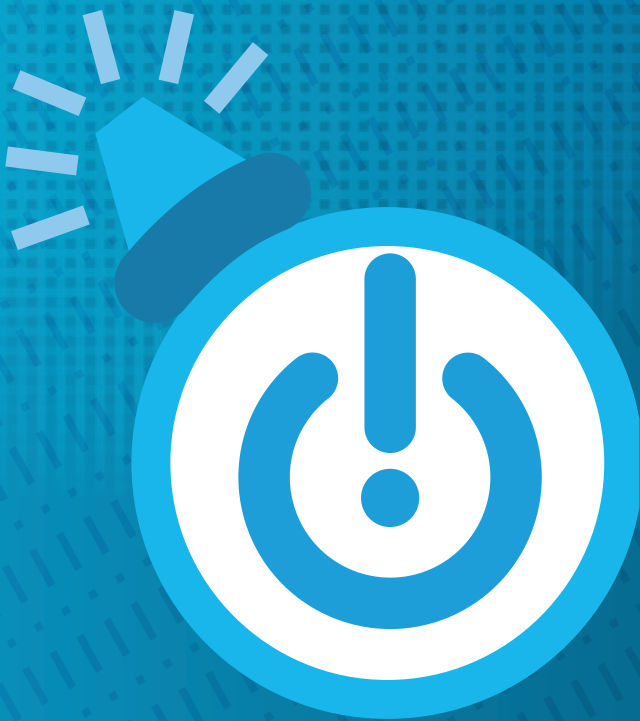
FINAL REPORT

ITU-D STUDY GROUP 2

QUESTION 22-1/2

UTILIZATION OF TELECOMMUNICATIONS/ICTs FOR DISASTER PREPAREDNESS, MITIGATION AND RESPONSE



5TH STUDY PERIOD 2010-2014

Telecommunication Development Sector

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QUESTION 22-1/2:

Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response

ITU-D Study Groups

In support of the knowledge sharing and capacity building agenda of the Telecommunication Development Bureau, ITU-D Study Groups support countries in achieving their development goals. By acting as a catalyst by creating, sharing and applying knowledge in ICTs to poverty reduction and economic and social development, ITU-D Study Groups contribute to stimulating the conditions for Member States to utilize knowledge for better achieving their development goals.

Knowledge Platform

Outputs agreed on in the ITU-D Study Groups and related reference material are used as input for the implementation of policies, strategies, projects and special initiatives in the 193 ITU Member States. These activities also serve to strengthen the shared knowledge base of the membership.

Information Exchange & Knowledge Sharing Hub

Sharing of topics of common interest is carried out through face-to-face meetings, e-Forum and remote participation in an atmosphere that encourages open debate and exchange of information.

Information Repository

Reports, Guidelines, Best Practices and Recommendations are developed based on input received for review by members of the Groups. Information is gathered through surveys, contributions and case studies and is made available for easy access by the membership using content management and web publication tools.

Study Group 2

Study Group 2 was entrusted by WTDC-10 with the study of nine Questions in the areas of information and communication infrastructure and technology development, emergency telecommunications and climate-change adaptation. The work focused on studying methods and approaches that are the most suitable and successful for service provision in planning, developing, implementing, operating, maintaining and sustaining telecommunication services which optimize their value to users. This work included specific emphasis on broadband networks, mobile radiocommunication and telecommunications/ICTs for rural and remote areas, the needs of developing countries in spectrum management, the use of ICTs in mitigating the impact of climate change on developing countries, telecommunications/ICTs for natural disaster mitigation and relief, conformance and interoperability testing and e-applications, with particular focus and emphasis on applications supported by telecommunications/ICTs. The work also looked at the implementation of information and communication technology, taking into account the results of the studies carried out by ITU-T and ITU-R, and the priorities of developing countries.

Study Group 2, together with ITU-R Study Group 1, also deals with Resolution 9 (Rev. WTDC-10) on the "Participation of countries, particularly developing countries, in spectrum management".

This report has been prepared by many experts from different administrations and companies. The mention of specific companies or products does not imply any endorsement or recommendation by ITU.

Table of Contents

Page

QUESTION 22-1/2
Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response

1 Introduction

ITU-D Q22-1/2 addresses Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response. This study question and its work plan were adopted by the World Telecom Development Conference (WTDC) in Hyderabad in 2010. This is the final report of ITU-D Q22-1/2, summarizing its activities and findings over the last four year study cycle, covering the period from 2010-2013.

This Q22-1/2 final report comprises information gathered under the tasks of the work plan including (1) examination of terrestrial, space-based and integrated telecom/ICTs to assist affected countries (2) country and sector member case studies and experiences on use of telecommunications/ICTs for disaster relief and response; (3) Examination of the role that Administrations and Sector Members and NGO's have in addressing disaster management and the effective use of telecommunications/ICTs; and (4) Best Practices/Guidelines in implementation of telecom/ICTs for disaster prediction, detection, monitoring, response and relief.

During the study cycle, Question 22-1/2 worked on three primary outputs which are annexed to the Final Report:

– Updated Handbook on Emergency Telecommunications

– Framework for Online Toolkit for Emergency Telecommunications

– Handbook on Telecommunication Outside Plant in Areas Frequently Exposed to Natural Disasters

These are available as Appendices to this report.

The Handbook on Emergency Telecommunications updates the 2nd edition (2005) in order to take account of new technologies and developments. The key concept behind this new version is that it will be made available in an online format. The online text will allow easy access to the subject matter for emergency managers and telecommunications/ICT professionals, while the on-line tool-kit will provide diverse information resources needed by those implementing emergency telecommunications. This format will furthermore allow Q22-1/2 and BDT to regularly update the content as technologies evolve and new information is obtained, including the ability to offer some multi-media content, content in various languages, and to provide links to information resources within the ITU (Resolutions, Recommendations, Reports) and to online resources of external and Member organizations in lieu of duplicating the efforts of other expert groups. Once finalized, the new online Handbook and toolkit will remain a 'living document' that can be updated on an ongoing basis as new information and case studies become available.

The development of the Handbook on Outside Plant was tasked to ITU-D Study Group 2 by WTDC-10 in Resolution 34 to help provide developing countries with guidance on how to develop ICT infrastructures that could withstand natural disasters. The Handbook on Outside Plant was developed by Q22-1/2 with close collaboration and expert contributions of the other Sectors of ITU, particularly ITU-T Study Group 15.

While progress has been made, emergency telecommunications continues to be a priority for many developing countries. Continued work by Q22-1/2 is needed to support countries in developing disaster communications management plans or frameworks, including consideration of ways in which to ensure a favorable regulatory environment to enable implementation of relevant technologies. Given the continuous evolution of technology and new lessons being learned by Administrations and Sector Members following any disaster event, the work of Q22-1/2 also should continue its examination of country case studies and technology examples. This work is expected to continue during the next study cycle.

2 Background

In light of recent natural and man-made disasters, great attention and effort has been directed towards the application of telecommunications/ICTs for the purpose of disaster preparedness, mitigation, response, and recovery.

The ITU's work in emergency telecommunications touches all three Sectors. Most recently, the ITU World Radiocommunication Conference (WRC-12) and Radiocommunication Assembly (RA-12) adopted new and revised Resolutions in support of continued work in the area of radiocommunications for disaster management. In 2012, ITU-T formed a Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR) that has been examining requirements and standards in support of disaster relief, mitigation and recovery. Working parties and study groups in both ITU-R and ITU-T have been advancing important studies, reports and recommendations on the use of telecommunications/ICTs for disaster preparedness, mitigation, response and recovery. Refer to **Annex 1** for a listing of relevant outputs of the ITU related to emergency telecommunications.

The ITU-Development Sector has been addressing the issue of disaster telecommunications for several years. During the 2006-2010 study period, ITU-D Study Group 2 published a **Report on Guidelines for using a content standard for alerts and notifications in disasters and emergency situations** (2008) regarding implementation of ITU-T Recommendation X.1303 on the Common Alerting Protocol (CAP), **Report on use of remote sensing for disaster prediction, detection and mitigation** (2008), and **Guidelines for Implementation of Satellite Telecommunications for Disaster Management in Developing Countries** (2009) – all which offer guidance for ITU Members on use of telecommunications technologies and services for disaster telecommunications management.

Developing countries continue to seek support in development of disaster communications management expertise. Within the ITU Development Sector, WTDC-10's adoption of a revised Resolution 34 (Rev. Hyderabad, 2010) on the role of telecommunications/information and communication technology in disaster preparedness, early warning, rescue, mitigation, relief and response, the updated Programme 5 on least developed countries, countries in special need, emergency telecommunications and climate-change adaptation, and a renewed Study Question 22-1/2 all reinforced the importance of the continued disaster telecommunications work of the Sector for the benefit of developing countries.

In the 2010-2014 study period, Question 22-1/2 continued to assist and guide developing countries in the following areas:

– continued examination of terrestrial, space-based and integrated telecommunications/ICTs to assist affected countries with utilizing relevant applications for disaster prediction, detection, monitoring response and relief, including consideration of Best Practices/Guidelines in implementation;

– provide information on the effective use of telecommunications/ICTs for disaster preparedness, response and recovery, including consideration of how existing systems and infrastructures can be integrated into disaster management frameworks, and how to help ensure redundancies and resiliency of networks and infrastructures from the effects of natural disasters;

– examination of the role that Administrations and Sector Members and non-governmental organizations have in addressing disaster management and the effective use of telecommunications/ICTs.

3 Telecommunications/ICTs in Support of Disaster Detection, Mitigation, and Response

Telecommunications and information communication technologies, services and applications have long been demonstrated as critical tools for coordinating response and relief efforts and allowing citizens to communicate often lifesaving information. During the study cycle, Question 22-1/2 examined telecommunications technologies and services that are being deployed for disaster relief and response purposes, including information on how those technologies and services were used in specific disaster events. ITU-D document numbers are cited so that readers may refer to the complete case study documentation on the ITU website.

3.1 Super Base Stations – People's Republic of China[1]

Following China's experiences with various types of natural disasters, China Mobile has deployed Super Base Stations (SBS) which were developed to withstand different types of natural disasters.

Following natural disasters in 2008, China had identified the importance of improving communications network survivability, particularly by building a number of network elements to withstand major natural disasters, avoid communication shut-downs and ensure key communication support when the next disaster should happen. With this background, China Mobile proposed the innovative concept of SBS, and carried out large-scale deployments, with good results.

Based on research about damage caused to communication facilities by natural disasters such as earthquakes, floods, typhoons and snow, the SBS, which was designed to keep working during such disasters, was developed by improving the base station's construction standards regarding communication equipment, power supply, transmission, building, and installation techniques. Compared to normal base stations, the SBS has more reasonable location, stronger backstop, its own oil machine for power supply and satellite transmission equipment.

The SBSs, which keep working through large disasters, are thus able to ensure mobile communication coverage in important regions, and are able to ensure government departments' communications. Through satellite transmission, SBSs, which are widely deployed across the country, offer an independent, high-reliability emergency communications network, in order to effectively enhance the disaster prevention and resilience ability of public communication networks. To resist different types of natural disasters, SBSs are divided into several types: anti-earthquake type, anti-flood type, anti-typhoon type, anti-snow type, comprehensive type, etc. Among these types, there are differences in transmission systems, power supplies, communications equipment reinforcement, building, site selection and so on.

China Mobile has been implementing SBSs in China, although other telecom companies have not yet deployed such base stations. According to the distribution of natural disasters the last 50 years, China Mobile filters out hazard-prone areas and then builds one SBS in every county. China Mobile has completed more than 1,500 SBSs, with a total investment of 1.09 billion yuan, of which the base station construction investment is about 0.78 billion and the ancillary equipment such as satellite communications devices investment is 0.31 billion. There are 2,800 counties in China, and SBSs have covered 54% counties. This innovative and large-scale deployment can be a useful reference for other countries to enhance disaster mitigation ability of communication networks.

[1] Document 2/104 (People's Republic of China) – China Deployed Super Base Stations on a Large Scale.

Importantly, on 14 April 2010, the Yushu earthquake with a magnitude of 7.1 paralyzed a large part of the local communication networks in China. However, one SBS in Yushu county kept working with aftershocks and electricity interruption, and provided communication services for earthquake relief workers, demonstrating the capabilities of the SBS.

3.2 Korea Government Radio Network[2]

The Korea Government Radio Network is a TRS- based nation-wide digital radio network, which is designed to support systematic on-scene emergency management in the case of disasters. This high-tech emergency network would replace currently separated-operating radio communications network of agencies and provide an interoperable common network.

When a disaster occurs, on-scene emergency workers from emergency management, rescue and assistant agencies use wireless devices. But they use different radio communications technologies including UHF, VHF, Analog TRS or Digital TRS. Even if they use the same mobile network, direct or indirect inter-communication is not possible because of different frequency band use. In response, Korea has aimed to significantly enhance disaster response capabilities with the KGRN project.

Compared to a conventional radio communication network, KGRN would have many advantages: excellent disaster response including nation-wide service areas, all call paging function, data communications, high security and no interference. Furthermore, the establishment of common network prevents overlapping investment and promotes frequency reuse.

After concluding that wireless communications breakdown between trains worsened the damage of 2003 Deagu subway fire, Korea developed the KGRN establishment plan and completed the establishment of the TETRA-based network by December 2007 in Seoul, Busan, Daegu, Incheon and Gyeonggi province.

The Korean government is exploring the technical, economic and policy feasibility of TETRA, WiBro and iDEN technologies for nation-wide KGRN construction. The Ministry of Public Administration and Security, in particular, is working to establish common ground with relevant organizations, closely review the feasibility of new technologies, and come up with a new Nation-wide KGRN plan in 2011 by securing radio frequencies and making a Standard Operating Procedure (SOP). The government had planned to conduct a feasibility study in 2012 and start to expand the existing KGRN across the country from 2013. An upgraded KGRN, the combination of the existing TETRA network with up-to-date functions of wireless communications network, is also expected to be built.

3.3 SaaS Type Application Services in Support of Earthquake Recovery[3]

Fujitsu Limited, Japan offered lessons learned about the response to the earthquake that occurred on 11 March 2011, including information on the importance of using cloud services and developments to help reduce vulnerability. The case study specifically relates to support provided to elderly victims and information gathered via questionnaires to better understand needs and conditions.

Database of assessment result

The assessment covered a variety of items for dietary life, hygienic conditions, facilities in the shelters, and understanding of elderly persons, persons requiring nursing care support, children and foreigners. As volunteers had intended to input data and calculate using Excel at first, a lot of efforts would have been required. To avoid such cumbersome work, Fujitsu provided "CRMate" – an SaaS type application service.

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[2] Document 2/INF/28 (Korea Information Society Development Institute (KISDI), Republic of Korea).

[3] Document RGQ22-1/2/16 – Contribution to the Tohoku Earthquake rebuilding by providing SaaS type application service (Fujitsu Limited, Japan).

The information collected by the assessment was stored into a database for matching the data and final results which could be recorded as an activity report. An important factor in the success was that volunteers themselves had a consciousness of keeping records and disclosing information to the public. In the assessment, the volunteers patrolled refuge areas in 22 municipalities over five weeks and discovered the needs of 505 items. 232 of 505 items were to be addressed by the Joint Project.

The effects of introduction of SaaS type service

Resolution of physical distance by utilizing the cloud: At first, the Joint Project dispatched each team to each area to collect information about needs. The data matching team was located at an office in Sendai to analyze the information collected from each area. However, the information collected depended upon the quality of each volunteer's data. Due to preparation of a unified format, the variation in the quality of reports could be eliminated. In addition, by using the cloud (SaaS), many volunteers were able to input data at the same time regardless of the physical distance. Furthermore, the team was able to see overall trends because the information could be observed in the database on sight. For example, if there was a high frequency of certain keywords, they could take actions to respond.

Improved efficiency through the high-speed data aggregation function: "Shunsaku" - a high-speed data aggregation function - also offered substantial effects for matching disaster victims who had special needs with professional Non-profit organizations (NPOs). It was time-consuming to aggregate the assessment information from each area every day; however, with "Shunsaku", they could increase work efficiency and reduce workload.

In the disaster area, as the recovery phase moved towards the reconstruction phase, the Joint Project started to hand over the assessment and matching roles in the refuges to local residents like NPOs and individuals. Also, disaster victims in the refuges were moving into temporary houses. The Joint Project continued to collect needs for people living in temporary housing who required special care and then connect those needs with professional assistance organizations. For resident NPOs who took over the roles from the Joint Project and could easily match the needs, Fujitsu also provided a "Social Network Service" that enabled them to exchange the accumulated information and share among other NPOs.

Lessons learned from this earthquake will remain very valuable, including understanding what tools, such as cloud based services, that can best help relieve and recovery workers aggregate and share critical data to support citizens' needs.

3.4 Emergency.lu[4]

In the event of a natural disaster or humanitarian emergency, there is an immediate challenge to coordinate the relief effort, at a time when connectivity is often interrupted or damaged or where responses are needed across wide spread physical areas and often challenging operating environments. Until there is a network, connectivity, and communications, effective aid cannot take place. Local infrastructure is often unable to provide any of these coordination and response prerequisites in the short time frame needed.

emergency.lu was formed as a public-private partnership to fill the need for a rapid response communication and coordination system with global capacity. The public-private partnership provides multi-layer support for the first hours and days following a large-scale disaster, and integrates into existing communications infrastructures used in humanitarian operations. A Luxembourg-initiated solution, emergency.lu leverages technology and expertise of a consortium of companies and organizations to support the efforts of existing humanitarian groups: SES TechCom, Hitec, and Luxembourg Air Rescue have joined in a public-private partnership with the Ministry of Foreign Affairs of Luxembourg.

[4] Document RGQ22-1/2/28 Emergency.lu Rapid Response Communications Solution (SES World Skies).

The two-phase solution combines satellite infrastructure and capacity, communication and coordination services, and satellite ground terminals. Within the first 12 to 20 hours after a disaster, emergency.lu provides equipment transportation and sets up instant broadband connectivity using a "Rapid Deployment Kit": an inflatable 2.4m antenna that can establish an up- and down-link in less than an hour, providing high speed internet connectivity for voice, data, and image transmission. This link is then used to create a local wireless network to which aid workers can connect at no cost. As a second phase, the team provides a "Regular Deployment Kit," using satellite ground terminals for long term service.

Since its inception, emergency.lu has established a partnership with the UN World Food Programme (WFP), the global lead of the Emergency Telecommunications Cluster (ETC), and will be collaborating with United Nations agencies to integrate fully into existing humanitarian response infrastructures. Specifically, WFP and emergency.lu are working together to incorporate emergency.lu with the Emergency Preparedness Integration Centre (EPIC), which is an inter-agency programme providing infrastructure, hardware and software solutions to meet demands for efficiency in communications and coordination in humanitarian work.

3.5 Let's Get Ready! Mobile Safety Project[5]

Qualcomm Wireless Reach™ and Sesame Workshop, the nonprofit educational organization behind Sesame Street, have collaborated on a 3G mobile safety project to help families with young children in China learn about emergency preparedness. The "Let's Get Ready!" project uses a 3G mobile website, mobile application and fun content featuring Sesame Street characters to create an interactive and engaging learning experience for children ages 3-6 and their caregivers. The project emphasizes the importance of knowing your name and address, having an emergency plan, packing an emergency kit, and learning about people and places within the community that can help in an emergency.

3.6 Applications of Integrated Emergency Communications Dispatching System (IECDS)[6]

In China, all kinds of unexpected events and disasters occur frequently, so a request has been put forward to all levels of government and departments to improve emergency communications dispatching abilities. At present, the means of government emergency communication dispatching is still relatively weak – only through simple methods of fixed telephone and fax etc., which has single function and low efficiency. Therefore, there is a need to establish a system with integrated dispatching functions to meet the needs of emergency management for government.

The Integrated Emergency Communications Dispatching System (IECDS) fully utilizes existing communication resources to accomplish the interoperation of the various types of communication systems and to realize calling and scheduling across different networks, such as public communication networks, special communication networks, satellite communication networks, computer networks, trunking communication systems, high frequency communication systems, and so on. Thus, the reliable guarantee of emergency telecommunications will be provided in disaster prevention and reduction with integrated functions of dispatching, multi-channel fax, digital recording etc.

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5 Document 2/340, Contribution to case study library: Let's Get Ready! Mobile Safety Project (Qualcomm Incorporated).

6 Document 2/318, Applications of Integrated Emergency Communications Dispatching System (IECDS) in disaster prevention and reduction (People's Republic of China).

3.7 Ad Hoc Network Technology[7]

Providing first aid in emergency situations is an important task. However, as a result of natural disasters, telecommunications infrastructure can be completely destroyed. Working subscriber terminals (smart phones or tablets), which should be able to be used to communicate with the outside world, become useless. Deploying base stations in areas where an emergency situation takes place is much more difficult due to time and material costs. The solution of such problems can be ad hoc networks. However, use of the standard tools of wireless ad hoc networks (MANET networks) is excluded because of the need of preparation of mobile terminals before the formation of the network.

A.S. Popov Odessa national academy of telecommunications (Ukraine) has proposed a mechanism that allows spontaneous creation of an ad hoc network without the need of pre-treatment of subscriber terminals. This is useful in situations where there is a variable number of subscriber terminals involved in the formation of the network, as well as a variable type and quantity of available information resources on the network. This mechanism can be effectively used for information exchange between the user terminals of people affected by natural disasters and terminals of people that organize help.

3.8 ITU-R Studies of Radiocommunication Systems

For the past several years, ITU-R working parties have been developing Recommendations and Reports related to use of various radiocommunication systems for disaster management, which serve as valuable resources for developing countries. Throughout the study cycle, Q22-1/2 had established liaison relationships with various ITU-R working parties who relayed information on the latest developments on radiocommunications for disaster relief and response. A more complete list of relevant ITU-R Reports and Recommendations are found in **Annex 1** as well as in the updated Handbook on Emergency Telecommunications.

Importantly, WRC-12 adopted several outcomes specifically to help advance disaster communications, including revisions to Resolution 644 on “Radiocommunication resources for early warning, disaster mitigation and relief operations” and Resolution 646 on “Public protection and disaster relief” to reflect developments since the previous WRC. Moreover, the WRC approved an agenda item 1.3 for WRC-15 to review and revise, as necessary, Resolution 646 to address developments in broadband PPDR.

ITU-R Study Group 4 – Satellite Services

WP4A, WP4B and WP4C have long been involved in studying the use of satellite services for disaster relief and response operations. In 2011, ITU-R Study Group 4 adopted a revised Report M.2149-1 “Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies,” and in 2012 it approved a revised Recommendation ITU-R M.1854-1 “Use of mobile satellite service (MSS) in disaster response and relief.” These mobile satellite services resources complement similar efforts related to the Fixed Satellite Service: Recommendation S.1001-2 “Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations” and the 2012 revised Report Rep. ITU-R S.2151-1 “Use and examples of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations.” Both resources highlight satellite technologies and services and their use for disaster relief operations. It is noted that in 2009 ITU-D Study Group 2 adopted an implementation guidelines related to these Recommendations and Reports in ‘Guidelines for Implementation of Satellite Telecommunications for Disaster Management in Developing Countries (2009)’.

[7] Document 2/292, Contribution to case study library: 5.x Ad hoc network technology (Odessa National Academy of Telecommunications n.a. A.S. Popov (Ukraine)).

ITU-R Study Group 5 – Terrestrial Services

In 2012, Study Group 5 adopted Question 209-4/5 “Use of the mobile, amateur and amateur satellite services in support of disaster radiocommunications” which is attributed to WP5A and WP5D. WP5A also is the lead on WRC-15 Agenda item 1.3 “to review and revise Resolution 646 (Rev.WRC-12) for broadband public protection and disaster relief (PPDR), in accordance with Resolution 648 (WRC-12)”. Through regular liaisons, Q22-1/2 was kept informed about developments in Study Group 5 related to emergency communications.

In 2011, Study Group 5 approved a revised Report ITU-R M.2085-1 “Role of the amateur and amateur-satellite services in support of disaster mitigation and relief”. In 2012, Study Group 5 approved a revised ITU-R M.2014-2, “Digital land mobile systems for dispatch traffic.” Most recently ITU-R Working Parties 5A and 5C have started the revision work of Recommendation ITU-R F.1105-2, “Fixed wireless systems for disaster mitigation and relief operations” in order to add systems of transportable mobile backhaul links, which are interoperable with a transportable mobile base station in a vehicle. Additionally, WP5A is working to revise Recommendation ITU-R M.2009, “Radio interface standards for use by public protection and disaster relief operations in some parts of the UHF band in accordance with Resolution 646 (Rev.WRC-12)” and Recommendation ITU-R M.2015, “Frequency arrangements for public protection and disaster relief radiocommunication systems in UHF bands in accordance with Resolution 646 (Rev.WRC-12)”. ITU-R Working Party 5D is also developing a Report on “The use of International Mobile Telecommunications (IMT) for broadband public protection and disaster relief (PPDR) Applications”.

ITU-R Study Group 6 – Broadcasting Services

ITU-R Study group 6 is the lead in broadcasting services, critical for providing information to the public after a disaster. ITU-R Study Group 6 adopted the Question ITU-R 118-1/6 “Broadcasting means for public warning, disaster mitigation and relief,” which is attributed to WP6A. WP6A is developing a report, “the importance of radio and television broadcasting for emergency information to the public” which considers the essential role of terrestrial radio and television broadcasting as a medium for rapid and reliable dissemination of accurate emergency information to the public in the event of natural disasters, man-made catastrophes, terrorist attacks, and similar events which endanger the safety of the public.

ITU-R Study Group 7 – Science Services

ITU-R Study Group 7 is the lead in areas related to meteorological services and the earth exploration satellite service and their application to disaster detection, early warning and relief. Recommendation ITU-R RS.1859, “Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies” offers an overview of how such systems may be used. It is noted that this Recommendation has a related ITU-D **Report on use of remote sensing for disaster prediction, detection and mitigation** (2008) which provides guidance for developing countries on use of remote sensing systems.

3.9 ITU-T Studies in Support of Emergency Telecommunications

ITU-T Study Group 15 on Networks, Technologies and Infrastructures for Transport, Access and Home is one of the lead groups in ITU-T in addressing issues related to outside plant. In 2012, ITU-T adopted a new Recommendation ITU-T L.92 “Disaster management for outside plant facilities” which gives an overview of the technical considerations for protecting outside plant facilities from natural disasters. The objective of this Recommendation is to share observations, knowledge, experiences and practices internationally, so that local engineering practices can be adopted to improve the disaster resistance performance of outside plant facilities. Additional information on Telecommunications Outside Plant can be found in the ITU-D Handbook on this topic. ITU-T Study Group 2 also has a lead role in emergency communications within the ITU-T.

In 2012, ITU-T formed a Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR) that has been examining requirements and standards in support of disaster relief, mitigation and recovery. One important study reviewed by the FG-DR&NRR relates to "Emergency Communication System for Persons with Hearing and Speaking Disabilities". This study is related to emergency call arrangement for fire and ambulance that can be used by persons with hearing and speaking disabilities in Japan.

A more complete list of relevant ITU-T Recommendations are found in **Annex 1** as well as in the updated Handbook on Emergency Telecommunications.

4 Country Case Studies

Understanding how countries and organizations plan for disasters and implement certain telecommunications technologies and services in response to specific disasters and then reviewing the data and lessons aggregated following those disasters are extremely useful to support disaster preparedness. The ITU-D Study Groups has established a Case Study Library as a means to accumulate such knowledge and experience and allow for that information to be shared with other members. The following are summaries of the case studies examined by Q22-1/2 in the 2010-2014 study cycle.

4.1 Japan[8]

Following the earthquake and tsunami in Japan in March 2011, the Ministry of Internal Affairs and Communications of Japan, and other entities in Japan, sought to aggregate data and lessons learned regarding how Japan's networks/telecommunications infrastructure and existing plans/processes responded to the disaster and to initiate steps to be better able to use ICTs to respond to future disasters. Japan's case study offered an excellent example of how a country can assess and learn from a disaster, and then develop an action plan to help prepare for the next disaster. A few points to highlight:

– Use of Satellite communications. In addition to existing MSS terminals already pre-positioned by public safety officials in Japan, ITU, through its partnership with private sector, helped deploy a total of 153 satellite communications equipment units to support the MIC's response including 78 Thuraya phones, 13 Iridium phones, and 62 Inmarsat BGAN terminals.

– Impact of power outages on communications networks in the aftermath of a disaster. For example, some mobile base stations were not damaged by the earthquake, but not operational due to fuel shortages.

– Early warning – Japan had already had an early warning system deployed for earthquakes which provides notices televised and mobile phone alerts.

– Emergency Municipal Radio Communication System: Connected national administrative organs, designated public corporations, prefectures, and municipalities through a radio communication system to transmit information among administrative institutions, and to spread information to local residents. 92% of local government offices had been connected prior to the earthquake.

– Information needs: Japan analyzed the various needs of citizens highlighting 'information' as one of the key trends on a daily basis.

– The influx of traffic caused congestion on mobile networks.

[8] Document 2/INF/77 + Annex

– Use of ICTs, online applications and social media – citizens and companies developed new and innovative information sharing tools to help locate family and friends, search evacuation center lists, get traffic/road condition updates, and obtain government notices.

– Japan formed a Study group to consider communications for a future large scale disaster. The group focused on issues related to (1) network congestion; (2) measures in the event that base stations or relay stations are damaged (2) future network infrastructure and disaster resiliency; and (4) the manner of future internet utilization considering internet usage during the earthquake.

4.2 Burkina Faso[9]

Burkina Faso was hit by major flooding in 2009, which helped strengthen the political will to put in place an effective national mechanism for disaster prevention and response. As a result, the government of Burkina Faso has taken steps through various decrees and regulations to establish its national civil protection policy and response plans across multiple agencies of the government.

Regulatory texts governing disaster management

In Burkina Faso, the regulatory framework governing the organization of disaster relief comprises the following texts:

– Decree issued by the Ministry for Civil Protection, adopting the national civil protection policy.

– Decree issued by the Ministry for Civil Protection, establishing a response plan. The text formally establishes a response plan ("ORSEC Plan"), with a geographical segmentation of the country.

– Joint Order issued by the Ministry for Civil Protection and the Ministry for Social Action, governing the organization of relief operations. Its provisions specify how relief operations are to be organized when a response plan is set in motion, with the participation of the competent and nominally designated public and private bodies.

– Joint Order issued by the Ministry for Civil Protection and the Ministry for Social Action, laying down the arrangements governing launch, implementation and lifting of the response plan.

Disaster intervention strategy

The aforementioned order governing the organization of relief operations stipulates that any relief intervention shall involve:

– a crisis committee, under the authority of the highest-ranking official of the administration in the area affected, which shall plan, coordinate and monitor the execution of actions to deal with the situation;

– two types of support units: a "liaison-transmission" unit and an "information-public relations" unit;

– five types of operational intervention groups in the field.

The "liaison-transmission" unit handles the implementation of the transmission systems necessary for conducting and coordinating operations. The resources placed at its disposal include both public transmission facilities and the facilities of telecommunications companies. The unit is coordinated by the Armed Forces, and it includes representatives of the telecommunications companies.

[9] Document 2/90

Once the response plan has been lifted, further operations in the realm of humanitarian aid, rehabilitation and rebuilding are handled by the "National Council for Emergency Relief and Rehabilitation" (CONASUR), a permanent structure with a permanent secretariat, whose primary mission is to act to mitigate the effects of disasters for the populations.

Telecommunications in the national disaster intervention planning mechanism

As stated above, the provision of communication facilities occupies an important place in the national disaster management strategy. It is for this reason that the "liaison-transmission" unit is directly attached to the command structure in charge of relief operations. When a national response plan is set in motion, the necessary resources (including telecommunication facilities) are mobilized by the Ministry for Civil Protection, which may have recourse to requisitioning if necessary.

Under the auspices of the Ministry for Social Action and CONASUR, a national multi-risk contingency plan for disaster preparedness and response is being developed. The adoption of this plan will ultimately provide a telecommunication component geared to disaster preparedness and response, comprising, *inter alia*: i) the deployment of terrestrial and satellite telecommunication equipment for risk alert and monitoring (natural risks, health risks, etc.); ii) sharing and public dissemination of information on risks; iii) implementation of reliable and flexible telecommunication resources for humanitarian relief and assistance.

Conclusion

Burkina Faso is equipped with a well-designed array of legal and institutional arrangements for disaster preparedness and response. The mechanism relies on the availability of the necessary communication facilities for each intervention phase. It would be beneficial to continue to add to and strengthen the telecommunication aspects of the mechanisms already in place, by taking on board standards, agreements and international best practices in the field of emergency telecommunications.

4.3 People's Republic of China[10]

Twelfth Emergency Communications Five Year Plan

At the end of 2011, China's Ministry of Industry and Information Technology officially released its twelfth emergency communication five-year plan. Based on an assessment of past emergency communications effectiveness, combined with predicted requirements for future situations, the plan puts forward the guiding ideology, basic principles, development goals and major tasks for emergency communication in the next five years.

Development goals

The plan puts forward five development goals.

1. Under an emergency situation, there should be an ability to submit information initially at or above the county-level administrative divisions. On-site command communication abilities should achieve 90% or above within 12 hours of receiving an incident report. Important sectors' communication reliability should significantly improve in the disaster-prone areas at or above the county-level.
2. Establish a unified command, well-coordinated emergency communication' command system, and build safe and reliable means of emergency communication command.
3. Have integrated orbital-aerial-terrestrial emergency communication security capabilities to improve public communication network survivability.

[10] Document 2/193

4. Improve the emergency deployment ability of security teams, so that each team can independently address 2 up concurrent events.

5. Build an advanced technical support system, and the industrial chain should take shape.

Major tasks

The plan put forward six major tasks.

1. Continue to improve emergency communication planning, and improve emergency communication structures and coordination mechanisms.

2. Enhance the emergency communication command abilities of governments and enterprises; enhance the abilities for remote consultation, information release, intelligent decision-making, and resource management; improve the command management system.

3. Build the integrated orbital-aerial-terrestrial emergency communication security network system; strengthen the public networks' survivability and emergency service capability; enhance the ability of the emergency satellite communication system; support to promote the development and construction of emergency communication systems such as aerial communication and digital trunking communication. Build more than 3,000 super base stations, covering 70% of the country's counties. Promote the pilot test about the public network's emergency priority, and gradually transform the existing public mobile communication network.

4. Construct the emergency communication reserve system, and build reserve centers in the central cities and remote areas. Strengthen emergency communication equipment, and promote equipment to develop to broadband, miniaturization, standardization.

5. Strengthen construction of emergency communication professional security teams; unify security teams' names and logo; explore the implementation of emergency communication security practitioners post qualification; strengthen education and training.

6. Enhance emergency communication technical support system; focus on building national emergency communication laboratories; strengthen infrastructure work such as planning and standards; study applications of new technologies in emergency communication; promote industry development of equipments' research, development and manufacture.

Conclusion

China is a vast country where natural disasters frequently occur, and therefore the government attaches great importance to emergency communications. The release of the twelfth five-year plan is to identify development goals and tasks for the next five years, to speed up the construction of emergency communications networks, and to protect people's lives and properties and contribute to social stability. Some of the goals and tasks in the plan are formulated under China's present situation, which should be a useful reference for developing countries.

4.4 Cote d'Ivoire[11]

Emergency telecommunications is a global priority today, particularly with the increased risk of natural disasters associated with climate change.

Background

Like other coastal countries, Cote d'Ivoire incurs risks of natural disasters due to climate change affiliated coastal erosion (storms, rainfall, and thermal shock), natural seismic movements (tsunamis and landslides cliffs) and finally storms, cyclones and hurricanes. Cote d'Ivoire is not yet a signatory to the Tampere Convention.

Overview

Emergency Communications Actors in Côte d'Ivoire

– National Office of Civil Protection (ONPC) is responsible for coordinating relief in collaboration with units including GSPM (Fire-fighters), National Police and CIAPOL (Ivorian Center for Antipollution).

– SAMU (emergency medical assistance). The SAMU collaborates on the management of land transport with the Mobile Emergency and Resuscitation (SMUR). The SAMU manages airborne and helicopter evacuations and provides contingency plans in case of disaster.

Interventions are supported via intense planning, including by:

– Les plans rouge or ORSEC (Organization Response Civil Security). It is a versatile system of crisis management by the rescue organization and identification of public and private resources that could be put in a disaster.

– POLLUMAR is an emergency plan to develop strategies effectively and quickly against any accidental pollution at sea, lagoon and coastal area.

Implementation of the single emergency number 112 in Côte d'Ivoire

The telecommunications regulator, ATCI, has initiated a project for the implementation of a single emergency number and an emergency center to unite calls to this number. This number called "Sécuriss 112" was due to be functional in 2012.

National Strategic Plan for Emergency Telecommunications

The Ministry of PTIC formed a national committee charged with developing a draft national strategic plan for emergency telecommunications by June 2012. This plan was due to include:

– defining the means of transmission and communication procedures for rapid deployment of these means;

– management of priority communications and proactive alerts;

– a clear definition of the roles of all stakeholders and national coordination mechanisms and international cooperation;

– the mechanisms by which various stakeholders use emergency telecommunications resources;

– the establishment of a permanent forum for consultation among stakeholders , including the Amateur Radio community, to regularly assess the operational action plans and provide recommendations for improvement;

[11] Document RGQ22-1/2/INF/3 Côte d'Ivoire – original is in French.

– geographic information systems to offer reliable information on population distributions, risk areas in order to predict damage;

– mechanisms for raising awareness and informing people about the existence and use of telecommunications facilities in case of emergency;

4.5 Cameroon[12]

Cameroon offered detailed information about actions taken to develop and implement Cameroon's National Emergency Telecommunication Plan.

The importance of electronic communications networks in the prevention and management of disasters is undeniable. It is important that in every society, measures are taken to ensure the normal functioning of these systems in normal times and in case of a disaster. These measures should cover facilities, infrastructure and organizations and constitute a plan for emergency telecommunications. The implementation of the Plan activities can only be effective through collaboration or cooperation between the various stakeholders.

Cameroon established a National Committee on Emergency Telecommunications (NETC) in which all emergency telecommunications stakeholders are represented. The NETC, which is part of the National Committee for Disaster Management, is a platform for multi-stakeholder consultation responsible for facilitating the implementation of Cameroon's National Plan for Emergency Telecommunications. As part of the plan development process, Cameroon reviewed recent disasters experienced in the country and their impact, as well as sought to develop understanding of the vulnerability, or resiliency, of telecommunications infrastructures to such disasters.

Organization of disaster management in Cameroon

Pursuant to Decree No. 2005/104 of 13/04/2005, the Ministry of Territorial Administration and Decentralization is responsible for the coordination of national and international actions related to disasters in conjunction with the administrative authorities and other authorities involved in the management of crisis situations.

Other stakeholders in disaster management are the National Police, the Ministry of Defence (National Gendarmerie Corps of Engineers and Firemen), the Ministry of Public Health (UAS), the Ministry of Scientific Research and Innovation (IRGM and INC) , the Cameroon Red Cross, the High Commissioner for refugees (UNHCR), the United Nations Fund for Children (UNICEF), the United Nations Development Programme (UNDP) , the World Health Organization Health Organization (WHO), the International Federation of Red Cross and Red Crossing (IFRC), etc.

Roles of Key Organizations in Telecommunications Disaster Management

Ministry of Posts and Telecommunications

The Ministry of Posts and Telecommunications is responsible for the development and implementation of government policy on telecommunications and information technology and communication. In this regard, several measures have been taken to ensure the provision of emergency telecommunications in Cameroon, including the creation of an emergency telecommunications pilot project.

[12] Document RGQ22-1/2/INF/4 Cameroon

Agency for Regulation of Telecommunications (ART)

ART is responsible for regulation, control and monitoring of the activities of operators in the telecommunications sector. As such, it processes applications for licenses and prepares related decisions. In this context, measures have been taken to integrate specifications for operators and operators of electronic communications networks for provision of emergency telecommunications services, including:

– Free emergency calls (17, 117, 18, 118...)
– Obligations for operators to have plans for prevention and mitigation of disasters
– Allocation of licenses to radio amateurs
– Regular organization of seminars and conferences to raise awareness and ensure better service provision of emergency telecommunications.

ART also supports the coast guard station/port in Douala to help ensure safety of life at sea.

Operators of electronic communications networks

Electronic communications operators are called to collaborate with the Government to ensure business continuity in case of a disaster.

Media

Generally, information about a disaster is broadcast on Television and Radio. Several media organizations are involved to support disaster planning.

Strategic Action Plan

Cameroon identified the following strategic priorities for its National Plan of Emergency Telecommunications:

1. Building networks and services for public safety and emergency services
2. Building networks and services for disaster mitigation – focus on public networks
3. Promoting the development of the telecommunications sector to facilitate the mitigation of disasters, and promote disaster relief and rehabilitation after the disaster.

In addition to the technical aspects of infrastructure and telecommunications systems necessary for the prevention and management of disasters, Cameroon considered organizational and legal aspects. In order to facilitate the provision of telecommunication resources for the prevention and management of disasters, officials are also taking into account the legal and regulatory framework for telecommunications and other provisions to facilitate the use of telecom resources. Such considerations include the need for training and human capacity building to support preparedness and response efforts.

The National Emergency Telecommunications Plan outlines the responsibilities of the different stakeholders in emergency telecommunications in the implementation of the plan. Cameroon stressed the importance of collaboration and coordination between stakeholders, underscoring the importance of the National Committee on Emergency Telecommunications (NETC) in the implementation of this Plan.

4.6 Democratic Republic of Congo[13]

Democratic Republic of Congo is at risk to both natural and man-made disasters: eruptions from the Nyamulangira and Nyiragongo volcanoes and displacement due to wars and insecurity caused by armed groups, epidemics, accidents due to derailment trains and aircraft crashes, fires, shipwrecks etc.

Key DRC stakeholders in disaster management are:

– Ministry of Interior and National Security (Police, Immigration, Fire Service)
– Ministry of Health
– Ministry of Social Affairs
– Ministry of PTT
– Humanitarian Associations

There are two basic types of telecommunications networks used for disaster management in the DRC.

– Public networks: fixed telephone networks, mobile networks, network radio and television broadcasting and internet networks.
– Private networks: telecommunications owned by private companies, parastatals, non-governmental organizations, etc.

These networks offer channels of communication for people affected by disasters to inform their relatives, allow for public alerting for populations and to help plan relief operations. Telecommunications networks also allow rescue teams to coordinate relief operations after a response is triggered.

Use of telecommunications for disaster management

Although there are no specific regulations that govern the use of telecommunications in disaster, the Government has established provisions in operator licenses that require operators to facilitate relief teams to use their networks during a disaster. In addition, Regulations guide the holding, circulation and use of satellite terminals such as Iridium, Thuraya, and Inmarsat, including by State officials and non-governmental organizations and humanitarian associations.

These telecommunications resources have helped disaster management improve significantly; for example, by helping mitigate the effects of an Ebola outbreak in 2008 compared to a similar outbreak in 1995, and addressing the needs of displaced populations due to wars in DRC. Additionally, to protect the population of the city of Goma against volcanic eruptions, a public warning system has been installed.

Next steps and recommendations

Although there has been progress in the management of disasters in Democratic Republic of Congo, there is still a need for more work, including ensuring that institutions in charge of disaster management have access to communications systems, as part of the obligation for operators.

