer. Yagi beams can have more than three elements, usually by adding more directors. Directors and reflectors are called parasitic elements, since they are not fed directly.

Communication in different directions may be achieved by turning the array using a rotator in the azimuthal (horizontal) plane, to point it in different directions.

**Figure 15 – A three-element Yagi showing the reflector, driven element and director supported by a boom**




#### 4.3.7.1 Log-periodic arrays

Log-periodic antennas are an alternative directional antenna. They have wider bandwidth but lower directional gain than a Yagi.

A log-periodic antenna is a system of driven elements, designed for operation over a wide range of frequencies. Its advantage is that it exhibits essentially constant characteristics over the frequency range – the same radiation resistance (and therefore the same SWR), and the same pattern characteristics (approximately the same gain and the same front-to-back ratio).

## 5 Power sources and batteries

### 5.1 Power safety

As in antenna work, for safety purposes any electrical work should be done with a second person present. A switch should never be used in the neutral wire without also disconnect the equipment from an active or “hot” line.

All communications equipment should be reliably connected to an Earth ground by means of a separate heavy gauge wire. The power wiring neutral conductor should not be used for this safety ground. This places the chassis of the equipment at Earth ground potential for minimal RF energy on the chassis. It provides a measure of safety for the operator in the event of accidental short or leakage of one side of the power line to the classis.

No battery should be subjected to unnecessary heat, vibration or physical shock. The battery should be kept clean. Frequent inspection of leaks is recommended. Electrolyte that has leaked or sprayed from the battery should be cleaned from all surfaces. The electrolyte is chemically active and electrically conductive, and may ruin electrical equipment. Acid may be neutralized with sodium bicarbonate (baking soda), and alkalis may be neutralized with a weak acid such as vinegar. Both neutralizers will dissolve in water, and should be quickly washed off. The neutralizer should not be allowed to enter the battery. Gas escaping from storage batteries may be explosive. Keep flames or lighted tobacco products away.

When working with generators, keep safety foremost in your mind. Gasoline is a dangerous chemical and there is no scope for carelessness. Fuel should be stored only in the proper containers, well away from the generator and out of the sun. The generator should be turned off and cool before adding new fuel. Gasoline and oil-soaked rags should be disposed of properly. If they are tossed in a pile, they could catch fire by spontaneous combustion. A fire extinguisher should be kept near the generator. Smoking should not be allowed near the generator.

Internal combustion engines produce heat. The larger the engine, the higher the speed, the greater the heat produced. The combination of fuel fumes and engine heat in a small enclosure is dangerous. Generator exhaust fumes can be lethal. Whether gasoline, diesel, natural gas or propane is used, be sure that exhaust fumes are properly vented out of the operating area. Natural ventilation is usually not sufficient to maintain a safe atmosphere. A blower or ventilator fan should be used to bring fresh air from outside, with an exhaust fan installed to expel the heat.

## 5.2 Mains power

Mains power should be used when available to save any self-generated power systems for backup purposes. Even unreliable mains power can be used to charge batteries.

Electrical service enters buildings in the form of two or more wires to provide 100-130 V or 200-260 V alternating current at 50 or 60 Hz. The circuits may be divided into several branches and protected by circuit breakers or fuses.

A ground fault circuit interrupter (GFCI or GFI) is also desirable to safety reasons, and should be a part of the electrical power wiring if possible.

## 5.3 Power transformers

Numerous factors should be considered in selecting transformers, such as input and output volt-ampere (VA) ratings, ambient temperature, duty cycle and mechanical design.

In alternating-current equipment, the term “volt-ampere” is often used rather that the term “watt.” This is because ac components must handle reactive power as well as real power. The number of volt-amperes delivered by a transformer depends not only upon the dc load requirements, but also upon the type of dc output filter used (capacitor or choke input), and the type of rectifier used (full-wave centre tap or full-wave bridge). With a capacitive-input filter, the heating effect in the secondary is higher because of the high peak-to-average current ration. The volt-amperes handled by the transformer may be several times the power delivered to the load. The primary winding volt-amperes will be somewhat higher because of transformer losses.

A transformer operates by producing a magnetic field in its core and windings. The intensity of this field varies directly with the instantaneous voltage applied to the transformer primary winding. These variations, coupled to the secondary windings, produce the desired output voltage. Since the transformer appears to the source as an inductance in parallel with the (equivalent) load, the primary will appear as a short circuit if dc is applied to it. The unloaded inductance of the primary must be high enough so as not to draw an excess amount of input current at the design line frequency (normally 50 or 60 Hz). This is achieved by providing sufficient turns on the primary and enough magnetic core materials so that the core does not saturate during each half-cycle.

To avoid possibly serious overheating, transformers and other electromagnetic equipment designed for 60 Hz systems must not be used on 50 Hz power systems unless specifically designed to handle the lower frequency.

## 5.4 Batteries and charging

The availability of solid-state equipment makes it practical to use battery power under portable or emergency conditions. Hand-held transceivers and instruments are obvious applications, but 100 W output transceivers may be practical users of battery power (for example, emergency power for HF transceivers).

Low-power equipment can be powered from two types of batteries. The *primary* battery is intended for one-time use and is then discarded; the *storage* (or *secondary*) battery may be recharged many times.

A battery is a group of chemical cells, usually connected in series to give some desired multiple of the cell voltage. Each assortment of chemicals used in the cell gives a particular nominal voltage. This must be taken into account to make up a particular battery voltage. For example, four 1.5 V carbon-zinc cells make a 6 V battery and six 2 V lead-acid cells make a 12 V battery.

### 5.4.1 Battery capacity

The common rating of battery capacity is ampere-hours (Ah), the product of discharge current and time. The symbol *C* is commonly used; C/10, for example, would be the current available for 10 hours continuously. The value of C changes with the discharge rate and might be 110 at 2 A but only 80 at 20 A. Capacity may vary from 35mAh for some of the small hearing aid batteries to more than 100 Ah for a size 28 deep-cycle storage battery.

Sealed primary cells usually benefit from intermittent (rather than continuous) use. The resting period allows completion of chemical reactions needed to dispose of by-products of the discharge.

The output voltage of all batteries drops as they discharge. “Discharged” condition for a 12 V lead-acid battery, for instance, should not be less than 10.5 volts. It is also good to keep a running record of hydrometer readings, but the conventional readings of 1.265 charged and 1.100 discharged apply only to a long, low-rate discharge. Heavy loads may discharge the battery with little reduction in the hydrometer reading.

Batteries that become cold have less of their charge available, and some attempt to keep a battery warm before use is worthwhile. A battery may lose 70% or more of its capacity at cold extremes, but it will recover with warmth. All batteries have some tendency to freeze, but those with full charges are less susceptible. A fully charged lead-acid battery is safe to –26 °C or colder. Storage batteries may be warmed somewhat by charging or discharging. Blow touches or other flame should never be used to heat any type of battery.

A practical discharge limit occurs when the load will no longer operate satisfactorily on the lower output voltage near the “discharged” point. Much gear intended for “mobile” use may be designed for an average of 13.6 V and a peak of perhaps 15 V, but will not operate well below 12 V. For full use of battery charge, the gear should operate well (if not at full power) on as little as 10.5 V with a nominal 12 to 13.6 V rating.

Somewhat the same condition may be seen in the replacement of carbon-zinc cells by NiCd storage cells. Eight carbon-zinc cells will give 12 V, while 10 for the same voltage. If a 10-cell battery holder is used, the equipment should be designed for 15 V in case the carbon-zinc units are plugged in.

### 5.4.2 Primary batteries

One of the most common primary-cell types is the alkaline cell, in which chemical oxidation occurs during discharges. When there is no current, the oxidation essentially stops until current is required. A slight amount of chemical action does continue, however, so stored batteries eventually will degrade to the point where the battery will no longer supply the desired current.

The alkaline battery has a nominal voltage of 1.5 V. Larger cells capable of production more milliampere hours and less voltage drop than smaller cells. Heavy duty and industrial batteries usually have longer shelf life.

Lithium primary batteries have a nominal voltage of about 3 V per cell and by far the best capacity, discharge, shelf life and temperature characteristics. Their disadvantages are high cost and that they cannot be readily replaced by other types in an emergency.

The lithium-thionyl-chloride battery is a primary cell and should not be recharged under any circumstances. The charging process vents hydrogen, and a catastrophic explosion can result. Even accidental charging caused by wiring errors or a short circuit should be avoided.

Silver oxide (1.5 V) and mercury (1.4 V) batteries are used where nearly constant voltage is desired at low currents for long periods. Their primary application is in small equipment.

Primary batteries should not be recharged for two reasons: It may be dangerous because of heat generated within sealed cells, and even in cases where there may be some success, both the charge and life are limited. One type of alkaline battery is rechargeable and is so marked.

### 5.4.3 Secondary batteries

The most common type of small rechargeable battery is the nickel-cadmium (NiCd), with a nominal voltage of 1.2 V per cell. Carefully used, these are capable of 500 or more charge/discharge cycles. For long life, the NiCd battery should not be fully discharged. Where there is more than one cell in the battery, the most-discharged cell may suffer polarity reversal, resulting in a short circuit or seal rupture. All storage batteries have discharge limits, and NiCd types should not be discharged to less than 1.0 V per cell. Nickel cadmium cells are not limited to "D" size and smaller cells. They also are available in large varieties ranging to mammoth 1 000 Ah units having carrying handles on the sides and top for adding water, similar to lead-acid types. They are used extensively for uninterruptible power supplies.

For high capacity, the most widely used rechargeable battery is the lead-acid type. In automotive service, the battery is usually expected to discharge partially at a very high rate and then to be recharged promptly while the alternator is also carrying the electrical load. The most appropriate battery for extended high-power electronic applications is the so-called "deep-cycle" battery. These batteries may furnish between 1 000 and 1 200 Wh per charge at room temperature. When properly cared for, they may be expected to last more than 200 cycles. They often have lifting handles and screw terminals, as well as the conventional truncated cone automotive terminals. They may also be fitted with accessories, such as plastic carrying cases, with or without built-in chargers. Lead-acid batteries are also available with gelled electrolyte. Commonly called "gel cells", these may be mounted in any position sensitive.

An automotive lead-acid battery was designed for one task: to deliver a lot of current for a brief period of time. Its output voltage does not remain constant during its discharge cycle, and it is not a good idea to discharge it completely. An automobile battery will not tolerate too many deep-discharge cycles before it's ruined.

A deep-discharge lead-acid battery is much better suited emergency power needs. It can be discharged repeatedly without damage, and will maintain full output voltage over much of its discharge cycle. This type of battery is available at automobile- and marine-parts supply outlets. They are not much more expensive than regular automobile batteries and are designed to deliver moderate current for long periods of time.

The nickel metal hydride (NiMH) battery is similar to the NiCd, but the cadmium electrode is replaced by one made from a porous metal alloy that traps hydrogen; therefore the name of metal hydride. Many of the basic characteristics of these cells are similar to NiCds. For example, the voltage is very nearly the same, they can be slow-charged from a constant current source and they can safety be deep cycled. These are also some important differences: They have higher capacity for the same cell size often nearly twice as much as the NiCd types. The typical size AA NiMH cell has a capacity between 1 000 and 1 300 mAh, compared to the 600 to 830 mAh for the same size NiCd. Another advantage of these cells is a complete freedom from memory effect. NiMH cells do not contain any dangerous substance, while both NiCd and lead-acid cells do contain quantities of toxic heavy metals.

The Lithium-ion (Li-ion) cells is another possible alternative to the NiCd cell. For the same energy storage, it has about one third the weight and one half the volume of NiCd. It also has a lower self-discharge rate. Typically, at room temperature, a NiCd cell will lose from 0.5 to 2% of its charge per day. The lithium-ion cell will lose less than 0.5% per day and even this loss rate decreased after about 10% of the charge has been lost. At higher temperature the difference is even greater. The results are that Lithium-ion cells are a better choice for standby operation where frequent recharge is not available. One major difference between NiCd and Li-ion cells is the cell voltage. The nominal voltage for NiCd cell is about 1.2 V. For the Li-ion cell it is 3.6 V with a maximum cell charging voltage of 4 V. Li-ion cells cannot be substituted directly for NiCd cells. Chargers intended for NiCd batteries must not be used with Li-ion batteries, and vice versa.

## 5.5 Inverters

One source of ac power for use in the field is a dc-to-ac converter, or more commonly, an inverter. The ac output of an inverter is a usually square wave. Therefore, some types of equipment cannot be operated from the inverter. Certain types of motor are among those devices that require a sine-wave output. Aside from having a square-wave output, inverters have some other traits that make them less than desirable for field use. Commonly available models do not provide a high power handling capability. Higher power models are available but are quite expensive.

## 5.6 Generators

For long-term emergency operation, a generator is a requirement. The generator will provide power as long as fuel is available. Proper care is necessary to keep the generator operating reliably, however.

For these periods when the generator is shut down, battery power can be used until the generator can be reactivated. The lubricating oil level should be checked periodically.

If the oil sump becomes empty, the engine can seize, putting the station out of operation and necessitating costly engine repairs.

Remember the engine will produce carbon monoxide gas while it is running. The generator should never run indoors and should be placed away from open windows and doors to keep exhaust fumes from coming inside.

Generators in the 3-5 kW range are easily handled by two people and can provide power for radios and other electrical equipment. Most generators provide 12 V dc output in addition to 120/240 V ac.

Some generators have a continuous power rating and an intermittent power rating. If the total station requirement exceeds the available generator power, transceivers draw full power only while transmitting and that they are not going to be transmitting 100% of the time. It is necessary to ensure that the total possible power consumption does not exceed the intermittent power rating of the generator.

Generators should be tested regularly. Fuel should be fresh. Operator level maintenance (tune-up or oil change) should be performed regularly. Spark plugs should be checked carefully and spare spark plugs should be maintained. The air cleaners should be checked and cleaned according to manufacturer's instructions.

The generator should be checked for proper operation. If there are any fuel leaks, it should be turned off immediately and the problem corrected. The muffler should be inspected. All protective covers should be in place. The output voltage should be tested. If the generator does not have a built-in over-voltage protector, the voltage should be correct before applying power to radio equipment.

Finally, the generator should be checked for radio noise. Some generators are not fully suppressed for ignition noise. If there is a problem, it may be possible to use resistor-type spark plugs or spark-plug wires. A good Earth ground with a ground rod may help minimize noise.

### 5.6.1 Installation considerations

Any internal combustion engine is noisy and bothersome when communication equipment is being operated nearby. The placement of a power plant is important, regardless of its size. An engine running at 3 600 rotations per minute, even with an efficient muffler system produces noise and vibration. The engine vibrations are conducted thought the base upon which the engine is mounted to the ground or walls of the building housing the system. Brick or concrete-block construction will reduce the noise level, but if the generator shack is metal, there is less noise abatement. Metal panels may vibrate in sympathy with the sound source add to the din. Applying a hardening caulking compound to the vertical edges of the metal panels cab eliminate some of the noise, as can the use of sound-deadening material in lining the shack.

The distance between the alternator and the operating must be considered. Sound intensity varies inversely with the square of the distance from the source. The noise at a distance of 20 meters will be one-fourth that at a distance of 10 meters. At 30 meters, it will be one ninth.

Fuel consumption must be considered, both from an installation aspect and as a safety problem. Fuel will be used at the rate of 2 to 4 litres per hour is a 2.5-5 kW generator. There should be an ample reserve plan of at least 48 hours of operation. If the fuel is gasoline, safe storage can be a problem. Store gasoline in an area separate from the area housing the generator. Transfer only enough fuel at one time to fill the power unit’s tank. If you in an area where propane or natural gas are available, it might be worthwhile to consider these options as a fuel source. Some alternators are supplied with multiple-fuel capabilities (gasoline or natural gas/propane). A special carburetion system is required for natural gas or propane.

### 5.6.2 Generator maintenance

Proper maintenance is necessary to obtain rated output and long service life from a gasoline generator. A number of simple measures will prolong the life of the equipment and help maintain reliability.

The manufacturer’s manual should be the primary source of maintenance information and the final word on operating procedures and safety. The manual should be thoroughly covered by all persons who will operate and maintain the unit.