It is recommended that the Government consider:

– Establishing a formal structure for disaster management that would include the Ministries of PTT, Ministry of Social Affairs , Ministry of Interior and Decentralization, the national police;
– Developing a national emergency telecommunications plan to integrate into the national emergency plan;

[13] Document 2/17

– Seeking technical and financial assistance from the ITU to develop a national plan for emergency communications and the establishment of a system of disaster management including the reorganization of satellite telecommunications services for emergencies;

– Equipping disaster management officials with efficient means of communication;

– Training people capable of conducting intervention operations on sites likely affected by disasters.

5 Collaboration with Other Organizations

Disaster response is necessarily a multi-stakeholder effort. Public, private, citizen and NGO communities each have roles in aiding disaster response and recovery. In the event of a disaster, each of these must come together to exchange information and facilitate the response. To take advantage of the expertise and experiences of these entities, Q22-1/2 exchanged information with and about as wide a group as possible.

5.1 Satellite Imagery and Space-based Information

Q22-1/2 received information about[14] and included participation by several organizations affiliated with satellite imagery and space-based information for disaster management. Two UN programs (UNOSAT and UN-SPIDER) and one regional initiative (SERVIR) on earth observations each contribute to disaster monitoring and earth observation. The World Meteorological Organization (WMO) is the UN lead organization for questions relating to the weather, climate and water, also offered guidance and expertise related to its role in disaster management.

Global Initiatives

– UNOSAT: The United Nations Institute for Training and Research (UNITAR) was established in 1965 as an autonomoeus body within the United Nations system with the purpose of enhancing the effectiveness of the UN through appropriate training and research. UNOSAT, the UNITAR Operational Satellite Applications Programme, was implemented in 2003 with the support of the European Organization for Nuclear Research (CERN) and in partnership with UN and non-UN organisations. UNOSAT is “a technology-intensive programme delivering imagery analysis and satellite solutions to relief and development organisations within and outside the UN system to help make a difference in critical areas such as humanitarian relief, human security, strategic territorial and development planning. UNOSAT develops applied research solutions keeping in sight the needs of the beneficiaries at the end of the process.” Although UNOSAT specializes in analyzing data from a vast array of sources and forwarding the results to its clients, it also provides hands-on training with Geographic Information System (GIS) equipment.

– UN-SPIDER: UN-SPIDER - the United Nations Platform for Space-based Information for Disaster Management and Emergency Response - (2/INF/67 + Annex) works with UN Member States to serve as a facilitator for access to spaced-based remote sensing data that is collected by existing missions worldwide, such as NASA and ESA, for use in the full cycle of disaster management. Through its work it has been able to establish general guidance in using satellite communications in disaster mitigation and response. UN General Assembly Resolution 61/110 of 14 December 2006 established the "United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) as a United Nations programme, with the following mission: "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle". The UN-SPIDER operates under the United Nations Office of Outer Space Affairs (UNOOSA)

[14] Document RGQ22-1/2/04

and under its broad mandate includes providing training and building the capacity within nations to handle disasters.

Regional Initiatives

– SERVIR: "a Regional Visualization and Monitoring System that integrates earth observations (e.g. satellite imagery) and forecast models together with in situ data and knowledge for timely decision- making to benefit society." SERVIR offers training and has opened regional operational centers in Latin America and Caribbean, East Africa and South Asia.

Additionally, the Space Frequency Coordination Group has an online database which contains sources of satellite-based remote sensing data helpful in times of natural and manmade disasters.

5.2 Regional Organizations and Activities

– Due to the importance of regional coordination in the area of disaster preparation and response Q22-1/2 sought to increase collaboration with regional organizations such as CITEL who also are undertaking work on emergency communications.

– The ITU BDT hosted several workshops in association with regional groups and organizations to review national and regional plans for disaster communications preparedness and response. Overviews of these workshops were provided to Q22-1/2 throughout the study period. Full reports and presentation copies can be found on the ITU website:

– **ITU Asia-Pacific Regional Multi-stakeholder Forum on Emergency Telecommunications (Ulaanbaatar, Mongolia on 8-11 July 2011)** – The Forum was organized by the ITU and hosted by the Mongolian Information, Communication Technology and Post Authority (ICTPA) with the support of the Government of Australia through the Department of Broadband, Communications and the Digital Economy, the Communications Regulatory Commission (CRC) of Mongolia, and the Economic and Social Commission for Asia and the Pacific (ESCAP).

– **Workshop on the use of Telecommunications in Disaster Prevention and Mitigation (Mar del Plata, Argentina, 29 August 2011)** – This workshop, hosted with the Inter American Telecommunication Commission (CITEL), focused on the role of information and Communication Technologies before, during, and after disasters strike. A summary of conclusions may be found in Document SG2/INF69.

– **Workshop on Saving Lives Through Emergency Telecommunications (Abidjan, Ivory Coast, 16-18 November 2011)** – The Forum organized by the Agence des Télécommunications de Côte d'Ivoire (ATCI) brought together country representatives, international organizations, civil protection agencies, academic institutions and other stakeholders involved in disaster management to discuss the role of telecommunications/ICTs in saving lives. The meeting considered important topics such as (1) the Role of telecommunications/ICTs in disaster management; (2) Tampere Convention, the importance of its ratification; (3) National Emergency Telecommunications Plans and (4) Country experiences in disaster management.

– **Emergency communications, Climate Change, e-waste and Cyber Security Awareness Workshop (Lusaka, Zambia, 28 November-2 December 2011)** – This workshop was organized with the Zambia ICT Authority (ZICTA). The Forum brought together country representatives, international organizations, civil protection and enforcement agencies, academic institutions and other stakeholders involved in disaster management and the environment to discuss the role of telecommunications/ICTs in improving lives.

- **Workshop on the Use of Telecommunication/ICTs for Disaster Management: Saving Lives (Harare, Zimbabwe, 28-30 November 2011)** – This workshop was organized by the ITU jointly with the Zimbabwean telecommunications regulator, PORTRAZ, to bring together the main stakeholders active in the dissemination of ICTs and their use for disaster mitigation, and to serve as a forum in which they can map out concrete strategies and adopt practical measures aimed at giving ICTs a central role to play in disaster prevention and management, i.e. early warning, preparedness, relief and response.
- **Symposium on Disaster Communications (Sendai, Japan – 16 March 2012)** – The Ministry of Internal Affairs and Communications (MIC) Japan and ITU jointly organized a Symposium on Disaster Communications on 16 March 2012 in Sendai City focused on the application of telecommunications/ICTs for the purpose of disaster preparedness, mitigation, response and recovery. Lessons were drawn by Japan following the Great East Japan Earthquake of 11 March, 2011. The one-day symposium was followed by an excursion around Sendai City, Miyagi Prefecture, one of the affected areas.
- **ITU Multi-stakeholder Forum on Emergency Telecommunications (Bogota, Colombia, 24-26 July 2012)** – ITU and the Ministry of Information and Communication Technologies of Colombia brought together national agencies involved in disaster risk reduction and disaster management, private telecommunication entities, United Nations Agencies, and Non-Governmental Organizations to discuss and exchange views on how to assist countries and communities to mitigate, respond and cope with natural disasters.
- **Multi-stakeholder Forum on the Role of Telecommunications/ICT in Disaster Management and Climate Change (Guatemala City, Guatemala, 5-7 November 2012)** –ITU and the Superintendencia de Telecomunicaciones of Guatemala brought together national agencies involved in disaster risk reduction and disaster management, private telecommunication entities, United Nations Agencies, and Non-Governmental Organizations to share knowledge, discuss and exchange views on how to assist countries and communities to mitigate, respond and cope with natural disasters.

5.3 Other United Nations Entities

- The UN has set up an International Strategy for Disaster Reduction (ISDR). The ISDR is a system of partnerships involving a number of different stakeholders: governments, intergovernmental and non-governmental organizations, international financial institutions, scientific and technical bodies, specialized networks, civil society and the private sector. All have a role in assisting nations and communities in reducing disaster risks.
- The overall aim of the ISDR is to provide support in order to reduce disaster risks and create a “culture of prevention” among populations. The UN thus wants to involve every individual in efforts to reduce loss of life, socio-economic devastation and environmental damage.
- The 10-year Hyogo Framework for Action came out of the World Conference held in Kobe, Hyogo, Japan, from 18 to 22 January 2005. This Framework identifies five priorities for action.
  - Priority Action 1: Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
  - Priority Action 2: Identify, assess and monitor disaster risks and enhance early warning.
  - Priority Action 3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
  - Priority Action 4: Reduce the underlying risk factors.
  - Priority Action 5: Strengthen disaster preparedness for effective response at all levels.

– The Office for the Coordination of Humanitarian Affairs (OCHA) is a department of the United Nations secretariat set up in December 1991 under General Assembly Resolution 46/182. It is intended to improve the UN's response to emergencies arising from complex natural disasters.

5.4 The Tampere Convention

This international treaty was adopted on 18 June 1998 by 75 countries during the first International Conference on Emergency Telecommunications in Tampere, Finland in 1998. It calls on States to provide prompt telecommunication assistance to mitigate the impact of a disaster, and to ensure the installation and operation of reliable telecommunication resources. Regulatory obstacles to the use of telecommunication services to mitigate the impact of disasters are removed, including those relating to the allocation of frequencies and payment for using them, and protection is provided for technicians using equipment. The treaty sets out procedures for requesting and providing telecommunication assistance and recognizes the right of a State Party to direct, coordinate and supervise telecommunication assistance provided within its territory under the terms of this treaty.

The Convention came into force on 8 January 2005 (ratified by 30 countries). As of 9 November 2012, there were 60 signatories and 46 States had ratified.

5.5 Europe

In 1996 the European Commission's Humanitarian Aid and Civil Protection Directorate General (ECHO) launched a specific disaster preparation programme called "DIPECHO" (Disaster Preparedness ECHO) with the aim of mitigating the impact of natural risks.

The programme involves close collaboration between European humanitarian aid organizations, UN agencies, local NGOs and the national authorities of the countries affected. It covers seven regions vulnerable to natural disaster: Caribbean, Central America, South America, Central Asia, South Asia, South-East Asia and South-East Africa, and South-West Indian Ocean.

DIPECHO thus provides help to developing countries, and its projects are accordingly simple and inexpensive. For example, training, awareness raising, local early warning systems, and planning and forecasting tools.

The European Commission has also initiated a process to combat risks of natural disasters caused or exacerbated by climate change.

This is a long-term process focusing on disaster prevention and risk reduction in the European Union and in developing countries. It plays a part in implementing the Hyogo Action Framework, which envisages action at the community level: establishing an inventory of information and current best practices, drawing up guidelines on mapping dangers and risks, creating links between stakeholders and policies throughout the disaster management cycle through improved training and awareness raising, improved access to early warning systems and better targeting of community funding. The Hyogo Action Framework also advocates improved policy dialogue with the developing countries, making risk reduction an integral part of EU policies and actions, and the drawing up of regional plans.

5.6 International Amateur Radio Union (IARU)

The amateur and amateur-satellite service is an important component to emergency response communications. In 1979, ITU adopted Resolution 640 acknowledging the existence of extensive radio amateur networks that can be used in emergencies and calls on administrations to make use of amateur service resources. Using the terms of No. 25.9A of the Radio Regulations, it encourages administrations to take the necessary steps to allow amateur stations to prepare for and meet communication needs in support of disaster relief. In addition, Recommendation ITU-R M.1042 gives guidance for administrations on the development of amateur and amateur-satellite networks supporting preparedness and radiocommunication during disaster and relief operations.

5.7 Non-Governmental Organizations (NGOs)

Télécoms sans Frontières (TSF), founded in 1998, is a non-governmental humanitarian organization specializing in emergency telecommunications. Based in France (http://www.tsfi.org/) TSF operates in more than 50 countries and is considered a "First Emergency Telecom Responder" within the UN Emergency Telecom Cluster (ETC) and a partner of ITU. Teams of TSF telecom and IT specialists can 1) intervene anywhere in the world within 24 hours to provide emergency telecom services; 2) use ICT tools and their own experience to work with partners on designing more effective long-term development missions; and 3) participate in training initiatives and other capacity building missions in order to optimize the emergency response of governments and local NGOs by making more effective use of ICTs in an emergency. The key priority for TSF is to reach affected areas and set up telecommunication services as quickly as possible, within the first few hours of the emergency. The initial phase of the emergency response is crucial because it is then that lives are still saved.

6 Accessibility

Special consideration should be given for persons with disabilities in disaster situations, particularly in preparedness. In one survey during the East Japan Earthquake in 2011, it was found that death rates for persons with disabilities were twice as high as for persons without disabilities. The work and contributions of ITU Joint Coordination Activity on Accessibility and Human Factors (JCA-AHF) have helped provide information regarding the importance of compiling and distributing best practices for accessibility in the context of emergency communications.[15] Additional work in the area of disaster communications and accessibility is planned for the next ITU-D study cycle and for incorporation into the Draft Handbook on Emergency Telecommunications.

The ITU-T Focus Group on Audio-Visual Accessibility (FG-AVA) also contributed to the work of Q22-1/2 in providing information on strategies and tools particularly related to media accessibility including broadcasting and telecommunincations:[16]

– As an emergency develops, TV and radio broadcasting play key roles to get emergency alerts to people living in the areas affected by the disaster. Broadcasting emergency alerts should be made accessible to persons with visual and/or auditory impairments in the form of speech, captions/subtitles and sign language offered in parallel.

– Early-warning systems which alert citizens about the occurrence of a disaster and provide information about the steps they should take (including evacuation) save lives in the affected areas. Information such as tsunami alerts and evacuation announcements should use multi-modal means of distribution so that persons with hearing or visual impairments can access them. For example, a tsunami siren should be accompanied by blinking flashlight.

– An important life-saving tool in emergency communications are mobile reception terminals for early-warning systems. An example of such early warning systems is the Emergency Warning Broadcasting System (EWBS) in Japan, which allowed alerts to be distributed to mobile TV receivers, allowing passengers on a train to receive the notification.

– Persons with disabilities also require special consideration when evacuated or staying in public facilities. These considerations include communication tools such as text communication or sign language interpretation services, as well as audio information for the visually impaired.

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[15] Document 2/327, Proposed modifications on ITU-D Handbook on Emergency Telecommunications (G3ICT).

[16] Document 2/244, LSOR from FG AVA to ITU-D on draft third edition of "Handbook on Emergency Telecommunications" (FG AVA).

– Information about services should be distributed in a *lingua franca* or in multiple languages both in written and spoken form, in order to assist foreigners. For example, use of subtitles in multiple languages through an integrated broadcast system, or provision of an automatic translation technology such as a smart-phone application could alleviate difficulties faced by those who do not speak the local language.

7 Conclusions and Best Practice Guidelines

Reviewing these technical and country case studies helps illuminate several key themes that may support countries in their own planning and preparedness efforts. The following section provides conclusions and best practices to help capture these key themes.

Telecommunications are integral to disaster management. Governments, private sector entities, NGO's, and citizens use telecommunications/ICTs to collect and communicate information to save lives and coordinate relief efforts. Main considerations related to technologies: (1) more work is needed to help make telecommunications infrastructures more resilient to disasters, especially in developing countries whose infrastructure is less able to withstand a catastrophic disaster; (2) diversity of transmissions (redundancy) and network capacity considerations for spikes immediately following a disaster are important to ensure communications are not interrupted; (3) new bandwidth intensive tools (such as mapping tools, cloud services, smart phones) are changing emergency communications; (4) disaster plans should be continuously reviewed and updated to take account of technology changes or as uses of existing telecommunications are better understood.

Enabling environment. In addition to infrastructure and technology considerations, having an enabling regulatory and policy framework in place is important to ensure that emergency telecommunications response is not hindered.

Information management. One of the most important assets in managing any disaster response or recovery effort is 'information'. Preparedness efforts should consider information requirements for various organizations involved in relief and response efforts, as well as citizens, to ensure that telecommunications infrastructures and systems are available following a disaster.

Enabling citizens to communicate. Whereas public safety officials or relief organizations may have been a focus for disaster communications planning and response, telecommunications are empowering citizens to more actively engage in disaster response, such as through increased use of social media and mobile phones. Emergency telecommunications planning should take account of the ways in which citizens communicate information.

Disaster response is multi-stakeholder. Governments cannot – and do not – address disasters alone. These entities must also coordinate in advance of disasters. In the event of a disaster, government, private sector, NGOs, citizens must all come together to exchange information and facilitate a response. Because of this, many countries engage with a vast array of stakeholders when developing a national disaster telecommunications plan, including through development of Public Private Partnerships and other mechanisms to support collaboration.

Preparedness. Preparedness. Preparedness. Advance planning is critical for saving lives. This cuts across all of disaster response, with telecommunications/ICTs playing a role in almost every area of disaster response management. Pre-positioning ICT equipment, planning for excess capacity requirements, training of personnel, or educating citizens on alerting tools and escape plans – all are best implemented when planned in advance.

Public warning and alerts. Public warning and alert systems are critical to help save lives. Depending on the types of disasters and the communication needs of populations, a variety of systems have been implemented. Collaboration with weather mapping organizations that monitor conditions via satellite can help support public warning systems.

Satellite connectivity is essential: Satellite links play an important role in allowing for a layer of redundancy to support disaster response and relief efforts, given their geographic coverage, independence from terrestrial infrastructures, and mobile and transportable applications that can be used anywhere. In many cases terrestrial network failures means that satellite services are the only available means of communications in the immediate aftermath of a disaster. Many countries include satellite communications systems as a component of national disaster telecommunications plans.

National and regional emergency communications plans and systems: Having a national plan in place can greatly support response efforts in the case of a disaster. Because disasters can affect multiple countries, regional collaboration also is critical.

Power supply: Many projects have demonstrated the importance of independent power sources, including use of solar powered batteries, to ensure continued functionality in the event of a failure of the power grid.

Role of the media: The media plays an important role in delivering important information to citizens, and the additional presence of news organizations following a disaster results in a surge in activity. Broadcasting services often are also considered part of an emergency communications plans.

Interoperability: Communication exchanges between divergent systems and organizations is an essential component. Systems should examine ways to facilitate interoperability as needed.

Integration of disaster communications in national telecommunications development plans: In some cases, countries have taken disaster communications into account when developing overall plans for telecommunications development. Developing countries, when considering how to ensure connectivity for citizens, particularly in remote and rural areas, should take emergency communications and disaster risk reduction aspects into account. In many cases equipment and services, as with the case of mobile telemedicine units, can serve dual purposes of providing essential every-day services to citizens and serving critical needs during a disaster.

Accessibility: When developing disaster communications plans, particular emphasis should be paid to access for persons with disabilities and special needs who often require additional considerations to ensure that any warnings or alerts are received in a timely manner, and in an accessible format, and that specialized needs are addressed during relief and recovery periods. Such considerations include mobility, sight, hearing, intellectual capacity, cognitive characteristics, mental health, linguistic and cultural background, etc., and how these may impact a person or groups' ability to receive critical information and respond in an emergency scenario.

Conclusion

Each of these best practices has been identified through the period of study of Question 22-1/2 in 2010-2014. As more disasters take place, and new technologies and applications are developed, additional information should be made available to help countries develop and update their national disaster telecommunications plans. It is expected that work will continue in the next cycle to allow the ITU-D Study Groups to continue benefitting from the most recent innovations in disaster telecommunications.

Annexes

Annex 1: **List of ITU Resolutions, Recommendations and Reports Related to Emergency Telecommunications**

Annex 2: **List of Contributions**

Appendices

Appendix 1: **Updated Handbook on Emergency Telecommunications.**

Appendix 2: **Framework for the Online Toolkit on Emergency Telecommunications**

Appendix 3: **Handbook on Telecommunication Outside Plant in Areas Frequently Exposed to Natural Disasters**

Annex 1: List of ITU Resolutions, Recommendations and Reports Related to Emergency Telecommunications

Plenipotentiary Resolution 36 (Guadalajara, 2010), Telecommunications/Information and communication technology in the service of humanitarian assistance.

Plenipotentiary Resolution 136 (Rev. Guadalajara, 2010), The use of telecommunications/information and communication technologies for monitoring and management in emergency and disaster situation for early warning, prediction, mitigation and relief.

WTDC Resolution 34 (Rev. Hyderabad, 2010), The role of telecommunications/information and communication technology in early warning and mitigation of disasters and humanitarian assistance.

Hyderabad Action Plan Programme 5 (Hyderabad, 2010).

Resolution 646 (Rev. WRC-12), Public protection and disaster relief.

Resolution 647 (Rev. WRC-12), Spectrum management guidelines for emergency and disaster relief radiocommunications.

Resolution 644 (Rev. WRC-07), Radiocommunication resources for early warning, disaster mitigation and relief operations.

Resolution 673 (WRC-07), Radiocommunications use for Earth observation applications.

Resolution ITU-R 53-1, The use of radiocommunications in disaster response and relief.

Resolution ITU-R 55-1, ITU studies of disaster prediction, detection, management and relief.

Recommendation ITU-R S.1001-2, Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations.

Recommendation ITU-R BO.1774-1, Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief.

Recommendation ITU-R M.1854-1, Use of the mobile-satellite service for disaster response and relief

Recommendation ITU-R M.1042-3, Disaster communications in the amateur and amateur-satellite services.

Recommendation ITU-R M.1043-2, Use of the amateur and amateur-satellite services in the developing countries.

Recommendation ITU-R M.1044-2, Frequency sharing criteria in the amateur and amateur-satellite services.

Recommendation ITU-R F.1105-2, Fixed wireless systems for disaster mitigation and relief operations.

Recommendation ITU-R M.2009, Radio interface standards for use by public protection and disaster relief operations in some parts of the UHF band in accordance with Resolution 646 (Rev.WRC-12).

Recommendation ITU-R M.2015, Frequency arrangements for public protection and disaster relief radiocommunication systems in UHF bands in accordance with Resolution 646 (Rev.WRC-12).

Recommendation ITU-R M.1637, Global cross-border circulation of radio communication equipment in emergency and disaster relief situations.

Recommendation: ITU R RS.1859, Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies.

Recommendation ITU-T X.1303, Common alerting protocol (CAP1.1).

Recommendation ITU-T L.92, Disaster management for outside plant facilities.

Recommendation ITU-T E.106, International Emergency Preference Scheme for disaster relief operations (IEPS).

Recommendation ITU-T E.107, Emergency Telecommunications Service (ETS) and Interconnection Framework for National Implementations of ETS.

Recommendation ITU-T E.161.1, Guidelines to select Emergency Number for public telecommunications networks.

Recommendation ITU-T Y.1271, Framework(s) on network requirements and capabilities to support emergency communications over evolving circuit-switched and packet-switched networks.

Recommendation ITU-T Y.2205, Next Generation Networks - Emergency Telecommunications - Technical Considerations.

Handbooks and Reports

Report ITU-R S.2151-1, Use and examples of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief.

Report ITU-R M.2149-1, Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies

Report ITU-R M.2085-1, Role of the amateur and amateur-satellite services in support of disaster mitigation and relief.

Report ITU-R M.2014-2, Digital land mobile systems for dispatch traffic.

Report ITU-R M.2085, Role of the amateur and amateur-satellite services in support of disaster mitigation and relief.

Report ITU-R M.2033, Radio communication objectives and requirements for Public Protection and Disaster Relief (PPDR).

ITU-D Report on use of remote sensing for disaster prediction, detection and mitigation (2008).

ITU-D Report on Guidelines for using a content standard for alerts and notifications in disasters and emergency situations (2008).

ITU-D Report on Guidelines for Implementation of Satellite Telecommunications for Disaster Management in Developing Countries (2009).

Compendium on ITU’s Work on Emergency Telecommunications (2007).

Best Practice on Emergency Telecommunications (2007).

Annex 2: List of Contributions

Number	Date	Source	Title
[327]	8/30/2013	Chairman, ITU-T JCA-AHF	Liaison Statement from JCA-AHF to ITU-D SG2- Draft revisions for ITU-D Handbook on Emergency Telecommunications
[318]	8/13/2013	China (People's Republic of)	Applications of Integrated Emergency Communications Dispatching System (IECDS) in disaster prevention and reduction
[310]	7/22/2013	ITU-T Study Group 15	Liaison statement from ITU-T SG15 to ITU-D SG2 Q22-1/2 on the Approval of new Recommendation ITU-T L.92 (reply to ITU-D-SG2-LS07/2/47-E)
[292]	7/8/2013	Odessa National Academy of Telecommunications n.a. A.S. Popov	Emergency telecommunications networks
[275]	8/26/2013	Rapporteur for Question 22-1/2	Draft Report on Q22-1/2 (Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response)
[266]	6/4/2013	ITU-R Study Groups - Working Parties 5A and 5C	Liaison Statement from ITU-R WP5A and WP5C to ITU-D SG 2 Question 22-1/2 on Fixed wireless systems for disaster mitigation and relief operations
[260]	9/18/2013	Rapporteur for Question 22-1/2	Report of the Rapporteur Group Meeting on Question 22-1/2, Geneva, 3 April 2013
[251]	5/20/2013	ITU-R Disaster Relief Liaison Rapporteur	Report from the ITU-R Disaster Relief Liaison Rapporteur
[250]	5/9/2013	ITU-R Study Groups - Working Party 6A	Liaison Statement from ITU-R WP6A to ITU-D SG2 Question 22-1/2 on the importance of radio and television broadcasting for emergency information to the public
[248]	5/6/2013	ITU-T JCA-AHF	Liaison Statement from ITU-T JCA-AHF to ITU-D Q20-1/1, Q14-3/2 and Q22-1/2 on contact person for JCA-AH
[247]	4/17/2013	ITU-T Focus Group on DR & NRR	Liaison Statement from ITU-T FG on DR&NRR about the Status report of the Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR)
[246]	4/15/2013	ITU-T Focus Group on AVA	Liaison Statement from ITU-T FG-AVA to ITU-D Q22-1/2 on LSOR from FG AVA to ITU-D on draft third edition of "Handbook on Emergency Telecommunications"
[238]	9/19/2012	Chairman, ITU-T Focus Group on DR & NRR	Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR)
[224]	9/11/2012	Rapporteur for Question 22-1/2	Status Report for the ITU Handbook on "Telecommunication outside plant in areas frequently exposed to natural disasters"
[223]	9/11/2012	Rapporteur for Question 22-1/2	Three draft chapters for the ITU Handbook "Telecommunication outside plants in areas frequently exposed to natural disasters"
[193]	9/3/2012	China (People's Republic of)	China Released the Twelfth Emergency Communication Five-year Plan
[181]	8/25/2012	International Amateur Radio Union (IARU)	Revision of BDT Handbook on Emergency Telecommunications - Progress Report and Request for Guidance Regarding Publication Format

Number	Date	Source	Title
[170]	8/3/2012	BDT Focal Point for Question 22-1/2	New developments pertaining to the work on ITU in the area of emergency telecommunications
[152]	6/4/2012	ITU-R Study Groups - Working Party 4B	Liaison Statement to ITU-D Study Group 2 Question 22-1/2 - ITU Handbook for Telecommunications Outside Plants in Areas Frequently exposed to Natural Disasters
[149]	6/15/2012	ITU-R Study Groups	ITU-R Study Group 5 Questions to be brought to the attention of ITU-D SG 2
[137]	5/7/2012	Rapporteur and Vice-Rapporteur for Question 22-1/2	Report of the Rapporteur Group Meeting for Question 22-1/2 Sendai, Thursday 15 March 2012
[133]	9/16/2011	ITU-D Study Group 2, Question 22-1/2	Liaison Statement to ITU-T Study Group 15 and ITU-R Study Group 5
[125]	9/10/2011	Viet Nam (Socialist Republic of)	Contents needed for Outside Plant Guidelines/Handbook
[104]	8/19/2011	China (People's Republic of)	China Deployed Super Base Station on a Large Scale
[91]	7/14/2011	BDT Focal Point for Question 22-1/2	Information on activities related to emergency telecommunications undertaken within the framework of HAP Programme 5
[90]	7/14/2011	Burkina Faso	Use of telecommunications for disaster preparedness and response: Case of Burkina Faso
[68]	6/20/2011	Rapporteur for Question 22-1/2	Report of the Rapporteur's Group Meeting on Question 22-1/2, Geneva, 23 (P.M.) - 24 (A.M.) March 2011
[49]	9/15/2010	ITU-D Study Group 2, Question 22-1/2	Liaison statement to ITU-R Study Group 7 on continued work of ITU-D Study Group 2 Question 22-1/2: Utilization of Telecommunications/ICT for Disaster Preparedness, Mitigation and Response
[48]	9/15/2010	ITU-D Study Group 2, Question 22-1/2	Reply Liaison statement to ITU-R Study Group 4 Working Party 4C on Preliminary Draft Revisions to Recommendation ITU-R M.1854 and Report ITU-R M.2149
[47]	9/15/2010	ITU-D Study Group 2, Question 22-1/2	Liaison statement to ITU-T Study Group 15 in Reply to the Liaison statement of the 25 August 2010 on Planned ITU-D Handbook on Telecommunications outside Plant in Areas Frequently Exposed to Natural Disasters.
[37]	9/8/2010	Acting Rapporteur for Question 22-1/2	Draft Work programme for Question 22-1/2
[36]	9/2/2010	BDT Focal Point for Question 22-1/2	Background Document on Question 22-1/2
[17]	8/26/2010	Democratic Republic of the Congo	Importance des télécommunications pour la gestion des catastrophes
[15]	8/27/2010	ITU-T Study Group 13	Liaison response on defining a physical architecture of NGN specifying various network elements
[14]	8/27/2010	ITU-R Study Groups - Working Party 4B	Liaison Statement to ITU-D Study Group 2 Q.22/2 for Action and ITU-R Working Parties 4A and 5A for Information Draft List Of Terminology On Emergency Telecommunications

Number	Date	Source	Title
[12]	8/27/2010	ITU-R Study Group - Working Party 4C	Liaison Statement to ITU-D Study Group 2 (Question 22/2) and the BDT Programme 5 Preliminary draft revisions of Recommendation ITU-R M.1854 "Use of mobile satellite service (MSS) in disaster response and relief" and of Report ITU-R M.2149 "Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies"
[11]	8/27/2010	ITU-T Study Group 15	Liaison Statement Proposal for a revised draft of new ITU-T Recommendation "Technical considerations on protecting outside plant facilities from natural disasters" L.tcosp
[9]	8/27/2010	ITU-T Study Group 15	Response on standards related to telecommunications outside plant for disaster preparation and mitigation
[8]	8/24/2010	ITU-T Study Group 5	Reply to ITU-D SG2 on Standards related to Telecommunication Outside Plant for Disaster Preparation and Mitigation
[34]	4/25/2013	ITU-D Study Group Question 22-1/2	Liaison Statement from ITU-D Q22-1/2 to ITU-T Study Groups 5 & 15, ITU-T FG on DR&NRR and ITU-R WP4B
[33]	4/16/2013	Telecommunication Development Bureau	Final List of Participants for the Rapporteur Group Meeting for Question 22-1/2, Geneva, 3 April 2013
[32]	3/27/2013	Rapporteur for Question 22-1/2	ITU Handbook "Telecommunication outside plants in areas frequently exposed to natural disasters"
[31] +Ann.1	3/19/2013	International Amateur Radio Union (IARU)	Status Report on Joint Study Group 2 and BDT Project for Revision of the ITU-D handbook on Emergency Telecommunications
[30]	3/12/2013	Rapporteur for Question 22-1/2	Status Report for the ITU Handbook on "Telecommunication outside plant in areas frequently exposed to natural disasters"
[29] (Rev.1)	3/6/2013	Rapporteur for Question 22-1/2	Draft Agenda for Rapporteur Group Meeting on Question 22-1/2, Geneva, Wednesday, 3 April 2013
[28]	3/5/2013	SES WORLD SKIES	Emergency.lu Rapid Response Communications Solution
[27]	2/20/2013	ITU-T Focus Group on DR & NRR	Liaison Statement to ITU-D SG1 Question 20-1/1 and SG2 Question 22-1/2 from FG DR&NRR on Study on "Emergency Communication System for Persons with Hearing and Speaking Disabilities"
[26]	2/12/2013	ITU-T JCA-AHF	Liaison Statement to ITU-D Study Groups 1 and 2 from JCA-AHF about a reply liaison statement to the Facilitator of Correspondence Group on "Handbook on Emergency Telecommunications" third draft edition (8 January 2013) - request for comments
[25]	2/12/2013	ITU-T JCA-AHF	Liaison Statement to ITU-D Study Groups 1 and 2 from JCA-AHF about a reply liaison statement to ITU-T Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR)
[24]	2/22/2013	ITU-T Focus Group on AVA	Liaison Statement to ITU-D Study Group 2 Q22-1/2 from FG-AVA regarding LS from FGAVA to ITU-D on draft third edition of "Handbook on Emergency Telecommunications"
[23]	2/4/2013	BDT Focal Point for Question 22-1/2	Work of ITU in the area of emergency telecommunications
[22]	11/13/2012	THALES Communications	Prevention of natural disasters at the global level

Number	Date	Source	Title
[21]	10/5/2012	ITU-T Study Group 15, Rapporteur Q17/15	Liaison Statement from ITU-T SG 15 to ITU-D SG 2 Question 22-1/2 for reporting the progress on the draft new Recommendation ITU-T L.dmosp
[20]	3/15/2012	ITU-D Study Group 2, Question 22-1/2	Liaison Statement to ITU-R Study Group 4
[19]	4/11/2012	Telecommunication Development Bureau	Final List of participants - Rapporteur Group Meeting for Question 22-1/2 Sendai, 15 March 2012
[18]	3/13/2012	Telecommunication Development Bureau	List of information documents
[17]	3/12/2012	International Amateur Radio Union	Progress Report on Revisions to ITU-D Handbook on Emergency Telecommunications
[16] +Ann.1	3/9/2012	Fujitsu Limited	Contribution to The Tohoku Earthquake rebuilding by providing SaaS type application service
[15]	3/1/2012	BDT Focal Point for Question 22-1/2	New developments pertaining to the work on ITU in the area of emergency telecommunications
[14]	2/28/2012	Rapporteur for Question 24/2	Overview of RA-12 and WRC-12 Resolutions that concern the work of Questions 24/2 and 22-1/2
[13]	2/28/2012	Rapporteur for Questions 22-1/2 and 25/2	Report on developments at WRC-12 of possible interest to developing countries
[12]	2/20/2012	Rapporteur for Question 22-1/2	Draft New Handbook "Telecommunication outside plants in areas frequently exposed to natural disasters": Objectives, table of contents, working methods and work plan
[11]	11/28/2011	ITU-R Study Groups - Working Party 7C	Liaison Statement to ITU-D Study Group 2 and the World Meteorological Organization Additional Information in Support of Question 22-1/2
[10]	1/10/2012	Alcatel-Lucent USA Inc.	Disaster Planning
[9]	1/20/2012	Rapporteur for Question 22-1/2	Draft Agenda of the Rapporteur's Group meeting on Question 22-1/2, 15 March 2012 - 15 March 2012, Japan [Sendai]
[8]	4/7/2011	Telecommunication Development Bureau	Final list of participants for the Rapporteur's Group Meeting on Question 22-1/2 Geneva, 23 (PM) - 24 (AM) March 2011
[7]	3/24/2011	Rapporteur for Question 22-1/2	Letter to UNSAT, UN-SPIDER and SERVIR on request for contributions to the work on ITU-D Study Group 2 Question 22-1/2: Utilization of Telecommunications/ICT for disaster preparedness, mitigation and response
[6]	3/21/2011	Rapporteur for Question 22-1/2	Questionnaire on Implementation of Early Warning /Disaster Relief systems in Member States
[5]	3/21/2011	Rapporteur for Question 22-1/2	Draft Outline for Disaster Communications Plan Guidelines
[4]	3/14/2011	United States of America	Information on expert organizations addressing use of satellite-based remote sensing data for disaster mitigation and response
[3]	3/2/2011	International Amateur Radio Union (IARU)	ITU Handbook for Emergency Telecommunications

Number	Date	Source	Title
[2]	2/21/2011	BDT Focal Point for Question 22-1/2	New developments pertaining to the work on ITU in the area of emergency telecommunications
[1]	1/14/2011	Rapporteur for Question 22-1/2	Draft Agenda of the Rapporteur's Group meeting on Question 22-1/2 Wednesday 23 March 2011, 1430 - 1730 hours and Thursday 24 March 2011, 0930 - 1730 hours

Appendix 1: Updated Handbook on Emergency Telecommunications.

International Telecommunication Union

ITU HANDBOOK ON EMERGENCY TELECOMMUNICATIONS

(online edition 2013)

This Handbook on Emergency Telecommunications is written to serve as a close companion to those involved in the noble work of providing as well as using telecommunications for disaster mitigation and relief. It simplifies and demystifies the complex technical issues that characterize the fast evolving field of telecommunications especially in this era of convergence and emergence of next generation networks. While this handbook is meant to be simple, it is comprehensive, compact and contains useful factual information that is concise and organized for easy access especially by practitioners.

For further information

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Table of Contents

Preface

It is great pleasure for me to present this edition of the Handbook on Emergency Telecommunications. This edition has its roots in the Handbook on Disaster Communications prepared under the auspices of ITU-D Study Group 2, for Developing Countries that was published in 2001. Owing to the fast revolving nature of both the technologies and the regulatory framework related to disaster mitigation and relief coupled with the high frequency with which disasters are occurring, we found it necessary to review the 2005 edition to address most of the topical issues related to this topic.

While an attempt has been made to deal with all important aspects, this Handbook is by no means encyclopedic. The aim has been to produce an updated user-friendly product that demystifies complex technical issues, is comprehensive, compact and contains useful factual information that is concise and organized for easy access by those seeking quick reference.

This edition has been revised by the Group of experts of the ITU-D Study Group 2 on Emergency Telecommunication. This revised version of the Handbook has 4 new chapters taking into account issues relevant to emergency telecommunication and climate change that were not covered in the previous version.

It is my fervent hope that this edition will add value to all those actively involved in humanitarian assistance and those interested in this subject because Telecommunications remain the bloodstream to disaster relief and mitigation.

Brahima Sanou
Director,
Telecommunication Development Bureau
International Telecommunications Union

Chapter 1

Telecommunications for Disaster Mitigation and Relief

Introduction

"Use what is available" is the obvious reaction when being confronted with an emergency situation. "Know what is available and know how to use it" is the only way to apply this basic principle.

The next step in response is the mobilization of additional resources. At this point, telecommunications are indispensable. Again, knowledge about what is available and how to make best use of it is essential. ITU-D Study Group 2 decided in 1999, to create a handbook that would help to provide such information and to serve as a reference on the application of all available telecommunication and ICT resources towards the most noble of tasks: to prevent, and, where this is not possible, to alleviate the suffering of people affected by catastrophes.

The 12 years since the publication of the first edition of the ITU-D Handbook on Disaster Communications" in 2001 have seen a dramatic increase in telecommunication and ICT tools as well in the possibilities to facilitate information about their use in emergency situations. A hard-copy third edition of the handbook would have to be considerably larger than its predecessors if means for storing and retrieving of information would not have become available, and without continuous updating, it could not reflect the latest developments.

Thanks to the availability of (ICT), the three parts of the 2005 edition can now be presented in the form of a compact reference book, complemented by an electronic "tool-kit" containing detailed information about the application of specific types of telecommunications/ICTs, equipment, networks and services in emergency response. To serve as an overview and quick reference for all practitioners in humanitarian assistance the publication remains available in hard copy, while the "tool-kit" replaces the former "technical annex" and provides access to the in-depth information required by those responsible for the application of telecommunication/ICT resources to humanitarian tasks.

The efficiency of all emergency response, from the day-to-day work of institutional responder such as fire-fighters to the complex and unforeseeable tasks of the numerous professional and volunteer partners in humanitarian assistance, depends on telecommunications and ICTs. At the same time, for those affected by the impact of a disaster, the availability of telecommunications is a need comparable to the need for food and shelter. A sudden disruption of communication networks is a disruption of social networks and therefore of structures that are vital for survival and recovery. This disruption puts a great responsibility on the telecommunication service providers and makes them indispensable partners in humanitarian assistance.

In spite of all the progress in technology, a handbook can never replace preparedness and training. From disaster prevention through alerting and responding all the way to rehabilitation, results depend on careful studies of risks and vulnerabilities, on the application of lessons learned from the past, and, most of all, on team-work. The present, third edition of this handbook was therefore developed by the collaborative efforts of a correspondence group including members from all telecommunication services involved in emergency response, and from organizations and authorities as well from the private sector.

Chapter 2

The Organizational Framework of Emergency Telecommunications

2 Introduction

The description of the organizational framework of emergency telecommunications requires the definition of the two words, emergency and telecommunication. The first edition of this handbook appeared in 2001 as the handbook on disaster communication. Recent developments required the change to its present title. By definition, an *emergency* is simply a situation requiring urgent response. Depending on the circumstances, initial response will be provided by whoever is present, using whatever means are available on site. Any other additional intervention deemed necessary can best be mobilized mainly through *telecommunications*.

An emergency situation might develop into a *disaster*, either due to its very nature, or as a consequence of insufficient response to the initial event. The magnitude of the event will require resource mobilization on a regional or even international scale; *communication* related to a disaster will however include activities well beyond an alert requesting emergency response, made through the normally available means of telecommunications. Corresponding to the use of the four terms in recently developed documents and in the work of ITU Study Groups considering the subject matter, the present second edition of the handbook covers the use of Telecommunications as the logistics of information exchange in emergency and disaster situations. It does not cover communications in the sense of content, and its scope is not limited to Telecommunications in the strict sense of the word.

2.1 Prevention and Preparedness

Prevention, the avoidance of hazards, is primarily a local task. Telecommunications play a key role in the distribution of hazard knowledge and the creation of threat awareness. They are quickly vital tools for early warning. *Preparedness* to respond to emergencies is a task of institutional responders, commonly known as emergency services, but it is also the responsibility of telecommunication providers to be ready to respond to emergencies that threaten the continued operation of the telecommunications that all other responders depend on. Due to the character of such services, their telecommunication equipment and networks must be in a permanent state of readiness. Response to disasters, including relief operations following such events, is likely to involve institutional responders, typically national and international humanitarian organizations. Different from usually local emergency services, these responders need to be prepared to operate in unpredictable locations and under widely different conditions. The reliable operation of telecommunications under these circumstances is a great challenge, but one that must be planned for and met.

2.2 Response

Appropriate response depends first of all on rapid and accurate information exchange. An increasing complexity of administrative structures and the distribution of responsibilities in the response among authorities go parallel to an increasing number of available communication links. Public networks, such as the fixed line and mobile telephone system are the mainstay of first level alert.

With the involvement of partners from outside the immediate vicinity of an event, the responsibilities and thus the communication requirements shift to larger dimensions. Decision-making in such unpredictable operation conditions becomes a process involving a multitude of institutions. In these circumstances, private networks, such as dedicated radio networks including satellite links may be used to bridge information gaps and facilitate information exchange.

2.3 Typical Scenarios

Among the oldest tools for an electronic "cry for help" were fire alarms. Pressing a button on a street corner would ring a bell at the fire brigade, providing information only about one fact: the emergence of an emergency in the vicinity of that alarm button.

This basic system developed into publicly accessible communication facilities allowing the exchange of information in two directions with increasing bandwidth and increasing information content. Over the years the tools available to the emergency services have improved both in terms of the services and applications they offer and in terms of diversity. It is for this last point that inter-operability becomes a key issue, and will be a main consideration in Part 2 of this handbook.