Fuel should be clean, fresh and of good quality. Many problems with gasoline generators are caused by fuel problems. Examples include dirt or water in the fuel land old, state fuel. Gasoline stored for any length of time changes as the more volatile components evaporate. This leaves excess amount of varnish-like substances that will clog carburetor passages. If the generator will be stored for a long period, it is good to run it until all of the fuel is burned. Faulty spark plugs are a common cause of ignition problems. Spare spark plugs should be kept with the unit, along with tools needed to charge them.

### 5.6.3 Generator earth ground

A proper ground for the generator is necessary for both safety reasons and to ensure proper operation of equipment powered from the unit. Most generators are supplied with a three-wire outlet. Some generators require that the frame be grounded also. An adequate pipe or rod should be driven into the ground near the generator and connected to the provided clamp or lug.

## 5.7 Solar power

A solar cell is a very simple semiconductor. Solar cells are, in fact, large-area semiconductor diodes. Simply explained, when the photons contained in light rays bombard the barrier of this semiconductor, hole electron pairs inside this P-N junction are freed, resulting in a forward bias of the junction, just as in phototransistors. This forward-biased junction can deliver current into a load. Because the exposed area of a solar cell can be quite large, the forward current proceed can be substantial. It follows that the output current of a photocell is directly proportional to the rate of photon bombardment, and thus to the exposed are of the photocell.

### 5.7.1 Types of solar cells

Originally, solar cells were made by cutting slides of grown silicon-crystal rod and subjecting them to doping and metallization process. These solar cells are called monocrystalline cells because each unit consists of only one crystal plate. The shape of these cells is the same as that of the silicon rod from which they are cut: round. A slice of this material with an area of 50 mm can be made into one photocell, but a slice of this size could also be used to produce upwards of a thousands transistors.

Most are polarity protected with a diode in series with the positive voltage line. When it gets dark, and the output voltage drops, the diode ensures that the panel won't start drawing current from the battery.

Solar panels typically deliver 15 to 18 volts at 600 to 1 500 mA in full sunlight. This will not damage a high-capacity battery, such as a deep-cycle unit. All you need do is hook up the battery, put the solar panel in full sunlight, and charge away. The battery will regulate the maximum voltage from the panel.

If you're going to use a solar panel to recharge a smaller battery, such as a Nickel-Cadmium (NiCd) battery or gelled-electrolyte lead-acid battery, you'll need to pay a bit more attention to detail. These types of batteries can suffer damage if charged too quickly, so a regulated charge is necessary.

A dc-ac converter, or inverter converts 12 volts to a square-wave ac output at approximately 60 Hz. Inverters are limited to about 100 to 400 watts, however, and some equipment (especially motors) cannot be powered by a square wave. An inverter will run a few light bulbs or a small soldering iron and can be a useful addition to a battery-operated station. Some newer ones use switching technology and are quite lightweight.

Polycrystalline cells are typically manufactures as rectangular blocks of seemingly randomly arranged silicon crystals from which the cell plates are cut. These cells are recognized by their shape, random pattern and colourful surface. Polycrystalline cells are less expensive to manufacture than monocrystalline cells. Reliable amorphous panels are available from many manufactures. These panels come in several forms: mounted on thin glass, framed, and even mounted on flexible substrates, such as steel.

### 5.7.2 Solar cell specifications

Depending on construction, each cell has an open-circuit, when exposed to the sun, of 0.6 to 0.8 V. This output voltage drops somewhat when current is drawn from a solar cell. This is called the cell's *load curve*. Open-circuit voltage is approximately 0.7, and output voltage at optimum load is normally 0.45. Output current is maximum with shorted output terminals. This maximum current is called the short-circuit current, and is dependent on the cell type and size. Because a cell's output current remains relatively constant under varying load conditions, it can be considered to be a constant-current sources.

As with batteries, solar cells may be operated in series to increase output voltage, and/or in parallel to increase output-current capability. Several manufactures supply arrays or panels with a number of cells in a series-parallel hook-up to be used, for example, for battery charging.

Techniques have been developed for the construction of amorphous cells whereby the cells are manufactured in series by cutting metal layers that have been vapour deposited on the amorphous silicon mass. This cutting is done with a laser. Cell width is such panels may be up to several feet, and the output-current capability of these relatively economical panels is excellent.

Solar-cell efficiency varies: Monocrystalline cell have efficiencies up to 15%; polycrystalline cells, 10 to 12%; amorphous cells, 6.5 to over 10%, depending on the manufactures process.

The output power of solar arrays or panels is specified in watts. Typically, the listed wattage is measured at full exposure to sunlight, at a nominal potential of 7 V for a 6-V system, 14 V for a 12-V system, and so on. You can calculate the maximum current that can be expected from a solar panel by dividing the specified output power by the panel voltage.

### 5.7.3 Storing solar energy

Because the sun does not shine 24 hours per day at many locations, some means of storing collected energy must be used. Batteries are commonly used for this purpose. Battery capacity is generally expressed in ampere-hours (Ah) or milliampere-hours (mAh). This rating is simply the product of discharge current and discharge time in hours. For example, a fully charge 500-mAh NiCd battery of good quality can deliver a discharge current of 100 mA for a period of 5 hours, or 200 mA for 2½ hours before recharging is required. Three types of rechargeable batteries are commonly used:

Nickel-cadmium (NiCd) batteries: NiCd are mostly used in relatively low energy applications such as hand-held transceivers, scanners, etc. The development of consumer electronics has contributed to the rapidly increasing availability (and somewhat-less-rapidly decreasing cost) of NiCd. Major advantage of NiCd: They are hermetically sealed, operate in any position and have a good service life (several hundred charge/discharge cycles), if they are properly maintained.

Gelled-electrolyte lead-acid batteries: These hermetically sealed batteries are available in capacities from below 1 Ah to more than 50 Ah. They are ideal for supplying energy to a radio station, but their cost (for capacities above 10 Ah) is rather high. For portable and low power stations, thought, this type of battery is difficult to beat. The cells can be operated in any position, but should be charged in an upright position. If properly maintained (no deep discharges-cell polarity reversal is possible under these conditions-and they stored in a fully charged state), gel cells last a long time (500 or so cycles).

Other lead-acid batteries: These are available in the standard automotive version, in the marine/recreational vehicle deep-discharge version and in the golf-cart variety. Differences: Automotive batteries usually fail (because of the thin plate and insulation material used in their construction), resulting in premature internal short circuits. Golf-cart and marine/recreational vehicle batteries have thicket plated with more rigid insulation between them, so these batteries can with stand deeper discharge without plate deformation and internal failure. Deep discharge batteries provide the best value in a ham station. Some of these batteries require attention (the electrolyte level must be maintained), and they last longest when kept charged. Because these batteries use a wet electrolyte (water), and most of them are not hermetically sealed, they must be kept upright.

### 5.7.4 A typical application

Here's a practical example of how to calculate power requirements for a solar-powered HF radio station. The first thing to do is define the power demand. Assume a 100-W transmitter. The assumption is that 100 W is the peak power consumption, and occurs only during CW operation and SSB voice peaks when a 13.6-V nominal supply (a fully charged battery) is provided.

The most reliable way to calculate realistic power requirements is to determine the power used over a longer period of time (say) a week or month. Because most of us have more or less recurring weekly habits, we'll take one week as the base period. (One can substitute numbers to adapt this calculation for the transmitter, under typical operating circumstances.) Assume that the transmitter is turned on five days. Of each two-hour period, 1½ hours is spent listening, and transmitting takes the remaining half hour.

Assume that the current consumption of the transceiver during receive is 2 A; during the 100-W peaks on transmit, current drawn is 20 A. The owner's manual for transmitter should give the maximum dc current drain. The average current consumption during SSB transmitting is only about 4 A. Therefore, we need a battery that can supply a peak current of at least 20 A and an average current of 4 A. Now calculate the total energy consumed in ampere hours over a one-week period:

Receiving: 2 A × 21/2 hours/day × 5 days = 25 Ah

Transmitting: 4 A × ½ hours/day × 5 days = 10 Ah

The total energy used per week is 25 + 10 = 35 Ah, or per day (average) is 35 ÷ 7 = 5 Ah. If we had a perfect system, all we would need to do is supply 35 Ah per week (5 Ah per day) to the battery. In practice, imperfections in battery construction cause some loss (self discharge), for which the charging system must compensate.

Next, calculate the minimum battery capacity required for this application. The system should be designed so that sufficient energy is available to run the equipment for two consecutive sunless days (this is rather arbitrary – some locations are worse than others in this regard). Because these sun less days could be days on which operation is necessary and because it is not good to discharge a battery to less than 50% of its capacity (for maximum battery life), this battery must have a capacity of lest 2 (days) × 5 Ah) ÷ 0.5 (for the 50% charge capacity left after 3 days without sunshine) = 20 Ah. If the location is likely to be without sunshine for as much as an entire week, the battery requirement would be 7 × 5 ÷ 0.5 = 70 Ah. Add about 10% to this number to compensate for self-discharge and other losses. (Typically, this means to procure the next-larger-size battery than the initial calculations indicated.)

To keep the battery sufficiently charged, firstly estimate the average number of hours of sunshine per year in the area. This information can be found in an almanac. As a guide, average annual sun exposure is approximately 3 200 hours per year in sunny regions, less elsewhere (down to about 1 920 hours per year in the far northern climates).

The solar panel should be mounted in a fixed position with an optimum angle relative to the Earth. In temperate zones, it could vary from about 30° in the summer up to about 60° in winter. Fixed-mounted solar panels cannot pick up maximum energy from the sun, for obvious reasons. In practice, they receive only 70% of the total sunlit time, which is anywhere between 1 340 and 2 240 hours per year (between 26 and 43 hours per week), depending on location.

The remaining system planning is easy. Earlier calculations showed that the solar cells must replenish 35 Ah per week, plus 10% to compensate for losses, or about 38.5 Ah or battery capacity. With solar energy available in the Sunbelt for 43 hours per week, the required charge current is 38.5 Ah ÷ 43 hours of sunshine = 0.9 A. In the northern part of the US, this is 38.5 Ah ÷ 25.8 hours = 1.5 A.

In the 12-V system described here, the solar panel operates, with a fully charged battery at about 13.6 V, plus the voltage drop of a series diode. With a fully loaded panel voltage of 14 V, a panel rated at 21 W (14 V × 1.5 A) is required in northern climes. In practice, this power can be obtain from good quality solar panel with a surface area as small as 65 $cm^2$. In sunny regions only 12.6 W (14 V × 0.9 A) of solar energy may be needed.

### 5.7.5 Some practical hints

Solar panels can be wired in series to provide increased output voltage. If the total output of the cell array exceeds 20 V, shunt diodes may be wired across each solar cells. Similarly, solar panels can be wired in parallel to yield increased output-current capability.

A series diode should be installed to prevent discharge of the battery into the panels. A Schottky diode can be used in applications where it is important to maintain the lowest voltage drop (and minimum loss of charge current).

Precaution should be taken to prevent battery overcharging and related gas discharge inside the battery. Several manufacturers supply simple charge regulators that serve this purpose by disconnecting the solar panel from the battery when the battery is fully charged. Some of these chargers allow charging to resume when the battery has reached a measurable level of discharge. Note: These values are only valid for lead-acid batteries; and entirely different set of charge criteria exists for NiCds.

### 5.7.6 Installing solar panels

If you plan to permanently install solar panels, consider mounting them at ground level on a simple wooden or metal frame, or mounting the m on the roof. Roof mounting is more appropriate if you have a roof that slopes at the correct angle (30-60°), and in the right direction (anywhere between a kittle east of south and southwest is acceptable). The easiest way to mount panels permanently is with a silicone adhesive. First, series diodes should be mounted on the back of each panel.

If the solar panels are going to be located in an area where they might be subjected to lightning, it is especially important to ground the metal frames of the solar panels. A separate wire should be used for this Earth ground, that is, not combined with one of the power leads.

## 6 Repeaters and trunked networks

### 6.1 Communication beyond line-of-sight through relays

At VHF and UHF, some type of relay system or network is required for reliable communications beyond line-of-sight.

### 6.2 Terrestrial repeater

A single repeater station in a favourable location (on a hill or atop a building) may be used to retransmit signals between points not having line-of-sight.

### 6.3 Trunked land mobile radio systems with a central controller

Trunking is the automatic sharing of a common pool of possibly 10 or more frequencies in a multiple repeater system. Trunking may be performed at a single site or multiple sites for wide-area coverage.

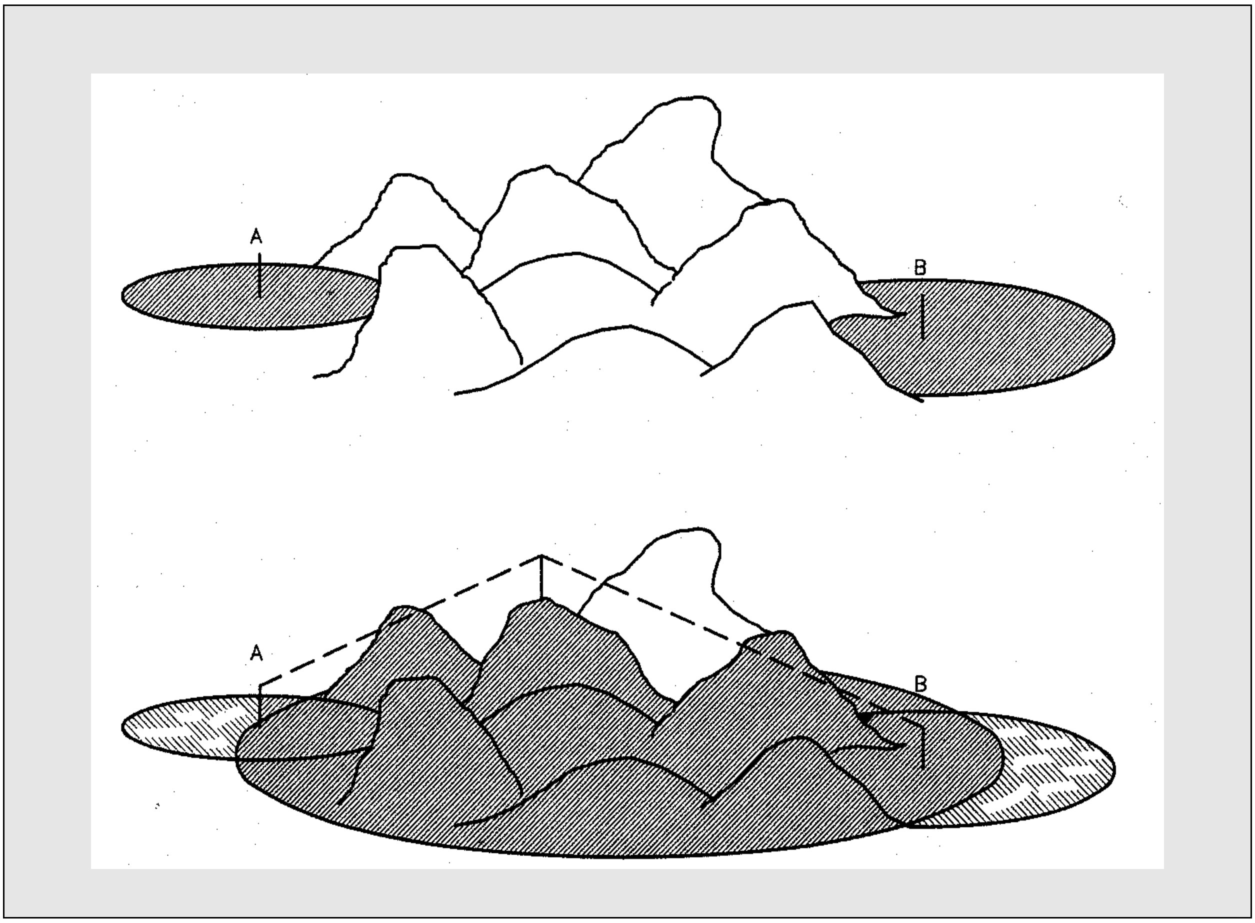
Trunked systems are based on the premise that each user transmits only a small percentage of time, thus it is possible to provide more overall capacity with a band than if each station or group of users had its own frequency. Linked repeaters provide better geographical coverage than a single repeater. A trunked network includes some redundancy, which can be beneficial in disaster situations. If prearranged, trunked systems may include an emergency feature for speech or data calls to specified mobile units.