Today, international disaster response and relief operations following catastrophic events are no longer limited to natural disasters such as earthquakes, but extend to wars, post terrorist attack scenarios and other man-made disasters. Planning for reliable Telecommunications is critical irrespective of the nature of a disaster because existing publicly accessible Telecommunications networks might be disrupted by the event itself, or even get overloaded due to increased demand for service. To ensure that the most important calls get through in these overload situations, an end-to-end priority calling scheme must be established and implemented well in advance of the emergency. This priority calling scheme should also make provisions to ensure that the priority extends to international communications, both outgoing and incoming. Provision of timely and additional private networks might be hindered by regulatory restrictions if appropriate arrangements are not put in place well in advance to pave way for effective participation by the players involved in international response.

2.4 The Partners in Disaster Response

Initial response to any disaster is the responsibility of the local community. National, Regional, and International assistance are only mobilized when it is realized that the required assistance goes beyond the resources and capacities of the local response mechanisms. Involvement of entities outside a sovereign state's borders is conducted on a "request-offer-acceptance" basis. In all cases, coordination with national authorities is paramount. To help ensure the continued operation of communications networks, operators should consider entering into mutual aid agreements with other operators outside of their local region, enabling them to enlist the aid of operators unaffected by a local disaster in times of crisis. When operating under volatile and difficult conditions, many organizations providing humanitarian assistance rely on dependable telecommunication and ICT networks and systems to coordinate their operations.

2.5 National Disaster Management Structures

The attribution of disaster-related functions differs from country to country. In most cases, it 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 at each level is as essential as the vertical "lines of command". For emergency telecommunication to be effective, established links between disaster coordinators and Telecommunications/ICT authorities and service providers at each level are required. This need for coordination throughout the national structures also applies to international humanitarian assistance. In the latter case, the national government is the primary counterpart of the foreign providers of assistance, but their operational activities must be fully integrated with those at various national 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. Its counterpart is the entity or official designated as national disaster manager. At the local level, an on-site operational coordination center (OSOCC) ensures the integration of international assistance with the national and local partners. Reliable telecommunications/ICTs are paramount to the effective functioning of each of these mechanisms and for their coordinated interaction.

2.6 International Disaster Management Structures

It is to some extent due to the availability of global real-time telecommunications/ICTs that response to emergencies and in particular to major disasters includes more and more international partners. Some of these are institutional bodies while others may be constituted ad-hoc in response to acute needs. All of them will however respond to what information is made available to them, and their response will be determined by the timeliness and reliability of this information.

2.6.1 United Nations Entities

The United Nations (UN) system includes specialized agencies for the various aspects of humanitarian work, including disaster response. Their cooperation is ensured through the UN Office for the Coordination of Humanitarian Affairs (OCHA), headed by the UN 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 immediately alert the international community to mobilize appropriate resources in cases where international assistance is likely to be required.

In addition to maintaining its own telecommunication networks, OCHA carries out the functions of the Operational Coordinator as mandated by the Tampere Convention [see Chapter4]. The office regularly convenes the Working Group on Emergency Telecommunications (WGET), an open forum including all UN entities and numerous international and national governmental and non-governmental organizations involved in disaster response as well as experts from the private sector and academia. In between the two annual plenary meetings, the WGET partners meet in *ad hoc* working groups on specific issues and maintain a continuous exchange of information through electronic means.

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 UN 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. Furthermore, the UN entities most commonly involved in disaster response include 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 extend 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.

2.6.2 The International Telecommunication Union (ITU)

The International Telecommunication Union (ITU) is the UN's specialized agency for Information and Communication Technologies (ICTs), in charge of allocating spectrum and satellite orbits, developing the technical standards that ensure networks and technologies seamlessly interconnect, and striving to improve access to ICTs to underserved communities worldwide. ITU is committed to connecting the entire world's population protecting and supporting their fundamental right to communicate.

ITU has been founded on the principle of international cooperation, having a membership constituted by the public (Member States, including ICT Regulators) and private sector (leading academic institutions and private companies), making it unique among the other UN organizations.

Today, ICTs have become a key tool to monitor, manage and control emergency services, water supplies, power networks and food distribution chains. As ICTs support health care, education, government services, financial markets, transportation systems and environmental management, ICTs also have the capability to permit everyone to communicate.

The work of the Union is undertaken by its three sectors. The ITU Radiocommunication Sector (ITU-R) works at ensuring interference-free operations of radio communication systems by developing and helping with the implementation of the Radio Regulations, as well as updating these instruments in an efficient and timely manner. The establishment of Recommendations intended to assure the necessary performance and quality in operating radio communication systems is key priority for the sector. ITU-R also seeks ways and means to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum and satellite-orbit resources and to promote flexibility for future expansion and new technological developments.

The developing of international standards known as ITU-T Recommendations takes place at the Telecommunication Standardization Sector of the Union (ITU-T). These standards act as defining elements in the global infrastructure of Information and Telecommunication Technologies (ICTs). They are critical to the interoperability of ICTs and whether exchanging voice, video or data messages, these standards enable global communications by ensuring that countries' ICT networks and devices speak the same language. The international standards are an essential aid to developing countries in building their infrastructure and encouraging economic development helping to reduce costs for all: manufacturers, operators and consumers.

Fostering of international cooperation and delivering technical assistance in the creation, development and improvement of telecommunication/ICT is done by the Telecommunication Development Sector (ITU-D). This sector is crucial in discharging the Union's dual responsibility as a United Nations specialized agency and executing agency for implementing projects under the United Nations development system or other funding arrangements, so as to facilitate and enhance telecommunication/ICT development by offering, organizing and coordinating technical cooperation and assistance activities.

Article 1, Section 2 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 and recommendations adopted by past and recent World Telecommunication Development Conferences and World Radiocommunication Conferences, and ITU's Plenipotentiary Conferences, as well as its active role in activities related to the Tampere Convention. The role of the Union under the Tampere Convention and related instruments is more specifically dealt with in Chapter 3.

The three sector of the Union are continuing working together to enhance the mandate given in Article 40 of their Constitution which states that "…telecommunication services must give absolute priority to all telecommunications concerning safety of life at sea, on land, in the air or in outer space…" On this regard, telecommunications for saving lives have been given a priority, which is why new Resolutions and Recommendations on the importance of emergency telecommunications have been adopted, a Framework for Cooperation in Emergencies was created and a Focus Group addressing this topic was established. ITU will continue increasing its work with the aim of saving lives through ICTs.

2.6.3 The International Committee of the Red Cross (ICRC)

The International Committee of the Red Cross (ICRC) is an impartial, neutral and independent organization whose exclusively humanitarian mission is to protect the lives and dignity of victims of armed conflict and other situations of violence and to provide them with assistance. The ICRC also provides assistance to victims of natural disasters occurring in conflict areas. The ICRC maintains its own telecommunications networks to support its humanitarian assistance activities.

2.6.4 International Non-Governmental Organizations

The International Federation of Red Cross and Red Crescent Societies (IFRC) is the world's largest humanitarian organization, providing assistance without discrimination as to nationality, race, religious beliefs, class or political opinions. The IFRC is generally recognized as having an international legal personality, benefiting from the privileges and immunities granted to international organizations. The IFRC comprises 187 member Red Cross and Red Crescent National Societies, a secretariat in Geneva and more than 60 delegations strategically located to support activities around the world. The IFRC carries out relief operations to assist victims of disasters, working through its unique network of National Societies, and combines this with development work to strengthen the capacities of its member National Societies. The IFRC maintains its own telecommunication networks and supports its National Societies when normal channels of telecommunications are disrupted by a disaster."

2.6.5 National Governmental Institutions providing International Assistance

Similar to international 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, providing their assistance under bi-lateral arrangements with the receiving country or act as implementing partners in UN’s relief operations. National organizations for international assistance usually provide Telecommunications/ICTs for their own needs, and often support other institutions, such as the UN, NGOs and national rescue services, with telecommunication support. National non-governmental organizations may in some cases assume similar roles to those of national governmental organizations.

2.6.6 National Non-Governmental Institutions providing International Assistance

Numerous national NGO’s have agreements with partner organizations in neighboring countries and/or are in a position to provide assistance abroad e.g. in cooperation with national Institutions of their home country providing assistance in the sense of paragraph 2.6.5 above.

2.7 Organizing Emergency Telecommunications

Real time information exchange is the backbone of all cooperation in emergency response, including preparedness and prevention, and in the assistance of those affected by disasters. The rapid technological developments and the numerous tools, equipment and networks available, have opened new possibilities. They can, however, not fulfill their task in the service of humanitarian work, if they are not fully integrated throughout the development and the implementation of operational concepts. Telecommunications/ICTs are tools of an organizational structure, but they also need their own organizational support. The availability and applicability of the most appropriate means of telecommunication in emergency situations is a result of close cooperation between those involved in humanitarian work, the manufacturers of equipment, and the service providers who run the various networks. This relationship will make objective assessments of what these technologies can and cannot do in various situations.

Chapter 3

The Regulatory Framework

3 Introduction

Maritime distress and safety communications have traditionally enjoyed privileges such as absolute priority and exemption from fees. The same rules apply for communications with and among aircraft. These privileges do not however apply to emergency telecommunications on land. Their applicability in emergency and disaster situations has been recognized only recently, but much still remains to be done.

Telecommunications have a dual character. While their control and regulation is considered as an element of sovereignty of each State, by their nature, they do not respect national borders. For this reason, international regulation is indispensable, and national regulation is left to deal with issues related to national interest. In the area of emergency telecommunications, this means that an international framework has to be established and that international legal instruments have to be created to provide guidance. At the same time, national legislation to safeguard national interests has to conform to enacted, applicable international law.

3.1 The Creation of an International Regulatory Framework for Emergency Telecommunications

Effective and appropriate humanitarian assistance cannot be provided in the absence of functioning telecommunications. This is all the more important when there are many players on the ground be it before, during or after a disaster. Owing to this importance, various concerned parties involved in both disaster relief and mitigation as well as telecommunication development have over the years 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, a declaration of experts without the status of a legal document, stressing the need to create an international legal instrument on telecommunication provision for disaster mitigation and relief.

The Conference recognized that regular communication links were often disrupted during disasters, and that regulatory barriers often crippled the use of emergency Telecommunications equipment across national boundaries. The Declaration requested the United Nations Emergency Relief Coordinator to cooperate with the International Telecommunication Union (ITU) and other relevant organizations in solving this and other regulatory hurdles in support of 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). This Resolution urged all administrations to remove national regulatory barriers in order to allow the unhindered use of Telecommunications in disaster mitigation and relief. It also requested 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.

A few months later, the ITU Plenipotentiary Conference (PP-94, Kyoto, 1994) endorsed the WTDC resolution by its Resolution No. 36 (Disaster Communications). This resolution reiterates the need for an International Convention on Disaster Communications, and reinforces WTDC-94 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.

These resolutions were further reinforced by Resolution No. 34 and Recommendation No. 12 of the Istanbul World Telecommunication Development Conference of 2002 (WTDC-02) and Resolution No. 36 of the Marrakech Plenipotentiary Conference of 2002 (PP-02).

Pursuant to these resolutions, and the mandate derived from the Inter Agency Standing Committee (IASC, the UN advisory body on humanitarian affairs), the Working Group on Emergency Telecommunications (WGET) was established. Since 1994 the UN Office for the Coordination of Humanitarian Affairs (OCHA) and its predecessors, UNDRO and DHA, convene its meetings, which serve as an open forum for the discussion of all emergency telecommunication related issues. The WGET includes all partners in humanitarian assistance and emergency telecommunications. This includes UN entities as well as major international and national, governmental and non-governmental organizations, and is open to experts from the academia and the private sector. Among its basic tasks of coordination and standardization of information exchange in humanitarian assistance, 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 proposed convention and its national implementation.

In the same way, the second World Telecommunication Development Conference (WTDC-98, Valletta) adopted Resolution No. 19 that goes beyond the endorsement of all the aforementioned resolutions. It invites the UN Emergency Relief Coordinator and the WGET to collaborate closely with ITU in supporting administrations as well as international and regional telecommunication organizations in the implementation of the Convention. The ITU Telecommunication Development Sector was invited to ensure that proper consideration 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 International Regulatory Instruments on Emergency Telecommunications

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 nongovernmental organizations participated in the Intergovernmental Conference on Emergency Telecommunications (ICET-98) at Tampere, Finland. On 18 June 1998, 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. In 1998, the ITU Plenipotentiary held in Minneapolis unanimously urged national administrations to sign and ratify the Tampere Convention as soon as practicable. Its resolution 36 also calls for a speedy application of the Convention. Furthermore, the 54th session of the United Nations General Assembly, 1999, in its Resolution 54/233 also called for the ratification and implementation of the Tampere Convention.

3.3 The Tampere Convention

The Tampere Convention came into force in 2005. The structure of the Convention follows the format, which is characteristic of international treaties, and its text contains, in addition to the substantive paragraphs, the stipulations required in 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 related major legal instruments, such as various Resolutions of the United Nations and those of the International Telecommunications Union, which led to the birth of 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.
- 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 Telecommunications 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.

3.5 Emergency Telecommunications in the National Regulatory Framework

The implementation of international legal instruments may require changes to national laws and ordinances. In the case of the Tampere Convention, whilst the application of this convention concerns primarily telecommunication authorities, it also impacts a number of other government services such as those responsible for import, export and border control. Advice and support on the creation of enabling telecommunication regulation and legislation in various countries for the successful implementation of the Tampere Convention can be obtained from the development arm of the ITU (ITU-D). This is in accordance with Article 12.2 of the Tampere Convention.

3.5.1 The Development of a National Disaster Telecommunications Concept

As part of the implementation of the Tampere Convention, pilot projects will have to be carried out in several developing countries aimed at assessing the strengths, weaknesses, opportunities and threats of the existing disaster communications networks. These projects should attempt to study and evaluate 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 – will be presented for consideration by the appropriate national authorities as basis for improving or building a national concept for Disaster Telecommunications.

3.5.2 An overall Concept

The specific situation in each country will have to determine the structure of the study. The WGET secretariat can assist in the identification of experts with experience in the assessment of national disaster communications structures and the development of concepts.

3.5.3 Methods and Scope of a Study

Studies of this nature require the full involvement of disaster managers and Telecommunications entities if the studies are to achieve the set objectives. In these studies focus should be on all available communications networks i.e. public networks as well as private networks such as those run by public safety institutions, links to maritime and aeronautical networks, other specialized networks, and links to the Amateur Radio Service.

3.5.4 Confidentiality Considerations

Experience shows that gathering information on network vulnerability may not be possible without the approval of senior management and governmental officials since the vulnerability of National Telecommunications systems might be of great interest to would-be-saboteurs. For this reason, accurate information about the exact layout of networks may be hard to obtain as it might be considered classified as a strategic installation. In that case telecommunication staff may be reluctant to give information, when questions are asked for the purpose of disaster preparation and network operators may not give information unless they receive clearance from designated government officials. 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 be required before such clearance is given.

3.5.5 Need for Coordinated Approach

Emergency preparedness is most effective when the responsibilities, resources and objectives of government and industry are merged through joint planning. Such planning fosters a sense of common purpose amongst separate jurisdictional authorities and results in a spirit of cooperation that arises during the planning process as well as in actual emergency situations. Furthermore, such cooperative and coordinated approaches provide a forum in which problems can be openly discussed, mutually acceptable solutions sought, and agreements reached. One example for this is the successful creation of the Canadian National Emergency Telecommunication Committee (NETC) and of 10 Regional Emergency Planning Committees (RETC).

3.5.6 Telecommunications Operators

In many countries de-regulation and privatization of Telecommunications has taken place, resulting in competing operators. Information about the capacity of an operator's network may be of commercial interest to a competitor. This can result in reluctance on the part of operators to respond to questions. An instruction to release such information would have to come from the most senior level of management. Experience has shown that "Business Continuity Managers", often reporting directly to the Chief Executive Officer (CEO), are strategic persons to work with. Such individuals are best placed to know about the vulnerabilities of the existing system. Because of the critical part telecommunication plays in responding to disasters, telecommunications companies must have a "business continuity plan", detailing such things as the position of spares and the logistical plans for rapid restoration of services, and restoration of data. The United States telecommunications industry has identified a set of Best Practices that deal with many aspects of maintaining reliable telecommunications, including disaster response.

3.5.7 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.

3.5.8 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, and network designers engineer networks accordingly. Traffic on any network still functional after a disaster 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 may 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, based on either the specific line or a code entered by the user. 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 the United States, Government Emergency Telecommunications Service (GETS) provides priority service to identified users on wireline calls, and Wireless Priority Service (WPS) provides priority access on wireless calls. 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.

An international emergency preference scheme for disaster relief is under consideration in the ITU Standardization Sector (ITU-T).

3.5.9 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 and is discussed later. When planning for a disaster, operators should consider all of the supporting infrastructure on which their systems depend and consider ways of protecting from and reacting to failures of these supporting infrastructures.

3.5.10 Recovery

When equipment is damaged or destroyed, it must be replaced or repaired quickly. The operator will need rapid assistance from the supplier of the systems, who may be outside the country. This replacement of damaged equipment again points to the need for international priority communications. The application of the Tampere Convention may help in this regard as it may facilitate the rapid passage of such equipment through customs authorities and may break whatever importation restrictions might have been imposed on a country by other State Parties. Mutual aid agreements with other operators may also aid in the swift restoration of telecommunication services.

3.5.11 The Implementation of the 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 telecommunications plan. Such a plan must be periodically exercised to ensure it is up to date and workable. ENISA has also published a good practice guide on planning for and conducting national exercises.

3.6 The need for a common approach

Improvements to the regulatory environment for the optimum use of Telecommunications in the service of response emergencies and disasters and of preparedness and prevention measures can only be achieved by joint efforts of all partners involved. It is the task of all national and international *providers of assistance*, to create the necessary awareness among the national regulators. It is the task of the *providers of telecommunication services and the suppliers of equipment*, to include provisions for the use of their goods and services in emergency telecommunications. It is the task of the *representatives of nations taking part* at Conferences run by international organizations to articulate the need for all entities to render support to all initiatives that favor the development, deployment and use of emergency Telecommunications.

ITU forums provide one such opportunity. A common and coordinated approach by all stakeholders results in a win-win outcome. The private sector that manufactures and provides the right equipment, creates a market for themselves and participate through their corporate responsibility; assistance provides benefit from efficient and appropriate telecommunications; the national authorities fulfill their role of ensuring a quality life for the citizenry, and those affected by disaster end up, being the ultimate beneficiaries as humanitarian assistance delivery will be facilitated by efficient information flow.

Chapter 4

Telecommunications and ICTs as Tools for the Providers of Emergency Response

4 Introduction

Telecommunications/ICTs are indispensable tools for the operational emergency management. The speed of response and, most of all, the appropriateness of such response, depend on the real-time exchange of information among a multitude of parties. Reliable Telecommunications/ICTs are also a prerequisite for the safety and security of those who often risk their own lives in their efforts to save lives and to alleviate the suffering caused by disasters. Last but not least, success in mobilizing resources depends to a large degree on the quality of reporting from the site of an event. In remote islands and rural areas most do not have access to a mobile phone or the Internet and therefore, it may take weeks before national governments receive any information to help such areas with relief services they need.

To allow an effective and appropriate use of Telecommunications in the service of emergency response, the users of Telecommunications as well as the providers need to be aware of the particular operational aspects of emergency telecommunications. Disaster managers are often confronted with the task of defining requirements, and they can do so most realistically if they not only know what is available, but are informed of what is feasible under given specific circumstances of an emergency situation.

Telecommunication service providers include enterprises providing services to the public or to specific users, mostly on a commercial basis, as well as those telecommunication services established and run by emergency services and disaster response organizations. They also include the amateur radio service as a non-commercial resource provided by skilled volunteers. This segment of the handbook will look at two main elements. The first analyses the most common modes of telecommunications. The second looks at the networks and services using these various modes of telecommunications.

4.1 Interoperability and Interworking

A major difficulty experienced by players involved in disaster management is the incompatibility of their Telecommunications equipment and software. This problem has been experienced in almost all operations making the exchange of information difficult. This challenge is similar to that of military operations, which share with emergency operations a number of characteristics, such as a rapidly and often unpredictable changing physical and social environment, and the need for rapid and inter-dependent decision-making at all levels. Their Telecommunications requirements are comparable. The military terms of tactical and strategic telecommunications best describe what has to be provided for a coordinated response to any emergency having more than local implications.

In order to deal with this challenge, standardization of Telecommunications networks is essential to achieve compatibility and make the exchange of information possible at least within the two groups i.e. technical and strategic networks. So far, gateways seem to be the only realistic solution although not an ideal one.

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 a time. For this, one needs solid knowledge of the structures and procedures of the networks involved. However, in strategic telecommunications, automatic gateways that have been developed between different systems require the technical staff to be familiar with the technology and how it may be utilized.

4.2 Telecommunication Modes

Practically all modes of communication on public and private networks have their role in emergency telecommunications. The following sections give an overview of available modes, which will be described in more detail in the electronic tool-kit:

a) Voice

This is the most common and most suitable mode of communication for the real-time transmission of short messages and it has minimal equipment requirements. Its applications in disaster communications range from point-to-point wired field telephone links, VHF and UHF hand-held or mobile transceivers to satellite phones. It also includes public address systems and broadcasts via radio. Voice has as its major pitfall the lack of permanent record making the transmission and reception of complex information difficult. It however, remains, the only mode that does not require user interface making it the most personal mode of communications. In a critical situation this remains the most preferred mode.

b) Data links

Data links were in fact the earliest forms of electronic communication. The telegraph was in use long before the telephone, and wireless telegraphy preceded radiotelephony. It was the development of electronic interfaces and peripheral equipment replacing the human operator translating between Morse code and written text that made data communications for many applications superior to voice. The first such interface with practical applications in disaster telecommunications was the teleprinter or teletype machine, commonly known in commercial usage as "Telex".

c) Advance Digital Technology

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. Further development led to even more efficient methods of data communications on both wired and radio links. The Internet as the most prominent tool for data communication has been dealt with in a more detailed way in a separate chapter. The Internet Protocol (IP) has also been adopted as the common standard of communications in dedicated radio networks of the major partners in international humanitarian assistance. The "Packet Radio" mode is most commonly used on VHF and UHF. Its derivative "Pactor" and various similar, often proprietary modes allow, through suitable gateways, the use of HF radio links for practically all functions of the Internet. Newer versions, such as "Pactor III" have further enhanced the speed and reliability of data communication.

d) Telefax

Telefax 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 were carried as analogue signals over voice circuits such as the telephone network. The development in digital technology has led to new forms of image transfer, including the applications on the World Wide Web, and the use of fax mode has been greatly reduced.

e) Other advanced modes

Other advanced modes including those used for image transmission over broadband links, have provided new opportunities and have improved the provision of real-time information to many more publics beyond those in the fore-front of emergency responses such as the media. Their higher demand on bandwidth and on equipment tends to restrict their application in emergency situations.

Chapter 5

Public Communication Networks

5 Introduction

For the purpose of this Handbook on Emergency Telecommunications, a public network refers to that which ordinary citizens have access to. This is important to recognize because in the event of a disaster the public will tend to initiate calls to other areas of the country hit by a disaster and from that country to other countries where loved ones are located, resulting in the overload of the Telecommunications network. Typically a public network is designed to allow about 5-10% of the subscribers to call and receive calls at the same time. However, in emergencies more people make calls and tend to talk longer resulting in jamming, blocking or congestion of the network. There are a number of measures that can be taken to deal with this challenge.

5.1 The Public Switched Telephone Network (PSTN)

The Public Switched Telephone Network (PSTN) was initially built to serve telephones, but in reality it carries nearly all Telecommunications signals making the transmission of other applications and services possible. As nearly all public networks are interconnected, this should be thought of as the public telecommunications network, and is the foundation for all electronic communications. Failure of the public network results in more losses than that of just the telephone service. For this reason, those involved in emergency response must have a clear understanding of the operations of these networks and what can interfere with such networks functioning.

5.1.1 Local Wireline Distribution (Twisted Pair, Last Mile, Local Loop)

Unless one is using some kind of wireless system, voice and data transmission from a subscriber to the local exchange will be via a local cable. In many places, telephone lines may be open wires, or cables with numerous pairs of wires, suspended from poles. Such pole routes are themselves vulnerable to disasters involving high winds and earthquakes. Any disaster causing just one of the poles on the route to fall down, or the cable to be cut even at one point, could disrupt the circuit. Restoring service may take days especially if the roads are inaccessible. A more preferred approach is to have cables buried underground in ducts, thus reducing their vulnerability. Therefore, it is advisable to have all disaster management centers connected through underground cables as this significantly reduces the risk of loss of service.

The "local loop" used on the PSTN had the advantage that the telephone at the user's premises was powered from a battery at the telephone exchange. If power at the user's premises was lost, the phone would still work as long as the line was not damaged. However, this does not apply to cordless phones, which will have a home base station powered by the domestic power, nor does it apply to broadband connections, which are quickly replacing analog lines for basic telecommunications. Telephone connections over broadband connections require power for the digital modem at the end location.

5.1.2 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. In some locations it provides lower cost and quicker installation than traditional wire line local loop. One problem with WLL is that if the power in the user's house 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. 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 available.

"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 i.e. public or private.

5.1. 3 Switches (Telephone Exchange, Central Office)

Digital switches still provide a significant portion of the network capacity, but newer equipment is replacing the standard central office switch. This equipment is smaller and can be distributed at various locations. This equipment is the foundation upon which all forms of electronic communications is built and therefore should be treated as part of a country's critical infrastructure. Consideration should be given to implementing a priority communications system to provide the most important messages, whether voice, data, or video with an enhanced probability of getting through in overload conditions, It should be stated that this equipment needs to be provided with back-up power to ensure its continued operation in the event of a commercial power interruption. This may include dual power feeds, battery back-up, and auxiliary power generation, as well as a tested plan for supplying fuel to the generator during extended outages. The buildings that house this equipment should be hardened structures, with tight physical security and be located out of harm's way (e.g. flood planes) as much as possible.

5.1.4 The Trunk and Signaling System (Long Distance system)

Trunk lines are links between switches; they carry calls on the long distance routes between cities. Trunks often carry hundreds or thousands of calls on one link, by a process called multiplexing. The links may be implemented by microwave radio, copper cables, or optical fiber, depending on the expected capacity of the link. The trend is now to use optical fiber systems. To reduce vulnerability, cables are often buried. In developing countries, the most economical and popular way to carry trunks is by microwave relay stations. These are repeater stations, usually mounted on hills or high buildings. Microwave relay stations are however, often located in exposed locations, and may sometimes be in remote areas that are difficult to access. Given the importance of these remote stations, state assistance in getting rapid access to these stations is strongly recommended.

Many modern trunk systems feature automatic recovery systems, such as Sonnet rings and other automatic re-configuration methods so that a redundant link or route can take the load from a failed link. This of course depends on quite a lot of redundant capacity being designed into the system in the first place. There are also cost considerations and in the present de-regulated environment mainly small operators in developing countries who have limited resources consider this a luxury. Even in well developed countries there have been spectacular flops, caused by the gradual erosion of redundant capacity as it is sold to paying customers in today's highly competitive business. When the network rings are broken, there may not be enough spare capacity in the ring to carry the entire resulting load. For this reason, government may have to ensure that margins of redundancy are kept, in the national interest. A special case is the "Signaling system No. 7" also known as the "CCITT 7" system. This is a special network which is used for switches to talk to each other, to help get the call set-up. It is however, not carried on a special network, but is often added to the normal links. The loss of the trunk network may also disturb the function of the SS7 system, causing general signaling problems in the network.

5.2 Wireless Networks

Mobile networks and technology are becoming increasingly relied on before, during and after disasters by responders, governments and citizens. Mobile networks can facilitate the communication of early warning messages, critical emergency and relief information and help affected populations connect with loved ones and assistance. SMS, cell-broadcast, voice and data services and a growing number of mobile applications and mobile-enabled social media platforms can be a lifeline in disasters. Due to the nature of terrestrial infrastructure, spikes in usage volume and intersection with other utilities including commercial power, mobile networks are also vulnerable to disruption or failure in some kinds of disasters. Improving network resilience and management, pre-positioning supplementary restoration solutions like cell-on-wheels (COWs), back-up power solutions and fuel access and addressing information and coordination gaps should be part of comprehensive disaster planning both within the mobile industry and with other stakeholders. Smart phones have the ability to transmit voice, text messages, pictures, and other forms of data and are often the primary telecommunication tool in disaster areas.

5.3 Satellite Terminals and Satellite Phones

Several systems, differing in their technological concept and their applications, are available for use in emergency operations. For the user, the difference is primarily in the size of the equipment and the coverage required.

5.3.1 Mobile Satellite Terminals

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 early 1980’s, 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 geostationary satellites. Legacy mobile terminals communicating through Land Earth Stations (LES) handle traffic supported by PSTN and other public networks. Four satellites cover the surface of the earth with the exception of the Polar Regions. Part 3 of this handbook includes a map of the areas covered by the operational satellites. LES are located in various countries, within the range of one or more satellites. The communication links consist of a connection between the user’s terminal and one satellite, a link from the satellite to an LES, and the connections from there into a terrestrial public network.

From 2005 Inmarsat introduced a next generation of mobile terminals called BGAN (Broadband Global Area network) that have the ability to support voice and data simultaneously, with data speeds capable of up to 492Kbp/s in a contended environment. Operation is similar to a terrestrial broadband service. These terminals range in size with the largest being the size of a modern laptop, or A4 sheet of paper.

An additional three satellites (the I4 constellation) were launched between 2005 – 2008 to exclusively support the BGAN infrastructure. All traffic sent over the terminals is then landed at Inmarsat owned and operated Satellite Access Stations (SAS). These SAS’s which are separate to the earlier mentioned LES’s then route the traffic over PSTN or Internet links.

All Inmarsat terminals need to be set up so that their antenna can “see” the satellite covering the operational area. Most terminals have provisions to remotely locate the antenna outdoors, separate from the actual user equipment. Particular models of Inmarsat BGAN terminals can be used in a vehicle while in motion using specialized antennas for mobile land or maritime and aeronautical markets. These specialized antennas compensate for the movement of the vessel, vehicle or aircraft.

5.3.2 Direct Video (and Voice) Broadcasting

Another low cost and practical method of gaining satellite connection is to use the services of the Broadcast satellite. Typically in such schemes a circuit board is installed into a personal computer.

Software then installs this as if it were an Internet service provider. The computer then gets fairly good speed Internet access over the satellite link, but at a much lower cost than with conventional VSAT.

However the user is contending openly with other users at the same time, so there is no guarantee as to quality of service as there is with conventional VSAT.

Pros

- inexpensive.
- easy to ship.
- easy to set up, little ground work required for setting up.
- readily available from the shelf.
- quite OK and reliable for Internet browsing.

Cons

- Shared bandwidth.
- In complex emergencies when lots of other users deploy the same system even browsing becomes slow.

Problems with TCPIP e-mail exchange (like Notes replication). The priority on those systems is given to HTTP and during peak browsing hours (at the point where the beam lands) this almost wipes out the email replication. However during night time hours even the replication works quite well. Pricing is significantly lower than with conventional VSAT, both in the capital costs of the equipment and in the monthly running costs.

Use has also been made of the downlink only data facility provided by world space radio's, Direct Voice Broadcasting. It has been used, for example to update intranet files that are small. Worldspace is DVoiceB. Typically it is used by FTPing daily update files of Intranet content to a Worldspace up-link site. WorldSpace then broadcast the file over its satellites to receivers in field offices. The receivers have a data adapter that feeds the bit steam to the USB port of a laptop running a client software. The laptop is effectively a single machine web server serving a mirror of the Intranet site. There is no cost charged to the receiving partly, but there is a cost per megabyte charged for sending data.

The best configuration today is using a PCI card, to be installed in a Desktop PC, that has two receivers making it possible to receive both data and a voice simultaneously. This has very modest costs and could be compared to the costs associated with VHF radio.

5.4 End User Equipment

5.4.1 Facsimile (Fax)

A facsimile machine (FAX) consists of a scanner, a computer, a modem and a printer in one unit. This combination allows the transmission and reception of pictures on a piece of paper.

You can use this to transmit hand sketched diagrams, messages in hand written script and photographs. A general weakness of fax is that it is usually carried over normal telephone circuits. It is therefore subject to all the shortcomings of the PSTN. Furthermore most fax machines depend on external power.

5.4.2 Smart Phones

Advanced concept mobile phones can communicate in a large number of modes, including voice, text, pictures, and video. Such devices can replace a number of other, previously used devices, but they still depend on the wireless network to operate. The capacity of their batteries is limited by small physical shape of the units and such handheld multi-functional terminals run out of power quickly with heavy use. A means of recharging their batteries therefore needs to be foreseen in order make them useful beyond the first hours after an emergency situation.

5.4.3 Hand-held Satellite Telephones

Services of the Global Mobile Personal Communication Systems (GMPCS) allow the use of equipment very similar to terrestrial cellular telephones. They are particularly suitable for situations where a high degree of mobility is required, and while they still need a line-of-sight connection to the satellite or satellites, their mostly-omni directional antennas need not be aligned accurately. Different systems offer specific advantages but also have specific restrictions in respect to their applications in emergency telecommunications.

5.5 Priority Schemes

During a disaster extreme loads will likely be put upon networks. During such times, while all calls are important to the persons making them, some calls (e.g., first responders, network restoration calls) are more important for the common good, and therefore a priority scheme to ensure that those calls are completed should be considered.

Various system of priority are currently available. Some close the network to all but identified special users, while some leave the network available to all, but move priority users “to the head of the line” in terms of access to system resources. In the United States, Government Emergency Telecommunications Service (GETS) provides priority service to identified users on wireline calls, and Wireless Priority Service (WPS) provides priority access on wireless calls. An international emergency preference scheme for disaster relief is under consideration in the ITU Standardization Sector (ITU-T). With the move to all IP networks, where voice calls are mixed in with all other types of data traffic, a new priority scheme may be required.

National priority schemes are a good first step, but disaster response often requires communications across national borders. For this reason priority calling scheme should also make provisions to ensure that the priority extends to international communications, both outgoing and incoming. (http://www.ewi.info/pic).

Chapter 6

The Internet

6 Introduction

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 some form of targeted broadcasts.

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 than they are likely to use. In the context of disaster telecommunications 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 cannot be expected to conduct information searches. They neither possess the time, nor, in most cases, 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 and other graphic communication modes.

6.1 Applications

The use and application of the Internet to emergency Telecommunications is unquestionable. The following are some of the ways that this technology can contribute in disaster relief:

- Sending and receiving email and using web-based directories to communicate with 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 websites 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. Generally, the web is associated with high bandwidth and costly connectivity. A lot more need to be stated concerning the web, for instance the need to maintain 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 hold true. The high vulnerability of solid-state technology to static electricity and electromagnetic pulses requires special consideration and has, in the past, in some cases been overcome by re-introduction of vacuum tube technology in particularly critical telecommunications applications. Other important issues pertaining to the Internet-based information exchange are reviewed in the following section.

6.2 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 and spam could seriously affect computer systems at crucial points just when they are needed most.

Focus should not only be on sending messages on the net but also on ensuring security. It is therefore necessary to employ secure technologies that are now readily available off the shelf in order to authenticate the source of the message. This includes the use of digital or electronic signatures created and verified by cryptography, the branch of applied mathematics that concerns itself with transforming messages into seemingly unintelligible forms and back again. This form of signatures use what is known as "public key cryptography", which employs an algorithm using two different but mathematically related "keys", one for creating a digital signature or transforming data into a seemingly unintelligible form, and another key for verifying a digital signature or returning the message to its original form.

6.3 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.

6.4 Accuracy

The quality of information to be found on the Internet is probably no better or no worse than information available through more traditional channels. The Internet decreases the time lag between events and the posting of information about them. This free market of information gives equal play time to valuable information as well as 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 information before forwarding or applying it.

6.5 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 7

Private Networks

7 Introduction

The term "private network" is used here to describe communications facilities available to specialized users like fire brigades, police, ambulances, utilities, emergency teams, civil protection, transport, government, ministries, and defense. These networks can also be used by business, corporate, and industry users. The network is usually owned by the private users themselves who can share it eventually in a multi – organizational environment. The users usually manage their private network, in some cases an operator can do it for his private customers.

These networks come in different forms. They can be wired or wireless, and they can share public networks resources, they can be fixed or offer mobility. These can be classified as:

- land mobile radio networks,
- maritime networks,
- aeronautical networks,
- enterprise networks,
- virtual private networks,
- location networks,
- satellite networks.

7.1 Land Mobile Radio (LMR) services

7.1.1 Land Mobile networks

The access to private Land Mobile Radio networks (LMR) is reserved to closed group of mobile users who make short exchanges of voice and data of an operational nature during day-to-day, emergency and disaster situations for Public Protection and Disaster Relief (PPDR).

The communications can be duplex but can also be half duplex where one user can talk at a time by pressing a Push To Talk (PTT) button. The LMR networks differ from public telecommunication networks as they offer specific services like immediate call set up, Group call, Emergency call, Priority call, end-to-end Security, ambiance listening. LMR networks offer very short call set up times, simultaneous voice and data, mobility, high robustness and ease of use in harsh urban, wide areas, mountainous environments. They can cover different sizes of coverage from one cell of a few meters to large countrywide areas and they can also be set up quickly if needed. LMR is a family of standards and technologies which can be combined to offer the required Voice and Data service. This is due to the fact that emergency users have specific varying needs according to their role as civil protection, police, and emergency teams. For example the security level needed is different between users, the data rate of information is varied, and the type of terrain of the critical missions is different as it could be urban, rural, or a hot spot.

LMR systems are categorized as Narrow, Wide and Broad band according to the increasing width of their radio channel and to the data rate offered.

ITU-R report 8A/205 defines the radio communications objectives and requirements for Public Protection and Disaster Relief (PPDR). Three typical scenarios have been identified. These are day-to-day operations, (large) emergency, and public events, disasters. Typical applications (Data base access, messaging) are identified. Then, depending on the LMR system in use (narrow, wide and broad band) the possible applications are listed in order of importance depending on the Scenario.

7.1.2 The different modes of operation

LMR systems offer six possible main modes of working:

- **Direct mode** where the communications are done directly between the terminals without using an infrastructure. This is very practical. It is like a walkie-talkie mode where everyone in the range can listen to the conversations if they are on the same radio channel.
- **Network mode** where the communications are under the control of the LMR network infrastructure composed of Radio Base Stations and Switches.
- **Dual watch** where the terminal is in both direct mode and in network mode.
- **Repeater mode** meant to extend the coverage around a vehicle, or in a building.
- **Gateway mode** meant to connect two different incompatible systems.
- **Ad hoc mode** where the terminals themselves have an information routing role as there is no infrastructure.

7.1.3 The different main services offered

LMR systems offer a wide range of tele-services such as the following:

- Group calls allowing communication between a calling party and one or several called parties belonging to the same group. This is also called talk group.
- Emergency calls with automatic call set-up and pre-emptive calls.
- Broadcast call allowing one caller to transmit to multiple parties.

LMR systems offer a wide range of services:

- Security services such as: Authentication of the user, end-to-end encryption of the voice and data, protection against intrusion, and key management.
- Mobility services such as: Hand over, cell location registration, and presence check. The speed can be up to aircraft helicopter speed in order to allow air to ground communications.
- Voice Services such as: Access priority, discreet listening, preemptive priority, call authorized by dispatcher, presence check, call duration limitation, dynamic regrouping, and group merging.
- Data services such as : Access to a database, GPS support for location, short messaging, file transfer, and status transmission Video, and telemedicine can be supported if the data rate permits. Data rates offered by these systems vary between 2.4 kbit/s for short messages, images, and database query, to several Mbit/s for telemedicine, video, and file transfer.

LMR private networks serve emergency and disaster communications in two ways:

- The regular users of the LMR network may be involved in disaster response activities. The different organizations may have different LMR systems and then they inter-work through Gateways or through the Emergency Control Centers.
- The LMR network may be used temporarily as a back up to carry information from and to users who are not part of the mission critical user group.

The following sections look at the services that could be provided as part of emergency Telecommunications within the context of the two options discussed above.

7.1.4 Technologies

This section will not cover the technical details of each listed system as they are described in ITU documents ITU-R report M.2014 dealing with technical and operational characteristics spectrum efficient digital dispatch systems for international and regional use, and ITU-R 8A/109E which the Land Mobile handbook on digital dispatch systems. Radio propagation is a complex process, but some principles are useful to know in order to understand the classification of related technologies and their evolution. Before discussing the various systems, a few key points deserve mentioning:

- Analogue radio technology is being replaced by digital technology which allows secure services, better spectrum efficiency, larger coverage, better quality of service, data transmission, duplex, and hand over.
- The larger the radio channel the more data it can transmit when needed by specific applications.

A classification is done according to the size of the band. These bands could be defined as, narrow (for example 25 kHz channel width), wide (for example 300 kHz channel width) and broadband (for example 2 MHz channel width).

- The wider the band the higher the data rate.
- The higher the data rate the smaller the radio coverage.
- The higher the frequency the higher the penetration.
- Mobility makes transmission more difficult due to fading and change of radio cells while moving, this can introduce discontinuity in communication if no hand-over is performed.
- Antenna technology can boost range of the same radio technology.
- Modulation techniques can boost data rates for the same radio channel width.
- Increasing power transmission can increase the coverage.

Technologies under this theme can be classified as analogue or digital systems. Digital systems can further be classified on the basis of whether they are Narrow band, Wide band or Broad band. LMR systems initially use narrow band radio channels and may use trunking in order to share radio resources between multiple users in an optimized use of frequency. Wide band and broadband radio channels are generally used when higher data rates are needed for services such as file transfer, video, and telemedicine Analogue systems include the popular MPT1327. Below is a more detailed look at digital systems:

- ***Narrow band digital mobile systems***: TETRA, APCO 25, TETRAPOL and iDEN as listed and described in ITU-R document M.2014 and ITU-R 83/109E for LMR as well as DIMRS and IDRA. Other proprietary systems exist which are not standardized such as EDACS, FHMA.

  These systems are used in all types of terrain and coverage. They carry voice and data at rates up to 36 kbit/s.

- ***Wide band digital mobile systems*** are under development and are aimed at increasing the data rate. They are an evolution of the narrow band systems and are generally upward. Examples are: an evolution of the narrow band systems and are generally upward compatible. They are TAPS, TEDS in ETSI, APCO 34 and TETRAPOL in TIA. Some mobile public networks have developed a limited subset of LMR services like GSM/Pro and GSM R. Wide band is intended but not exclusively for urban areas where data traffic can be most critical. Data rates can go up to a few 100 kbit/s.
- ***Broad band digital mobile systems*** allowing very high data rates of a few megabits are under development for PPDR users and can be classified as follows: Body, Personal, Local, Metropolitan, and Wide Area Networks (BAN, PAN, LAN, MAN, WAN) depending on the coverage. Some technologies can already be used as WLAN – Wi-Fi but they still must be adapted to the users specific needs for example security concerns. It must be noted that these systems are mostly intended for hot spots emergency situations.

A subset of LMR services are offered on some public networks such as GSM, PSTN, and IP. The point to note here is that public networks are generally overloaded and end up being partially or completely destroyed in emergency and disaster situations. For this reason, these services are more appropriate for day-to-day operations and for some emergency situations.

These LMR technologies are robust against noise, and they offer the same coverage for voice and data irrespective of the type of terrain.

The equipment can be:

- Terminals such as portable handsets, mobiles, a data terminals.
- Radio Base stations.
- Switches.
- Gateways to other networks.
- Repeaters.
- Emergency control centers.