A trunked system has at least one control channel that continuously transmits the computer-generated digital data needed to control vehicular and hand-held radios within range. Channels are assigned to a group only when there is traffic, making the channels free for other users. This is accomplished in a way that users hear only the traffic intended for their group and in a way that is completely transparent to the users. There are two types of trunking control systems, known as dedicated control channel and distributed control channel. In the dedicated control system, the control channel operates on one frequency. The distributed type uses any idle channel for control transmissions.

Mobile units are assigned identifiers and a home repeater. When a mobile unit is not transmitting, it always monitors the home repeater for data messages. When a mobile transmits, it identifies through a digital handshake protocol that takes only a fraction of a second.

Characteristics of digital land mobile systems are described in Report ITU-R M.2014. These systems include a trunked and non-trunked capability to permit direct mobile-to-mobile and group speech call facilities with user options to permit selective and secure calling.

**Figure 16 – In the top drawing, stations A and B are unable to interoperate because propagation is blocked by hills. In the bottom drawing, a repeater station is able to relay signals between stations A and B**




## 6.4 Trunked land mobile radio systems without a central controller

There are also trunking systems using multi-channel access techniques and appropriate protocols that do not require a central controller for the detection of an idle radio channel, known as "Personal Radio System" and "Digital Short Range Radio." Both systems work in the 900 MHz frequency band. They provide up to 80 channels and use a transmit power of up to 5 W. More detailed data of these systems are given in Recommendation ITU-R M.1032.

All radios in these systems are normally in the standby state on a control channel, ready to receive a selective calling signal. A calling station looks for and finds an idle traffic channel and stores its number in its memory. Then the calling station transmits on a control channel, a selective calling signal including at least its own identity, the identity of the called station and the number of the identified idle channel. The standby stations detecting their identity code in the received signal, move to the indicated traffic channel and enter into communication. At the end of the communication all units return again to the standby mode.

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# Appendices

## List of abbreviations

| | |
|---|---|
| A | Ampere |
| ac | Alternating current |
| A/D | Analogue-to-digital |
| Ah | Ampere-hour |
| AM | Amplitude modulation |
| AMTOR | AMateur Teleprinting Over Radio |
| ARES | Amateur Radio Emergency Service |
| ARQ | Automatic Repeat reQuest (error-control technique) |
| AX.25 | Amateur Packet Radio Link Layer Protocol |
| CANTO | Caribbean Association of National Telecommunications Operators |
| CDERA | Caribbean Disaster Emergency Response Agency |
| CEO | Chief Executive Officer |
| COW | Cell On Wheels |
| CP | Command Post |
| CQ | General call (to all radio stations) |
| CW | Carrier wave (Morse radiotelegraphy) |
| DAMA | Demand assigned multiple access |
| DDI | Direct dial in |

| | |
|---|---|
| DHA | Department of Humanitarian Affairs (now OCHA) |
| DMT | Disaster Management Team (UN) |
| DSC | Digital Selective Calling |
| DSL | Digital Subscriber Line |
| DSP | Digital Signal Processing |
| ELT | Emergency Location Transmitter |
| EOC | Emergency Operations Center |
| Fax | Facsimile |
| FD | Field Day (amateur) |
| FEC | Forward Error Control |
| FM | Frequency modulation |
| FSTV | Fast scan television |
| FTP | File Transfer Protocol |
| GLONASS | GLObal NAvigation Satellite System |
| GMDSS | Global Maritime Distress and Safety System |
| GMPCS | Global Mobile Personal Communications by Satellite |
| GPS | Global Positioning System |
| GSM | Global System for Mobile Communications |
| GSO | Geostationary orbit (satellite) |
| HAZMAT | Hazardous materials |
| HF | High frequencies (3-30 MHz) |
| HTML | Hypertext Markup Language |
| IAPSO | The Inter-Agency Procurement Services Office (UNDP) |
| IARU | International Amateur Radio Union (NGO) |
| IASC | Inter Agency Standing Committee (UN advisory body) |
| ICAO | International Civil Aeronautical Organisation |
| ICET | Intergovernmental Conference on Emergency Telecommunications |
| ICRC | International Committee of the Red Cross |
| IDNDR | International Decade for Natural Disaster Reduction |
| IF | Intermediate frequency |
| IFRC | International Federation of Red Cross and Red Crescent Societies |
| IMO | International Maritime Organization |
| IP | Internet Protocol |
| ISDN | Integrated Services Digital Network |

| | |
|---|---|
| ITA | International Telegraph Alphabet |
| ITU | International Telecommunication Union |
| ITU-D | Telecommunication Development Sector (ITU) |
| ITU-R | Radiocommunication Sector (ITU) |
| ITU-T | Telecommunication Standardization Sector (ITU) |
| kW | Kilowatt |
| LAN | Local area network |
| LEO | Low Earth orbit (satellite) |
| LES | Land earth station |
| MMSI | Maritime Mobile Service Indicator |
| NCS | Net Control Station |
| NGO | Non-governmental organisation |
| NiCd | Nickel cadmium (cell) |
| NiMH | Nickel metal hydride (cell) |
| NOTAM | Notice to Airmen |
| NVIS | Near-vertical-incidence-sky wave (propagation) |
| OCHA | Office for the Coordination of Humanitarian Affairs (UN) |
| OSOCC | On-side operations co-ordination centre |
| PACSAT | Packet (radio) satellite |
| PACTOR | PAcket Transmission Over Radio |
| PBBS | Packet bulletin board system |
| PBX | Private Branch Exchange |
| PCS | Personal Communications Systems |
| PLB | Personal locator beacon |
| PLMN | Public Land Mobile Network |
| POP | Post Office Protocol |
| POTS | Plain Old Telephone System |
| PSTN | Public Switched Telephone Network |
| RBS | Radio base station |
| RF | Radio frequency |
| RTTY | Radioteletype (narrow-band direct-printing radiotelegraph) |
| SDR | Swiss Disaster Relief Unit, Software Defined Radio |
| SELCAL | Selective Calling |
| SET | Simulated Emergency Test |

| | |
|---|---|
| SITOR | SImplex Teletype Over Radio (narrow-band direct-printing radiotelegraphy system used in the maritime mobile service) |
| SOLAS | Safety of Life at Sea |
| SRSA | Swedish Rescue Services Agency |
| SSB | Single sideband |
| SSTV | Slow scan television |
| SWR | Standing wave ratio |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TCO | Telecommunications Coordination Officer |
| TNC | Terminal Node Controller (packet radio) |
| UNHCR | United Nations High Commissioner for Refugees |
| UNDAC | United Nations Disaster Assessment and Coordination |
| UNDP | United Nations Development Programme |
| UNICEF | United Nations Children's Fund |
| UNOG | United Nations Organisation, Geneva |
| UHF | Ultra high frequencies (30-3 000 MHz) |
| USAT | Ultra small aperture terminal |
| USD | United States Dollar |
| V | Volt |
| VHF | Very high frequencies (30-300 MHz) |
| VITA | Volunteers in Technical Assistance |
| VSAT | Very Small Aperture Terminal |
| W | Watt |
| WAN | Wide area network |
| WAP | Wireless Access Protocol |
| WFP | World Food Programme |
| WHO | World Health Organization (UN) |
| WLL | Wireless local loop (generally replaced by fixed wireless access (FWA) |
| WTDC | World Telecommunication Development Conference |
| WGET | Working Group on Emergency Telecommunications |
| WRC | World Radiocommunication Conference |
| WWW | World Wide Web |