All these can be fully included in self powered containers which can be carried either by air or by road to the emergency site.

The range of PPDR reserved frequencies used by the different systems varies according to countries and systems which makes inter-operability difficult. Work is however ongoing in ITU to have the same frequencies designated worldwide or at least per region, as defined in the World Radio Conference WRC-03.

7.1.5 Interoperability/Inter working

Often different organizations have different telecommunication systems yet they are expected to coordinate operations and talk to each other at the emergency – disaster site. They also are expected to communicate with other local or remote users.

In order for critical users involved in disaster operations to obtain inter-operability the following measures should be taken:

- Use of the same technology in the same frequency band so as to make roaming from one network to another possible using the same terminal.
- Use of the same equipment in direct mode on the same frequency.
- Use of multi mode equipment handling different technologies in the same band. This is possible thanks to a new technology called Software Defined Radio (SDR).
- Use of multi band equipment in the same technology covering several radio frequency bands.

The mission critical users can inter work if:

- They can communicate through the emergency control centre of each mission critical users organization. Emergency operations are coordinated locally on the spot or remotely. This is done in the Emergency Control Centre which can be fixed or mobile, local or remote, in a vehicle, or in a shelter The emergency control centre user can monitor the on the spot users, he may have information on a computer screen where he may view the location of the users and vehicles on maps in real time He can also communicate with the on site users or the remote users.
- They can use gateways which are intermediate equipment to interconnect different technologies LMR, Satellite, GSM, public network.

It must be emphasized that in these situations of inter-operability and interworking, the services offered end-to-end can be a subset of those offered by the different networks separately. For example end-to-end security is no longer ensured if transcoding is needed at the gateway.

7.1.6 Wireless Private Area Networks

Private Area networks are just as can be noted from the name, private. These have a reserved licensed or un licensed frequency band for private use. These technologies have radio channels with a large frequency band of several MHz and belong to the broadband LMR family. There are different technologies offering different data rates, services, and distances of communication. The coverage depends on the type of antenna used, figures given for range, and frequency. Data rates are given only for indication.

Applications developed on top of the wireless private area networks standards allow the use of these private area networks for PPDR. They are classified according to their range as Local, Personal and Body Area Networks.

Wireless Local Area Networks (WLAN)

WLAN are radio links allowing very high data rates exchanges (between 10 Mbits /s and 100 Mbit/s) in direct mode between equipment such as portable computers, but with no or very little mobility. This equipment can also work in an ad hoc mode. This technology uses for instance the 2.5 GHz unlicensed frequency range or 5 GHz range. This requires one to be careful due to potential interferences as several other systems are in this unlicensed frequency range.

Wireless LAN standard IEEE 802.11 (also called Wi-Fi) has many versions named a, b, c, and d. One has to check compatibility between equipments versions and the security level offered by each version used.

The range is around 100 meters depending on the environment, such as the obstacles like walls It is very sensitive and easily affected by terrain features.

The data rates depend on the number of users and can decrease rapidly. With an increase in the number of users, data rate cannot be guaranteed when other applications are running. ETSI HIPERLAN 2 is another standard converging to IEEE 802.11 which includes a high level of Security and Quality of Service and hand over. However, mobility is very low.

Wireless Personal Area networks (PAN)

PAN are used between pieces of equipment in close proximity like a portable computer, a PDA and a printer for example. Infra-red and Blue tooth are examples of technology used. They allow short range data communications of a few meters, mainly for file access, file transfer, query. The frequency is in the range of 2.4 GHz and data rates are of a few 100 kbit/s. Mobility is not offered or very slow.

Wireless Body area networks (BAN)

BAN allow communications between different equipment that you wear on your clothes. Distances are very short and are around one meter, Technologies like Ultra Wide Band (UWB) are used. The frequency is in the range of 3.5-10 GHz and the data rates can go up to one Gbit/s. UWB offers integrated 3D location service and suppers from slow mobility.

7.1.7 Coverage

These LMR technologies do not provide the same land size coverage. For example, a Wireless LAN network allows only a few hundred meters coverage while penetration for radio is variable, and Satellite radio is known to have a major drawback in not being able to provide coverage indoors. It must also be recalled that the higher the frequency band, the higher the possible data rate but the smaller the cell coverage. Some systems can be configured from one cell to large national networks with many cells by adding a combination of Switches, and of Radio base stations. Repeaters are instrumental in extending the coverage area, while gateways make interconnection different telecommunication networks possible. It is also important to have some idea of the coverage size in order to avoid loss of communications.

As a general guideline, narrow band LMR technology offers coverage of one cell which is between 40 to 70 km in network mode, and a few kilometers in direct mode.

Wide band LMR technology can offer about the same coverage as narrow band using new antennas techniques such as MIMO. But generally speaking, coverage is smaller, and half the narrow band coverage. Broad band LMR offers smaller coverage, ranging from a few meters to a few kilometres. In concluding this segment, it is fair to state that the figures given above are an estimate as coverage also depends on topographical factors.

7.1.8 Public Safety LTE

Several countries have designated spectrum to provide an public safety network that utilizes Long Term Evolution (LTE) and provides many of the advancements in wireless technology that are commercially available. This provides first responders with a high-speed, nationwide network dedicated to public safety, and helps eliminate the problem of interworking that occur when various first responder organizations have their own systems.

7.2 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 telecommunications. As its own emergency telecommunication system, the maritime service uses the Global Maritime Distress and Safety System (GMDSS). This service is only of use to ships and Marine Rescue centres for the purpose of safety of life at sea (SOLAS).

7.2.1 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 to establish 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 call sign. 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 screens of communications terminals on board ships in range of the calling station. The originator will specify the desired ship, 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.

7.2.2 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.

7.3 The Aeronautical Radio Service

The Aeronautical radio service has frequency bands allocated for communication with and among aircraft, additional bands are allocated for Radio Navigation equipment such as used during instrument flight. A station intending to communicate with aircraft in flight needs:

A. Authorization to do so – either be an air-traffic controller, or a licensed pilot. In emergency operations relief workers on the ground must, to operate legally, obtain a special temporary authorization from the air-traffic authority of the country concerned.

B. Have an “air band” radio transceiver (normally a portable unit).

Normal Land Mobile VHF equipment is technically incompatible with that used in the aeronautical band; this is not only due to the different frequency allocations, but primarily because the aeronautical service on VHF uses amplitude modulation (AM), whereas FM is the standard on VHF in the Land Mobile Service.

7.3.1 Aeronautical Networks

Civil aircraft are equipped with two 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. Most communication is performed using assigned single frequencies in Simplex mode, without repeaters. The aircraft's height above the terrain determines the possible communication range. More height means more range. The operator on the ground should try to position himself such as to have an unobstructed view of the approaching aircraft, especially as his hand-held unit has a low transmitter output power and a “poor” antenna.

The international standard emergency frequency is 121.5 MHz. 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 MHZ should **only** be used in the case of genuine life threatening emergencies. 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 there is need to communicate with aircraft in flight. 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.

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 however not be monitoring 121.5 MHz or 123.45 MHz, but rather a local or regional flight information frequency – unless he is instructed to be Standby on 123.45 MHz.

In addition, some long-range and some “bush operation” aircraft, (but not all), may be fitted with HF radio equipment using the Upper Side Band (USB) modulation system. 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.

7.3.2 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 to provide reports to the respective control authorities. In addition these station also provide phone patches to landline telephones for personal calls, such as home to family members. This expensive 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 used for flight operations are to be avoided by others as these are strictly reserved for aeronautical users.

7.3.3 NOTAM

When filing a flight plan, pilots are provided with Notices to Airmen (NOTAM), safety related messages, referring to the path of their intended flight. In the case of major disaster response activities with involvement of air operations, details about air drop sites, temporary airstrips and related communications rules may be published in a NOTAM.

7.3.4 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 frequency bands other than aeronautical AM radio equipment, and additional equipment would have to be installed on board but this would be time consuming and would have implications with respect to air safety regulations.

Never operate a hand-held transceiver inside an aircraft **without prior permission of the pilot in command** as "wild" radiations can impede the performance of vital aircraft systems (navigation and even electronic engine control units). The high noise level in aircraft make it very difficult or even impossible to use a hand-held transceiver in a 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 crew-member should monitor this radio, independent of aeronautical radio traffic and use headphones. A skilled operator may then even succeed to get an extended range especially if the station is at a good height making it possible to relay emergency traffic.

7.3.5 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 the 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.

7.3.6 Satellite equipped Aircraft

Since about 2005 even smaller aircraft are getting equipped with airborne satellite communications systems. Mainly INMARSAT and some have IRIDIUM units installed). Ask the aircraft operator about the details (type of system and calling number), such that you can organize a matching system for the relief crew on the ground. Do not forget to brief the relief crew on how to use the respective satellite communication equipment.

7.4 Location Services

Radio navigation systems have a complementary role in disaster communications. Hand-held equipment for personal use are available at low cost, and subscriptions or licenses are not required. The system most commonly used is the Global Positioning System (GPS), operated by the US Government. Available is also GLONASS, run by the Russian government, and an additional system, GALILEO, is being set up by Europe. GPS (and also the other mentioned systems) is using a set of satellites and ground stations. Some of the satellites must be in sight of the hand held in order to allow positioning. This is why this system works outdoor, and in open areas. There are however indoor systems such as UWB (Ultra Wide Band) that can be used.

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, affordability and simplicity may well be more important than seeking to obtain the highest accuracy. In disaster situations, position finding serves three main purposes which are outlined below. Speed and time can be computed.

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. Location services will help facilitate the searching process.

7.4.1 Automatic vehicle Location services

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, i.e. 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. However, the exact locations on maps can be shown by using Global Information Systems (GIS).

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 even allows the use 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 available for the tracking of individual users.

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.

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.

7.4.2 Personal Locator Beacons (PLB)

A Personal Locator Beacon (PLB) is a body worn small radio transmitter designed to transmit positions, plus some information about the user, to a rescue center. PLBs are intended primarily for the personal use by 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 highsecurity risks.

7.5 The Enterprise private services

Enterprise systems are small-scale systems intended for use by businesses and organizations. Except for their small size, their structures are similar to those of the corresponding public systems to which they are inter-connected through gateways. They can be wired or wireless.

Larger institutions often maintain their own enterprise systems over wide areas which can be transnational, between several sites.

In case of disaster, companies need to be able to be back to business quickly. Backing up their responsibility but they quickly must restore Telecommunications to be able to get back into business. They need to reconnect to the back up information systems, and need to be able to allow remote workers to run their business again.

7.5.1 The Private Branch Exchange (PBX)

This 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. Connections among the extensions of the PBX are therefore independent of any external network infrastructures.

Connection to the public networks and Internet is ensured by gateways.

Today, IPBX technology allows the use of IP and Voice over IP (VoIP) where the PABX is a software based technology running on Personal Computers acting as multimedia terminals and can be interconnected by wire or wireless. Voice and Data run on IP.

Mobility in the enterprise can be added with wireless technologies like WLAN Wi-Fi and /or the Digital Enhanced Cordless Telephones (DECT).

The CENTREX service is a PABX function offered by the public network itself, it then is vulnerable to disasters.

The Intranet is the own internal Internet of the company accessible by the internal wired or wireless multimedia personal computers. It may be connected to the outside through firewalls and can be accessed securely remotely by:

- **SOHO** which is the Small Office-Home Office using the Internet services through Virtual Private Networks (VPN).
- **ROBO** which is the Remote Office-Branch Office using the VPNs.

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 keep control of the quality 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 only work if it has power. Generally, switches have battery backup power for a few hours. If the regular power remains disrupted for a longer period, a back-up generator will be required. A PBX may take some time to reboot after power disruptions.

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. Permanent private links to other parts of the organization do not necessarily ensure immunity from failures by the public system. If any part of the public system is affected by a switch power failure, private lines may be disrupted as well. Connection by direct cable-connection, that does pass through elements of other networks, may overcome this problem.

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

7.6 Unlicensed Local and Wide Area Networks

Unlicensed networks are often used in case of emergency and disaster as they are private networks often separated from the public networks.

7.6.1 (Virtual) Private Networks

Many medium and large organizations operate their own network interconnecting computers for electronic mail service, data base accesses, and intranet. The servers of the company are connected to the office computers by means of a Local Area Network (LAN), which in some cases may cover various premises of an enterprise. Such an arrangement is known as a Wide Area Network (WAN). The links can be wired or wireless locally or remotely.

LANs and WANs have switches 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.

Business users may be located remotely at home or in Agencies which have to be connected securely to the company servers remotely.

VPNs are Virtual Private Networks set up on public networks offering a secured remote access. They allow private users to share public networks securely between them. Specific functions are needed on the public network to handle security and at the company premises to provide firewalls. Specific software is added at the remote end terminal in order to do a "secured tunnel" for communications end-to-end. In case of disaster they allow the user to work remotely and securely from home for example if offices are destroyed.

7.7 Satellite Very Small Aperture Terminal (VSAT)

VSAT, (Very Small Aperture Terminal), Private Satellite systems.

The great thing with VSAT is that no one else is sharing your bandwidth, so you can be sure that the panicking population, who will be jamming public systems, will not have any effect on your ability to make calls or send data. This is particularly valuable in disasters, as overload of public networks always occurs in the acute phase of the emergency, (which is, unfortunately for you, just the time you need to communicate).

Also, since the only other part of the system is up in space, it is unlikely that the disaster will destroy enough infrastructures to impede satellite communications, provided that you have power, and the storm has not destroyed your dish or knocked it off alignment.

In the past, VSAT was so expensive, (in the order of hundreds of thousands of dollars), and difficult to deploy that only the "Big Boys" could play this game, but now the cost and convenience has changed significantly, (in the order of a few thousand dollars), so it is becoming more and more common to find it in use even for small low budget operations.

The slightly curious legacy name of the service derives from its history. Previously, satellite tracking was for Astronomers and other observers of the heavens. Astronomers call the size of their telescope lens or mirror its 'Aperture'. Many expressions from astronomy legacy have carried over into satellite communications, with several words used to describe the same thing.

When satellite communications was first established in the 60's, Tennis court sized dishes were needed. In later phases in the 80's and 90's much smaller 'dinner table' sized dishes were used, which made the cost of the dishes within the reach of medium sized enterprises. The quaint legacy term, (Very Small Aperture Terminal) comes from comparing these private dishes with the enormous sized dishes which were used at first.

During the 2000's, terrestrial television has been supplemented by satellite television. Whereas previously satellite communications tended to use frequencies near to 7GHz, (The C Band) now frequencies near to 14GHz are more common (Ku Band). Since the 'gain' of a dish depends on the wavelength of the frequency, the result of higher frequencies is smaller dishes, which are now more likely to be 'trash can lid' sized, rather than the dinner table sized dishes that we were used to at C band.

Also, since millions of domestic households have switched to Ku band receivers for their TV and radio, prices of such equipment have fallen along with large volume. In many rural locations where broadband is not yet provided, private households use Ku band dishes to get their two way broadband internet connection. The technology is all housed in a set top box, about the size of a video player. The unit acts just like a regular domestic router. In fact almost everywhere in the world can how obtain broadband internet on demand, (provided the local regulatory authorities will license it).

One significant difference between VSAT systems and, for example, sat phone systems, is the way that pricing is done. Typically, the user pays a monthly fee for access to the satellite, and there is no pricing based on how much data is sent, or how far away it is sent. This is much closer to the kind of 'all you can eat' tariff that we are used to for internet broadband connection.

Where applications are sending a lot of data over long distances, this can be attractive because the costs of such a station are well understood by the management.

Chapter 8

Converged Networks

Introduction

Internet Protocol (IP) is a packet switched protocol which has become very popular for telecommunications networks, because it is cheap, and can be adapted, both for sophisticated **DATA** applications, and also for 'Voice Over Internet Protocol' (**VOIP)** and even video network applications. VOIP is rapidly gaining particular favor presently. Computers can run an application, such as SKYPE which provides voice (and videophone) on the computer without extra hardware.

VOIP telephones look superficially like the phones that we are all well used to. This means that almost no training is needed as almost anyone can work out how to use a telephone. They carry out their signaling either on a dedicated server, which does not even have to be local to the site, or the router itself can run a voice services application which can take care of the phones without needed an extra box. Calls on site pass over the local LAN, while other calls go over the same IP link that is carrying the other traffic to the outside.

Packet data in the IP protocol is typically charged at a very low priced 'all you can eat' tariff, in which the distance of connection is not taken into account at all, so the costs of transmission is usually trivially small. (N.B. with some very important exceptions that you must know about). This allows long phone calls over long distances via VOIP to have very low costs, which is attractive to international organizations as long international conference calls are a significant feature of operations.

Whereas in the past we would install different physical networks for each need, today we use low cost commercial off the shelf equipment, **COTS**, to convert our packet, streaming, data and voice traffic into a standardised Internet Protocol packet switched format so we can use the same hardware and save money. This is called "**Converged**" networking.

Chapter 9

The Amateur Service

9 Introduction

Among the Radio Services defined in the Radio Regulations (RR), and regulated by this international treaty governing all aspects of radio communication, the Amateur Service (RR S1.56, Geneva 1998) is the most flexible one. Using modes from Morse code and voice to television and most advanced data modes, communicating in allocated frequency bands ranging from 136 kHz (long wave) throughout the HF (short wave), VHF and UHF all the way into the GHz range, Amateur Radio was throughout its history and still is today at the forefront of technology. Amateur Radio operators can form a global (long range) network, but they are equally at home when it comes to local (short range) or even satellite communications. Most of all, however, they acquire their skills because of their personal interest and hands-on learning experiences in the subject of radio communications, and they are the experts in achieving extraordinary results with whatever limited resources are available.

These characteristics make the Amateur Service a unique asset for communications under the often extreme conditions encountered in emergency and disaster response. Its technical information and training material covers the most critical aspects of emergency telecommunications based on the experience gained during more than 100 years of public service communications. The operational characteristics of many elements of emergency radio telecommunications are best explained on the example of the Amateur Service. Most of the content of Chapter 5 is thus applicable to all radio communication services utilized in response to emergencies and disasters.

The Amateur Service should not be confused with “citizens band” or “personal radio” operations, which are forms of public networks. Amateur Radio operators have to pass an examination given by or on behalf of the respective national administration prior to the issuance of an individual, personal operator’s license. The International Amateur Radio Union (IARU) is the federation of the national Amateur Radio associations existing in most countries. It represents the interests of the Amateur Radio Service in the International Telecommunication Union (ITU) and in international conferences. The IARU supports emergency telecommunication applications of its members and ensures the exchange of information and experience among them.

9.1 The Roles of the Amateur Service in Emergency Telecommunications

Its wide scope of activities and the skills of Amateur Radio operators make the Amateur Radio Service a valuable asset in practically all sectors of emergency telecommunications. The following few points characterize this service:

- It has a large number of operational Amateur Radio stations in all regions and almost all countries of the world, providing a network which is independent from any other. It has in many cases provided the first and often for a long time only link with areas affected by disaster.

  Examples for this go back to the early days of radio, but are also found in most recent events, such as the role played when hurricanes hit islands in the Caribbean and the earthquake in Haiti in 2010. Even if they are not working with any served agency, radio amateurs report what they see and their situational awareness in the first hours can provide responders information on where to go and what to expect there.

- Their skills make Amateur Radio operators a prime human resource for emergency telecommunications. Many operators apply their skills and experience in the service of humanitarian assistance, be it temporarily as volunteers with governmental or non-governmental organizations, or as emergency telecommunication professionals with units of international organizations and other disaster response institutions.
- The training programs and emergency simulation exercises developed by some of the national Amateur Radio societies are applicable to all sectors of emergency telecommunications and can be adapted for training of all potential users of telecommunication in emergency situations.
- The technical documentation, literature and electronic resources, available for the Amateur Radio Service, are unique resources for information on how to solve problems with often very limited and possibly improvised means.

The importance of the Amateur Radio Service in emergency telecommunications has been recognized in many documents and was reconfirmed by the World Radiocommunication Conference WRC-2003 (Geneva, 2003), which modified article 25 of the Radio Regulations, facilitating emergency operations of Amateur Radio stations and related training of operators, and encouraging all States to reflect these changes in their national regulations.

9.1.1 Amateurs as Professionals – The Served Agency Relationship

In situations where a professional and helpful attitude is maintained, served agencies point with pride to Amateur Radio volunteer efforts and accomplishments. Although the name says “Amateurs,” its real reference is to the fact that they are not paid for their efforts. It need not imply that their efforts or demeanor will be anything less than professional.

No matter which agency is served, emergency management, the Red Cross or others, it is helpful to remember that volunteers are unpaid employees. The relationship between the volunteer communicator and served agency will vary somewhat from situation to situation, but the fact is that *the volunteers are working for the agency*. It doesn’t matter whether they are part of a separate radio group like the Amateur Radio Emergency Service (ARES®), or part of the agency’s regular volunteer force.

How Professional Emergency Responders Often View Volunteers

Unless a positive and long established relationship exists between professionals and volunteers, professionals who do not work regularly with competent volunteers are likely to look at them as “less than useful” and this attitude may carry over to volunteers in general. Police agencies are often distrustful of outsiders – often for legitimate information security concerns. Volunteers are often viewed as “part timers” whose skill level and dedication to the job vary widely. The establishment of relationships and joint training *before* an emergency is important.

Specific Agency Relationships

The relationship between the volunteer communicator and the served agency can be quite different from agency to agency, and even between different offices of the same agency. While many national communication groups have existing “Memoranda of Understanding” (MoU), sometimes called a “Statement of Understanding” (SoU) or “Statement of Affiliation” (SoA) in place with served agencies that define their general relationships, the actual working relationship is more precisely defined at the local level. Different people have different ideas and management styles, agencies in one area can have different needs from others, and these can affect the working relationship between the agency and its telecommunications volunteers. Emergency communications groups often have their own written agreements with their served agency’s local office.

9.1.2 Emergency Telecommunication Organizations & Systems

Such Emergency communication organizations are what make an efficient response possible.

They provide training, and a forum to share ideas and develop workable solutions to problems in advance of a real disaster so the response will occur more smoothly, challenges will be dealt with productively and the served agency's needs met.

9.2 Amateur Service Networks and their Ranges

Three types of radio networks are typical for the Amateur Radio Service, and all three are encountered in major disaster response operations.

9.2.1 Short-range networks

Typically these provide operational or tactical communications at the site of a disaster and with the surrounding areas. They can include fixed, mobile and portable equipment and are mostly using frequencies in the VHF and UHF spectrum.

9.2.2 Medium-range Networks

Typically these provide communication from the site of an event to organizational and administrative centers outside the affected area, or to headquarters of response providers in neighboring countries. They also ensure communication with vehicles, vessels and aircraft operating outside the coverage of available VHF or UHF networks. Communication at medium distances of 100-500 km may be accomplished by near vertical-incidence sky-wave (NVIS) propagation at the lower HF frequencies of up to about 7 MHz.

9.2.3 Long-range networks

These provide the links with headquarters of international emergency and disaster response providers. They also serve as backup connections between offices of such institutions in different countries or on different continents. Amateur stations routinely communicate over long distances, typically beyond 500 km, using oblique-incidence sky wave propagation in HF.

9.2.4 Amateur Service satellites

Satellites can serve as an alternative to HF sky wave links for medium and long-range communication. The Amateur Radio Service does not at this stage operate geostationary satellites or interlinked satellite constellations, its satellites cannot therefore provide continuous global coverage. The Amateur Radio satellite service uses specific frequencies within the allocated bands, mostly in the VHF range and above.

There are two primary types: the single-Channel “Repeater” Satellites and the Linear Transponder Satellites.

9.3 Operating Frequencies

Different from most other services, the Amateur Radio Service enjoys the privilege of band allocations, the use of which is left to the self regulation of the Amateur Radio associations. Flexible use of the rare commodity of frequency spectrum thus allows particular flexibility in operations. The allocated frequency bands are described and their characteristics given in 5.2. above. Within these bands, “Center of Activity” frequencies for emergency networks have been established by IARU.

In emergency situations, and when other means of communication are not available, any station of any service can establish contact on any frequency that it can technically operate on. In such a situation, stations of the Amateur Radio Service can be contacted, or can initiate contacts with, stations of other services such as the maritime or the land fixed or mobile service.

In some countries, specific frequencies (channels) have been defined as national emergency frequencies. Due to the dynamic use of frequencies within the allocated Amateur Radio bands, a permanent reservation of such channels outside times of acute emergencies is however problematic and a restrictive policy in respect to the use of the available spectrum might prove counter-productive. In some cases, national administrations have assigned frequencies adjacent to the allocated Amateur Radio bands to specific disaster response organizations, thus facilitating communications with stations of this service and allowing the use of Amateur Radio equipment and antennas with ease.

There is no worldwide IARU band plan. IARU band plans are adopted at the regional level by the three regional conferences. Inquiries concerning the band plans should be directed to the respective regional organizations:

- Region 1 - Europe, Africa, Middle East and Northern Asia.
- Region 2 (PDF) - the American Continent, east Pacific
- Region 3 (DOC) – India, SE Asia, Australia, west Pacific
- http://www.iaru.org/ituzonesc.gif - Map of IARU regions

9.4 Communication Modes

Stations of the Amateur Radio Service are authorized to use a wide variety of transmission modes, provided the allocated frequency bands, IARU and national band plans, and national regulations provide the bandwidth needed for the particular mode chosen. The selection of the appropriate mode in any specific case depends on numerous factors, including the volume and nature of the information to be transmitted, technical specifications of the equipment available and the quality of the communications link. The following communication modes are most commonly used in the Amateur Radio Service as well as in other services such as the Maritime and the fixed and Land Mobile Services:

- ***Radio Telegraphy:*** Use of the international *Morse code* is still widespread throughout the Amateur Radio Service and can play an important role in disaster communications, particularly when only elementary equipment or low transmitter power are available. The use of Morse code also helps to overcome language barriers in international telecommunications. Its effective use requires operators with skills greater than the minimum licensing requirements. Its primary asset is that Morse code can often be heard despite high background static and noise.
- ***Data communications:*** These have the advantage of accuracy and of creating records for later reference. Messages can be stored in computer memory or on paper. Digital data communication requires additional equipment such as a desktop or laptop computer communication interface, processor or modem. The communication processor performs encoding and decoding, breaks the data into transmission blocks for transmission and restores incoming data into a stream. It also compensates for transmission impairments, compresses and decompresses data, and handles analogue-to-digital and digital-to-analogue conversions. As with most computerized systems, developments are changing rapidly.

9.5 Repeater Stations

Repeater Stations or Relays are used to extend the communication range of VHF and UHF stations. The signals can be analog, such as VHF-FM, or digital, such as APRS and D-Star. Positioned in elevated locations they allow communication between fixed or mobile stations separated by obstructions such as mountains or tall buildings when operating in an urban environment. A repeater station receives on one channel and transmits on a different frequency, usually within the same band. Filters, so called duplexers, prevent interference between its simultaneously operating transmitter and the receiver. Important considerations for the location of a repeater station are not only its geographical coverage, but also its power requirements. Rechargeable batteries, supplied from solar cells or wind generators are the most common solutions. Special forms of repeaters are the analog or digital transponders such as used in the satellites of the Amateur Radio satellite service. Like terrestrial relays, they re-transmit a received signal on a different frequency; their geographical coverage or “footprint” is however much larger. Transponders on board balloons or aircraft have successfully been used by radio amateurs and might be available as an additional tool for emergency telecommunications. Digital transponders have the capability to store received messages, and to re-transmit them on demand, at the time when the receiving station is within their range.

9.6 The Organization of Amateur Radio Emergency Service

The Amateur Radio Service is a continuous activity. At any given time, at least some networks and operators of this service are available and can assume a role in emergency telecommunications without delay. Additional resources can be mobilized on very short notice. But for an efficient application of the service to emergency and disaster response, a higher degree of preparedness, including training, exercises and mobilization procedures, is desirable.

The structures of cooperation between the Amateur Radio Service and the national authorities, emergency services and disaster response providers depend on the situation in each country. The outline presented in the following sections is mostly based on the concepts used in the USA. The general principles should however be applicable in most parts of the world. In all cases, decisive factors include the number of Amateur Radio stations involved and the number of certified operators, as well as the structures of national response mechanisms.

Amateur Radio emergency communications is provided by several different types of emergency telecommunications organizations; ARES®, RACES, ACS, SKYWARN, SATERN, REACT, etc. All play an important part in serving their communities.

9.6.1 The Amateur Radio in Emergency Service

While the Amateur Radio Emergency Service® (ARES®), sponsored by the American Radio Relay League, has the longest history of public service of any Amateur Radio emergency telecommunications provider organizations, ARES is not an organization itself but a volunteer *program* of the ARRL and consists of licensed amateurs who have voluntarily registered their qualifications and equipment for telecommunications duty in the public service when disaster strikes. While local groups may use the name ARES, it signifies only their primary activity is in participation with the overall program. The only qualification, other than possession of an Amateur Radio license, is a sincere desire to serve.

All licensed amateurs are eligible for membership in ARRL’s ARES program. Members of ARES groups either use their own personal emergency-powered equipment, or operate equipment that the group has acquired and maintains specifically for emergency telecommunications.

Even a cursory look through the membership of the IARU shows that different countries have adapted Amateur Radio’s capabilities to their emergency needs in different ways. While some countries such as the USA are based on volunteers, others are founded upon governmental agencies. In addition, there are specialized groups such as Search and Rescue which use Amateur Radio communications as a tool for other goals and not for the communications itself. In many regions the linkage between Amateur Radio emergency groups and the national society may be quite thin. Despite this, Standard Operational Procedures (SOP) are a key element in all emergency operations. In emergency telecommunications such SOP need to be in place in particular on message format and handling, the use of simplex channels, repeater operations, and on station identification. Following such standard principles of operations is preferable to the introduction of new and possibly not previously exercised ad hoc procedures.

Training – Amateur Radio operators may not need training on basic communication skills or general technical matters. They do however need to become familiar with the operational environment and with the partners they may serve. To provide for this, many ARES groups develop Memoranda of Understanding (see section 5.1.a) which provide for regular joint exercises.

Training should focus on the following subjects: emergency telecommunications, 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. A drill or test that includes interest and practical value makes a group motivated to participate because it is purpose or goal oriented. 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.

Exercises – Drills should include the activation of emergency networks; including the assignment of mobile stations to served agencies, the originating and processing of messages and the use of emergency-powered equipment. As warranted by traffic loads, liaison stations may need to be assigned to receiving traffic on a local network 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.

The Emergency Operations Center (EOC) or Command Post (CP) is usually established by the authorities in charge of a disaster response operation. 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 to 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 telecommunications, concentrate on gathering data from all partners involved, and mobilize and dispatch the requested means of response.

9.6.2 Traffic handling

"Traffic" refers to the messages being sent. "Traffic handling" includes the forwarding of messages from and to others outside the circle of Amateur Radio operators. Where national regulations allow, Amateurs Radio stations can handle such third party traffic both in routine situations and in times of disaster. To do this efficiently, networks of radio operators are created. Network structures differ in the various countries.

The types of networks include

Open (Informal) Nets

During an open emergency net, there is minimal central control by a Net Control Station, if indeed there is an NCS at all. Stations call one another directly to pass messages. Unnecessary chatter is usually kept to a minimum. Open nets are often used during the period leading up to a potential emergency situation and as an operation winds down, or in smaller nets with only a few stations participating.

Directed (Formal) Nets

A directed emergency net is created whenever large numbers of stations are participating, or where the volume of traffic cannot be dealt with on a first-come first-served basis. In a communication emergency of any size, it is usually best to operate a directed net. In such situations the NCS can prioritize traffic by nature and content.

In a directed net, the NCS controls all net operations. Check-ins may not "break into" (interrupt) the net or transmit unless specifically instructed to do so by the NCS, or unless they have an emergency message. The NCS will determine who uses the frequency and which traffic will be passed first. Casual conversation is strongly discouraged and tactical call signs will probably be used. Tactical call signs can be assigned to stations at various sites, locations and different purposes. For example mobile operators can often be assigned the sign "rover 1", "rover 2" and so on.

At his/her discretion, the NCS operator may often elect to create a “sub net” depending on the volume of traffic and its content and nature. In this case a “sub net” NCS may be appointed to take over the newly created net. (See tactical nets below).

The message formats chosen to handle traffic on a network depends on operational conditions and its selection requires 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 network frequencies, characterize most typical tactical communications. One way to make tactical network operation transparent is to use tactical call-signs, i.e. words that describe a function, location or agency, rather than call signs of the Amateur Radio Service. When operators change shifts or locations, the set of tactical calls remains the same. Call-signs like “Event Headquarters”, “Network 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 their formal, assigned, individual call signs.

9.6.3 Typical Situations for Amateur Radio Emergency Telecommunications

Despite the wide spectrum of requirements in a disaster situation, Amateur Radio operators should neither seek nor accept any duties other than those foreseen in the agreements regarding their status in an emergency operation. Volunteer communicators are not the decision makers in relief operations. We only provide telecommunications in support of those who do the actual emergency response.

Operators with skills in other fields such as search and rescue or first aid and affiliation to respective organizations need to decide in advance, which role they wish to accept within an operation.

- ***Initial Emergency Alerts*** may originate from individual Amateur Radio operators using their equipment and networks to bring an incident to the attention of the competent institutional emergency services. In many sudden disasters such as earthquakes, telephone and Internet communications were disrupted or overwhelmed in the first minutes and radio amateurs provided the first situational awareness reports that were used by responding agencies.
- In ***Search and Rescue*** operations, operators of the Amateur Radio Service can reinforce the professional teams by increasing their communication capabilities but also by making and reporting their own observations.
- ***Damage Surveys*** not only need communications between survey teams, but may have particular need for the abilities of APRS (section 5.4) to plot their location on a map using GPS in real time. When neighborhoods are destroyed, such as in a tornado, it can be hard to know just where you are as the normal landmarks no longer exist.
- ***Hospitals*** and similar establishments might in the aftermath of a disaster be without communications. In particular the coordination among various providers of health services may be compromised. While Amateur Radio cannot be used for normal or business purposes, a hospital based ARES operator might temporarily serve as replacement to a paging system and maintain critical interdepartmental communications. Local Amateur Radio emergency groups should prepare in advance for such hospital communications and ARES groups should be familiar with the communication structures they might be asked to replace.
- ***Hazmat Spills*** and other incidents involving hazardous materials may require the evacuation of residents and the coordination between the disaster site, command centers and the evacuation sites or shelters. ARES operators may be asked to establish communications with such institutions.

- ***Severe Weather Nets* are** a common use of radio amateurs in both a prevention and response role. While the National Weather Service's SKYWARN® program covers the USA, the Hurricane Watch Net covers the Caribbean and western Atlantic. Both report on observed conditions at ground level, often augmenting radar systems handicapped by the earth's curvature.

9.7 Third Party Communications in the Amateur Service

Under normal circumstances an, Amateur Service link connects two parties communicating with each other. In emergency situations, operators will 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 from a station of the Amateur Service, located and licensed in one country, is destined for a third party in another country, the Radio Regulations (RR) of the ITU concerning international third party traffic need to be respected. They provide that in the Amateur Radio Service such traffic is allowed only if a bilateral agreement exists between the national Administrations concerned, or in case of emergency operations and training for such. 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 be aware that it is a general rule for all radio communications that when safety of life and property is at stake, administrative regulations can be temporarily waived. Article 25 of the Radio Regulations, governing the Amateur Service, has been revised by the World Radiocommunication Conference (WRC-03, Geneva, 2003) to the effect, that third party traffic is authorized for emergency operations and related training.

9.7.1 Cautions and Confidentiality

Items that should never be sent include financial information, bank or credit card numbers, driver license or Social Security numbers, or any personal details that could lead to identity theft.

In some instances, the served agency may allow you to send certain "sensitive" information over more "discrete" modes, such as packet or other digital mode such as D-Star, Winlink or PSK 31, but be sure they fully understand that ***no Amateur mode can be considered truly "secure."*** The served agency is the ultimate authority on which information can or cannot be sent, and by which modes. You will need to make any agency aware in advance that the security of Amateur Radio telecommunications for confidentiality can never be guaranteed.

9.8 Optimizing the Use of the Amateur Service as a Public Service

The Amateur Radio operator is able to communicate using the widest variety of tools, and the Amateur Radio Service often makes the difference between "no communication" and a maybe less user-friendly, but functioning telecommunications. The fact that personal mobile communications are becoming readily available to the majority of the people worldwide does not make their users skilled communicators; they are merely consumers and not active participants. In an emergency situation, communication such as that provided by radio amateurs continues to play a critical role. It is up to the national administrations and to the providers of emergency response, to keep making best use of this time proven, invaluable resource. The most efficient way to achieve this is through establishing joint training exercises incorporating Amateur Radio elements with other response organizations.

Emergency training courses for Amateur Radio operators are available from several sources and many are listed in the toolkit files. What is the ICS?

The Incident Command System is a management tool designed to bring multiple responding agencies, including those from different jurisdictions, together under a single overall command structure. Before the use of the ICS became commonplace, various agencies responding to a disaster often fought for control, duplicated efforts, missed critical needs, and generally reduced the potential effectiveness of the response. Under ICS, each agency recognizes one "lead" coordinating agency and that person will handle one or more tasks that are part of a single over-all plan, and interact with other agencies in defined ways.

The Incident Command System is based upon simple and proven business management principles. In a business or government agency, managers and leaders perform the basic daily tasks of planning, directing, organizing, coordinating, communicating, delegating and evaluating. The same is true for the Incident Command System, but the responsibilities are often shared among several agencies. These tasks, or functional areas as they are known in the ICS, are performed under the overall direction of a single Incident Commander (IC) in a coordinated manner, even with multiple agencies and across jurisdictional lines. The ICS also features common terminology, scalability of structure and clear lines of authority.

For detailed information, see ARES Level 1 Unit 16 in the toolkit.

9.8.1 What to Expect in Large-Scale Disasters

Based on experiences over several years with many agencies and situations, a general pattern of initial communications problems may be expected.

What happens to critical communication assets during the onset of major disaster conditions? First, there is a huge increase in the volume of traffic on public-safety radio channels, accompanied by prolonged waiting periods to gain access. As the disaster widens, equipment outages frequently occur at key locations. Messages are not handled in order of priority, and urgent messages can be lost.

As agencies respond, the need arises for agencies to communicate with one another but many agencies have incompatible radio systems and use unfamiliar or unattainable frequencies, names, terms and procedures. Most agencies are reluctant to use another agency's system, or to allow theirs to be used by others. Simultaneously with a high volume of message traffic, stations must cope with messages having widely differing priorities. Also, priority and precedence designations differ among agencies if any are used at all.

Operational problems arise such as:

- High-volume traffic circuits with no supply of message forms.
- Using the only printed forms available that were designed for a different, unrelated agency or function.
- Attempting to decipher scribbling from untrained message writers;
- Using scribes who cannot understand radio parlance
- Becoming inundated with traffic volume so heavy it results in confusion over which messages are to be sent, which were sent, which have been received for delivery, and which have been received to be filed for ready reference.

9.8.2 The Incident Command System

The National Incident Management System (NIMS) developed in the USA provides a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work seamlessly to prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity, in order to reduce the loss of life and property and harm to the environment. It's heart is the ICS.

Chapter 10

Broadcasting

10 Introduction

Broadcast (Radio and TV) is a very powerful means to reach large sections of the public with information and advice. National regulations and customs differ from place to place as to how information is given to the public.

In some cases, the broadcaster allows only content created by their own staff, to be transmitted. Own presenters, principally news anchors, will make the announcements over the air. They will initiate a "News Flash" for this purpose, and interrupt normal programming. Journalists like to establish links with "Reliable Sources" in advance, so that they know who is the spokesperson for the government. Governments need to understand that journalists are trained to gather and then spread information, so if government spokesmen are giving out old and inaccurate information, journalists tend to dig and search information by themselves. To the citizens, the government will look slow and incompetent if all the details only come from the independent journalist. Since this may backfire after the event, it is important to engage with the media very early providing as accurate and timely information as possible.

Today, there is also a tendency for news journalist to want to appear to be "on the spot". They often quote commentators close to the scene of the event rather than those in the studio located in the capital. For this reason, there is need for government to move with this trend by setting up "media cities" close to the incident, but out of the "Hot Zone'. The media need locations for their cameras (preferably one where they can see the Hot Zone) and where their communications trucks can be safety sited. Creating a place where well informed spokespersons are located, and there is food, drink, power and broadband telecoms encourages the media to get its information from the right sources rather that from some uniformed and unreliable sources.

The Emergency Alert System (EAS), as is used in the USA is an example of another approach. By government mandate or voluntary participation, broadcasting stations are connected to an EAS data communications system. If there is an alert, a data burst is sent to the TV or radio stations in the countries concerned. In most cases, the running program is interrupted by a data burst transmitted over the air.

People can buy a decoder to read what the message says. Even radios playing pre-recorded music are interrupted with a special alert message. Today, most countries use this facility to warn drivers on road and traffic conditions. In the case of TV stations, a scrolling text bar can appear across the screen making clear text announcements.

Remote "opt out" is a system whereby a local radio station, (this may be automatic at night), can be controlled by another studio, say in the capital city. Local radio stations are often controlled by a clock, which switches to the big studio at news time, then back to local content at other times. By means of an out system, the main studio can cause the local station to stay connected to the news studio until the emergency announcements have been completed. The problem is that the local radio station may as a result fail to fulfill its obligation to transmit scheduled advertisements thus losing revenue. Some sort of agreement about this before it is done is required.

To ensure that this service is active all the time, planners should arrange for back up power and secure communications for broadcasting transmitters and their studios.

10.1 Mobile Emergency Broadcasting

Mobile Radio Stations can be quickly and cheaply moved into the affected area. However, locals should have powered radios or even wind up radios for them to be able to turn in. This is an efficient way of reaching out many people in the shortest time. However, there are a lot of political considerations to take into account.

Full consultation with relevant government authorities is imperative. Some governments are concerned about a free flow of information in times of national crisis. The concern is that certain broadcasts can cause panics if not well crafted.

Chapter 11

New Technologies and New Practices

11 Introduction

The continuous development in all sectors of communications can be reflected only in the format of an up-datable resources. The on-line tool-kit, which is part of this new version of the handbook is such a resource, and the following text can only give an overview of what research and developments are in progress at the time of publication.

11.1 The Common Alerting Protocol (CAP)

The Common Alerting Protocol (CAP) is a simple but general format for exchanging all-hazard emergency alerts and public warnings over all kinds of data networks. Approved by ITU-T in September 2007 as Recommendation x.1303, the CAP specification was formalized by the Organization for the Advancement of Structured Information Systems (OASIS).

CAP is a technical expression of a modern approach to warning systems. In accordance with social science research, CAP facilitates the coordination of multiple warning delivery systems in order to maximize warning effectiveness both in technical terms (reach and reliability) and psychological ones (corroboration and reinforcement.) Any single warning dissemination system can fail from time to time, and no single technology can always reach every desired recipient. More critically, individuals and groups have proven much more likely to actually take prompt protective action if a warning message is received consistently by multiple coordinated means. And yet the issuers of emergency alerts can ill afford additional, duplicative tasks.

The CAP message format, expressed either in XML (eXtensible Markup Language) or ASN.1 (Abstract Syntax Notation One), comprises the essential elements of any warning in a format independent of any particular transmission medium. This “Platonic Ideal” of the warning message can then be transformed as needed into the native format of delivery methods as diverse as sirens, flags, radio and TV broadcasts, digital and “social” media. While the form of the individual presentations will vary from medium to medium, the essential content cannot help but be consistent, and the alert message needs only to be composed and issued once.

The CAP format is a template for a complete and effective warning message. It can include text in multiple languages as well as digital attachments. Foreseeable alert texts can be prepared in advance and merely edited with up-to-the-minute details prior to issuance.

CAP alert messages support digital signatures that can be applied to ensure the authenticity and integrity of alerts from origination to delivery and for future reference. Thus CAP lends itself to the construction of integrated warning systems that allow multiple authorized originators to utilize multiple federated warning delivery methods quickly and effectively.

CAP is the foundation technology for the U.S. federal Integrated Public Alert and Warning System (IPAWS) and numerous other systems worldwide.

11.2 Developments with potential Application to Emergency Telecommunications

a) Cell Broadcasting was discussed in previous chapters on mobile networks. Increasingly, there is use of SMS-CB to broadcast information. SMS-CB causes short text messages in selectable languages to appear on the screen of the mobile phone, and then set off the alert tone. Advantages of SMS-CB vs. normal SMS.

- It transmits to everyone at the same time, taking about 20 seconds to deliver.
- It does so over dedicated broadcast channels, and thus neither causes, nor is affected by overload of the network.
- The sender of the message can select a single cell, or any number of cells to make the area of warning as big or as small as is required.

b) Cellular Emergency Alert Systems Association (CEASA) is one international organization that is seeking to develop and deploy a network of government-to-citizen warning systems, which deliver messages to users via cell broadcast.

c) IP Telephony is growing in popularity. It should be noted that a normal Internet application such as email or the web browser is not very sensitive to delays. Voice on the other hand is very sensitive to delay and will cause unintelligible words breaking if there are delays on the route.

Unlike conventional networks, IP packets can be stored in routers being queued for outgoing transmission. During an emergency, loading may make the output queues quite long and some packets may be discarded. IP telephony does not use TCP to request for a new packet resulting in the chopping of voices. The only way to avoid this is to use a well managed IP network to keep the loading and delays down to the barest minimum.

d) DVB

Digital video broadcast uses TV satellites to provide Internet access. It has the advantage of being significantly cheaper than conventional systems, but like any IP based system, suffers from contention at busy times. In other words it may be used with difficulty in times of emergencies.

e) ISTOS

ESA's concept for an Integrated Space Technologies Operational System (ISTOS) Wide Area Network. It is designed to improve the utilization of space technologies by end users working in the field of emergency management, by allowing the efficient interconnection of emergency application users to data and service providers, using integrated space technologies in telecommunications, earth observation and navigation.

f) STANAG is an emerging standard for HF data radio. This is a NATO standard for 9.6 kbit/s data over HF. Its deployment in emergency situations is yet to be tested.

g) Digital Trunked Radio Systems

We are witnessing the deployment on a wide-scale of Digital Trunked Radio Systems such TETRA (system offering advantages in terms of clarity, wide-area coverage, rich terminals and high security). In general the following are key elements associated with these systems:

- The old analogue systems were notoriously insecure and easy to listen into unless a secure encryption system was used. Digital systems normally feature very robust security such that even if a casual listener were to tune-in, data would appear as garbage.
- All terminals are uniquely identifiable. These will not be granted access to the system unless they are valid on that particular system and on the requested talk groups. In addition, each terminal can be remotely stunned or killed in case of it being lost. There is therefore no risk of an unauthorized person using a lost and found terminal.
- Digital systems are capable of transmitting both voice and data. They are also capable of point-to-point connection as well as mobile phone like through connection.

- Thanks to voice coding and compression, modern systems have up to 4 times more capacity than analogue services. As a result, there are more talk groups available thus remarkably reducing congestion.
- Whereas the traditional systems arranged talk groups on geographical basis, due to the need to use repeaters, trunked systems eliminates this problem making it possible to deploy talk groups on tactical basis which is much more convenient.
- Signals are cleaner and clearer thanks to speech coding and noise including squelch noise are eliminated thanks to speech coding.
- Many systems such as TETRA have a "simplex" mode otherwise known as "direct mode".
- Trunked networks can take the form of simple stand-alone repeaters or form more complex national networks. In disaster operation, it is advisable for several agencies to club together to build a single wide-area-network. There remains an option for the agencies to maintain separate talk groups or to have inter-agencies common talk groups that make and facilitate coordination. This however, requires that terminals are available to all agencies. Interworking could be a solution as terminals could be made available at least in the control room of other agencies. This is however, a subject yet to be dealt with by senior management at agency level as it possess a lot of challenges.

Annex: List of Acronyms

NOTE – This list aims to cover the main acronyms used in this handbook, but it is not exhaustive.

AM	Amplitude Modulation
APCO	Association of Public-Safety Communications Officials
APRS	Automatic Packet Reporting System
ARES	Amateur Radio Emergency Service
ASN1	Abstract Syntax Notation One
BAN	Wireless Body Area Networks
BGAN	Broadband Global Area Network
CAP	Common Alerting Protocol
CCITT	International Telegraph and Telephone Consultative Committee (Comité Consultatif International Téléphonique et Télégraphique)
CEASA	Cellular Emergency Alert Services Association
COTS	Commercial Off-The-Shelf
COW	Cell On Wheels
DDI	Direct Dial-In
DECT	Digital Enhanced Cordless Telephones
DHA	Department of Humanitarian Affairs (UN, now OCHA)
DIMRS	Digital Integrated Mobile Radio System
DSC	Digital Selective Calling
DVB	Digital Video Broadcasting
EAS	Emergency Alert System (USA)
EDACS	Enhanced Digital Access Communication System
ELT	Emergency Locator Transmitter
EOC	Emergency Operations Center
ETSI	European Telecommunications Standards Institute
FM	Frequency Modulation
FTP	File Transfer Protocol
GALILEO	Global Navigation Satellite System (GNSS)
GETS	Government Emergency Telecommunications Service (USA)
GHz	Gigahertz
GIS	Global Information System
GLONASS	Global Navigation Satellite System (Globalnaya navigatsionnaya sputnikovaya sistema)
GMDSS	Global Maritime Distress and Safety System
GMPCS	Global Mobile Personal Communication Systems

GPS	Global Positioning System
GSM	Global System for Mobile Communications
HF	High Frequency
HTTP	Hypertext Transfer Protocol
IARU	International Amateur Radio Union
ICET-98	Intergovernmental Conference on Emergency Telecommunications
ICRC	International Committee of the Red Cross
ICS	Incident Command System (USA)
ICT	Information and Communications Technology
IDNDR	International Decade for Natural Disaster Reduction, now UNISDR, International Strategy for Disaster Reduction
IEEE	Institute of Electrical and Electronics Engineers
IFRC	International Federation of Red Cross and Red Crescent Societies
IMO	International Maritime Organization
IP	Internet Protocol
IPAWS	Integrated Public Alert and Warning System
ISTOS	Integrated Space Technologies Operational System
ITU	International Telecommunication Union
ITU-D	ITU Development Sector
ITU-R	ITU Radiocommunication sector
Kbit/sec	Kilobit per Second
KHz	Kilohertz
LAN	Local Area Network
LES	Land Earth Station
LMR	Land Mobile Radio network
LTE	Long Term Evolution
MAN	Metropolitan Area Network
MHz	Megahertz
MMSI	Maritime Mobile Service Indicator
MoU	Memorandum of Understanding
NCS	Net Control Station
NGO	Non Governmental Organization
NIMS	National Incident Management System
NOTAM	Notice To Airmen
OASIS	Organization for the Advancement of Structured Information
OCHA	Office for the Coordination of Humanitarian Affairs
PABX	Private Automatic Branch Exchange

PAN	Wireless Personal Area networks
PBX	Private Branch Exchange
PCI	Peripheral Component Interconnect
PCM	Pulse-Code Modulation
PLB	Personal Locator Beacon
PPDR	Public Protection and Disaster Relief
PSK	Phase Shift Keying
PSTN	Public Switched Telephone Network
PTT	Push-To-Talk
RACES	Radio Amateur Civil Emergency Service
RBS	Radio Base Stations
REACT	Radio Emergency Associated Communication Teams
RETC	Regional Emergency Planning Committee
ROBO	Remote Office-Branch Office
RR	Radio Regulations of ITU-R
RTTY	Radio Teletype
SAS	Satellite Access Stations
SATERN	Salvation Army Team Emergency Radio Network
SDR	Software Defined Radio
SELCAL	Selective Calling
SET	Simulated Emergency Test
SMS	Short Message Service
SMS-CB	Short Message Service-Cell Broadcast
SoA	Statement of Affiliation
SOHO	Small Office-Home Office
SOLAS	International Convention for the Safety of Life at Sea
SOP	Standard Operational Procedures
SoU	Statement of Understanding
SRSA	Swedish Rescue Services Agency
TCO	Telecommunications Coordination Officer
TCP	Transmission Control Protocol
TCPIP	Transmission Control Protocol/Internet Protocol
TETRA	Terrestrial Trunked Radio
TIA	Telecommunications Industry Association
UHF	Ultra High Frequency
UN	United Nations
UNDAC	United Nations Disaster Assessment and Coordination

UNDP	United Nations Development Programme
UNDRO	Office of the United Nations Disaster Relief Coordinator (now OCHA)
UNHCR	United Nations High Commissioner For Refugees
UNICEF	United Nations Children's Fund
USB	Upper Side Band
UWB	Ultra Wide Band
VHF	Very High Frequency
VOIP	Voice Over IP
VSAT	Very-Small-Aperture Terminal
WAN	Wide Area Network
WFP	World Food Programme
WGET	Working Group on Emergency Telecommunications
WHO	World Health Organization
WIFI	Wireless Local Area Network
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop
WRC	World Radiocommunication Conference
WTDC	World Telecommunication Development Conference
XML	eXtensible Markup Language

Appendix 2: Online Toolkit Mapping for Handbook on Emergency Telecommunications.

International Telecommunication Union

ITU HANDBOOK ON
EMERGENCY TELECOMMUNICATIONS
ONLINE TOOLKIT MAPPING

(online edition 2013)

In light of rapidly changing technologies, and new information continuously learned from new disasters each year, the objective of Question 22-1/2 was not only to update the Handbook on Emergency Telecommunications, but also to provide the content online, and in a format that could (1) be more easily and quickly updated and amended; (2) allow for links to information resources (Resolutions, Recommendations, Reports) within the ITU and (3) provide links to external resources on emergency preparedness and disaster communications for reference by readers in lieu of duplicating the efforts of other expert groups.

The following Appendix provides a proposed mapping of the Handbook contents to online Resources applicable to the content of the Handbook. It is expected that in 2014, the BDT may be able to include the Handbook on the ITU website and that this mapping can serve as a guide for how the content will be placed online. Importantly, by visiting these links, visitors to the ITU website will be able to have access to a number of other Reports, Guidelines, Handbooks and Multi-media tools to support disaster communications preparedness.

Importantly, this is not intended to serve as a comprehensive listing of web resources, but can be updated regularly by Question 22-1/2 and the BDT Programme 5 as new information is obtained. It will be a living resource where ITU Members can continuously contribute new information resources that will particularly benefit developing countries.

Online Tookit

Preface

Chapter 1: Telecommunications for Disaster Mitigation and Relief

Chapter 2: Organizational Framework of Emergency Telecommunications

United Nations Entities

- UN Office for the Coordination of Humanitarian Affairs (OCHA)
  - www.unocha.org
- UN Working Group on Emergency Telecommunications (WGET)
  - http://www.humanitarianinfo.org/iasc/pageloader.aspx?page=content-subsidi-common-default&sb=13
- UN Disaster Assessment and Coordination (UNDAC) teams
  - http://www.unocha.org/what-we-do/coordination-tools/undac/overview
- UN Development Programme (UNDP)
  - http://www.undp.org/content/undp/en/home/ourwork/crisispreventionandrecovery/overview.html
- World Food Programme (WFP)
  - http://www.wfp.org/emergencies
- UN High Commissioner for Refugees (UNHCR)
  - http://www.unhcr.org/pages/503352e46.html
- World Health Organization (WHO)
  - http://www.who.int/topics/emergencies/en/
- UN Children's Fund (UNICEF)
  - http://www.unicef.org/emergencies/index.php

International Telecommunications Union

- ITU Development Sector (ITU-D)
  - http://www.itu.int/ITU-D/emergencytelecoms/
- ITU Radiocommunication Sector (ITU-R)
  - http://www.itu.int/ITU-R/index.asp?category=information&rlink=emergency&lang=en
- ITU Standardization Sector (ITU-T)
  - http://www.itu.int/ITU-D/emergencytelecoms/

International Non-Governmental Organizations

- International Committee of the Red Cross (ICRC)
    - http://www.icrc.org/eng/
- International Federation of Red Cross and Red Crescent Societies (IFRC)
    - http://www.ifrc.org/en/what-we-do/disaster-management/

National Governmental Institutions Providing International Assistance

- Swedish Rescue Services

General Guidelines and Reports Related to Emergency Communications

- Compendium on ITU's Work on Emergency Telecommunications (2007)
- ITU Best Practice on Emergency Telecommunications (2007)
- Humanitarianism in the Network Age – including World Humanitarian Data and Trends 2012 (UN OCHA)
    - http://www.unocha.org/hina
- ITU Framework for Cooperation in Emergencies
    - http://www.itu.int/ITU-D/emergencytelecoms/events/global_forum/ITU_IFCE.pdf
- Recommendations To Enhance Information and Communications Technology (ICT) Aspects of U.S. International Disaster Response
    - http://www.state.gov/e/eb/adcom/acicip/disasterresponse/179203.htm
- Question 22-1/2 Case Studies on Disaster Preparedness Frameworks and Plans
    - Japan
    - Burkina Faso
    - People's Republic of China
    - Cote d'Ivoire
    - Cameroon
    - Democratic Republic of Congo

Chapter 3: The Regulatory Framework

- Tampere Convention
    - http://www.itu.int/ITU-D/emergencytelecoms/tampere.html
- Example Regulatory Best Practices and Regulatory Frameworks
- National Coordinating Bodies
    - Canadian National Emergency Telecommunications Committee (NETC)
        - http://www.ic.gc.ca/eic/site/et-tdu.nsf/eng/wj00048.html
- Telecommunications Operators and Business Continuity Planning Examples
- Training, Exercises and Simulations

Chapter 4: Telecommunications as Tools for the Providers of Emergency Response

Chapter 5: Terrestrial Communications Systems

- Recommendation ITU-R F.1105-2, Fixed wireless systems for disaster mitigation and relief operations.
- Recommendation ITU-R M.2009, Radio interface standards for use by public protection and disaster relief operations in some parts of the UHF band in accordance with Resolution 646 (Rev.WRC-12).
- Recommendation ITU-R M.2015, Frequency arrangements for public protection and disaster relief radiocommunication systems in UHF bands in accordance with Resolution 646 (Rev.WRC-12).
- Recommendation ITU-R M.1637, Global cross-border circulation of radio communication equipment in emergency and disaster relief situations.
- Recommendation ITU-T X.1303, Common alerting protocol (CAP1.1).
- Recommendation ITU-T L.92, Disaster management for outside plant facilities.
- Recommendation ITU-T E.106, International Emergency Preference Scheme for disaster relief operations (IEPS).
- Recommendation ITU-T E.107, Emergency Telecommunications Service (ETS) and Interconnection Framework for National Implementations of ETS.
- Recommendation ITU-T E.161.1, Guidelines to select Emergency Number for public telecommunications networks.
- Recommendation ITU-T Y.1271, Framework(s) on network requirements and capabilities to support emergency communications over evolving circuit-switched and packed-switched networks.
- Recommendation ITU-T Y.2205, Next Generation Networks - Emergency Telecommunications - Technical Considerations.
- Report ITU-R M.2014-2, Digital land mobile systems for dispatch traffic.
- Report ITU-R M.2033, Radio communication objectives and requirements for Public Protection and Disaster Relief (PPDR).
- ITU-D Report on Guidelines for using a content standard for alerts and notifications in disasters and emergency situations (2008).
- Example Technology Case Studies from Question 22-1/2
  - Super Base Stations – China
  - Korea Government Radio Network

Chapter 6: Satellite Communications Systems

- Recommendation ITU-R S.1001-2, Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations.
- Recommendation ITU-R BO.1774-1, Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief.

- Recommendation ITU-R M.1854-1, Use of the mobile-satellite service for disaster response and relief.
- Report ITU-R S.2151-1, Use and examples of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief.
- Report ITU-R M.2149-1, Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies.
- Guidelines for Implementation of Satellite Telecommunications for Disaster Management in Developing Countries – ITU-D Study Group 2 Report.
  -
- Case Studies from Question 22-1/2
  - SaaS type application services in support of Earthquake Recovery (Fujitsu)
  - Emergency.lu (SES)
  - Role of MSS in Hurricane Felix – Nicaragua (Télécoms Sans Frontières)
  - Use of Satellite Systems in Gulf Coast Hurricanes (Iridium Satellite)
  - Role of satellite in Telemedicine during Pakistan Earthquake (Pakistan)
  - Satellite Radio (Bangladesh)

Chapter 9: The Amateur Service

- Recommendation ITU-R M.1042-3, Disaster communications in the amateur and amateur-satellite services.
- Recommendation ITU-R M.1043-2, Use of the amateur and amateur-satellite services in the developing countries.
- Recommendation ITU-R M.1044-2, Frequency sharing criteria in the amateur and amateur-satellite services.
- Report ITU-R M.2085-1, Role of the amateur and amateur-satellite services in support of disaster mitigation and relief.
- International Amateur Radio Union
  - http://www.iaru.org/
  - Links to regional chapters of IARU
- Case Studies in Use of Amateur Service from Question 22-1/2

Chapter 10: Broadcasting

- Recommendation ITU-R BT.1774-1, Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief.

Chapter 11: Space Science Services

- Recommendation: ITU R RS.1859, Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies.

Chapter 12: New Technologies and New Practices

- Case Studies from Question 22-1/2
  - SaaS type application services in support of Earthquake Recovery (Fujitsu)
  - Emergency.lu (SES)

Appendix 3: Handbook on Telecommunication Outside Plant in Areas Frequently Exposed to Natural Disasters

International Telecommunication Union

ITU HANDBOOK ON
TELECOMMUNICATION OUTSIDE PLANTS IN AREAS FREQUENTLY EXPOSED TO NATURAL DISASTERS

(online edition 2013)

Table of Contents

Chapter 1

Natural disasters and their management

1 Introduction

This chapter gives the definitions of the terms hazards, emergency, disaster and catastrophe which are widely used in this Handbook. Moreover there is a description of the characteristics of the most frequent natural disasters and of the methods for measuring their intensity. The four phases of disaster management for facing the effects of a hazard are also described as the basic role played by telecommunications in emergency management.

1.1 Hazards/emergencies/disasters/catastrophes

Hazards, emergency, disasters and catastrophes seem like different words that mean similar things, however, differences do exist. In disaster management it is important to distinguish the meaning of these terms.

A *hazard* is a source of danger or an extreme event that has the potential to affect people, property and the natural environment in a given location. There are a variety of risks in our natural environment. These risks include both healthy and safety danger which vary by location. For example tsunami dangers do not exist in places which are very far from the run-up zone at the ocean shore, while tsunami hazards are significant on the ocean coast.

To reduce the potential for casualties and damage from hazards, it is necessary to change the physical processes that generate hazardous events or change people behavior by living in less dangerous locations, building hazard-resistant structures, or improving the ability to respond and recover from extreme events.

The term *emergency* is used in two slightly different ways. First, the term is used to describe minor events that cause a few casualties and a limited amount of property damage. Common emergency include car crashes, house fires and heart attacks. Fire departments, police departments and emergency medics are the first responders to these events. These events affect few people, so only a few community agencies need to respond. In addition, these events are well understood, so communities have standard operating procedures for responding to them.

Second, the term emergency can refer to an imminent event. For example, a hurricane that is 48 hours from landfall creates an emergency situation because there is little time to respond. The urgency of the situation requires prompt and effective action. Unlike with the previous use of the term emergency, the event is not occurred, but the consequences are likely to be major, so many community agencies need to mount a coordinated response.

In this Handbook the term emergency is used in the second meaning as defined in ITU-T Recommendation L.81: “An emergency is a sudden, urgent, usually unexpected occurrence or event requiring immediate action.”

Disasters are sudden occasions that seriously disrupt social routines, cause adoption of unplanned actions to adjust to the disruption, and endanger valued social objects. They are defined by human casualties, property damage, and severe social disruptions. A volcanic eruption can produce massive environmental disruption. This can occur through lava flows, ash falls and mud flows. However, it is not a disaster unless it directly impacts people or the human use system in some fashion. Disasters interrupt the ability of major community systems to afford reasonable conditions of life. This means that significant subsystems in a community no longer work to allow people to pursue their work, recreation and other activities. A town's public health protections (sewage treatment or fresh water systems) may fail. The utility system may no longer provide electricity. The hospital system may no longer be able to accommodate as many patients. The telecommunication services can be interrupted.

ITU-T Recommendation L.81 gives the following definition: "Disasters are characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it. Disasters often result in great damage, loss, or destruction."

Catastrophe is a large scope of impact event that crosses multiple communities, produces very high levels of damage and social disruption and sharply interrupts community and lifeline services. A broad scope of impact greatly limits extra community support. In 2005, for example, Hurricane Katrina severely impacted large coastal areas of Louisiana, Mississippi and Alabama. In this setting, small towns that might otherwise count on help from larger urban centers simply found that all communities were unable to extend support. The levels of damage and social disruption are even greater than most disasters. Most of the buildings are damaged and destroyed. This includes common systems to maintain public health and safety. This disruption interrupts much preparedness and response planning. Plan for victim shelter and medical care in the community are rendered useless. Specific damage assessment is complex. It is difficult to get to the affected areas because of the debris on the roads and the destruction of roads. Following the 2004 tsunami in Indonesia, more than 90% of the medical personnel in several towns were killed. In Florida Hurricane Andrew seriously damaged or destroyed buildings housing police, fire, welfare and medical workers. Most community functions are sharply and concurrently interrupted. Lifeline infrastructures simultaneously fail. This interrupts electric power, fuel. water, sewer, transportation and telecommunication services.

Catastrophes are really exceptional events, which are not considered in planning outside plant protection.

1.2 Natural hazards: types, intensity, caused damages and critical areas/countries

Natural hazards are those that exist in the natural environment as result of meteorological, hydrological and geologic hazards that pose a threat to human population and communities. Natural hazards are often intensified in scope and scale by human activities including development and modification of the landscape and atmosphere. For example, the construction of communities in the floodplain or on barrier islands almost always increases risk associated with hurricane-force width, flooding and storm surge. When structures are constructed on or around seismic faults, the likelihood that they will be destroyed in a future earthquake event is greatly increased. Through better understanding of natural hazards and processes by which they affect the human and built environment, societies can better plan for these stressors and reduce vulnerability.

1.2.1 Meteorological hazards

1.2.1.1 Tornadoes

A tornado is a rapidly rotating vortex or funnel of air extending ground ward from a cumulonimbus cloud, exhibiting wind speeds of up to 482 km for hour. Approximately 1.200 tornadoes are spawned by thunderstorms each year in the United States. Most tornadoes remain aloft, but the few that do touch the ground are devastating to everything in their path. The forces of a tornado's wind are capable of lifting and moving huge volumes objects, destroying or moving whole buildings and siphoning large volumes from bodies of water and ultimately deposing them elsewhere. Because tornadoes typically follow the path of least resistance, people living in valleys have the greatest exposure to damages. Tornados have been measured using the Fujita-Pearson Tornado Scale since its creation in 1971 (Table 1-1).

Table 1-1: Enhanced Fujita-Pearson Tornado Scale

Category	Conditions	Effects
F-0	64-115 km/h	Chimney damage, tree branches broken
F-1	116-180 km/h	Mobile homes pushed off foundation or overturned
F-2	181-252 km/h	Considerable damage, mobile homes demolished, trees uprooted
F-3	253-330 km/h	Roofs and walls torn down, trains overturned, cars thrown
F-4	331-418 km/h	Well-constructed walls leveled
F-5	419-511 km/h	Home lifted out foundation and carried considerable distances, autos thrown as far as 100 meters

Building collapse and flying debris are the principals factors behind the deaths and injuries tornadoes cause. Early warning is key to surviving tornadoes, as warned citizens can protect themselves by moving to structures designed to withstand tornado-force winds. Doppler radar and other meteorological tools have drastically improved the ability to detect tornadoes and the amount of advance warning time available before a tornado strike. Improved communications and new technologies have also been critical to giving people advance warning.

Figure 1-1: A tornado

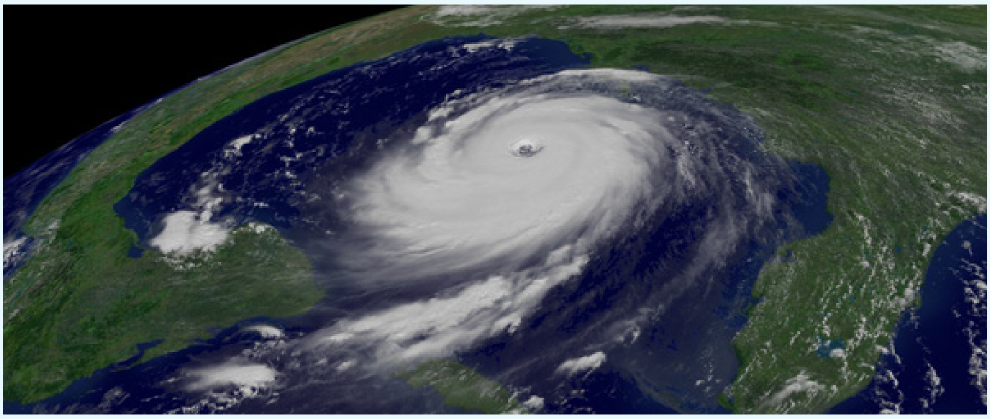
Buildings that are directly in the path of a tornado have little chance of surviving unless they are not specifically designed to withstand not only the force of the winds, but also that of the debris "missiles" that are thrown about. "Safe room" technology realized with engineered resistant design and special resistant materials offer in the path of a tornado great survival likelihoods.

1.2.1.2 Hurricanes

Hurricanes are cyclonic storms that begin as tropical waves and grow in intensity and size. Tropical waves continue to progress in size and intensity to tropical depressions and tropical storms as determined by their maximum sustained wind speed. The warm-core tropical depression becomes a tropical storm when the maximum sustained surface wind speed range from 62 km per hour to 117 km per hour. Tropical cyclonic storms are defined by their low barometric pressure, closed-circulation winds originating over tropical waters, and an absence of wind shear. Cyclonic storm winds rotate counter-clock-wise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Hurricane winds extend outward in a spiral pattern as much as 650 km around a relatively calm center of up 50 km in diameter known as the "eye". Hurricanes are fed by warm ocean waters. As these storms make landfall, they often push a wall of ocean water known as "storm surge" over coastal zones (see Section 1.2.2.1). Once over land, hurricanes cause further destruction by means of torrential rains and high winds.

Figure 1-2: A hurricane



Hurricane season runs annually from June 1 through November 30, August and September are peak months during the hurricane season. Hurricanes are commonly described using the Saffir-Simpson scale (Table 1-2).

Table 1-2: The Saffir-Simpson scale

Category	Conditions	Effects
1	Wind Speed: 119-152 km/h Storm surge: 1.2-1.5 m above normal	Primary damage to unanchored mobile homes, shrubbery and trees. Some coastal flooding and minor pier damage. Little damage to building structures.
2	Wind Speed: 153-177 km/h Storm surge: 1.6-2.4 m above normal	Considerable damage to mobile homes, piers and vegetation. Coastal and low-lying area escape routes flood 2-4 hours before arrival of hurricane center. Buildings sustain roofing material, door and window damage. small craft in unprotected mooring break moorings.

Category	Conditions	Effects
3	Wind Speed: 154-209 km/h Storm surge: 2.5-3.6 m above normal	Mobile homes destroyed. Some structural damage to small homes and utility buildings. Flooding near coast destroys smaller structures, larger structures damaged by floating debris. Terrain continuously lower than 1.5 m above sea level (ASL) may be flooded up to six miles inland.
4	Wind Speed: 210-249 km/h Storm surge: 3.7-5.4 m above normal	Extensive curtain wall failures, with some complete roof structure failure on small residences. Major erosion of beaches. Major damage to lower floors of structures near the shore. Terrain continuously lower than 3 m ASL may flood (and require mass evacuations) up to 9 km inland.
5	Wind Speed: over 250 km/h Storm surge: over 5.5 m above normal	Complete roof failure on many homes and industrial buildings. Some complete building failures. Major damage to lower floors of all structures of all structures located less than 4.5 m ASL and within 500 yards of the shoreline. Massive evacuation of low-ground, residential areas may be required.

Hurricanes are capable of causing great damage and destruction over vast areas. Hurricane Floyd in 1999 first threatened the states of Florida and Georgia, made landfall in North Carolina and damaged sections of South Carolina, North Carolina, Virginia, Maryland, Delaware, New Jersey, New York, Connecticut, Massachusetts and Maine. Single hurricanes can affect several countries, as was the case with Hurricane Mitch, which brought death and destruction to Nicaragua, Guatemala, el Salvador and Honduras.

1.2.1.3 Thunderstorms

Thunderstorms are meteorological events that bring heavy rains, strong winds, hail, lightning, and tornadoes. Thunderstorms are generated by atmospheric imbalance and turbulence caused by a combination of several conditions, including: unstable, warm air rising rapidly into the atmosphere; sufficient moisture to form clouds and rain; and upward lift of air currents caused by colliding weather fronts (cold and warm), sea breezes, or mountains.

A thunderstorm is classified as severe if its wind reach or exceed 93 km/h, it produces a tornado, or it drops surface hail at least 1.9 cm in diameter. Thunderstorms may occur singly, in clusters or in lines. Thus, it is possible for several thunderstorms to affect one location in the course of a few hours. These events are particularly devastating when a single thunderstorm affects one location for an extended period. Such conditions leads to oversaturation of the ground and subsequent flash flooding and slope erosion.

Lightning is a major secondary threat associated with thunderstorms. In the United States, between 75 and 100 Americans are hit and killed by lightning each year. Many air disasters have been linked to thunderstorms due to the unpredictable and turbulent wind conditions they cause and the threat of electronic or mechanical failure caused by lightning strikes. When humans or structures are hit lightning, the effect is devastating to both.

Figure 1-3: Thunderstorms and lightening

Hail is frozen atmospheric water that fall to the earth. Moisture in clouds becomes frozen into crystals at low temperatures and begins to fall under its own weight. Typically these crystals melt at lower temperatures, but in the right conditions they pick up more moisture as they fall and are then lifted to cold elevations, which causes refreezing. The cycle can continue until the individual hailstones reach several inches in diameter under the right conditions. Because of the strength of severe thunderstorms and tornadoes, both can cause this cyclic lifting, and therefore they are often accompanied by hail. When they fall, they can damage crops, break windows, destroy cars and other exposed properties, collapse roofs, and cause other destruction totaling nearly $1 billion each year in United States.

1.2.1.4 Severe winter weather

W*inter storms* occur when extremely cold atmospheric conditions coincide with high airborne moisture content, resulting in rapid and heavy precipitation of *snow* and/or *ice* (snowstorms). When combined with high winds, the event is known as a *blizzard*.

Figure 1-4: Severe winter weather

While there is no widely accepted standard for *extreme cold* temperatures, periods of colder than normal conditions exhibit a range of negative consequences, depending on where they occur and exactly how cold temperatures fall. Any time temperatures fall below freezing, there is the risk of death from hypothermia to humans and livestock, with the degree to which populations are accustomed to those temperatures a primary factor in resilience. Extreme cold can also lead to serious economic damages from frozen water pipes; the freezing of navigable rivers, which halts commerce and can cause ice dams; and the destruction of crops.

1.2.1.5 Severe summer weather

Wildfires (often called also wildland fires) are an annual and an increasing hazard due to air pollution (primarily smoke and ash which travel for miles causing further hazards to health and mechanical or electrical equipment), risk to firefighters, environmental effects and property destruction they cause.

Figure 1-5: Wildfires

1.2.2 Hydrological hazards

1.2.2.1 Floods and flash floods

A flood is an overabundance of water that engulfs dry land and property that is normally dry. Floods may be caused by a number of factors, including heavy rainfall, melting snow, an obstruction of a natural waterway, etc.. Floods are capable of undermining buildings and bridges, eroding shorelines and riverbanks, tearing out trees, washing out access routes, and causing loss of life and injuries.

Flash floods usually results from intense storms dropping large amounts of rain within a brief period, occur with little or no warning, and can reach full peak in only a few minutes.

Figure 1-6: Floods

Floods are the most frequent and widespread disaster in many countries around the world, due to the prevalence of human development in the floodplain. The close relationship between societies and water is the result of commerce (the transportation of goods has most commonly been conducted by water), agriculture, and access for drinking water. The adverse implication of this relationship has been a global increase in exposure to flood events. It is estimated that in the United States alone sustain an average of $2 billion to $3 billion in losses each year.

Floods are typically measured according to their elevation above standard water levels (of rivers or coastal water levels). This elevation is translated into the annualized likelihood of reaching such heights. For example, a flood depth that has a 1 percent probability of being reached or could be expected to occur once across a 100-year period would be considered a "100-year flood event". Typically, structures that are contained within areas likely to experience flooding in a 100-year flood event are considered to be within the floodplain.

1.2.2.2 Storm surges

Storm surges, defined as masses of water that are pushed toward the shore by meteorological forces, are the primary cause of the injuries, deaths and structural damages associated with hurricanes, cyclones, and other coastal storms. When the advancing surge of water coincides with high tides, the resulting rise in sea level is further exacerbated. Storm surges may reach several meters under the right conditions, as was the case of the Hurricane Katrina. Wind-driven turbulence becomes superimposed on the storm tide, thereby causing further damage to structures that are inundated through wave action. The surge height at landfall is ultimately dictated by the expanse and intensity of the storm, the height of the tide at the time of the landfall and the slope of the sea floor approaching land. The longer and shallower the sea floor, the greater the storm surge will be.

The storm surges are usually described using the Saffir-Simpson scale (Table 1-2).

1.2.2.3 Tsunamis

A tsunami is wave or series of waves that is generated by a mass displacement of sea or lake water. The most common generative factor behind tsunamis is undersea earthquakes that cause ocean floor displacement, but large tsunamis have been caused by volcanic eruptions and landslides as well. Tsunami waves travel outward as movements of kinetic energy (rather than travelling water) at very high speeds in all directions from the area of the disturbance, much like the ripples caused by a rock thrown into a pond. As the waves approach shallow coastal waters, wave speed quickly decreases and the water is drawn upward and onto land. Tsunamis can strike at heights of up to and over 30 m and extend onto land for 1 km or more (depending upon topography). The force of the water causes near total destruction of everything in the path.

Figure 1-7: A tsunami

The areas at the greatest risk from tsunamis are those lying less than 15 m above sea level and within 1.5 km of the shoreline. Successive crests (high water) and troughs (low water) can occur anywhere from 5 to 90 minutes apart. Tsunamis travel through deep water at approximately 725 km/h, so the areas closest to the point of origin experience the greatest destruction and have the least amount of forewarning. Most tsunami-related deaths are the result of drowning, while the loss of services and related health problems associated with the incredible destruction of the infrastructure (including the loss of hospitals and clinics, water pollution, contaminated food and water socks, and damaged transmission lines) adds to this statistics.

1.2.3 Geological hazards

1.2.3.1 Earthquakes

An earthquake is a sudden, rapid shaking of the earth’s crust that is caused by the breaking and shifting of rock beneath the earth’s surface. This shaking can cause the collapse of buildings and bridges, cause disruption of gas, electric and telecommunication services, and trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis). Structures constructed on consolidated landfill, old waterways, or other unstable soil are generally at greatest risk unless seismic mitigation has been utilized. Seismicity is not seasonal or climate dependent and can therefore occur at any time of the year.

Figure 1-8: Effect of an earthquake

Over one billion people worldwide live in seismic zones. Earthquake damage can be extensive, especially when buildings have been constructed without incorporation of seismic-resistant materials and designs.

Earthquakes are sudden, no-notice events despite scientists' and soothsayers' best efforts to predict when they will occur. Seismic sensing technology is effective as measuring and tracking seismic activity, but it is yet to accurately predict a major seismic event with any degree of accuracy.

Each year hundreds of earthquakes occur worldwide, though the vast majority are barely perceptible. As earthquake strength increases, its likelihood of occurrence decreases. Major events, which are greater than 6.5 to 7 on the Richter scale, are not frequent, but such events have been among the most devastating.

The strength and effects of earthquakes are commonly described by the Richter and Modified Mercally Intensity (MMI) scales. The Richter scale assigns a single number to quantify the strength and effect of an earthquake across the entire area affected according to the strength of ground waves at its point of origin (as measured by a seismograph). Richter magnitudes are logarithmic and have no upper limit. The MMI also measures the effects of earthquakes, but rather than applying a single value to event, it allows for site-specific evaluation according to the effects observed at each location. The MMI rates event intensity using Roman numerals I to XII. Determinations are generally made using reports by people who felt the event and observations of damages sustained by structures.

The relationship between the two scales is shown in Table 1-3.

Table 1-3: Modified Mercalli Intensity Scale and equivalent Richter scale

MMI Intensity	Damages sustained and sensations experienced	Richter scale equivalent
I-IV (Instrumental to Moderate)	No damage sustained. Sensation ranges from imperceptible to that of a heavy truck striking the building. Standing motor cars may rock.	≤ 4.3
V (Rather Strong)	Felt by near everyone, many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.	4.4-4.8
VI (Strong)	Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.	4.9-5.4
VII (Very Strong)	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.	5.5-6.1

MMI Intensity	Damages sustained and sensations experienced	Richter scale equivalent
VIII (Destructive)	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.	6.2-6.5
IX (Ruinous)	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.	6.6-6.9
X (Disastrous)	Most masonry and frame structures/foundations destroyed. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Sand and mud shifting on beaches and flat land.	7.0-7.3
XI (Very disastrous)	Few or no of masonry structures remains standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Widespread earth slumps and landslides. Rails bent greatly.	7.4-8.1
XII (Catastrophic)	Damage nearly total. Large rock masses displaced. Lines of sight and level are distorted. Objects are thrown into the air.	≥ 8.1

1.2.3.2 Volcanic eruptions

A volcano is a break in the earth’s crust through which molten rock from beneath the earth’s surface (magma) erupts. Over time, volcanoes will grow upward and outward, forming mountains, islands, or large, flat plateau called “shields”. Volcanic mountains differ from mountain chains formed through plate tectonics (movement of the earth’s crustal plates) because they are built through the accumulation of material (lava, ash flows and airborne ash and dust) rather than being pushed up from below.

Figure 1-9: Volcano

When pressure from gases and molten rock becomes strong enough to cause an explosion, violent eruption may occur. Gases and rock shout up through the opening and spill over or fill the area with lava fragments. Volcanoes cause injuries, death and destruction through a number of processes, including direct burns, suffocation from ash and other materials, trauma from ejected rocks. Airborne ash can affect people hundreds of miles away from the eruption and influence global climates for years afterward.

Volcanic ash contaminates water supplies, causes electrical storms, and can cause roofs to collapse under the weight of accumulated material. Eruptions may also trigger tsunamis, flash floods, earthquakes and rockfalls.

1.2.3.3 Mass Movements

The general category of mass movements includes several different hazards caused by the horizontal or lateral movements of large quantities of physical matter. Mass movements cause damage and loss of life through several different processes, including the pushing, crushing, or burying of objects in their path, the damming of rivers and waterways, the subsequent movement of displaced bodies of water (typically in the form of a tsunami), destruction or obstruction of major transportation routes and alteration of the natural environment in ways in which humans are negative impacted. Mass-movements hazards are most prevalent in areas of rugged or varied topography, but they can occur even on level land. The main categories of mass-movement hazards are quoted in the following.

Landslides. Landslides occur when masses of relatively dry rock, soil, or debris move in an uncontrolled manner down a slope. Landslides may be very highly localized or massive in size and they can move at a creeping pace or at very high speeds. Landslides are activated when the mechanism by which the material was anchored become compromised (through a loss of vegetation or seismic activity, for example).

Figure 1-10: Landslides and debris flow

Mudflows. Mudflows are water-saturated rivers of rock, earth, and other debris that are drawn downward by the force of gravity. These phenomena develop when water rapidly accumulates in the material that is moved, like during heavy rainfall or rapid snowmelt. Under these conditions, solid or loose earth can quickly change into a flowing river of mud. These flow move rapidly down slopes or through channels, following the path of least resistance, and often strike with little or no warning.

Rockfalls. Rockfalls occur when masses of rock or other materials detach from a steep slope or cliff and descend by freefall, rolling or bouncing. Rockfalls can occur spontaneously when fissures in rock or other materials cause structural failure or due to seismic or other mechanical activity (including explosions or the movement of heavy machinery).

Avalanches. An avalanche is a mass of ice or snow that moves downhill at a high velocity. Avalanches can shear trees, cover entire communities and highway routes, and level buildings in their path. Avalanches are triggered by a number of processes, including exceeding critical mass on a steep slope or disturbances caused by seismicity or human activity. As temperature increase and snowpack becomes unstable, the risk of avalanches increases.

1.3 Disaster management activities

Disaster management activities can be grouped into four phases as follows:

– Mitigation (Prevention): Activities that actually eliminate or reduce the probability and the effects of a disaster.

– Preparedness: Activities prior to disasters that are used to support the prevention of, mitigation of, response to, and recovery from disasters. In this phase, plans are developed to save lives and minimize disaster damage (for example, installing early warning systems).

– Response: Activities following a disaster. These activities are designed to provide emergency assistance for victims, to stabilize the situation and to reduce the probability of secondary damage.

– Recovery: Activities necessary to return all systems to normal or better (for example, rebuilding destroyed property, or the repair of other essential infrastructure).

The four above quoted activities phases are both indistinct and interdependent. They are indistinct because there is not an absolute "beginning" and "end" to each period. They are interdependent because actions undertaken in one phase affect the type and range of actions that can be undertaken in another phase. The four-activity framework is simple and widely accepted. By examining more in detail each of these phases, it is possible to have a picture of the emergency planner's role.

Mitigation activities try to eliminate or reduce the causes and the effects of a disaster. This is done either by reducing the likelihood of its occurrence or limiting the magnitude of its negative effects. The aim is to prevent a disaster before it happens. The potential human impact of an extreme natural event, such as floods, hurricanes, or earthquakes can be altered by modifying either the natural event system or the human use system or both. In floods, the loss of life or property can be reduced by dams or levees that confined the floodwaters. Land use restrictions (zoning) limit people's intrusion into the flood plain. More stringent design requirements for the infrastructures (e.g. telecommunication outside plants) can reduce the effects of a natural disaster. Only limited control can be exercised over natural event systems. The choice of whether to mitigate hazards by controlling the hazard agent or by controlling the human use system depends on political and economic decisions about the costs and benefits of each.

Preparedness activities protect lives and properties when threats cannot be controlled or when only partial protection can be achieved. These activities assume that a disaster will occur. Plans, procedures and resources must be in place in advance to support an effective response to the threat. Preparedness measures fall into two general categories. The first category is alerting members of response organizations and the public about the timing and extent of a potential disaster. The second category includes actions designed to enhance the effectiveness of the response.