## Morse code signals[1]

1.1 The following are the written characters that may be used and the corresponding Morse code signals:

1.1.1 *Letters*

| | | |
|---|---|---|
| a .- | i .. | r .-. |
| b -… | j .--- | s … |
| c -.-. | k -.- | t - |
| d -.. | l .-.. | u ..- |
| e . | m -- | v …- |
| accented e ..-.. | n -. | w .-- |
| f ..-. | o --- | x -..- |
| g --. | p .--. | y -.-- |
| h …. | q --.- | z --.. |

1.1.2 *Figures*

| | |
|---|---|
| 1 .---- | 6 -…. |
| 2 ..--- | 7 --… |
| 3 …-- | 8 ---.. |
| 4 …- | 9 ----. |
| 5 ….. | 0 ----- |

1.1.3 *Punctuation marks and miscellaneous signs*

| | | |
|---|---|---|
| Full stop (period)………………………………………… | [.] | .-.-.- |
| Comma…………………………………………………… | [,] | --..-- |
| Colon or division sign……………………………………. | [:] | ---… |
| Question mark (note of interrogation or request for repetition of a transmission not understood)………………………. | [?] | ..--.. |
| Apostrophe………………………………………………. | [‘] | .----. |
| Hyphen or dash or subtraction sign……………………… | [-] | -….- |
| Fraction bar or division sign…………………………... | [/] | -..-. |
| Left-hand bracket (parenthesis)………………………….. | [(] | -.--. |
| Right-hand bracket (parenthesis)………………………… | [)] | -.--.- |
| Inverted commas (quotation marks)(before and after the words)………………………………………………… | [“”] | .-..-. |
| Double hyphen…………………………………………… | [=] | -…- |
| Understood………………………………………………. | | …-. |
| Error (eight dots)………………………………………… | | …….. |

1 From Recommendation ITU-T F.1 Division B.

| | | |
|---|---|---|
| Cross or addition sign…………………………………… | [+] | .-.-. |
| Invitation to transmit……………………………………. | | -.- |
| Wait ………………………………………………….. | | .-… |
| End of work…………………………………………… | | …-.- |
| Starting signal (to precede every transmission)………… | | -.-.-- |
| Multiplication sign………………………………………. | [x] | -..- |

## Phonetic alphabet code[2]

| Letter to be transmitted | Code word to be used | Spoken as |
|---|---|---|
| A | Alfa | AL FAH |
| B | Bravo | BRAH VOH |
| C | Charlie | CHAR LEE or SHAR LEE |
| D | Delta | DELL TAH |
| E | Echo | ECK OH |
| F | Foxtrot | FOKS TROT |
| G | Golf | GOLF |
| H | Hotel | HOH TELL |
| I | India | IN DEE AH |
| J | Juliett | JEW LEE ETT |
| K | Kilo | KEY LOH |
| L | Lima | LEE MAH |
| M | Mike | MIKE |
| N | November | NO VEM BER |
| O | Oscar | OSS CAH |
| P | Papa | PAH PAH |
| Q | Quebec | KEH BECK |
| R | Romeo | ROW ME OH |
| S | Sierra | SEE AIR RAH |
| T | Tango | TANG GO |
| U | Uniform | YOU NEE FORM or OO NEE FORM |
| V | Victor | VIK TAH |
| W | Whiskey | WISS KEY |
| X | X-ray | ECKS RAY |
| Y | Yankee | YANG KEY |
| Z | Zulu | ZOO LOO |

2 From Radio Regulations Appendix **S14**.

## Figure code

| Figure or mark to be transmitted | Spoken as[3] (ICAO) | Code word (Appendix S14) | Spoken as (Appendix S14) |
|---|---|---|---|
| 0 | ZE-RO | Nadazero | NAH-DAH-ZAY-ROH |
| 1 | WUN | Unaone | OO-NAH-WUN |
| 2 | TOO | Bissotwo | BEES-SOH-TOO |
| 3 | TREE | Terrathree | TAY-RAH-TREE |
| 4 | FOW er | Kartefour | KAR-TAY-FOWER |
| 5 | FIFE | Pantafive | PAN-TAH-FIVE |
| 6 | SIX | Soxisix | SOK-SEE-SIX |
| 7 | SEV en | Setteseven | SAY-TAY-SEVEN |
| 8 | AIT | Oktoeight | OK-TOH-AIT |
| 9 | NIN er | Novenine | NO-VAY-NINER |
| Decimal point | DAY SEE MAL | Decimal | DAY-SEE-MAL |
| Hundred | HUN dred | | |
| Thousand | TOU SAND | | |

## Q Code[4]

Certain Q code abbreviations may be given an affirmative or negative sense by sending, immediately following the abbreviation, the letter C or the letters NO (in radiotelephony spoken as: CHARLIE or NO).

The meanings assigned to Q code abbreviations may be amplified or completed by the addition of other appropriate groups, call signs, place names, figures, numbers, etc. It is optional to fill in the blanks shown in parentheses. Any data which are filled in where blanks appear shall be sent in the same order as shown in the text of the following tables.

Q code abbreviations are given the form of a question when followed by a question mark in radiotelegraphy and RQ (ROMEO QUEBEC) in radiotelephony. When an abbreviation is used as a question and is followed by additional or complementary information, the question mark (or RQ) should follow this information.

All times shall be given in Coordinated Universal Time (UTC) unless otherwise indicated in the question or reply.

3 From ICAO Radiotelephony Procedures.

4 From Recommendation ITU-R M.1172, *Miscellaneous abbreviations and signals to be used for radiocommunications in the maritime mobile service*, Radio Regulations (1998).

| Abbreviation | Question | Answer or Advice |
|---|---|---|
| QRA | What is the name of your vessel (*or* station)? | The name of my vessel (*or* station) is … |
| QRB | How far approximately are you from my station? | The approximate distance between our stations is … nautical miles (*or* kilometres). |
| QRG | Will you tell me my exact frequency (*or* that of … )? | Your exact frequency (*or* that of … ) is ... kHz (*or* MHz). |
| QRH | Does my frequency vary? | Your frequency varies. |
| QRI | How is the tone of my transmission? | The tone of your transmission is …<br>1. good<br>2. variable<br>3. bad. |
| QRK | What is the intelligibility of my signals (*or* those of … *(name and/or call sign)*)? | The intelligibility of your signals (*or* those of … *(name and/or call sign )*) is …<br>1. bad<br>2. poor<br>3. fair<br>4. good<br>5. excellent. |
| QRL | Are you busy? | I am busy (*or* I am busy with … *(name and/or call sign)*). Please do not interfere. |
| QRM | Is my transmission being interfered with? | Your transmission is being interfered with …<br>1. nil<br>2. slightly<br>3. moderately<br>4. severely<br>5. extremely. |
| QRZ | Who is calling me? | You are being called by … (on … kHz(*or* MHz)). |
| QSA | What is the strength of my signals (*or* those of … *(name and/or call sign)*)? | The strength of your signals (*or* those of … *(name and/or call sign)*) is …<br>1. scarcely perceptible<br>2. weak<br>3. fairly good<br>4. good<br>5. very good. |
| QSB | Are my signals fading? | Your signals are fading. |
| QSO | Can you communicate with … *(name and/or call sign)* direct (*or* by relay)? | I can communicate with … *(name and/or call sign)* direct (*or* by relay through … ). |
| QSP | Will you relay to … *(name and/or call sign)* free of charge? | I will relay to … *(name of and/or call sign)* free of charge. |

| Abbreviation | Question | Answer or Advice |
|---|---|---|
| QSV | Shall I send a series of Vs (*or* signs) for adjustment on this frequency (*or* on … kHz (or MHz))? | Send a series of Vs (*or* signs) for adjustment on this frequency (*or* on … kHz (or MHz)). |
| QSW | Will you send on this frequency (*or* on … kHz (*or* MHz)) (with emissions of class …)? | I am going to send on this frequency (*or* on … kHz (*or* MHz)) (with emissions of class …). |
| QSX | Will you listen to … *(name and/or call sign(s))* on … kHz (*or* MHz), or in the bands …/channels …? | I am listening to … *(name and/or call sign(s))* on … kHz (*or* MHz), or in the bands …/channels … |
| QSY | Shall I change to transmission on another frequency? | Change to transmission on another frequency (*or* on … kHz (*or* MHz)). |
| QSZ | Shall I send each word or group more than once? | Send each word or group twice (*or* … times). |
| QTA | Shall I cancel telegram (*or* message) number …? | Cancel telegram (*or* message) number … |
| QTC | How many telegrams have you to send? | I have … telegrams for you (*or* for … (*name and/or call signs*)). |
| QTH | What is your position in latitude and longitude *(or according to any other indication)*? | My position is … latitude, … longitude *(or according to any other indication).* |
| QTR | What is the correct time? | The correct time is … hours. |

## Miscellaneous Abbreviations and Signals[5]

| Abbreviation or signal | Definition |
|---|---|
| AA | All after … *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).* |
| AB | All before … *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).* |
| ADS | Address *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).* |
| AR, | End of transmission. |
| AS, | Waiting period. |
| BK | Signal used to interrupt a transmission in progress. |
| BN | All between … and … *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition).* |

5 From Recommendation ITU-R M.1172 Miscellaneous abbreviations and signals to be used for radiocommunications in the maritime mobile service, Radio Regulations (1998).

| Abbreviation or signal | Definition |
|---|---|
| BQ | A reply to an RQ. |
| BT, | Signal to mark the separation between different parts of the same transmission. |
| C | Yes *or* "The significance of the previous group should be read in the affirmative". |
| CFM | Confirm (*or* I confirm). |
| CL | I am closing my station. |
| COL | Collate (*or* I collate). |
| CORRECTION | Cancel my last word *or* group. The correct word *or* group follows *(used in radiotelephony, spoken as KOR-REK-SHUN)*. |
| CQ | General call to all stations. |
| CS | Call sign *(used to request a call sign)*. |
| DE | "From …" *(used to precede the name or other identification of the calling station)*. |
| K | Invitation to transmit. |
| KA, | Starting signal. |
| MIN | Minute (*or* Minutes). |
| NIL | I have nothing to send to you. |
| NO | No *(negative)*. |
| NW | Now. |
| OK | We agree (*or* It is correct). |
| PBL | Preamble *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)*. |
| PSE | Please. |
| R | Received. |
| REF | Reference to … (*or* Refer to …). |
| RPT | Repeat (*or* I repeat) (*or* Repeat …). |
| RQ | Indication of a request. |
| SIG | Signature *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)*. |
| SVC | Prefix indicating a service telegram. |
| SYS | Refer to your service telegram. |
| TFC | Traffic. |
| TU | Thank you. |
| TXT | Text *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)*. |
| VA, | End of work. |
| WA | Word after … *(used after a question mark in radiotelegraphy or after RQ in radiotelephony (in case of language difficulties) or after RPT, to request a repetition)*. |
| WD | Word(s) *or* Group(s). |
| WX | Weather report (*or* Weather report follows). |

*Note:* When used in radiotelegraphy, a bar over the letters composing a signal denotes that the letters are to be sent as one signal.

## Procedure words[6]

## Signal strength and readability

| Signal strength | |
|---|---|
| **Spoken** | **Meaning** |
| LOUD | Your signal is strong. |
| GOOD | Your signal is good. |
| WEAK | I can hear you but with difficulty. |
| VERY WEAK | I can hear you but with great difficulty |
| NOTHING HEARD | I cannot hear you at all. |

| Readability | |
|---|---|
| **Spoken** | **Meaning** |
| CLEAR | Excellent quality. |
| READABLE | Good quality, no difficulty in reading you. |
| DISTORTED | I have problems reading you. |
| WITH INTERFERENCE | I have problems reading you due to interference. |
| NOT READABLE | I can hear that you are transmitting but cannot read you at all. |

| Procedure word | Meaning |
|---|---|
| ACKNOWLEDGE | Confirm that you have received my message and will comply (WILCO) |
| AFFIRMATIVE | Yes/Correct |
| ALL AFTER | Everything that you transmitted after … |
| ALL BEFORE | Everything that you transmitted before … |
| BREAK | Indicates separation of text from rest of message. |
| BREAK BREAK | I wish to interrupt an ongoing exchange of transmissions in order to pass an urgent message. |
| CALL SIGN | The group that follows is a call sign. |
| CANCEL | Annul the previously transmitted message. |
| CORRECT | You are correct or what you have transmitted is correct. |
| CORRECTION | An error has been made in this transmission (or message indicated). The correct version is … |
| DISREGARD | Consider that transmission as not sent. |

6 Adapted from UNHCR Procedure for Radio Communication and supplemental sources.

| | |
|---|---|
| DO NOT ANSWER – OUT | Station(s) called are not to answer this call, acknowledge this message, or to transmit in connection with this transmission |
| FIGURES | Numerals or numbers will follow. |
| HOW DO YOU READ? | What is the readability of my signal? |
| I SAY AGAIN | I repeat for clarity or emphasis. |
| MESSAGE FOLLOWS | I have a formal message which should be recorded (e.g.) written down |
| MONITOR | Listen out on … (frequency). |
| NEGATIVE | No/Incorrect |
| OVER | This is the end of this transmission and a response is necessary. |
| OUT | This is the end of my transmission. No answer is required or expected. (OVER and OUT are never used together.) |
| READ BACK | Repeat this entire transmission back to me exactly as received. |
| RELAY (TO) | Transmit the following message to all addressees or to the address immediately following … |
| REPORT | Pass me the following information … |
| ROGER | I have received your last transmission. (Not an answer to a question.) |
| SAY AGAIN | Repeat your last transmission or repeat the portion indicated by “ALL AFTER.” |
| SILENCE | Cease all transmission immediately. Maintain until lifted. |
| SILENCE LIFTED | Transmissions may resume after SILENCE has been previously ordered. |
| SPEAK SLOWER | Your transmissions are too fast. Reduce speed. |
| UNKNOWN STATION | The identity of the station heard is unknown. |
| VERIFY | Verify the entire message (or portion indicated) with the originator and send corrected version. To be used only when the addressee has serious questions about the validity of the message. |
| WAIT | Wait for a few seconds. |
| WAIT OUT | Wait for a longer period. I will re-establish contact when I return on the air. |
| WILCO | I have received your message and will comply. (ROGER is implied but not stated.) |
| WORD AFTER | The word of the message to which I refer is that which follows … |
| WORD BEFORE | The word of the message to which I refer is that which precedes … |
| WORDS TWICE | Communication is difficult. Transmit each word or phrase twice. |
| WRONG | The last transmission was incorrect. The correct version is … |

# RECOMMENDATION ITU-R P.1144-1

## GUIDE TO THE APPLICATION OF THE PROPAGATION METHODS OF RADIOCOMMUNICATION STUDY GROUP 3

(1995-1999)

The ITU Radiocommunication Assembly,

*considering*

a) that there is a need to assist users of the ITU-R Recommendations P Series (developed by Radiocommunication Study Group 3),

*recommends*

**1** that the information contained in Table 1 be used for guidance on the application of the various propagation methods contained in the ITU-R Recommendations P Series (developed by Radiocommunication Study Group 3).

NOTE 1 – For each of the ITU-R Recommendations in Table 1, there are associated information columns to indicate:

*Application:* the service(s) or application for which the Recommendation is intended.

*Type:* the situation to which the Recommendation applies, such as point-to-point, point-to-area, line-of-sight, etc.

*Output:* the output parameter value produced by the method of the Recommendation, such as path loss.

*Frequency:* the applicable frequency range of the Recommendation.

*Distance:* the applicable distance range of the Recommendation.

% *time:* the applicable time percentage values or range of values of the Recommendation; % time is the percentage of time that the predicted signal is exceeded during an average year.

% *location:* the applicable per cent location range of the Recommendation; % location is the percentage of locations within, say, a square with 100 to 200 m sides that the predicted signal is exceeded.

*Terminal height*: the applicable terminal antenna height range of the Recommendation.

*Input data:* a list of parameters used by the method of the Recommendation; the list is ordered by the importance of the parameter and, in some instances, default values may be used.

The information, as shown in Table 1, is already provided in the Recommendations themselves; however, the table allows users to quickly scan the capabilities (and limitations) of the Recommendations without the requirement to search through the text.