To alert people, it is necessary to be able to detect the threat. Detection and monitoring systems include rainfall and river gauges, radar detection and tracking of severe storms. Warning dissemination systems convey information about threats from authorities to the people.

Preparedness measures include:

– developing plans for the activation and coordination of response organizations;

– devising Standard Operating Procedures (SOPs) to guide organizations in the performance of their functions;

– training personnel in the use of those procedures;

– conducting exercises to test the effectiveness of these plans, procedures and training efforts;

– stockpiling resources;

– assembling inventories of community resources and determine their location.

Response activities are the actions of officials just before and during the disaster impact that protect public safety and minimize physical damage. This response begins with the detection of a threat. Response ends with the stabilization of the situation following disaster impact. Stabilization means that the risk of loss of life and property is back to the "normal" levels. Responses focuses on protecting people first. Response attempts to limit damages from the initial impact. Response also seeks to limit damage from secondary or repeated impacts.

Response activities to limit the primary impact include:

– securing the impact area;

– evacuating dangerous areas;

– conducting search and rescue for the injured;

– providing emergency medical care;

– sheltering evacuees and other victims;

– mounting operations to counter secondary threats;

– fighting urban fires and hazardous materials releases after earthquakes;

– identifying contaminated water supplies or other public health threats following floods;

– restoring telecommunication outside plants.

Response actions also assess damages and coordinate the arrival of converging equipment and supplies so they may be deployed to those areas most in needs.

Recovery activities begin after disaster impact has been stabilized and seek to restore lost functions. Recovery extends until the community is restored to a reasonable level of functioning. This may require long periods of time. In recovery it is to establish an acceptable quality of life. This may be improved upon as time passes. Recovery has been defined in terms of short-range measures versus long-range measures. Short-range measures include relief, rehabilitation and longer range measures as reconstruction. Relief and rehabilitation activities usually include:

– clearance of debris and restoration of access to the impact area;

– reestablishment of economic activities;

– restoration of essential government or community (including telecommunication) services;

– provision of an interim system for caring for victims, including housing, clothing and food.

Reconstruction activities tend to be dominated by rebuilding major structures and by efforts to revitalize the area's economic system. In some communities, leaders may view the reconstruction phase as an opportunity to institute the plans for change the existed before the disaster.

1.4 The role of communications in emergency management

Disasters often happen as sudden events that cause immense damage, loss and destruction. Disaster events occur due to the forces of nature or because of actions that stem from human sources or interventions. Disasters can have extreme magnitude, be long lasting, and cover wide geographic areas within national or international boundaries. In other words, disasters are variable in magnitude (energy), duration (time), and geographic area.

Hundreds of disasters occur each year all over the world; no country is immune. A confined disaster may be quite severe and yet by definition is local in nature. Disasters may affect an entire region, such as with nationwide or international emergency situations. Each disaster brings suffering, financial and social consequences. Regardless of the kind of disaster, telecommunications are needed to respond effectively and save lives.

The common thread to facilitate operations for all disaster recovery phases is the utility of fast, reliable, user-friendly emergency telecommunications that may be realized by technical solutions and/or administrative policy.

The goal is assured telecommunication capabilities during emergency situations. Disasters can impact telecommunications infrastructures themselves. Typical impacts may include: congestion overload and the need to re-deploy or extend telecommunications capabilities to new geographic areas not covered by existing infrastructures. Even when telecommunications infrastructures are not damaged by the disaster, demand for telecommunications soar during such events.

This Handbook is dedicated to the study of the improvement of the design of the telecommunication outside plants in areas frequently exposed to natural disasters. The scope is that of mitigating the effects of natural disasters by ensuring the continuity of telecommunication services.

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Chapter 2

The telecommunication outside plants technologies

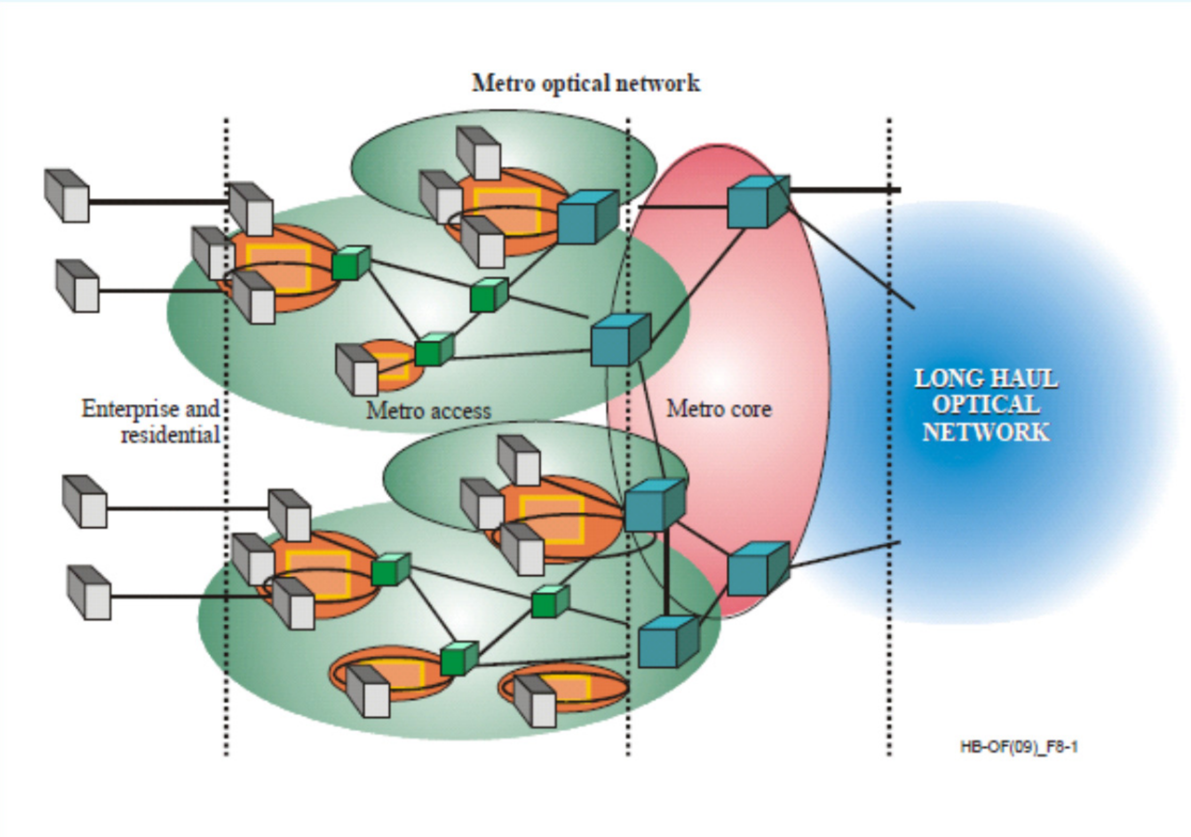
2 Introduction

Public telecommunication networks [PSTN (Public Switched Telephone Network/Public Switched Telecommunication Network), ISDN (Integrated Services Telecommunication Network), OTN (Optical Transport Network)] are the most capillary widespread telecommunication networks.

Public telecommunication networks provide not only telephone service, but they carry nearly all telecommunications services (e.g. data, Internet). This means that failure of the public telecommunication networks results in more losses than that of the only telephone service.

Modern telecommunication networks are generally subdivided in access networks, metropolitan access networks (or metropolitan networks), metropolitan core networks (or regional networks) and long-haul networks (or backbone networks) depending on the area they cover (Figure 2-1).

Figure 2-1: Structure of modern optical networks



For the purpose of this Handbook, a public network refers to the telecom network accessible to ordinary people. This is important to recognize because in the event of a disaster the number of simultaneous phone calls tends to a huge increase due to the fact that persons will tend to initiate calls to the region hit by a disaster and from that region to other regions or countries resulting in the overload of the public telecommunications network. It is well known that a public network is designed to allow about 5-10% of the subscribers to call and receive calls at the same time. However, in emergencies more people make calls and tend to talk longer resulting in jamming, blocking or congestion of the network.

Moreover, disasters will affect in general the telecommunication network as well, both directly (disruption of outside plant or exchanges) and indirectly, for example, by disruption of power supply lines. Due to the concurrency of these two facts, the network capacity will be heavily impaired just after the disaster when it will be needed to work at full capacity to allow fast recovery. Some segments of the networks are sometime protected by path diversity and equipment duplication so that in case of disaster, part of the network retains its full capacity unless a major switching node is completely destroyed.

The main purpose of this Chapter 2 is to indicate which are the outside plants generally deployed in the public telecommunication networks. Chapters 4, 5, 6 and 7 will be dedicated to the design, deployment and installation criteria for the outside plants of wireline systems, wireless terrestrial systems and satellite systems, which should be used in areas exposed to natural disasters.

2.1 Outside plants of wireline systems

2.1.1 Copper wires access

[For further information see ITU-T Handbook "Wireline Broadband Access Networks"]

2.1.1.1 Copper wires used at voice frequencies

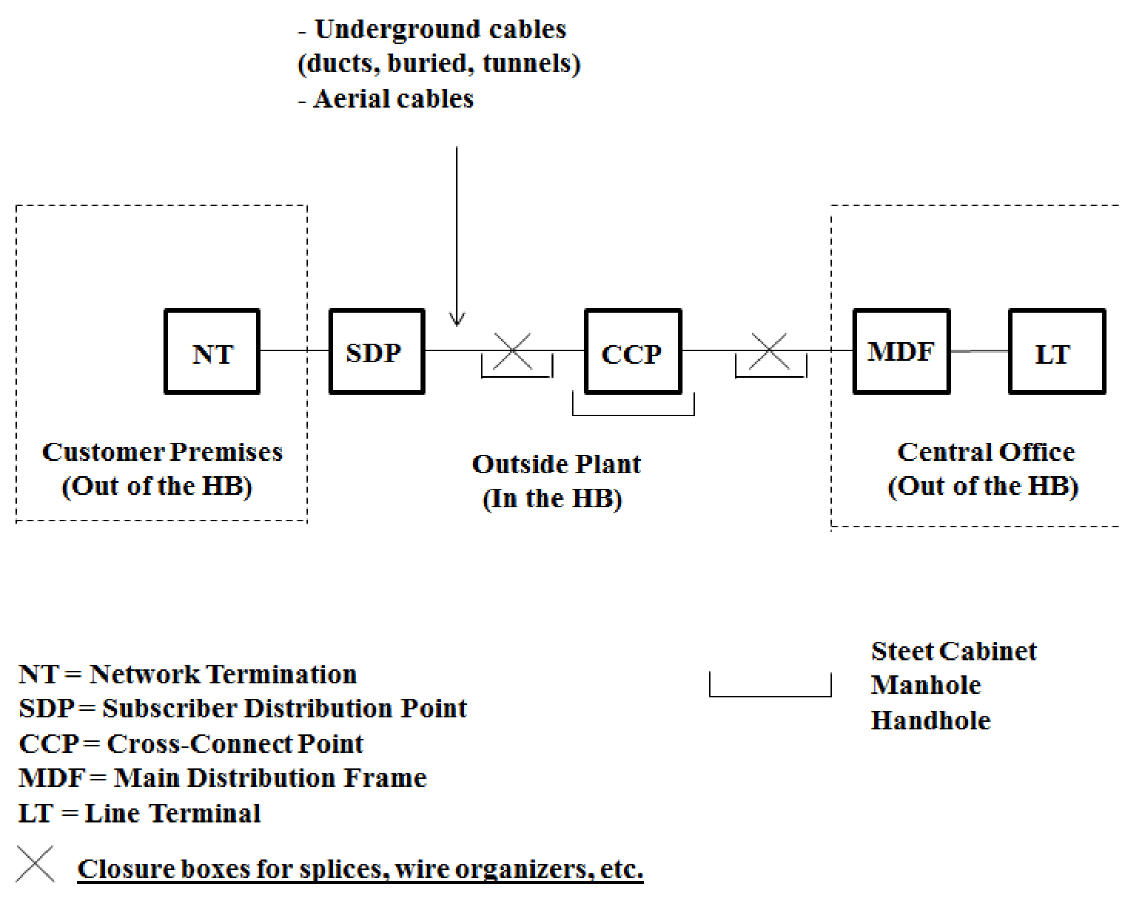
Until some decades ago the PSTN was made of copper wires only (copper pairs in the distribution segment, coaxial cables in the trunk network). Nowadays, copper has no application beyond local access and in rare cases for urban applications.

A general view of the physical model of the copper wire local loop plant is shown in Figure 2-2. Larger Central Offices (CO) may serve over 100,000 telephone lines; they all terminate at the Main Distribution Frame (MDF) in the CO. The loop plant consists of twisted wire pairs that are contained within a protective cable sheath. Within the Central Office, cables from switching and transmission equipment are lead to the MDF, which is a large wire cross-connect frame were jumper wires connect the CO equipment cables (at the horizontal side of the MDF) to the outside cables (at the vertical side of the MDF). The MDF permits any subscriber line to be connected to any port of any CO equipment. Cables leaving the Central Office are normally contained in underground conduit with up to 10,000 wire pairs per cable and are called feeder cables. The feeder cables extend from the CO to a wiring junction and interconnection point: the Cross-Connect Point (CCP). The CCP usually contains a small wire jumper panel that permits the feeder cable pairs to be connected to any of several distribution cables. The CCP is generally at 0.5 - 1.0 km from the customer premises and typically serves 1,500-3,000 living units. The CCP contains only a wiring cross-connect field; it has no active electronics. The loops emanating from the CCP to the customer are usually called "distribution plant".

Distribution cables contain 25 to 1000 pairs. For residential and small business areas, the distribution cable connects to the drop wires via a distribution terminal (SDP, Subscriber Distribution Point), which typically serves four to six leaving units. Inside wire is often two twisted pairs of 0.4 mm, even if a wide range of wiring practices may be found inside the customer premises.

In other words the feeder and distribution cables are configured as a cascade of cable sections of different diameters and lengths. The copper wire local loop is therefore a multi-level star network with cable branching at each intermediate distribution point.

Figure 2-2: The copper wire local loop plant



The copper wire "local loop" used in 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 lost, the phone will still work as long as the lines are not damaged.

The outside plants of the copper wire local loop are shown in Figure 2-2.

2.1.1.2 Copper wire access with xDSL

[For further information see ITU-T Handbook "Wireline Broadband Access Networks"]

Digital Subscriber Line (DSL) technology provides transport of high bit rate digital information over copper wire telephone subscriber lines. By the time the standardization of the xDSL systems started (about 20 years ago) copper-pair cable networks were already extremely widespread around the world. As a consequence, the objective of xDSL systems standardization was to exploit existing networks, re-using their physical and electrical characteristics.

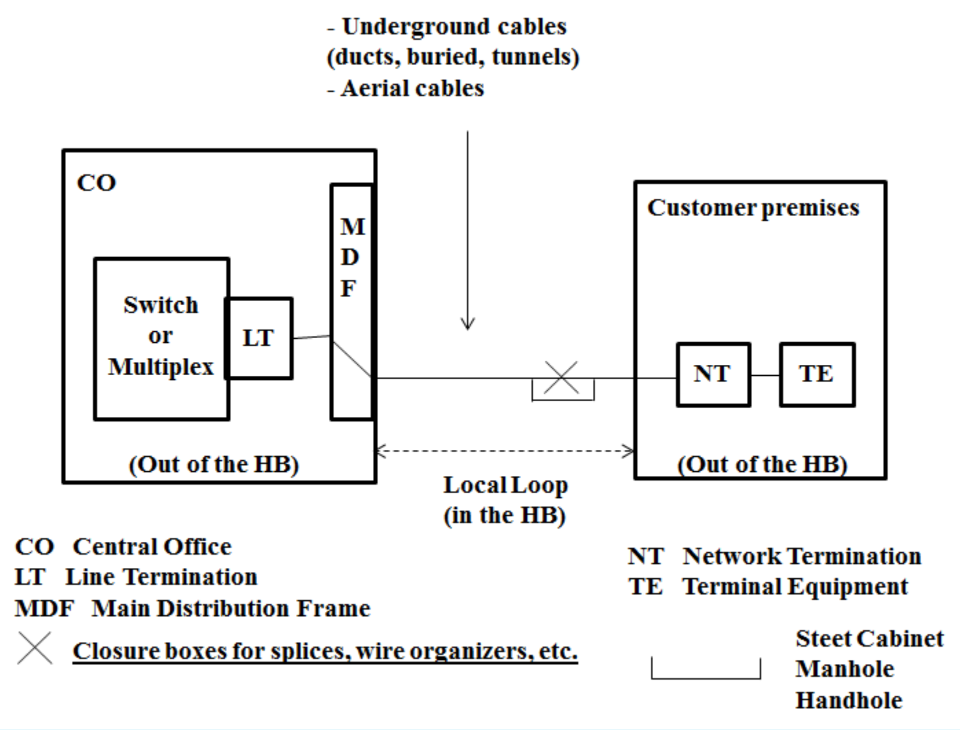
So DSL technology has added a new twist to the utility of telephone lines, which were originally constructed to carry a single voice signal with a 3.4 kHz bandwidth channel. They can now convey several tens of Mbit/s. High speed digital transmission via telephone lines requires advanced signal processing to overcome transmission impairments due to signal attenuation, crosstalk noise from the signals present on other wires in the same cable, signal reflections, radiofrequency noise and impulse noise. So the twisted wire pair infrastructure connect to virtually any home and workplace in the world, but DSL have their limitations and some of the copper pairs will require upgrade activity to permit high speed DSL operation.

A DSL consists of a local loop (telephone line) with a transceiver at each end of the wires. The transceiver is also known as a modem (modulator/demodulator). The transceiver at the network end of the line is called Line Termination (LT), the transceiver at the customer end of the line is known as the Network Termination (NT).

The majority of the DSLs are served via copper lines extending all the way from the central office to the customer's premises, as shown in Figure 2-3.

The outside plants of the copper access with xDSL are shown in Figure 2-3.

Figure 2-3: DSL Reference Model



Several species of DSL have resulted from the evolution of technology and the market it serves. The term xDSL applies to all the types of DSL family.

The upstream and downstream rates supported by the various xDSL technologies, both symmetric and asymmetric, are shown in Table 2-1.

Table 2-1: Transport capacity of the xDSL systems

	Bit rate	Maximum frequency
HDSL	1.544 and 2.048 Mbit/s (on one/two/three pairs)	485 kHz
SHDSL	192-5696 kbit/s (on one pair) 384-11392 kbit/s (on two pairs)	350 kHz
ADSL	6.144 Mbit/s downstream 640 kbit/s upstream	1.1 MHz

	Bit rate	Maximum frequency
Splitterless ADSL	1.536 Mbit/s downstream 512 kbit/s upstream	552 kHz
ADSL2	8 Mbit/s downstream 800 kbit/s upstream	1.1 MHz
Splitterless ADSL2	1.536 Mbit/s downstream 512 kbit/s upstream	552 kHz
ADSL2plus	16 Mbit/s downstream 800 kbit/s upstream	2.2 MHz
VDSL	52 Mbit/s downstream 2.3 Mbit/s upstream	12 MHz
VDSL2	50-200 Mbit/s bidirectional (e.g. 120 Mbit/s downstream and 80 Mbit/s upstream or 100/100 Mbit/s)	30 MHz

2.1.1.3 Outside plants of copper wires access

The main outside plants of copper wire access are shown in Figures 2-2 and 2-3. In Chapter 4 there is no specific section dealing with these outside plants for two reasons:

– most of these outside plants are the same used for the optical plants which are widely discussed in Chapter 4;

– as said above, nowadays copper has no application beyond local access and in rare cases for urban applications.

2.1.2 Optical fibre

[For further information see ITU-T Handbook “Wireline Broadband Access Networks”]

2.1.2.1 Optical fibre access

Optical fibre is used for access networks to major business customers in city or town centres and, increasingly, for residential access.

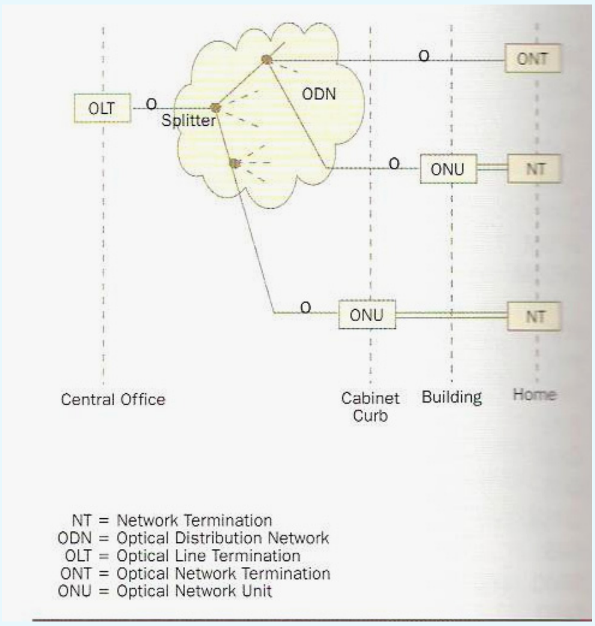
Optical fibre is capable of delivering bandwidth intensive integrated voice, data and video services at distances beyond 20 km in the access network. Various configurations can be imagined for the deployment of the optical fibre in the local access network. The most well known are Fibre to the Home (FTTH), Fibre to the Building (FTTB) and Fibre to the Curb (FTTC).

In the FTTH approach the optical fibre in the local access network can be used in a point-to-point (P2P) topology, with a dedicated fibre running from the local exchange to each end-user subscriber. While this is a simple architecture, in most cases it is cost prohibitive due to the fact that it requires significant outside plant fibre deployment as well as connector termination space in the local exchange. Considering N subscribers at an average distance L km from the central office, a P2P design requires 2N transceivers and N*L total fibre length (assuming single fibre is used for bidirectional transmission).

To reduce fibre deployment, it is possible to deploy a remote switch (concentrator) close to the customer (FTTC, FTTB). This reduces fibre consumption to only L km (assuming negligible distance between the switch and customers), but actually increases the number of transceivers to 2N+2 since there is one more link added to the network. In addition, a curb-switched architecture requires electrical power as well as back up power at the curb unit. Currently, one of the highest costs for local exchange carriers is providing and maintaining electrical power in the local loop. Moreover, as the service is given over the existing copper subscriber lines, the maximum speed achievable with xDSL systems is limited with respect to that of fibre-based systems.

An alternative solution to the two above quoted is to replace the hardened active curb-side switch with an inexpensive passive optical component. Passive Optical Network (PON) is a technology viewed by many network operators as an attractive solution to minimize the amount of optical transceivers, central office terminations and fibre deployment. A PON is a point-to-multipoint optical network with no active element in the signal path from source to destination (Figure 2-4). The only interior elements used in a PON are passive optical components such as fibre, splices and splitters. Access networks based on single-fibre PON require only N+1 transceivers and L km of fibre.

Figure 2-4: General structure of a PON [Figure 9-1 Manual Fibres]



At the network side there is an OLT (Optical Line Termination), which is usually installed at the local central office (CO). The OLT is the interface between all the users connected to the given PON and the metropolitan network. Such users have access to the services offered by the network, through the network terminal (NT), and to the optical network through the ONU (Optical Network Unit)/ONTs (Optical Network Termination).

The OLT and the ONUs are connected via an optical distribution network (ODN), which in many cases has a point-to-multipoint configuration with one or more splitters. Typical splitting factors include 1:16/1:32/1:64 or more.

PON splitters can be placed near the OLT or at the user sites, depending on the availability of fibres in the ODN, and/or on the ODN deployment strategy adopted by network operators.

The PON shown in Figure 2-4 is completely passive and the maximum distance between the OLT and the ONU is typically limited to 20 km at nominal split ratios. However, there are also solutions that include deployment of active elements in the network structure (e.g., optical amplifiers) when it is necessary to achieve a longer reach (e.g., up to 60 km) or to reduce the number of CO sites (CO concentration), or to connect a larger number of users to a single OLT port (e.g., where higher power budget is required due to a higher split ratio). Such solutions are typically referred to as “long-reach PON”.

As shown in Figure 2-4, a PON can be deployed in a FTTH (fibre to the home) architecture, where an ONU/ONT is provided at the subscriber's premises, or in FTTB (fibre to the building), FTTC (fibre to the curb) or FTTCab (fibre to the cabinet) architectures, depending on local demands. In the latter cases, the optical link is terminated at the ONU, and the last stretch to the subscriber's premises is typically deployed as part of the copper network using e.g., existing xDSL lines. Various types of xDSL family technologies are typically used, e.g., VDSL2 (Very high speed Digital Subscriber Line 2).

In order to reduce the need for dual fibre (one for each direction of transmission) ODNs, the PON systems can take advantage of the Wavelength Division Multiplexing (WDM) technique, where downstream (from the CO to the user) and upstream (from the user to the CO) channels are transmitted at different wavelengths: 1260-1360 nm for the upstream and 1480-1500 nm for the downstream.

Based on the supported upstream and downstream data rate, there two main categories of PON: the BPON (Broadband PON) and the G-PON (Gigabit capable PON).

BPON and G-PON systems are very similar at the physical layer with the main difference being the supported data rates. At present G-PON systems represent with the most widely used because of:

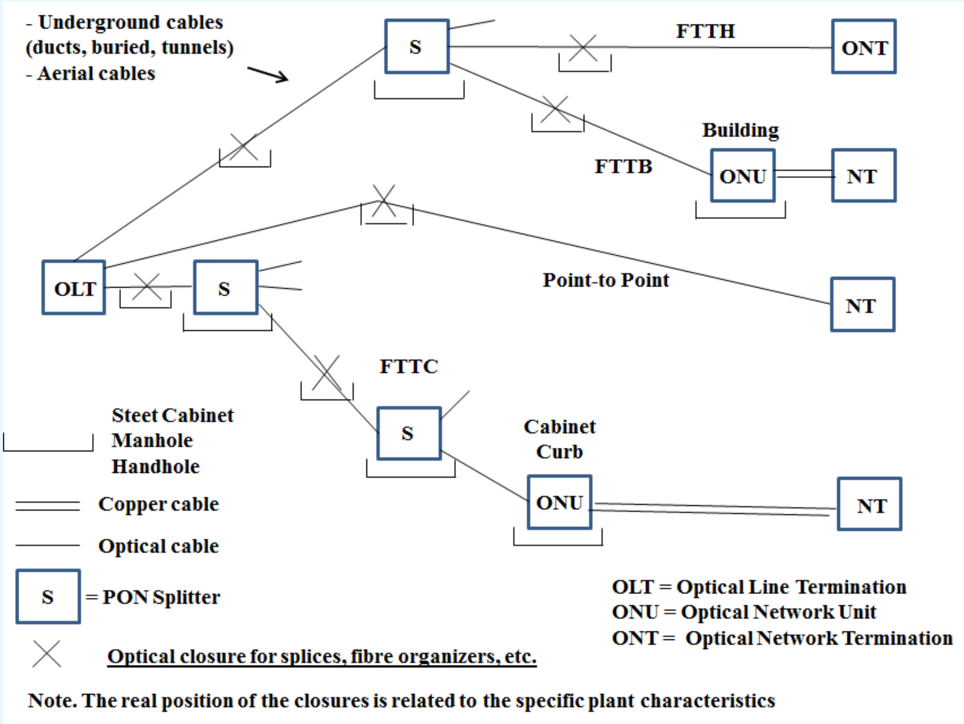
i) higher capacity (BPON: 622 Mbit/s downstream/155 Mbit/s upstream, G-PON: 2,488 Mbit/s downstream/1,244 Mbit/s upstream);

ii) higher split ratio (BPON 1:32, G-PON 1:64 with potential support for 1:128);

iii) maximum reach (BPON 20 km, G-PON supports optical amplifiers in the ODN, called reach extenders, which extend the system reach up to 60 km).

The main outside plants of an optical access networks are shown in Figure 2-5.

Figure 2-5: General structure of a PON



2.1.2.2 Optical fibre links in metropolitan and backbone networks

[For further information see ITU-T Handbook "Optical Fibres, Cables and Systems"]

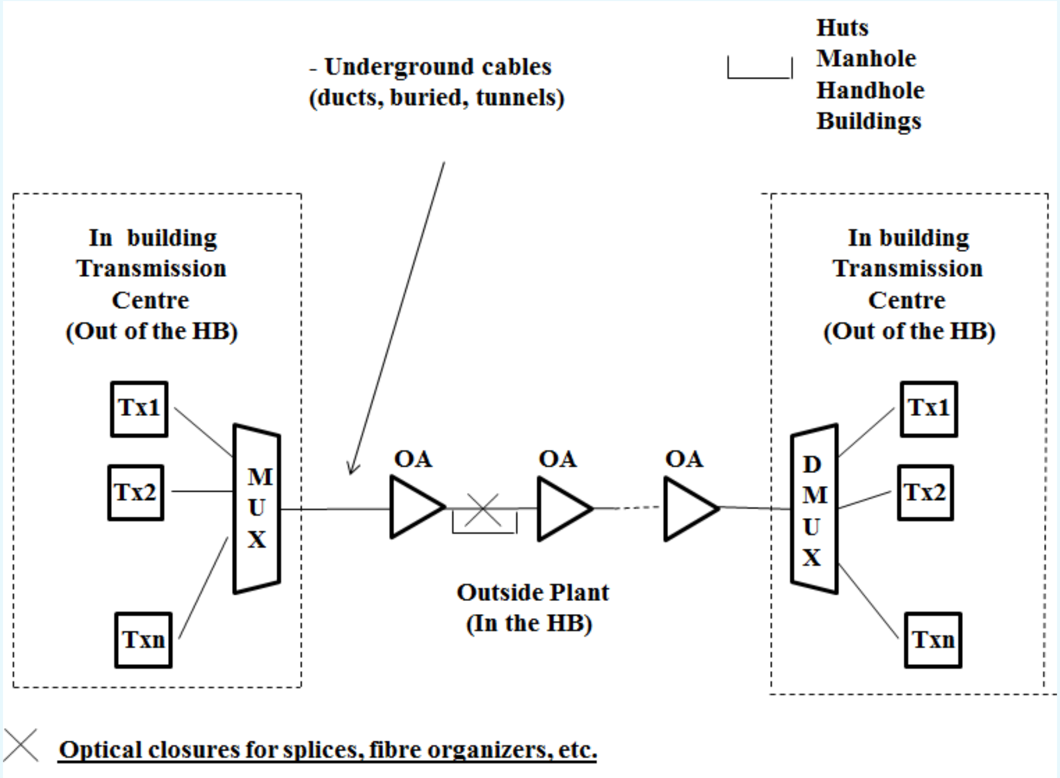
Optical fibre, with its unsurpassed capacity, is particularly suitable for metropolitan, regional and backbone (long distance) networks and plays a key role in migration to broadband services. It is favoured over terrestrial radio (microwave) transmission systems when the usage level is high enough to justify fibre's higher capital and operating costs.

The link length may vary from a few kilometres to thousands of kilometres, depending on the specific application. For example optical links are used to connect different equipment between two buildings placed a short distance apart. The low attenuation and wide bandwidth of optical fibres are not of primary importance for such links. Fibres are used mainly because of their other advantages, such as immunity to electromagnetic interference. The situation is different for systems which are used for high speed transmission across continents or between continents with a link length of hundreds/thousands of kilometres. Low attenuation and large bandwidths of optical fibres are important factors in these links in order to reduce the overall cost per unit transmission capacity.

When the link length exceeds a certain value, depending on the operating wavelength, it becomes necessary to compensate for fibre attenuation, as the signal would otherwise become too weak to be detected correctly. Fibre attenuation can be compensated by using optical amplifiers. Amplifiers are especially valuable for WDM systems as they can amplify many channels simultaneously. Point-to-point systems can be connected in a mesh structure.

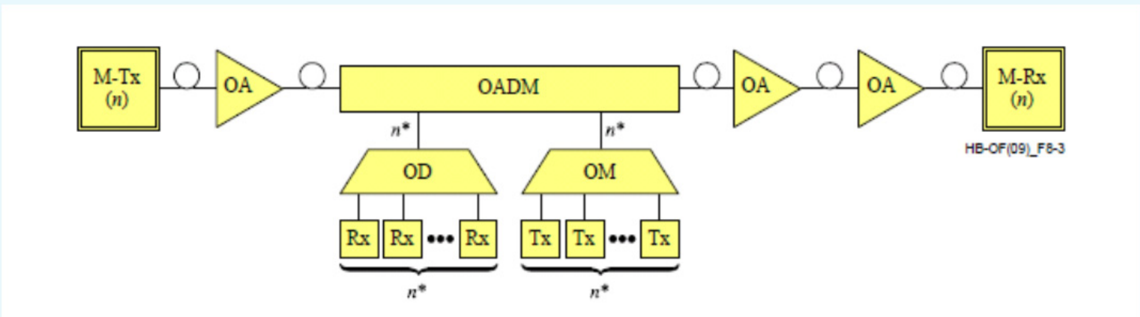
Figure 2-6 shows a typical trunk line in a point-to-point topology. Wavelength Division Multiplexing (WDM) is commonly used to increase the link capacity by sending many channels, with different wavelength (colours), over the same fibre. Figure 2-6 also shows the outside plants involved in this part of the optical network.

Figure 2-6: Point-to-point link with WDM optical transmission systems



Point-to-point links constitute the simplest kind of optical systems. Their role is to transport information available in the form of a digital bit stream, from one place to another. In order to introduce more flexibility in the long-haul network, other topologies have been implemented taking advantage from the introduction of all-optical routing devices such as Optical Add Drop Multiplexers (OADM) or Optical Cross Connects (OXC). OADM's allow the use of bus structures whose representation is shown in Figure 2-7.

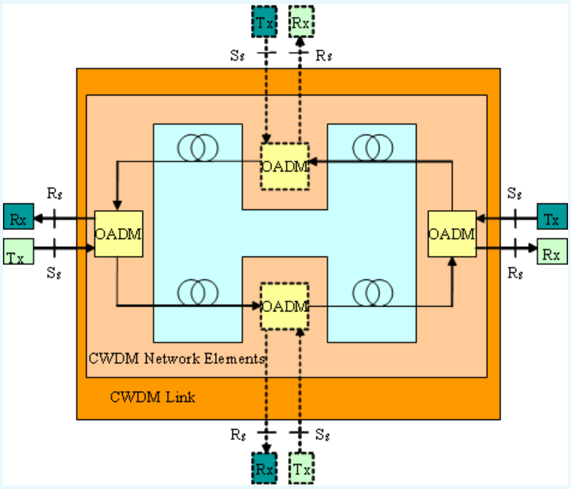
Figure 2-7: Example of bus structure for long-haul systems



In this example, a number (n) of WDM channels is travelling along the fibre and enters the OADM. A subset (n*) of WDM channels is dropped and added by the OADM. The number n* of dropped and added channels may range between 0 and n. This scheme can be generalized incorporating a sequence of optical amplifiers and optical add/drop multiplexers (OADMs). The outside plants are not indicated in the figure because they are the same indicated in Figure 2-6. As a matter of fact the OADMs are located inside buildings.

Many modern trunk systems feature automatic recovery systems, such as rings and other automatic re-configuration methods so that a redundant link or route can take the load from a failed link (Figure 2-8). This of course depends on quite a lot of redundant capacity being designed into the system in the first place. There are also cost considerations and in the present de-regulated environment many small operators in developing countries, who have limited resources, consider this a luxury. Even in well developed countries there have been spectacular flops, caused by the gradual erosion of redundant capacity as it is sold to paying customers in today's highly competitive business. When the network rings are broken, there may not be enough spare capacity in the ring to carry the entire load in case of a fault.

Figure 2-8: Ring configuration



2.1.2.3 Outside plants of optical fibre access and links

The outside plants of optical fibre access and of optical fibre links in metropolitan and backbone networks, shown in the previous figures can be roughly grouped as follows:

i) Optical fibres and cables (fibres, cables, cable protection, installation methods, etc.);

ii) Passive optical devices and nodes (splices, connectors, fibre organizers, passive optical splitters, optical closures, fibre distribution units, etc.);

iii) Active optical devices and nodes (ONU, DSLAM, xDSL Terminals, Reach Extender, etc.).

iv) Infrastructures (underground ducts/conduits, street cabinets, manholes, handholes, etc.);

The above plants are considered as outside plants because they are generally located in the plant between the buildings with switching and terminal equipment. They are shown in Figures 2-5 and 2-6 and are in the scope of this Handbook. Chapter 4 is dedicated to these plants.

2.2 Outside plants of wireless terrestrial systems

2.2.1 Microwave radio systems

[For further information see "Telecommunications and Data Communications Handbook", Ray Horak, John Wiley & Sons]

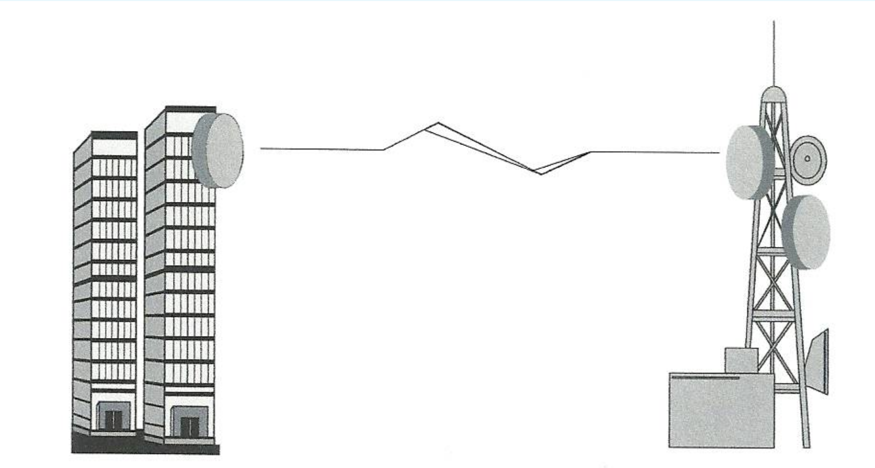
2.2.1.1 General characteristics

Microwave systems are point - to - point radio systems operating in the GigaHertz (GHz) frequency range. The *wavelength* is in the millimeter range, which is to say that each electromagnetic cycle or waveform is in the range of a millimeter, which gives rise to the term *microwave*. As such high frequency signals are especially susceptible to attenuation; they must be amplified (analog) or repeated (digital) frequently. In order to maximize the strength of such high frequency signals over long distances, the radio beams are tightly focused. Much as a light bulb in a flashlight is centered in a mirror that serves to focus the light beam, the microwave transmit antenna is centered in a concave, reflective metal dish that serves to focus the radio beam with maximum effect on the receiving antenna (Figure 2-9).

Similarly, the receiving antenna is centered in a concave metal dish that serves to collect a greater amount of incoming signal and reflect it into the receiver.

NOTE – Antennas serve both transmit and receive functions, with transmit and receive frequencies separated to avoid self-interference.

Figure 2-9: Point-to-Point microwave link

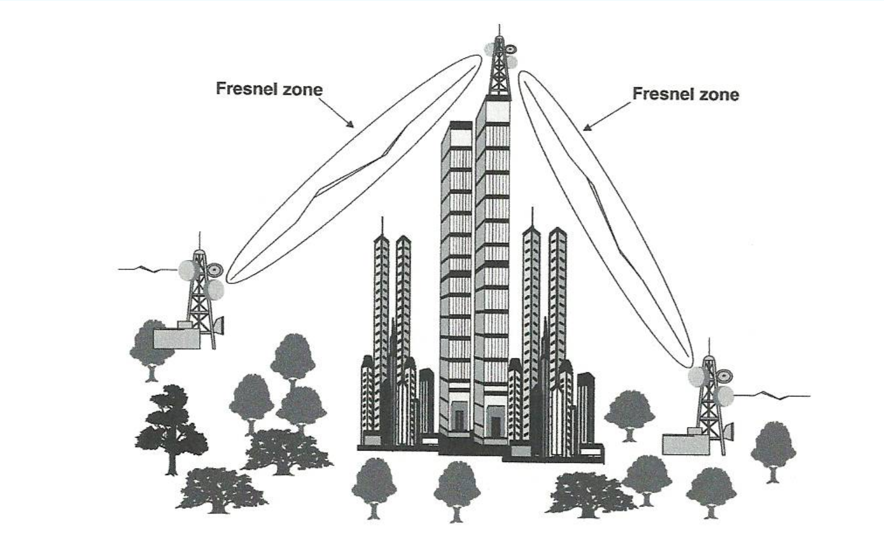


The requirement to so tightly focus the signal, clearly limits microwave to application as a *point - to - point*, rather than a *broadcast*, transmission system. Additionally, microwave is a *Line - Of - Sight* (LOS) technology as such high - frequency radio waves will not pass through solid objects of any significance (e.g., buildings, mountains, or airplanes). Actually, line of sight is not quite enough, as the signal naturally disperses (i.e., spreads out) in a conical pattern. As a result, portions of the signal reflect off of bodies of water, buildings, and other solid objects and can interfere with the primary signal through a phenomenon known as multipath fading. The impact of multipath fading is that multiple copies of the signal reach the receiving antenna at different levels of strength at slightly different times and slightly out of phase, thereby confusing the receiver and distorting the signal much like the *ghosting* effect that can be so aggravating at times to broadcast television viewers. So, additional clearance is required in the form of a Fresnel ellipse, an elliptical zone that surrounds the direct microwave path. In consideration of LOS and

Fresnel zone clearance, antenna positioning and tower height are important considerations in microwave path selection and network design.

Clearly, so to speak, antennas atop tall towers positioned on the roofs of tall buildings and the peaks of high mountains tend to provide optimum signal paths. Figure 2-10 illustrates a multi-hop microwave configuration with consideration given to Fresnel zone clearance.

Figure 2-10: Multi-hop microwave configuration with Fresnel zone clearance



If a microwave route traverses a smooth earth path involving no hills, mountains, bulges of earth, tall buildings, or other signal obstructions, the link length is sensitive to factors including frequency band, air quality, and curvature of the earth. Higher frequencies suffer more from attenuation than do lower frequencies. In the context of an airwave system such as microwave, air quality and environmental interference issues include dust, smog, agricultural haze, precipitation, fog, and humidity. Table 2-2 lists example international frequency bands allocated by the International Telecommunications Union – Radiocommunications Sector (ITU-R) for commercial microwave and makes clear the relationship between frequency band and antenna separation, assuming typical allowable power levels. These frequency bands are representative of those used throughout the world for microwave applications, although the specifics can vary from region to region and nation to nation.

At the lowest microwave frequencies, attenuation is low enough that the horizon becomes a major consideration, as the curvature of the earth limits LOS. In this scenario, it is necessary to consider the difference between optical LOS and radio LOS. True *optical LOS* is a straight line between the two antennas. *Radio LOS* can be somewhat longer as the density gradient in the atmosphere acts like a lens and tends to bend radio beams back toward the earth, as illustrated in Figure 2-11.