## Table 1 – ITU-R radiowave propagation prediction methods

| Method | Application | Type | Output | Frequency | Distance | % time | % location | Terminal height | Input data |
|---|---|---|---|---|---|---|---|---|---|
| Rec. ITU-R P.368 | All services | Point-to-point | Field strength | 10 kHz to 30 MHz | 1 to 10 000 km | Not applicable | Not applicable | Ground-based | Frequency<br>Ground conductivity |
| Rec. ITU-R P.370 | Broadcasting | Point-to-area | Field strength | 30 MHz to 1 000 MHz | 10 to 1 000 km | 1, 5, 10, 50 | 1 to 99 | Tx: effective height from less than 0 m to greater than 1 200 m<br>Rx: 1.5 to 40 m | Distance<br>Tx antenna height<br>Frequency<br>Percentage time<br>Rx antenna height<br>Terrain clearance angle<br>Terrain irregularity<br>Percentage locations |
| Rec. ITU-R P.1147 | Broadcasting | Point-to-area | Sky-wave field strength | 0.15 to 1.7 MHz | 50 to 12 000 km | 10, 50 | Not applicable | Not applicable | Latitude and longitude of Tx<br>Latitude and longitude of Rx<br>Distance<br>Sunspot number<br>Tx power<br>Frequency |
| Rec. ITU-R P.452 | Services employing stations on the surface of the Earth; interference | Point-to-point | Path loss | 700 MHz to 30 GHz | Not specified but up to and beyond the radio horizon | 0.001 to 50<br>Average year and worst month | Not applicable | No limits specified | Path profile data<br>Frequency<br>Percentage time<br>Tx antenna height<br>Rx antenna height<br>Latitude and longitude of Tx<br>Latitude and longitude of Rx<br>Meteorological data |

**Table 1 – ITU-R radiowave propagation prediction methods** (*continued*)

| Method | Application | Type | Output | Frequency | Distance | % time | % location | Terminal height | Input data |
|---|---|---|---|---|---|---|---|---|---|
| Rec. ITU-R P.528 | Aeronautical mobile | Point-to-area | Path loss | 125 MHz to 15 GHz | 0 to 1 800 km (for aeronautical applications 0 km horizontal distance does not mean 0 km path length) | 5, 50, 95 | Not applicable | H1: 15 m to 20 km<br>H2: 1 to 20 km | Distance<br>Tx height<br>Frequency<br>Rx height<br>Percentage time |
| Rec. ITU-R P.1146 | Land mobile<br>Broadcasting | Point-to-area | Field strength | 1 to 3 GHz | 1 to 500 km | 1 to 99 | 1 to 99 | Tx ≥ 1 m<br>Rx: 1 to 30 m | Distance<br>Frequency<br>Tx antenna height<br>Rx antenna height<br>Percentage time<br>Percentage location<br>Terrain information |
| Rec. ITU-R P.529 | Land mobile | Point-to-area | Field strength | 30 MHz to 3 GHz (limited application above 1.5 GHz) | VHF: 10 to 600 km<br>UHF: 1 to 100 km | VHF: 1, 10, 50<br>UHF: 50 | Unspecified | Base: 20 m to 1 km<br>Mobile: 1 to 10 m | Distance<br>Base antenna height<br>Frequency<br>Mobile antenna height<br>Percentage time<br>Ground cover |
| Rec. ITU-R P.530 | Line-of-sight<br>Fixed links | Point-to-point<br>Line-of-sight | Path loss<br>Diversity improvement (clear air conditions)<br>XPD<br>Outage<br>Error performance | Approximately 150 MHz to 40 GHz | Up to 200 km if line-of-sight | All percentages of time in clear-air conditions;<br>1 to 0.001 in precipitation conditions (1) | Not applicable | High enough to ensure specified path clearance | Distance<br>Tx height<br>Frequency<br>Rx height<br>Percentage time<br>Path obstruction data<br>Climate data |

## Table 1 – ITU-R radiowave propagation prediction methods *(continued)*

| Method | Application | Type | Output | Frequency | Distance | % time | % location | Terminal height | Input data |
|---|---|---|---|---|---|---|---|---|---|
| Rec. ITU-R P.533 | Broadcasting<br>Fixed<br>Mobile | Point-to-point | Basic MUF<br>Sky-wave field strength<br>Available receiver power<br>Signal-to-noise ratio<br>LUF<br>Circuit reliability | 2 to 30 MHz | 0 to 40 000 km | All percentages | Not applicable | Not applicable | Latitude and longitude of Tx<br>Latitude and longitude of Rx<br>Sunspot number<br>Month<br>Time(s) of day<br>Frequencies<br>Tx power<br>Tx antenna type<br>Rx antenna type |
| Rec. ITU-R P.534 | Fixed<br>Mobile<br>Broadcasting | Point-to-point via sporadic E | Field strength | 30 to 100 MHz | 0 to 4 000 km | 0 to 50 | Not applicable | Not applicable | Distance<br>Frequency |
| Rec. ITU-R P.616 | Maritime mobile | As for Recommendation ITU-R P.370 | | | | | | | |
| Rec. ITU-R P.617 | Trans-horizon fixed links | Point-to-point | Path loss | > 30 MHz | 100 to 1 000 km | 20, 50, 90, 99, and 99.9 | Not applicable | No limits specified | Frequency<br>Tx antenna gain<br>Rx antenna gain<br>Path geometry |
| Rec. ITU-R P.618 | Fixed satellite | Point-to-point | Path loss.<br>Diversity gain and (for precipitation condition) XPD | 1 to 55 GHz | Any practical orbit height | 0.001-5 for attenuation;<br>0.001-1 for XPD | Not applicable | No limit | Meteorological data<br>Frequency<br>Elevation angle<br>Height of earth station<br>Separation and angle between earth station sites (for diversity gain)<br>Antenna diameter and efficiency (for scintillation)<br>Polarization angle (for XPD) |

## Table 1 – ITU-R radiowave propagation prediction methods *(end)*

| Method | Application | Type | Output | Frequency | Distance | % time | % location | Terminal height | Input data |
|---|---|---|---|---|---|---|---|---|---|
| Rec. ITU-R P.620 | Earth station frequency coordination | Coordination distance | Distance of which the required propagation loss is achieved | 100 MHz to 105 GHz | up to 1 200 km | 0.001 to 50 | Not applicable | No limits specified | Minimum basic transmission loss<br>Frequency<br>Percentage of time<br>Earth-station elevation angle |
| Rec. ITU-R P.680 | Maritime mobile satellite | Point-to-point | Sea-surface fading<br>Fade duration<br>Interference (adjacent satellite) | 0.8-8 GHz | Any practical orbit height | To 0.001% via Rice-Nakagami distribution<br>Limit of 0.01% for interference(1) | Not applicable | No limit | Frequency<br>Elevation angle<br>Maximum antenna boresight gain |
| Rec. ITU-R P.681 | Land mobile satellite | Point-to-point | Path fading<br>Fade duration<br>Non-fade duration | 0.8 to 20 GHz | Any practical orbit height | Not applicable<br>Percentage of distance travelled 1 to 80%(1) | Not applicable | No limit | Frequency<br>Elevation angle<br>Percentage of distance travelled<br>Approximate level of optical shadowing |
| Rec. ITU-R P.682 | Aeronautical mobile satellite | Point-to-point | Sea-surface fading | 1 to 2 GHz | Any practical orbit height | To 0.001% via Rice-Nakagami distribution(1) | Not applicable | No limit | Frequency<br>Elevation angle<br>Polarization<br>Maximum antenna boresight gain<br>Antenna height |
| Rec. ITU-R P.684 | Fixed | Point-to-point | Sky-wave field strength | 30 to 500 kHz | 0 to 40 000 km | 50 | Not applicable | Not applicable | Latitude and longitude of Tx<br>Latitude and longitude of Rx<br>Distance<br>Tx power<br>Frequency |
| Rec. ITU-R P.843 | Fixed<br>Mobile<br>Broadcasting | Point-to-point via meteor-burst | Received power<br>Burst rate | 30 to 100 MHz | 100 to 1 000 km | 0 to 5 | Not applicable | Not applicable | Frequency<br>Distance<br>Tx power<br>Antenna gains |

(1) Time percentage of outage; for service availability, subtract value from 100.