Figure 2-11: Microwave path illustrating differences between optical and radio LOS

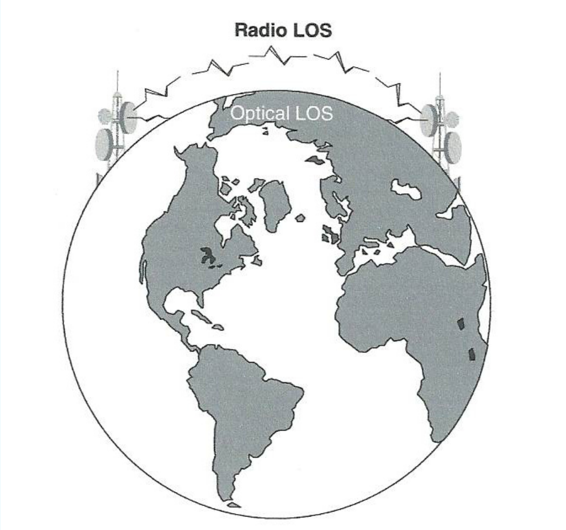


Table 2-2: Example of Microwave Frequency Bands (ITU) and Antenna Separation

Frequency Bands (GHz)	Typical Maximum Antenna Separation (km)
2-6	32-48
10-12	16-24
18-23	8-11
28-30	0.6-1.2

Microwave technology has been extensively used for long-haul point-to-point telecommunications. Competing long – distance carriers, first in the United States, found microwave a most attractive alternative to cabled systems, due to the relatively high speed and low cost of deployment. Where technically and economically feasible, however, fibre - optic technology currently is used in most long – haul applications.

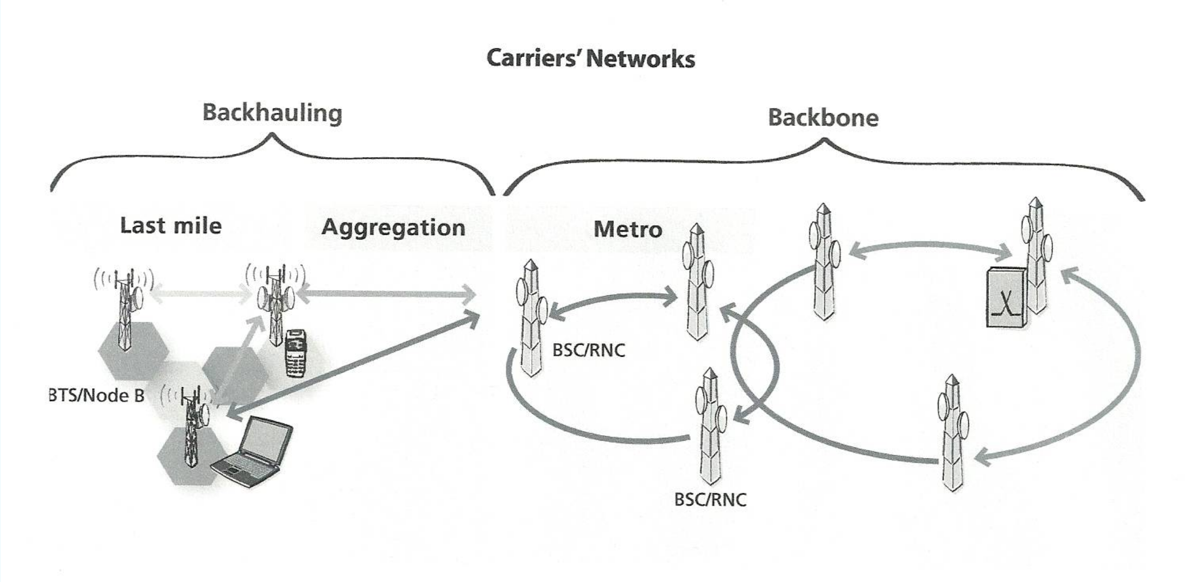
Contemporary there are numerous microwave applications such as private networks, carrier bypass, disaster recovery, interconnection of cellular radio switches, and WLL (Wireless Local Loop). Microwave certainly is an excellent alternative to cabled systems where terrain is challenging. In nations where regulatory authorities have liberalized telecommunications, emerging competitors find microwave to be an excellent means for deploying competing networks quickly and at low cost, particularly in WLL applications.

As cellular and PCS (Personal Communication Service) networks continue to grow, microwave radio links are deployed for connecting cell sites or backhauling traffic to the switch. The broad range of capacities and frequency bands provide ultimate flexibility for both long- and short-haul applications.

The unlicensed versions of the radio also permit rapid deployment of point-to-point links, allowing new cell sites to be turned up quickly to meet service demands.

Some of the above said applications are shown in Figure 2-12.

Figure 2-12: Some applications of microwave links



Source: Alcatel-Lucent, http://lightspeedt.com/wp-content/uploads/2011/06/MDR-8000_brochure.pdf

2.2.1.2 Outside plants of point-to-point microwave links

The outside plants of microwave links are essentially antennas and towers. Chapter 6 deals with these outside plants.

2.2.2 High Frequency radio systems

[For further information see "HF Communications: a system approach" Nicholas Maslin, Pitman]

2.2.2.1 General characteristics

High frequency (HF) is the ITU-designated range of radio frequency electromagnetic waves (radio waves) between 3 and 30 MHz. HF band is also known as the decameter band or decameter wave as the wavelengths range from one to ten decameters (ten to one hundred metres). The HF band is a major part of the shortwave band of frequencies, so communication at these frequencies is often called shortwave radio. HF communications are possible through ground wave paths. Moreover, because radio waves in this band can be reflected back to Earth by the ionosphere layer in the atmosphere (skywave propagation), these frequencies can be used for long distance communication, at intercontinental distances.

High operational flexibility, easy maintenance of equipment make High Frequency system techniques very useful in world communications; this is particularly emphasized in the case of large geographical areas with low density of telecommunications traffic. When the need for a new communications capability between two or more points is first envisioned, and HF radio link is suggested as a possible solution, a feasibility study is required to analyse and define the whole system.

2.2.2.2 Outside plants of HF radio systems

The outside plants of the HF radio systems are substantially the antennas, the basements and the power plants. Chapter 5 deals with this subject.

2.2.3 Cellular mobile networks

[For further information see "Telecommunications and Data Communications Handbook", Ray Horak, Wiley]

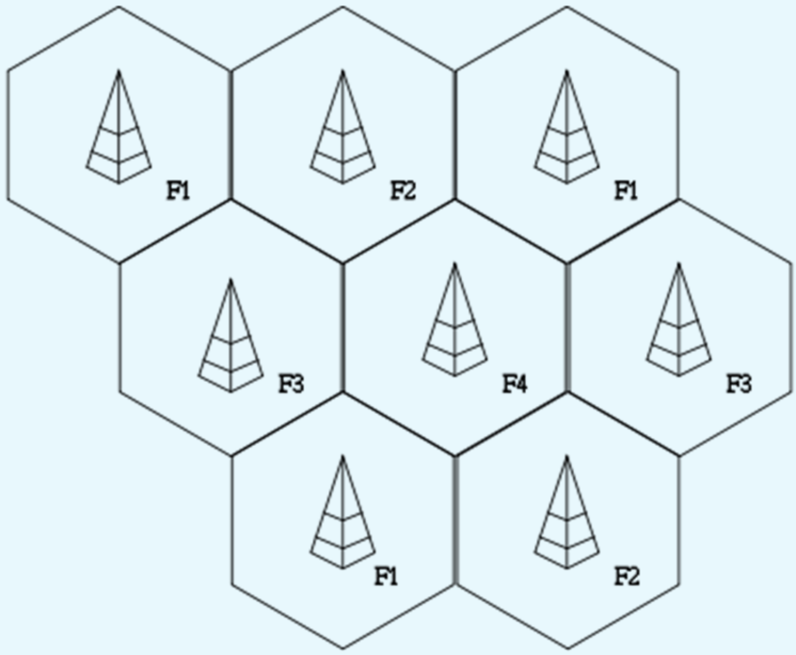
Note. Wireless, quite simply, refers to communications without wires. There are several types of wireless communications. Microwave and satellite communications are types of wireless communications deployed in high speed network backbone and access networks that are point to point, point to multipoint or broadcast in nature. Cellular mobile networks are another type of wireless communications which are local in nature and with an emphasis on mobility.

2.2.3.1 General characteristics

A cellular mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as Base Transceiver Station. In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell.

When joined together these cells provide radio coverage over a wide geographic area (Figure 2-13). This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

Figure 2-13: Example of frequency reuse factor or pattern 1/4



In a cellular radio system, a land area to be supplied with radio service is divided into regular shaped cells, which can be hexagonal, square, circular or some other regular shapes, although hexagonal cells are conventional. Each of these cells is assigned multiple frequencies which have corresponding radio base stations.

The increased capacity in a cellular network, compared with a network with a single transmitter, comes from the fact that the same radio frequency can be reused in a different area for a completely different transmission. Unfortunately, there is inevitably some level of interference to the signal from the other cells which use the same frequency. This means that, in a standard FDMA system, there must be at least a one cell gap between cells which reuse the same frequency.

In cities, each cell site may have a range of up to approximately 0.8 km, while in rural areas, the range could be as much as 7 km. It is possible that in clear open areas, a user may receive signals from a cell site 40 km away.

Radio waves are used to transfer signals to and from the cell phone. All of the cell sites are connected to telephone exchanges (or switches), which in turn connect to the public telephone network.

2.2.3.2 Outside plants of Base Transceiver Stations

The outside plants of the mobile (cellular) networks are substantially the Base Transceiver Stations. Chapter 5 deals with this subject.

2.3 Outside plants of satellite systems

[For further information see "Handbook on satellite communications" Wiley-ITU]

2.3.1 General characteristics

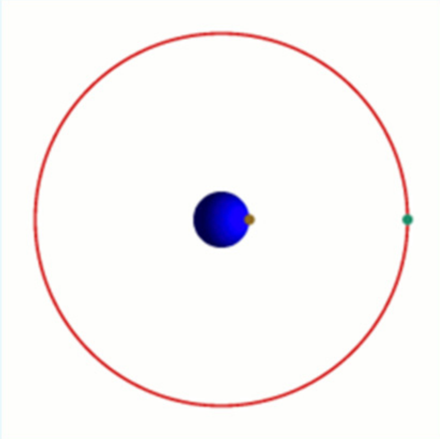
A communications satellite is an artificial satellite stationed in space for the purpose of telecommunications. Modern communications satellites use a variety of orbits including geostationary orbits and low (polar and non-polar) earth orbits.

For fixed (point-to-point) services, communications satellites provide a microwave radio relay technology complementary to that of communication cables. They are also used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals for which application of other technologies, such as cable television, is impractical or impossible.

2.3.1.1 Geostationary orbits

A satellite in a geostationary orbit appears, from earth, to be in a fixed position. This is because it revolves around the earth at the earth's own angular velocity (360 degrees every 24 hours, in an equatorial orbit) (Figure 2-14).

Figure 2-14: Geostationary orbit



A geostationary orbit is useful for communications because ground antennas can be aimed at the satellite without their having to track the satellite's motion. This is relatively inexpensive. In applications that require a large number of ground antennas, such as DirectTV distribution, the savings in ground equipment can more than outweigh the cost and complexity of placing a satellite into a geostationary orbit.

The main drawback of a geostationary orbit is that, with no direct line of sight, a satellite cannot service extreme northern and southern areas of the world. Another drawback is the height of the orbit, usually 36.000 kilometres, which requires more powerful transmitters, larger-than-normal (usually dish) antennas, and higher-sensitivity receivers on the earth. This distance also introduces a significant delay, of ~0.25 seconds, into communications.

2.3.1.2 Low-Earth-orbiting satellites

A Low Earth Orbit (LEO) typically is a circular orbit about 400 kilometres above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes. Because of their low altitude, these satellites are only visible from within a radius of roughly 1000 kilometers from the sub-satellite point. In addition, satellites in low earth orbit change their position relative to the ground position quickly. So even for local applications, a large number of satellites are needed if the mission requires uninterrupted connectivity.

Low earth orbiting satellites are less expensive to launch into orbit than geostationary satellites and, due to proximity to the ground, do not require as high signal strength (signal strength falls off as the square of the distance from the source, so the effect is dramatic). Thus there is a tradeoff between the number of satellites and their cost. The earth stations must "follow" the satellite in their movement in respect of the earth.

2.3.1.3 Satellite constellation

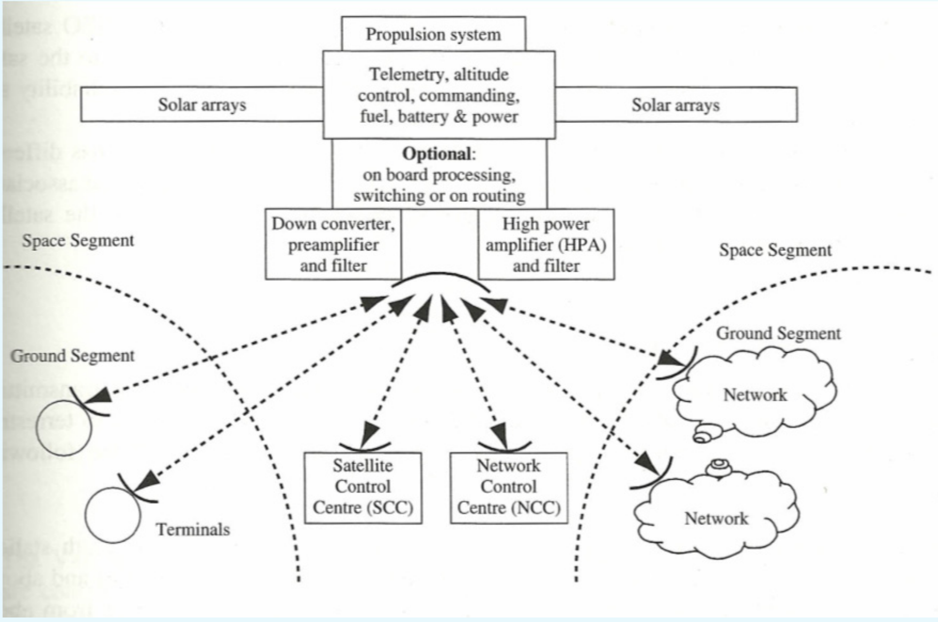
A group of satellites working in concert is known as a satellite constellation. Example of such constellations, intended to provide satellite phone services, primarily to remote areas, are the Iridium and Globalstar systems. The Iridium system has 66 satellites.

It is also possible to offer discontinuous coverage using a low Earth orbit satellite capable of storing data received while passing over one part of Earth and transmitting it later while passing over another part. This will be the case with the CASCADE system of Canada's CASSIOPE communications satellite. Another system using this store and forward method is Orbcomm.

2.3.1.4 Structure of a communications satellite

A typical satellite communication includes the following elements (Figure 2-15):

Figure 2-15: Satellite Networking



– space segment: one or several spacecraft with in-orbit spare capability. The spare capability could be transponders on the same spacecraft or it could be a whole spare spacecraft. Usually there is at least one spare spacecraft on the ground ready to be launched;

– earth station for communications: a system may include a great variety of earth stations. These stations may vary in size of dish, transmitting power, receiving sensitivity, capacity, access mode (FDMA, TDMA, CDMA), etc. Usually a certain number of these stations may constitute a subnetwork dedicated to a specific service;

– terrestrial distribution: from the earth station the signal is carried to the customers' premises through a terrestrial transmission medium. Coaxial cable, optical fibre cable, microwave link etc. can be used for carrying the signal to the user. The nature of the signal and the distance to be carried will influence the economics and the selection of the appropriate terrestrial transmission system. Quite often, when the signal is carrying messages to be widely distributed within a metropolitan area, a central office is located in the center of the city where the satellite system is carried for demultiplexing and distributing through the public distribution system.

  Even in cases in which the earth station is located at the premises of the end user, a short interconnecting facility may be required to reach the computer room, the private automatic branch exchange (PABX) room or the service equipment which requires the satellite transmission service. Networks of earth stations with the corresponding terrestrial distribution facilities may be dedicated to a particular user and they may also be simultaneously interconnected to a general purpose network including public telephone facilities;

– power supply: most of the terrestrial facilities, including the earth stations, require a backup power system in case of commercial power failure. The term "uninterruptable power supply" is used for special designs that switch automatically to the backup power generating system in case of commercial power failure: storage batteries absorb the load during the switching period. Such backup power systems can be very expensive, depending on the size and duration of the load that they have to carry and the sophistication of the design.

2.3.1.5 Satellite service categories

The ITU has three broad radiocommunications satellite service categories: Fixed Satellite Service (FSS), Mobile Satellite Service (MSS) and Broadcasting Satellite Service (BSS). While some of the basic characteristics of these services are similar, there are crucial differences in their network architecture, capabilities and service offerings.

FSS and BSS operators are capable of providing capacity for fixed-to-fixed and point-to-multipoint services. Both FSS and BSS typically operate from the geostationary (GSO) orbit 36,000 kilometers above the equator. Depending on how the system is configured, a single GSO satellite can be capable of offering service coverage of up to one-third of the Earth's surface.

MSS systems offer voice and lower-rate data services to portable satellite phones and vehicle-mounted terminals for ships, aircraft, trucks or automobiles. MSS systems operate from both the GSO and Low Earth Orbits (LEO), but the user is usually unaware of the orbit used and can simply connect, similar to how someone would use a cellular phone or modem without reference to the specific terrestrial network they are on.

Global Mobile Personal Communications Systems (GMPCS) fall under the MSS category, and indicate highly-portable variants of MSS systems. These applications are particularly suitable for situations where a high degree of mobility is required. While a line of sight connection to the satellite is required, their mostly-omni directional antennas need not be aligned accurately.

2.3.2.6 Outside plants of satellite systems

The outside plants of the satellite systems are essentially antennas, their basements and the power plants. An example is shown in Figure 2-16. Chapter 6 is dedicated to this subject.

Figure 2-16: Basement and antenna of a satellite system

Bibliography

The bibliography is indicated at the beginning of the various sections.

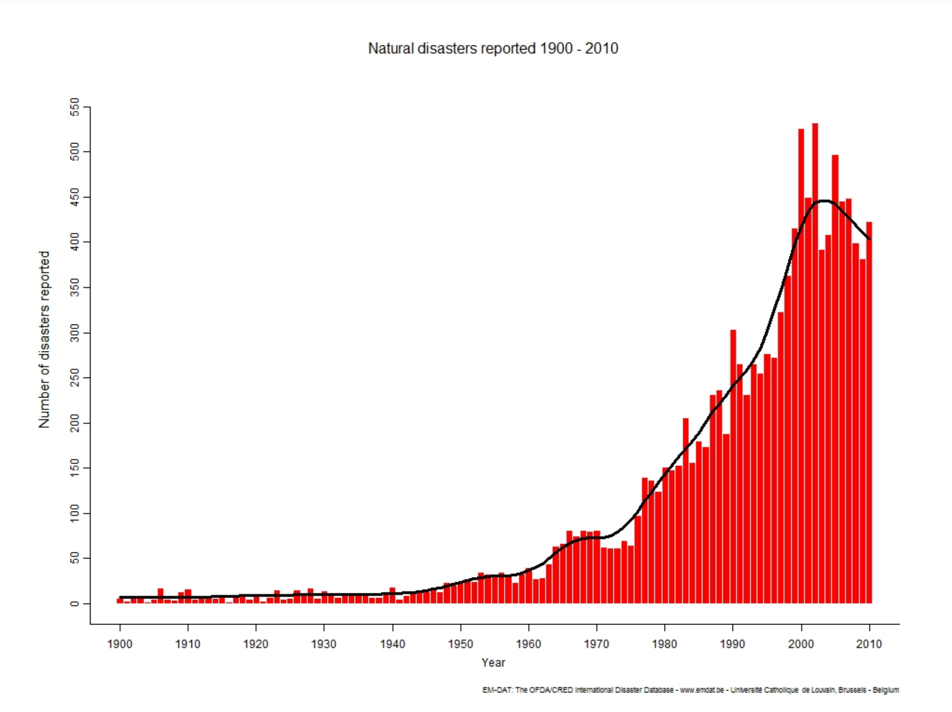
Chapter 3

Survey and evaluation of the natural disasters' impact on telecommunication outside plants

3 Introduction

The number of natural disasters has been rapidly increasing during the past years as shown in Figure 3-1. In the same way their impact on the outside telecommunication plants is becoming more and more devastating. This chapter outlines the effects of some major natural disasters on the telecommunication outside plants.

Figure 3-1: Natural disasters reported in the years 1900-2010



Source: EM-DAT The International Disaster Database.

3.1 Answers to the questionnaire on "Technical considerations on protecting outside plant facilities from natural disasters"

[For further information see ITU-T Recommendation L.92]

A questionnaire on "Technical considerations on protecting outside plant facilities from natural disasters" was sent to ITU-T Q17/15 members to collect materials such as observations, knowledge, experiences and practices of each country. Sixteen countries (Argentina, Costa Rica, Cyprus, Estonia, Indonesia, Iran, Japan, Korea, Mongolia, Mozambique, Poland, Spain, Switzerland, Tanzania, Turkey and Ukraine) replied to the questionnaire.

As illustrated in Figures 3-2 and 3-3, 81 percent of responded countries have experienced disasters and 87 percent of countries have experienced communication service interruption due to the failure of outside plant facilities.

Figure 3-2: Percentage of disaster experienced

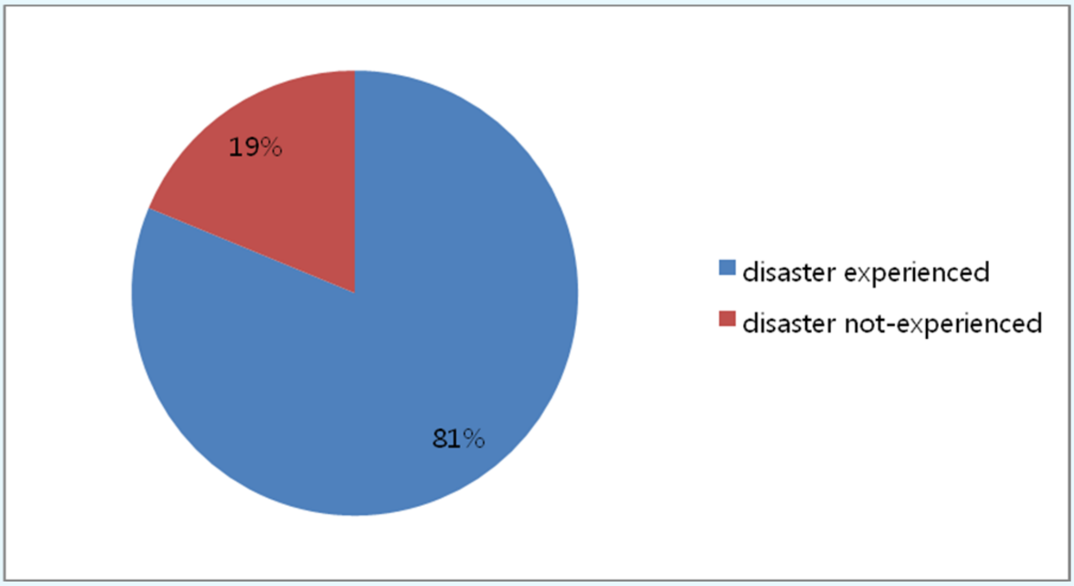
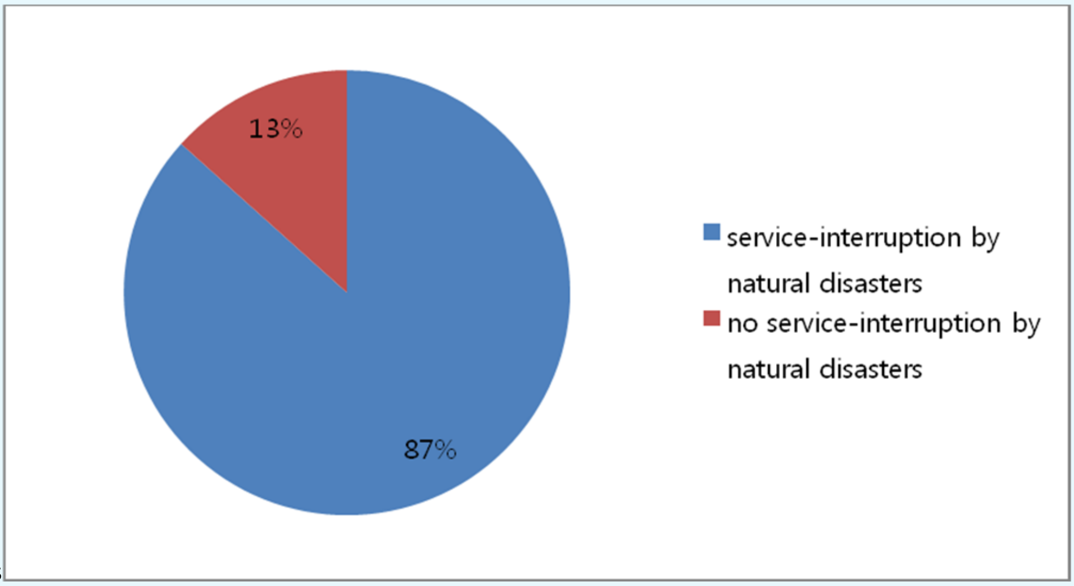


Figure 3-3: Percentage of service-interruption by natural disaster



It is found that the most frequently occurring natural disasters are flash floods and strong winds as illustrated in Figure 3-4. Among these natural disasters, flashfloods, earthquake, and strong winds are ranked as the most destructive (see Figure 3-5).

Figure 3-4: Most frequently occurring natural disasters

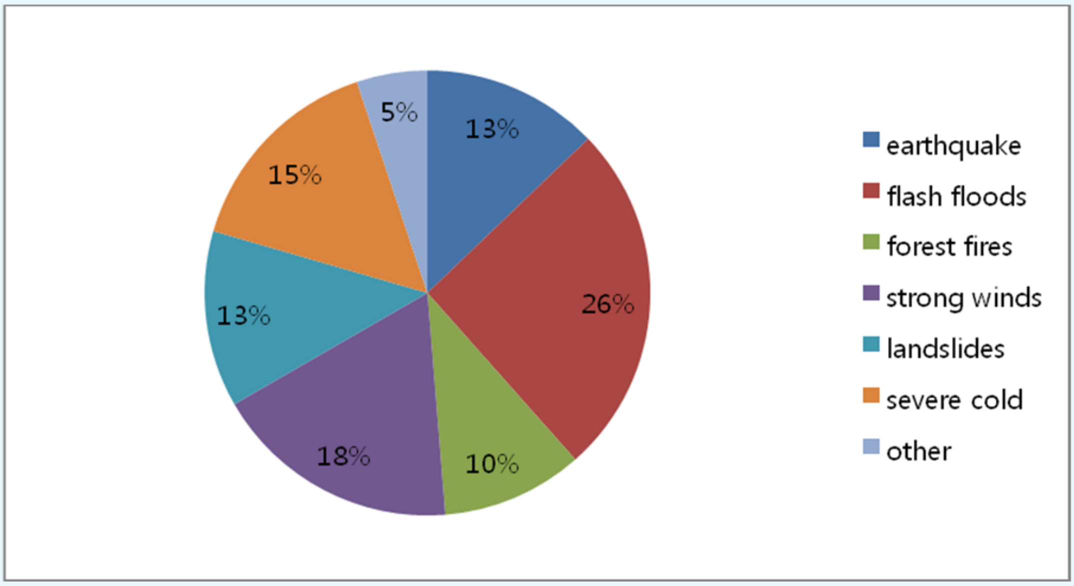
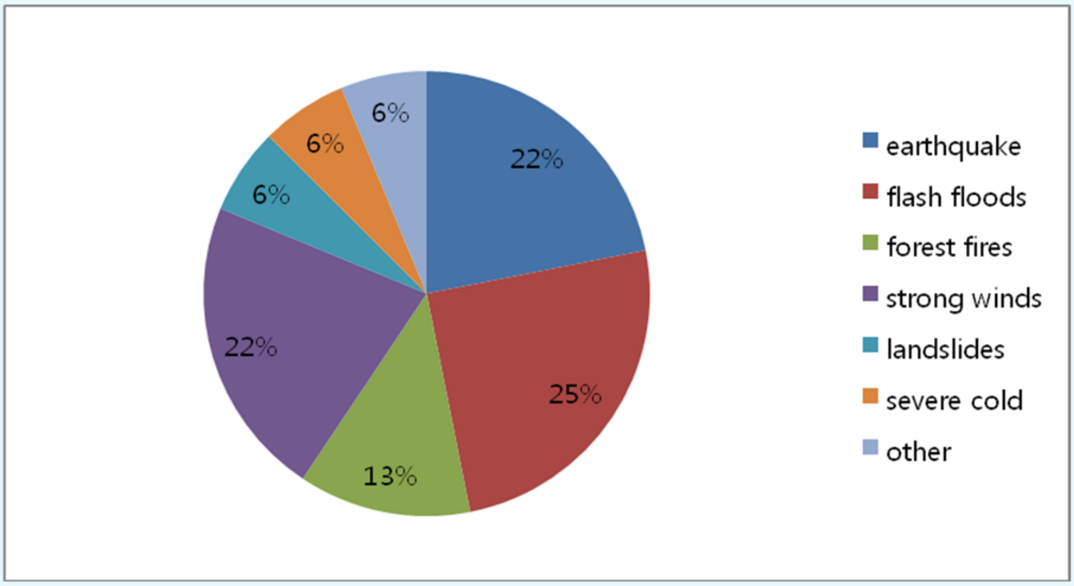


Figure 3-5: Most destructive natural disasters



Countermeasures for natural disasters are summarized in Table 3-1.

Table 3-1: Countermeasures for natural disasters

Natural disasters	Countermeasures
Earthquake	Rubber joints for cable tunnels, liquefaction countermeasures on manhole, extendable joints for ducts and seismic simulations; Increasing strength of materials which are used in outside plant facilities.
Flash floods	Water pumps, sealed pipe ends; Draining water out (from pits) whenever necessary using water pumps; Sealing the ends of the plastic tubes (at the manholes/pits of our underground infrastructure) with foam filler; Submersion detection modules and cable tunnel management systems; Installing drainage pumps in cable tunnels and installing flood walls in cable tunnels; Installing concrete structures at the site in which ground settlement may be expected due to heavy rains; Installing retaining structures or guardrails between outside plant facilities and steep slopes; Cables and cable joints within manholes and cable tunnels are normally constructed to be waterproof; Placing waterproof materials in cable tunnel ends inside manholes; Water-proof cable channels, tight joints of pipes for cable channels, water-tight manholes, and installing water pump in the cable tunnels.
Forest fires	Using fire breaks (isolating clean land strips-mostly in the rural area) allover the island; Protecting outside plant facilities with non-flammable or fire-retarding materials; Using non-flammable materials in cable structures.
Hurricanes/tornados/typhoons/wind storms (strong wind)	Using stay wires, protect our poles by using stay wires; Bracing poles alternatively with steel wires when the expected wind speed exceeds 40 m/s; Using bracing between poles in windy locations.
Landslides	Increasing the slope's stability; keeping away from landslide-prone areas.
Severe cold, snow, ice or heat	A manhole cover for snow covered areas and installing tubes for antifreeze in ducts; Outside plant facilities that are installed at sites where there is extreme heat or cold should be provisioned with adequate countermeasures in order to operate with stability; Outside plant facilities that are installed at the site or environment where its temperature difference is excessive should be provisioned with adequate countermeasures in order to operate with stability.

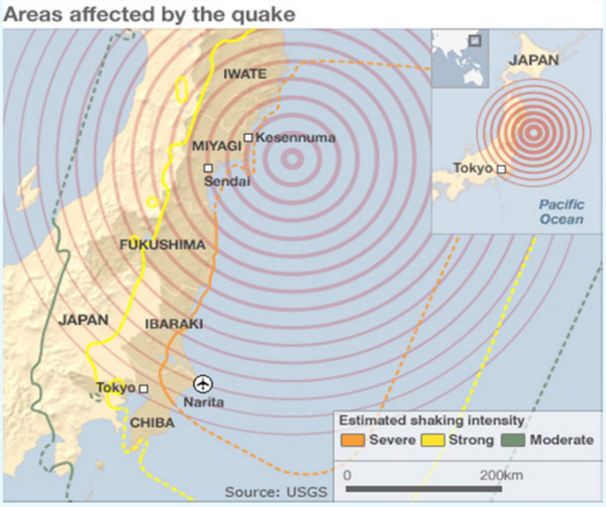
3.2 The Great East Japan earthquake and tsunami (11 March 2011)

[For further information see Bibliography.]

3.2.1 The main characteristics of the earthquake/tsunami

In Japan, infrastructure, and telecommunications infrastructure in particular, has been put to the test by the biggest earthquake ever recorded in the country's history, that struck at 14:46 hours on 11 March 2011 off the eastern coast of Japan (Figure 3-6).

Figure 3-6: Areas affected by the Great East Japan Earthquake



Source: ITU-T D.305 New Breeze, p. 3.

This earthquake can be characterized as follows:

– Earthquake generation date: 14:46, March 11th , 2011;

– Hypocenter: Coast of Sanriku (38.1°N/142.9°E, Depth of 24 km, Magnitude 9.0);

– Japan Meteorological Agency Seismic intensity scale (Over 6):

  • 7 (North of Miyagi),
  • 6 upper (South and middle of Miyagi, Fukushima, and so on),
  • 6 lower (South of Iwate, South of Gunma, and so on)

– The direction of the pressure axis of this reverse fault earthquake was from west-northwest towards east-southeast;

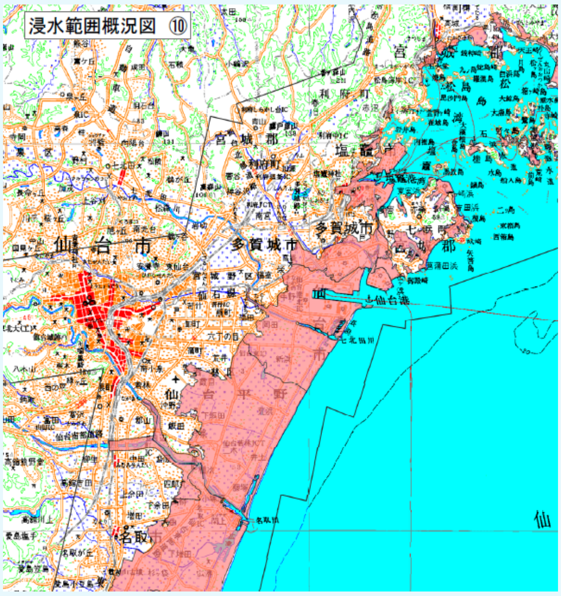
– The maximum amount of land shift was about 25 m, and the scale of the fault was about 200 km in a north-south direction and about 500 km in an east-west direction, as a result, large geographical displacement, 5.3 m enhancement in horizontal direction and 1.2 m in vertical direction, was introduced;

– The fault rupture expanded in the vicinity of the point where the destruction began, then progressed north and south, continuing for about three minutes.

A huge tsunami was generated by this quake, with maximum run-up height was about 38 m. The tsunami caused a flood of large coastal areas. The two natural disasters caused a catastrophe with about 390,000 buildings and houses, about 4,200 roads, about 120 bridges damages, and about 19,000 fatalities.

Figures 3-7 and 3-8 show the flood area generated by the tsunami. Figure 3-7 shows the area in Miyagi.

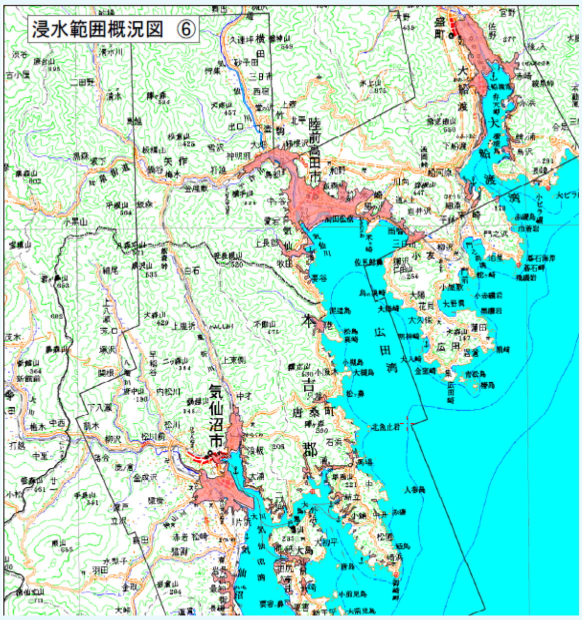
Figure 3-7: Chart of flood rate (I)



Source: ITU-T C896 slide 5.

Figure 3-8 shows the area in Iwate.

Figure 3-8: Chart of flood rate (II)



Source: ITU-T C896 slide 5.

In these area maps, flood area is indicated by red color. As shown in these figures, the tsunami had intruded deeply into land.

3.2.2 Damages to the telecommunication plants

The telecommunications plants as well suffered unprecedented earthquake and tsunami damage across a wide area, including the collapse, submersion and washing away of equipment inside telecommunications office buildings, the severing and destruction of underground cables and ducts, the collapse of utility poles, the destruction of aerial cables, and the collapse and washing away of mobile phone base stations. The disaster also caused long-term electrical blackouts, meaning even facilities undamaged by the earthquake and tsunami which ought to have been capable of providing service became non-functional due to shortages of batteries or fuel for private electric generators, etc.

As to the specifics of quake damage, the NTT East fixed telecommunications network suffered from cessation of functioning in 385 buildings, 6,300 km of coastal aerial cables being washed away or damaged, and 90 severed transmission routes, as well as 65,000 utility poles washed away or broken in coastal areas. As a result, approximately 1.9 million subscriber lines were affected. Meanwhile, transmission routes (entrance lines) between cellular and PHS base stations operated by NTT East Japan were damaged, and the damage to these routes and using up of batteries, etc., as electrical blackouts continued, resulted in a total of approximately 29,000 base stations shutting down. The damage inflicted on the telecommunications infrastructure by the March 11 earthquake was greater in scale than that caused by previous earthquakes, but swift restoration work by each telecommunications carrier meant that recovery was complete by the end of April with the exception of certain areas.

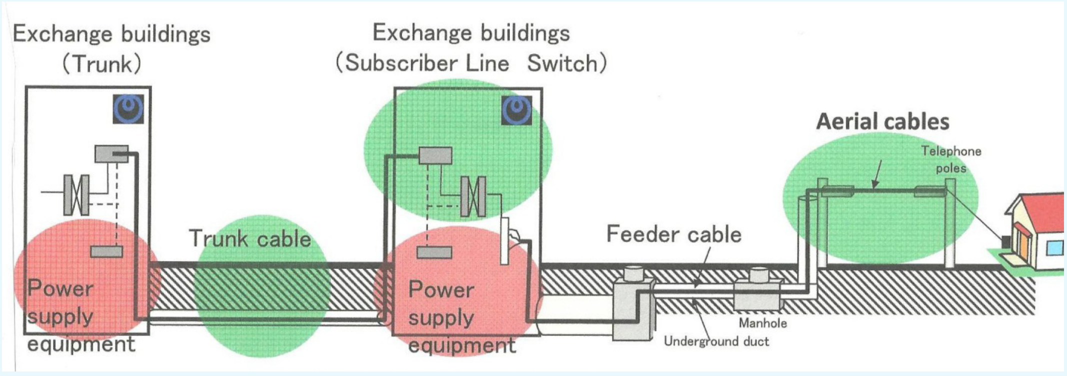
In conclusion the impact of the disasters can be summarized as follows:

- About 19,000 fatalities;
- Material damages estimated at US $ 210 billion;
- About 390,000 buildings and houses destroyed;
- About 4,200 roads destroyed;
- About 120 brides destroyed;
- Nuclear power plants severely damaged;
- Power, water and gas supplies cut.

The damage to the telecommunication infrastructure can be summarized as follows:

- NTT East’s fixed network (the damages on a typical site are shown in Figure 3-9)
  - 385 buildings being out-of-service. The tsunami destroyed outside plant and flooded buildings and accounted for about 20% of the damage, while the remaining 80% of buildings were put out of action as a result of the widespread and prolonged power cuts and the inability to refuel temporary generators.
  - 90 transmission routes were broken.
  - 6,300 km of coastal aerial cables washed away or otherwise damaged.
  - 65,000 utility poles washed away or otherwise damaged.

Figure 3-9: Situation of communications equipment damage



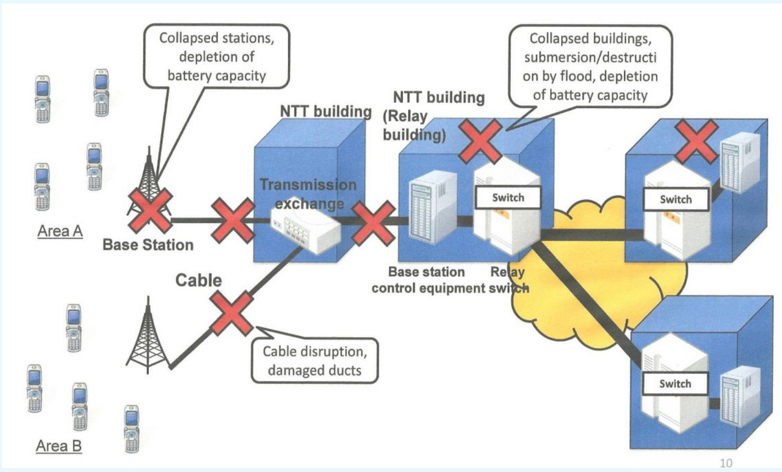
Totally destroyed or flooded buildings and cable severed by tsunami ⇒About 20% of damaged buildings (green)
Widespread, long term power cuts, "cuts to power fuel“ ⇒About 80% of damaged buildings (red)

Source: Natsuo Minamikawa, Sendai Seminar, March 2012, page 4.

– Total number of damaged fixed lines (of all the operators): about 1,9 million

– Total number of damaged base stations (cellular service): damages to the transmission routes between cellular base stations and the wired network, using up of batteries as electrical blackouts continued (Figure 3-10) resulted in a total of approximately 29,000 base stations shutting down.

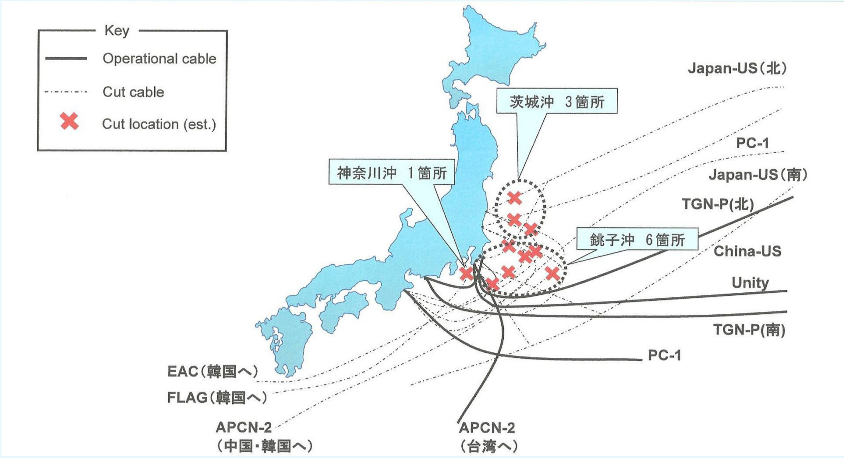
Figure 3-10: Damaged Points of Mobile Network



Source: ITU-D 2-INF-77, Sept. 2011, slide 10.

– Damage to submarine cables affected international dedicated lines, international IP-VPN (Virtual Private Networks), international subscriber services. (Figure 3-11)

Figure 3-11: Damages to submarine cables (KDD, Sendai Seminar Slide 7)



– Power blackout: practically all of Tohoku region suffered a power blackout, with many places experiencing a complete breakdown in communications. Portable radios were at times the only means left for obtaining information.

– Aerial facilities fared much worse than those underground with a damage rate of 0.3% for underground facilities and 7.9% for aerial facilities.

– The earthquake itself caused little damage in respect of the tsunami.

3.2.3 Recovery actions (emergency repair)

Telecom operators/carriers, have been working to restore damaged communications infrastructure and to support victims in the disaster area from the viewpoint of communication lifeline. As of the end of April, services had been restored at all disrupted fixed-line telephone exchanges operated by NTT East, with the exception of a few regions, 3 buildings in difficult area corresponding to the Fukushima nuclear power plant and 2 buildings in refuge island outside area. The above quoted results have been obtained mainly through the following actions/efforts.

3.2.3.1 Telecommunication infrastructures

– Efforts to restore communications infrastructure can be summarized as follows:
  - Deployment of base station vehicles and temporary base stations using satellite;
  - Deployment of battery vehicles;
  - Provision of satellite communications circuits (rental of ultra-small earth stations);
  - Deployment of temporary relay stations outside the area covered by MCA;
  - Release of restoration area map and provision of restoration information.

3.2.3.2 Transmission routes

Transmission routes are also used as entrance lines (transmission routes between mobile phone carriers' base stations and switching equipment), so when they are damaged in disasters, it will also lead to damage of mobile phone transmission routes and disruption of service. Telecom operators engaged in emergency repairs including clearing away of rubble, replacement of utility poles, and laying of cable. Meanwhile mobile phone carriers have been ensuring the viability of entrance lines through use of satellite circuits and fixed micro-lines, etc.

3.2.3.3 Submarine cables

Cut optical land cables along highways were found and repaired nonstop for two straight days (about 20 km worth) to hasten the recovery. The interrupted submarine cables, Japan-US, APCN2, China-US and PC-1, are shown in Figure 3-11.

Submarine cable traffic was rerouted on March 15 in order to restore international service.

3.2.3.4 Base stations and local stations

During the March 11 earthquake, a total of about 29,000 base stations for cell phones and PHS ceased functioning, and 385 NTT East telecommunications buildings stopped operating.

Emergency repairs to base stations and local stations entails (Figure 3-12):

– in place of damaged communications buildings, portable boxes containing communications equipment were delivered and set up, and communications services resumed;

– expanding the zones of existing base stations;

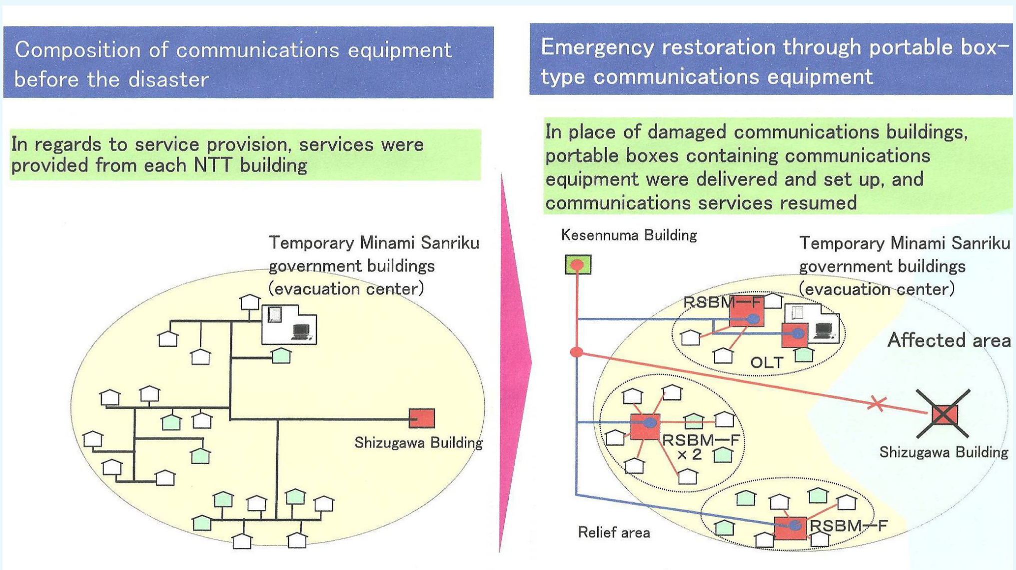
– deploying mobile and compact base stations (femtocells);

– setting up mobile base stations with satellite radio entrance line equipment;

– installation of small, transportable base stations equipped with land radio entrance;

– deploying outdoor line trunk accommodation units and shifted resources from other stations (laying in cable from other areas and out-rigging of network facilities).

Figure 3-11: Emergency restoration of equipment



Source: ITU-D Sendai Seminar March 2012, Natsuo Minamikawa slide 9.

The mobile service coverage had almost fully recovered by the end of June, with the exception of the restricted area around the Fukushima I Nuclear Power Plant, adopting the above quoted activities.

3.2.3.5 Ensuring stability of power supplies

Electrical blackout countermeasures for telecommunications facilities include requirements for the installation of backup generators or batteries (both backup generators and batteries in the case of switching equipment). In the wake of the March 11 earthquake blackouts were widespread and lasted for long periods of time, and even telecommunications facilities undamaged in the quake were subject to power shortages and service disruptions as batteries and fuel for generators were used up.

As a consequence, the March 11 earthquake highlighted the need for batteries, etc. that can last through long-term electrical blackouts. However it is not practical from a cost perspective to provide for batteries that can serve through very long-term blackouts as regards all telecommunications facilities.

3.2.4 Lessons learnt by the earthquake/tsunami

The earthquake and tsunami that struck Japan in March 2011 affected the access infrastructure such as conduits, cable tunnels, manholes and so on, essential to supporting communication systems. Technologies now exist that are earthquake-resistant but much current equipment is superannuated, in which about 50 % of conduits and about 40 % of cable tunnels are 30 years or more passed after the construction. Moreover, 80% or more manholes have been working for more than 30 years. A lot will undoubtedly be learned from analyzing the damage caused by the March disaster. **Some lessons learnt from damages caused to communications infrastructure are listed in the following Table 3-2.**

At this purpose it is of interest to look, as an example, to look at some cases of gaps between planning and reality.

Table 3-2: Lessons learnt

	Assumptions	Actual damage
Network Station facilities	– Earthquake preparedness: based on a 7 on the Seismic Intensity Scale – Tsunami preparedness: flood walls installed, floor height raised, etc.	– The vibrations from the earthquake had no effect on stations – The tsunami was larger than the assumptions and had wide spread impact
Switches and transmission equipment	Redundancy: redundant switches and transmission equipment, n+1 redundancy architecture should be used	– There were no problems switching to the redundant switches and transmission equipment – The earthquake affected a much wider area than expected and line equipment was damaged in many places
Backup power	The necessary backup power equipment was based on the different needs of each station. Examples: – Central office: backup power supply for more than 24 hours – Base stations: battery for at least 3 hours	– Batteries and backup power generation specifications were sufficient in terms of duration of power generation, etc. – The effects on equipment operation were as follows: • Central office no effect on equipment operations • Base stations black out conditions lasted longer than expected and a great number of stations were affected

Another consideration is related to water leaks caused by the disaster in the communications cable tunnel. Pumping stopped because of loss of power, but the communications cable was not affected and remained usable: optical fiber cable has proof stress to water. Concrete flaked off in the cable tunnel, but there was little damage. The reason for this is because the cable tunnel was built using technology that is in accordance with standards for earthquake resistance.

It might be asked why there was not more earthquake-resistant infrastructure in Japan. The answer is depressingly simple – because of the high cost of applying these technologies in construction.

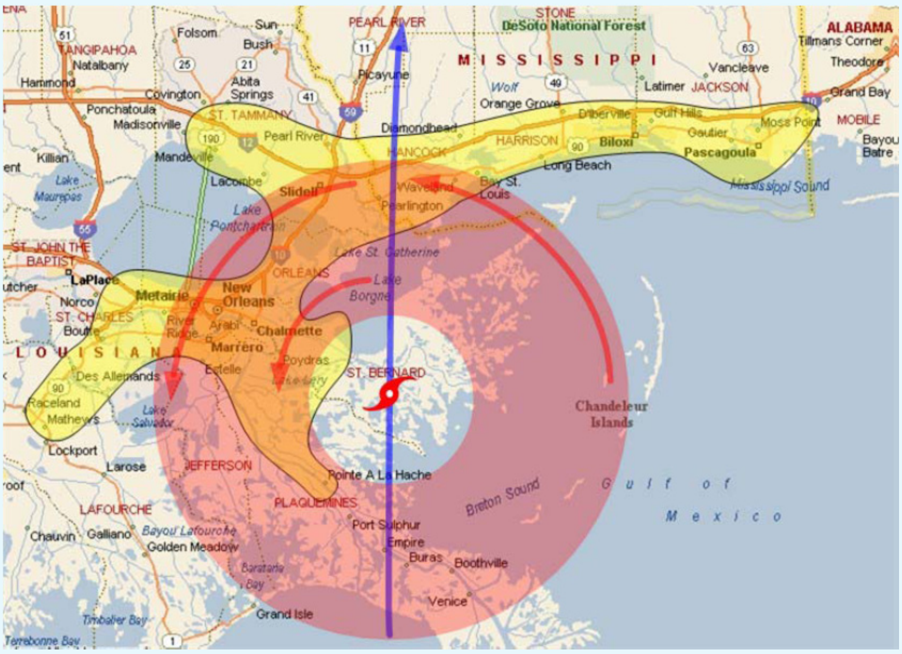
3.3 Hurricane Katrina (29 August 2005)

[For further information see Bibliography and, in particular, 16 and 17]

3.3.1 The main characteristics of the hurricane/flooding

Katrina developed as a tropical depression on August 23, 2005, in the southeastern Bahamas. It made its first landfall as a Category 1 storm near Hollywood in South Florida and continued westward across the state into the Gulf of Mexico, where conducive weather conditions, warm sea-surface temperatures, and an upper-level anticyclone allowed it to develop into a major Category 5 hurricane. By the time it made landfall at the Mississippi-Louisiana border on August 29, the huge storm system had 40-50 km radius. Although it had diminished to a strong Category 3 storm, it crashed into the shore with sustained winds of about 180 km per hour. Just six hours later, hurricane Katrina weakened to a tropical storm northwest of Meridian, Mississippi (Figure 3-13).

Figure 3-13: Hurricane Katrina at 6:45 local time on Aug. 29 2005



Source: Kwasinski, Bibl.17.

The area of hurricane force winds is indicated with a red donut. The path is marked with a blue vertical arrow and the wind direction with counterclockwise red arrows. The site survey region is the lightly-shadowed area

By the time it died out, Katrina had caused one of the worst damage the United States had ever seen. With losses estimated at more than $ 125 billion, it became the costliest hurricane in U.S history. Roughly 230 square kilometer in parts of Mississippi, Louisiana and Alabama – an area slightly larger than the Great Britain – were damaged. The number of death was about 2,000 persons. More than 1.7 million houses lost electricity and up to 1 million people were displaced.

Hurricane Katrina was a strong natural system. The catastrophic combination of high winds, extreme storm surge and flooding from levees breaches set the stage for disaster's impact. In terms of storm surge, the areas hardest hit were Hancock and Harrison Counties in Mississippi, which experienced surge heights of 7-8 m; the surge flattened block after block in the cities of Waveland, Bay St. Louis and Long Beach. The rest of the Mississippi's coast experienced a surge height of 5-6 m. The surge, which extended 9-10 km inland and up to 18 km along bays and rivers, left behind nothing but a few concrete slabs and pilings.

3.3.2 Damages to the Telecommunication infrastructures and recovery actions

The sheer force of the hurricane Katrina and the extensive flooding resulting from the breached levees severely tested the reliability and the resilience of communication networks in the Gulf Coast region. Katrina also affected areas of the Gulf Coast in varied fashions. In the high impact zones near Gulfport, MS and New Orleans, LA, the hurricane created much heavier damage to the infrastructure due to the strong winds and, in New Orleans, extensive flooding in the days after the storm. In less impacted areas, damage was less severe and recovery efforts were more easily accomplished.

As said above, to understand the precise impact that Hurricane Katrina had on telecommunication networks, it is useful to distinguish between the impact of the storm itself (i.e. hurricane force winds and rain) and the effects of what came later (extensive flooding from breached levees and widespread, long term power outages). As detailed below, it appears that most communication infrastructure in areas impacted by Katrina faired fairly well through the storm's wind and rain, in most cases sustaining only minor damage or damage that should have been promptly repairable. Indeed, the tower industry reported that all the towers in the path of the 2005 hurricane in the Southeastern and Gulf Coat areas of the United Sates, less that 1 % suffered any structural damage. The coastal areas that bore the brunt of the storm suffered the worst infrastructure damage from the hurricane. Not to diminish the significant impact of the hurricane itself, what made Katrina unique and particularly catastrophic were the unique conditions after the winds subsided – substantial flooding and widespread, extended power outages. These developments impacted telecommunication networks greatly, causing irreparable damage to submerged electronics and prolonged outages in many cases. The observations on how each type of communications infrastructure withstood Katrina and its challenging aftermath is presented below.

3.3.2.1 Public Safety Communications Networks

Public safety communications networks are generally built to be reliable in extreme conditions. To ensure this, the systems are planned to accommodate everyday peak service times as well as large incidents. They are also designed to account for radio systems disruptions, such as power outages, transmission failures, system interconnect failures and personal radio equipment failures. However, these systems are generally not designed for widespread catastrophes of long duration – the situation resulting from Katrina. As a result of the storm and its aftermath, public safety networks in the Gulf states experienced a large number of transmission outages that impacted the functionality of both primary and back-up systems. The loss of power and the failure of switches in the wireline telephone network also had a huge impact on the ability of public safety systems to function. Public safety personnel's apparent lack of familiarity with the operation of back-up or alternate systems (such as satellite systems) also limited functionality.

Wireline and Network Infrastructure Failures. Katrina and the subsequent levee breaches caused significant failures to the Public Switched Telephone Network (PSTN), particularly in the New Orleans area. Public safety radio networks rely on interconnection with the PSTN or by fixed microwave links to get communications through to public safety responders. Given PSTN failures. as well as damage to fixed microwave links, public safety communications were significantly affected.

In general, public safety’s antenna towers remained standing after the storm. The winds did not blow antennas out of alignment, requiring readjustment. However the main cause of transmission failures was loss of power (as discussed below). Most public safety radio systems by design are able to handle and manage a single or isolated subsystem failure or loss. However Katrina affected parts of four states, causing transmission losses at much greater number and over a larger area than public safety planning had envisioned.

Power for radio base stations and battery/chargers for portable radio devices are carefully planned for public safety systems. However, generators are typically designed to keep base stations operating for 24 to 48 hours. The long duration of power outages in the wake of Katrina substantially exceeded the capabilities of most of public safety’s back-up generators and fuel reserves. Similarly, portable radios and back-up batteries generally have an 8 to 10 hours duty cycle. Without access to power to recharge the devices and backup batteries, portable devices quickly ran out of power.

3.3.2.2 Wireline network

More than 3 million customer phone lines were knocked in the Louisiana, Mississippi and Alabama area following Hurricane Katrina. The wireline telephone network sustained significant damage both to the switching centres that route calls and to the lines used to connect buildings and customers to the network. Katrina highlighted the dependence on tandems and tandem access to SS7 switches. The high volume routes from tandem switches, especially in and around New Orleans were especially critical and vulnerable. Katrina highlighted the need for diversity of call routing and avoiding strict reliance upon a single routing solution. One tandem switch, which was critical for 911 call routing, was lost from September 4 to September 21. This switch went down due to the flooding that did not allowed for fuel to be replenished. Due to the high winds and severe flooding, there were multiple breaks and fibre network supporting the PSTN. Katrina demonstrated that in many areas there may be a lack of multiple fibre routes throughout the wireline network and that aerial fibre was more at risk than underground fibre. As with other private sector communications providers, lack of access to facilities due to flooding, lack of commercial power, and lack of security greatly hampered recovery efforts. Nevertheless, ten days after Katrina, nearly 90 percent of wireline customers in the Gulf region who had lost service had their service restored. However the vast majority of those customers were in the less impacted regions of the Gulf; regions that were harder hit sustained more infrastructure damage and continued to have difficulty in restoring service.

One of the solutions implemented to replace most destroyed switches was to provide limited services to priority lines with a digital loop carrier (DLC) system linked to an undamaged CO through an optical fibre cable (Figure 3-14).

Figure 3-14:Pass Christian CO showing the DLC system used to replace the destroyed switch

Source: Kwasinski, Bibl.17.

This implementation indicates that the outside plant was in adequate condition to support the lines connected to the DLC, and that the damage was more severe in the central network elements than in the distribution. Using DLC systems to replace destroyed switches is advantageous from a planning perspective because they can be quickly deployed and they provide more flexibility to adapt to uncertain demands. DLC cabinets fed by optical fibre cables were used to replace damaged copper feeder cables in six COs. Some DLC systems were operating in the area before the storm, mainly in areas of the Mississippi Gulf Coast, to provide service to subscribers far away from the corresponding central office. Only a few of these were destroyed. The undamaged sites were equipped with portable generators.

The most important disadvantage of using DLC cabinets so extensively is the logistical effort of deploying portable generators to each site to maintain service during long electric outages. Moreover reliability will be negatively affected when DLC systems replace a switch; subscriber circuit elements, such as DLC, are usually designed with a lower target reliability than main network components, such as a switch fabric.

Switch on wheel (SOW) had previously been used in some countries during the initial set-up of new networks. Although SOW are more expensive than DLC enclosures, they are more reliable, provide better functionality for trunks, and reduce congestion nodes by allowing better traffic distribution. SOW disadvantages include need for periodic maintenance and floating the batteries during the year.

As said before, the cause of the majority of central office outages was power-related. In New Orleans, flooding caused six CO failures, indicated in Figure 3-15.

Figure 3-15: New Orleans satellite picture showing the flooded areas

Source: Kwasinski, Bibl.17.

In a darker color with the location of 6 central offices that failed indicated with yellow dots. Levees breaches are marked with red dots.

In some of these sites, direct flood water contact damaged the genset, the fuel tanks or the power plants, but not the main communications equipment. In the other cases, high water levels or civil unrest prevented the possibility of reaching the site with fuel, as in Chalmette. With the exception of Lake CO, whose oldest switch suffered damage, extensive damage at these sites was prevented because the majority of the equipment was located on high floors. Lake CO suffered the highest floodwaters of all the central offices with power related outages. In this location, floodwaters reached more than 3 meters. Besides being in one of the lowest points in the city, the building is located 300 m from the London St. canal levee, which breached 800 m southwest of the central office.

Mid City was the other CO with equipment damage, in this case affecting the power plant located in the basement. Some of these central offices also had damage to copper feeders, probably when pumps that inject air into the cables failed to operate, either because of power failure or direct water contact at the cable entrance. Two other central offices that had direct flood-induced power failure were Michoud and Venice. The latter is Louisiana's southernmost central office located near the mouth of the Mississippi river 15 km west of the landfall point.

All the remaining failed central offices had outages due to genset engine fuel starvation. Two primary reasons for this failure were disrupted local diesel supply and obstructed roads. In these locations flooding did not persist and played no significant role in the outage.

Fuel consumption can be dramatically reduced by installing solar energy panels. In addition, solar power in COs used throughout the year can reduce expenses owed to the electric utility company. A long-term solution may also involve more complex distributed generation systems to reduce the dependency on the electric grid.

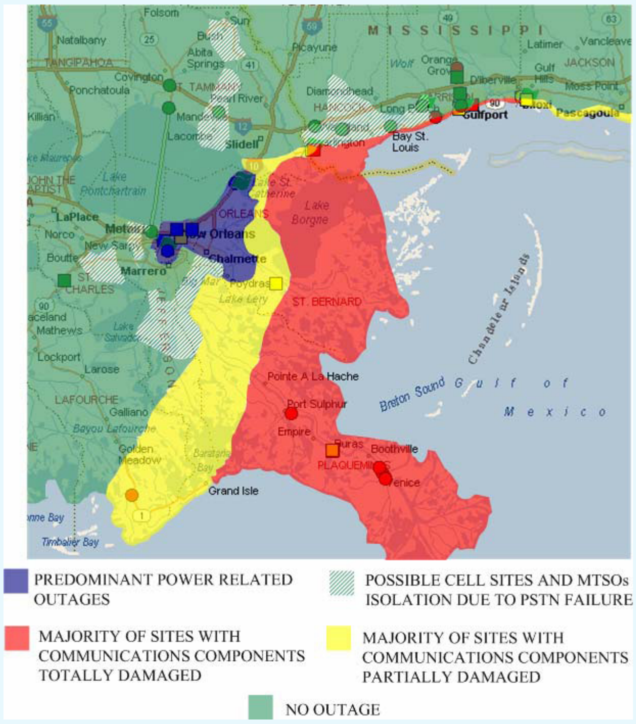
Equipment damage, not power outages, was the most important cause of transmission network failures. Sprint was the long distance carrier that suffered the most severe damage in its network, including the total loss of two key facilities: a POP (Point of Presence) in Biloxi and a switch in New Orleans. When these two facilities flooded, all the sites between them along the coast were cut off, affecting not only the transmission network, but also the links between mobile communications cells sites. Neither did loss of electric power play a role in the single outage reported by AT&T transmission network capacity by 5%. It was restored by redirecting traffic using software that automatically reconfigured transmission equipment and by installing a new optical fibre cable. An important factor in avoiding major disruptions in the AT&T network was keeping operational their main switch in New Orleans, located in Bellsouth's Main CO.

3.3.2.3 Wireless terrestrial Networks/Local Cellular

Local cellular and personal communication service (PCS) networks received considerable damage with more than 1000 base stations sites impacted. In general, cellular & PCS base stations were not destroyed by Katrina, although some antennas required adjustment after the storm. Rather, the majority of the adverse effects and outages encountered by wireless providers were due to the lack of commercial power or a lack of transport connectivity to the wireless switch (wireline T1 line lost or fixed microwave backhaul offline). As a matter of fact PSTN outages affected not only local calls using fixed lines, but also extended into wireless service. In particular many cell sites was isolation from their host mobile telephony switching office (MTSO) when their link through the PSTN was interrupted due to a CO outage. Wireless providers cited security for their personnel, access and fuel as the most pressing needs and problems affecting restoration of wireless service. However, within one week after Katrina, approximately 80 percent of wireless cell sites were up and running. Consistent with other systems, the 20 percent of base stations still affected were in the areas most impacted by Katrina.

As Figure 3-16 indicates, destruction of cell sites due to storm surge, flood and strong winds is found in the Plakuemines, the eastern half of St. Bernard Parish and a 1 km wide strip of the Mississippi Gulf Coast between the border of Louisiana and Mississippi, and Biloxy Bay. Even though this is a large area, it includes less than 1% of all cell sites in the affected region. Some of these sites had inadequate construction for a hurricane-prone zone, such as having the equipment on the ground of areas below sea level.

Figure 3-16: Map prepared by the authors showing sampled cell site locations and predominant failure type zones



Source: Kwasinski, Bibl.17.

The yellow areas in Figure 3-16 mark zones where the majority of the cell sites may have been only partially damaged rather than destroyed. At least one of the base stations in each of these locations survived. As in the previous area, less than 1% of the total cell sites affected by the Hurricane Katrina are located in this region. The fact that only a portion of a cell site may have been damaged at a particular cell site is explained by a lack of uniformity in cell site construction practices, such as having base stations installed at different heights with respect to flood plane. Figure 3-17 shows one of many such sites. In this case, the cell site was located approximately 1.5 m below sea level with all the base stations but one inside the south shelter installed on the ground. When the site flooded, the water reached the top of the fence indicated on Figure 3-17, avoiding damage to only the base station inside the south shelter.

Figure 3-17: Cell site in New Orleans with 2 indoor and 2 outdoor base stations. The south shelter is on the front of the picture

Source: Kwasinski, Bibl.17.

Wireless communications companies restored service in damaged cells either by direct repair or by using a cell on wheels (COW). Cellular base stations On Wheels were successfully used as needed to restore survive throughout the affected region. Over 100 COWs were delivered to the Gulf Coast region. A COW is a standard base station mounted inside a container that is placed on a trailer or directly inside the back of a truck. Figure 3-18 shows a COW setup next to a portable transmission site, which was likely used to restore Sprint's coastal links. Damaged cell site links were often replaced by microwave connections. One alternative is to use satellite links. However, there were few COWs and regular base stations using satellite links, likely because establishing them is not a standard feature of most base stations software.

Figure 3-18: Sprint-Nextel's COW (middle of the image) and portable transmission site

Source: Kwasinski, Bibl.17.

The widespread solution for powering cells during long lasting power outages was to use generator sets.

Cell sites without permanent gensets were equipped with portable generators, such as those depicted in Figure 3-19. In preparation for the storm, portable gensets were stored in safe places away from the storm but close enough to their assigned sites so that they could be deployed quickly. After the storm, taking the genset to the site was usually complicated because roads were damaged or filled with debris, and bridges were washed away. Security checkpoints and areas closed during rescue activities added more complication to the portable power distribution. The same logistic issues persisted during the refueling period that lasted several weeks in some areas. Several portable gensets were refueled daily by a single person who drove hundreds of miles every day. As with COs, an alternative solution to ease the logistic burden of deploying and refueling gensets would have been to have photovoltaic (PV) systems in cell sites.

Figure 3-19: Cell site in Biloxi, MS With 4 portable gensets

Source: Kwasinski, Bibl.17.

Another stationary generator not shown in the picture was also installed at the site.

Figure 3-19 shows a common occurrence in many cell sites; each company deployed and refueled its own portable genset to each location. Thus a significant number of cell sites received multiple gensets. Logistical burdens may have been eased if cellular companies and tower owners had coordinated their efforts so that only one genset was used at each site to power all the base stations. Cellular telephony companies made extensive use of COWs and portable diesel fueled gensets in Hurricane Katrina's aftermath. Cingular deployed approximately 500 portable gensets and 30 COWs. Verizon, Sprint-Nextel, Cingular South and T-Mobile also used hundreds of gensets and dozens of COWs. Because of all the mobile company efforts during the restoration process, a week after Katrina hit the coast, the cellular telephony networks were almost fully operational in the Gulf Coast and partially operational in New Orleans and Plaquemines. The mobile telecommunications networks proved to be more flexible and resilient to natural catastrophes than the PSTN, thanks to their modular architecture and the lack of fixed connection to the subscribers. Wire-line networks were more complicated to restore than wireless networks due to the PSTN fixed outside plants and especially non flexible CO main distribution frame.

Another advantage of cellular telephony networks over fixed telephony networks is their switch location; MTSO's do not need to be close to the demand centres and, thus, can be located further inland in less vulnerable locations. For instance, Verizon's switches maintained full operation during the storm because they were located further inland.,

3.3.2.4 Satellites systems/networks

Satellite networks appeared to be the communications service least disrupted by Hurricane Katrina. As these networks do not heavily depend upon terrestrial-based infrastructure, they are typically not affected by wind, rain, flooding or power outages. As a result, both fixed and mobile satellite systems provided a functional, alternative communications path for those in the storm-ravaged region. Mobile satellite operators reported a large increases in satellite traffic without any particular network/infrastructure issues. More than 20,000 satellite phones were deployed to the Gulf Coast region in the days following Katrina. Broadband capacity was provided by fixed satellite operators for voice, video and data network applications.

Nevertheless, there were functionality issues with satellite communications largely due to lack of user training and equipment preparation. Some satellite phones require specialized dialing in order to place a call. They also require line of sight with the satellite and thus do not generally work indoors. Users who had not been trained or used a satellite phone prior to Katrina reported frustration and difficulty in rapid and effective use of these devices. Satellite phones also require charged batteries. Handsets that were not charged and ready to go were of no use as there was often no power to recharge handsets. Additionally, most of Louisiana parishes (all but three) did not have satellite phones on hand because they had previously chosen to discontinue their service as a cost-saving measure.

3.3.3 Lessons learnt by Katrina

From the above description of the damages, it can be seen that there were three main problems that caused the majority of communications network interruptions: i) flooding; ii) lack of power and/or fuel; iii) failure of redundant pathways for communication traffic. Each of these three areas of concern is described below.

Hurricanes typically have flooding associated with them due to the torrential rainfall and storm surge associated with the storms. However, in addition to these sources of flooding, the levee breaks in New Orleans caused catastrophic flooding that was extremely detrimental to the communication networks. While communication infrastructure had been hardened to prepare against strong winds from a hurricane, the widespread flooding of long duration associated with Katrina destroyed or disabled substantial portions of the communications networks and impeded trained personnel from reaching and operating the facilities. In addition, as detailed below, the massive flooding cause widespread power outages that were not readily remedied (electric substations could not be reached nor were there personnel available to remedy the outages). The flooding also wiped out transportation options, preventing fuel for generators from getting where it needed to be.

Power and Fuel. Katrina caused extensive damage to the power grid. Significant portions of electrical facilities in Mississippi, Alabama and Louisiana – including both power lines and electric plants – were severely impaired due to wind and flooding. As a result, power to support the communications networks was generally unavailable throughout the region. This meant that, for communications systems to continue to operate, backup batteries and generators were required. While the communications industry has generally been diligent in deploying backup batteries and generators and ensuring that these systems have one to two days of fuel or charge, not all locations had them installed. Furthermore, not all locations were able to exercise and test the backup equipment in any systematic fashion. Thus, some generators and batteries did not function during the crisis. When generators were installed and operational, the fuel was generally exhausted prior to restoration of power. Finally, flooding, shortages of fuel and restrictions on access to the affected area made refueling extraordinary difficult. In some instances, fuel was confiscated by federal or local authorities when it was brought into the Katrina region.

Redundant pathways. The switches that failed, especially tandems, had widespread effects on a broad variety of communications in and out of the Katrina region. In addition, T1 and other leased lines were heavily used by the communications networks throughout the region, with those failures leading to loss of service. As an example, a major tandem switch in New Orleans was isolated, which meant that no communications from parts of New Orleans to outside the region could occur. This switch, an access tandem that carried long distance traffic through New Orleans and out to other offices, had two major routes out of the city (one to the east and one to west). The eastern route was severed by a barge that came ashore during the hurricane and cut the aerial fibre associated with the route. If only this route had been lost, the access tandem traffic could have continued. However, the western route was also severed – initially by large trees falling across aerial cables, then subsequently by construction crews removing debris from highway right-of-way. While there were provisions for rerouting traffic out of the city, the simultaneous loss of both of these two major paths significantly limited communications service in parts of New Orleans.

In conclusion, Katrina taxed each type of communications infrastructure in a variety of ways: i) strong winds and rain made it difficult for technical stuff to support and maintain the networks and blew antennas out of alignment; ii) heavy flooding following Katrina overwhelmed al large portion of the communication infrastructure, damaging equipment and impeding recovery; iii) single points of failure in vital communications links led to widespread communications outages across a variety of networks; iv) the duration of power outages far outlasted most generators fuel reserves, leading to the failure of otherwise functional infrastructure.

However, there were resiliency successes in the aftermath: i) a large portion of the communication infrastructure withstood the storm's wind and rain with only minor damage (as distinguished from levee breaches and power outages, which had a more devastating impact); ii) satellite networks, although taxed by extensive number of additional users, remained available and usable throughout the affected region. By examining the failures in network resilience and reliability, along with the successes, it is possible better to prepare infrastructure to withstand or quickly recover from future catastrophic events.

3.4 Disasters in China

[For further information see Bibliography 14]

In 2008, China suffered a series of disasters such as large snow and earthquake; communications played a prominent role in disaster relief, known as the rescue "lifeline". On 12 May, the Wenchuan earthquake, killing nearly 90,000 persons, caused communications to be fully blocked in 8 counties of Sichuan province and 5 counties of Gansu province, which caused great difficulties for disaster relief efforts. After emergence transfer of satellite phones, the external communication was gradually resumed. After the earthquake, it was concluded that it would has been very important to improve communications network survivability, and that especially building a number of network elements against major natural disasters could avoid communication islands and provide key communication support. To this background, China Mobile proposed the innovative concept of SBS (Super Base Stations), and carried out large-scale deployment, and achieved good results.

Based on research about communication facilities' damage caused by natural disasters such as earthquakes, floods, typhoons and snow, the SBS, which could keep working telecommunication services whatever happens, through improving base station's construction standards, power supply, transmission, building, installation techniques. Compared to normal base stations, the SBS has more reasonable location, stronger backstop, its own oil machine for power supply and satellite transmission equipment.

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Chapter 4

Outside plant of wireline systems to be deployed in disaster areas: design, implementation, operation and maintenance

4 Introduction

Recently, natural disasters such as earthquakes and floods have occurred more frequently. Outside plant facilities such as manholes and poles are occasionally damaged by these disasters, and as a result, telecommunication services stop. In order to minimize damage and/or to protect outside plant facilities safely, appropriate disaster management is needed.

The plants of optical fibre access and of optical fibre links in metropolitan and backbone networks can be roughly grouped as follows (see Chapter 1):

i) Optical fibres and cables;

ii) Passive optical devices and nodes;

iii) Active optical devices and nodes;

iv) Infrastructures for the outside optical plants.

The plants of type iii) are generally located inside the switching buildings. However with the introduction of the broadband access both on copper wires (e.g. xADSL terminals) and on optical fibres (e.g. ONU) some active devices are deployed between the switching buildings, so that they can also be considered in the scope of this Handbook.

The typical natural disasters, which may potentially affect outside plant facilities, can be classified in the following seven categories: earthquakes, tsunami, floods/flash floods, strong wind (hurricanes/tornados/typhoons/wind storms), landslides, forest fires, severe temperature conditions (cold, snow, ice or heat). (For further information see the Preface).

To make outside plant facilities more reliable and stable against disasters, it is recommended that disaster management should be provided. Disaster management activities can be grouped into the following four phases: Mitigation (Prevention), Preparedness, Response and Recovery (For further information see the Preface).

This Chapter 4 deals with the design requirements for the various elements of the wireline outside plants and with the possible management activities aimed at reduce the impacts of the natural disasters.

4.1 Requirements and design aspects of wireline outside plants

4.1.1 Optical fibres and cables

4.1.1.2 Optical fibres

[For further information see ITU-T Handbook "Optical Fibres, Cables and Systems", Chapters 1 and 2]

Optical fibres differ mechanically from copper and steel wires, mainly as regards elastic properties and failure mechanisms. Glass used for optical fibre behaves elastically up to a few percent, then it fails in brittle tension. The strength of fibres is mainly governed by the size of flaws, which are always present, under the influence of stress which causes the glass fibre to weaken. This weakening is accelerated if the stress is combined with moisture. When designing optical fibre cable, it is important to know the minimum strength of the fibres. For this reason, optical fibres are proof-tested to a certain stress level during manufacture. Studies of flaw growth mechanisms and accelerated aging experiments have shown that in order to achieve fibre lifetime of 20-40 years, the residual fibre stresses should not exceed 20-30% of the proof-test stress.

In special circumstances where the cable is to be used in a high moisture environment or for aerial cable applications taking into account large thermal changes and strong winds, it should be noted that a larger proof-test strain may be necessary or the installation must compensate for the conditions. For example, a heavier support strand may be used for aerial applications to limit strains.

A good cable design will limit the long-term strain to the safe levels above to prevent the growth of surface flaws, which could eventually lead to fracture of the fibres. The proof test strain may therefore be specified by the permissible strain and the required life time. Usually the fibre is proof tested with a load applied to the fibre. The value of the load is specified for each type of fibre in Recommendations ITU-T G.65x.

4.1.1.2 Optical cables

Terrestrial cables

[For further information see ITU-T Handbook "Optical Fibres, Cables and Systems", Chapter 2]

Optical cables are installed in various environments (aerial, buried, duct, tunnel, etc.) and are therefore exposed to different environmental conditions. The range of environmental conditions must be considered with great care in order to determine the cable construction that will continuously maintain the desired characteristics. The external factors relating to the various environmental conditions can be divided into two categories:

i) natural external factors (temperature, wind, water, earthquakes, etc.);

ii) man made factors (smoke, air pollution, fire, etc.).

The main objective in the design of an optical cable is to ensure that the protection technique used will maintain the good properties of the optical fibres, under all the kinds of conditions to which the cables may be exposed to during manufacture, installation, and operation. The external factors (natural and man-made) quoted above, as well as the type of installation of the cable in the telecommunication network are the basic requirements for determining the structure, the dimensions and the materials of an optical fibre cable.

The cable core should be covered with a sheath suitable for the relevant environmental and mechanical conditions associated with installation and operation. The sheath maybe of a composite construction and may include strength members or a protective armour to meet particular environmental conditions.

From a general point of view the main components of an optical cable may be divided into the following five groups:

i) optical fibre coatings;

ii) cable core;

iii) strength members;

iv) water-blocking materials (if necessary);

v) sheath materials (with armour, if necessary).

Aerial cables

[For further information see ITU-T Handbook “Optical Fibres, Cables and Systems”, Chapter 2 and Recommendations ITU-T L.26 and L.89]

In the event of damage to the cable sheath or to a splice closure, longitudinal penetration of water in a cable core or between sheaths can occur. The penetration of water causes an effect similar to that of moisture. The longitudinal penetration of water should be minimized or, if possible, prevented. In order to prevent longitudinal water penetration within the cable, techniques such as filling the cable core completely with a compound or with discrete water blocks or swellable components (e.g., tapes) are used. In the case of unfilled cables, dry-gas pressurization can be used.

Overhead cable vibrations are produced either by laminar wind stream causing curls at the lee side of the cable (aeolian vibration) or by variations in wind direction relative to the cable axis (galloping effect). A well-established surveillance routine will identify the activity in order to make a careful choice of the route and to decide installation techniques and/or the use of vibration control devices to minimize this type of problem.

During storage, installation and operation, cables may be subjected to several temperature variations. Generally, aerial cables are more exposed to significant temperature variation than underground cables. Therefore, this issue is very important. Expansion of the cable due to a variation in temperature to a high level may cause a significant reduction of the safe clearance to ground. Shrinkage of the cable due to a variation in temperature to a low level may cause the maximum working tension to be reached. Under these conditions, the variation of attenuation of the fibres shall be reversible and shall not exceed the specified limits.

The fibre strain may be caused by tension, torsion and vibration occurring in connection with wind pressure. Induced dynamic and residual strain in the fibre may cause fibre breakage if the specified long-term strain limit of the fibre is exceeded. To reduce any fibre strain induced by wind pressure, the strength member should be selected to limit this strain to safe levels, and the cable construction may mechanically decouple the fibre from the sheath to minimize the strain. Alternatively, to reduce fibre strain, the cable may be lashed to a high-strength support strand. In aerial installations, winds will cause vibrations and, in figure-of-eight and suspension wire installations, galloping of the entire span of the cable may occur. In these situations, cables should be designed and/or installed to provide stability of the transmission characteristics and mechanical performance. Cable installations should be designed to minimize the influence of wind.

The fibre strain may also be caused by tension occurring in connection with snow loading and/or ice formation around the cable. Induced fibre strain may cause excess optical loss and may cause fibre breakage if the specified long-term strain limit of the fibre is exceeded. Dynamic strain in the fibre may be induced by vibration caused by the action of snow and/or ice falling from the cable. This may cause fibre breakage. Under the load of snow and/or ice, excessive fibre strain may easily be induced by wind pressure. To suppress the fibre strain by snow loading and/or ice formation, the strength member should be selected to limit this strain to safe levels, and the cable profile may be selected to minimize snow loading. Alternatively, to suppress fibre strain, the cable may be lashed to a high-strength support strand. Cable should be designed and installed to provide stability of the transmission characteristics, cable sag/tension, fatigue of the strength member and tower/pole loading.

A knowledge of span, sag, wind and ice-loading is necessary to design a cable for use in aerial applications. The general criteria for the design of an aerial cable infrastructure are indicated in Annex 4A1.

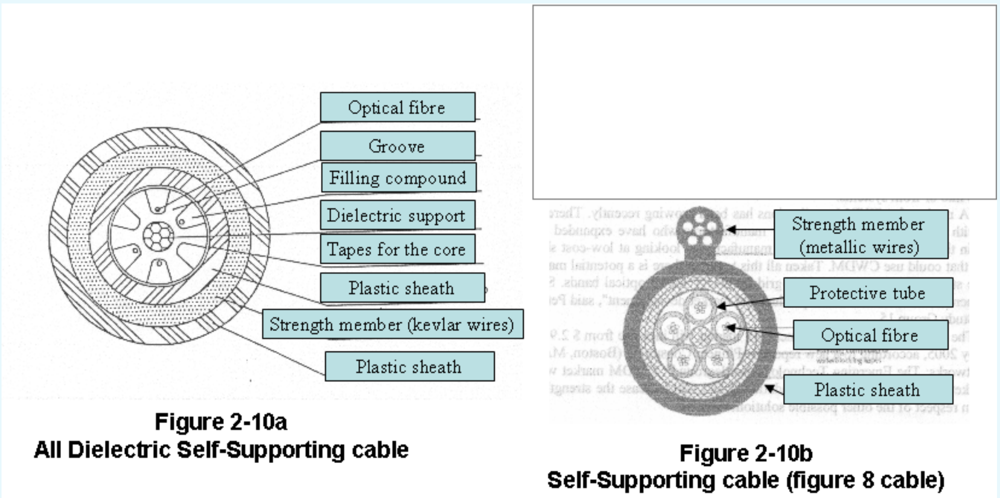
As quoted above, for aerial application, some special cable structures may be adopted:

– All Dielectric Self-Supporting (ADSS): the tensile element is provided by a non-metallic reinforcement (e.g., aramid yarns, glass-fibre-reinforced materials or equivalent dielectric strength members) placed under or within the plastic sheath; the outer shape is circular (Figure 4-1 a);

– Self-Supporting (SS) cable: the sheath includes a metallic or non-metallic bearing element, to form a figure ''8'' (Figure 4-1 b);

– Lashed cable: non-metallic cables installed on a separate suspension catenary and held in position with a binder cord or special preformed spiral clips.

Figure 4-1: Examples of aerial cable structures



Submarine cables

[For further information see ITU-T Handbook "Optical Fibres, Cables and Systems", Chapter 2 and ITU Recommendation G.978]

Underwater optical fibre cables are classified according to the ITU-T Recommendations, in the three following categories:

i) marinized terrestrial cable;

ii) repeaterless submarine cable;

iii) repeatered submarine cable.

Marinized terrestrial cables are generally used for crossing lakes and rivers. Repeaterless submarine cable is suitable for use in both shallow and deep waters for lengths up about 300 km. Repeatered submarine cables can be used in all underwater applications, mainly for deep waters on lengths that require the deployment of submerged repeaters.

The optical submarine cable is an underwater optical fibre cable designed to be suitable for shallow and deep water use, which is required to ensure protection of optical fibres against water pressure, longitudinal water propagation, chemical aggression and the effect of hydrogen contamination throughout the cable design life. The submarine cable is extensively tested to show it can be installed and repaired *in situ*, even in worst weather conditions, without any impairment of optical, electrical or mechanical performance or reliability.

The cable, with the cable jointing boxes, the cable couplers, and the cable transitions, should be handled with safety by cable ships during laying and repair operation (depth up to about 8,000 m); it should withstand multiple passages over the bow of a cable ship.

4.1.2 Passive optical devices and nodes

[For further information see ITU-T Handbook "Optical Fibres, Cables and Systems", Chapter 4 and 5, Recommendation ITU-T L.51].

The quality of an optical network is also determined by the performance of each of its individual devices/nodes.

Passive applies to devices that do not contain active electronics or other devices that are exothermic. On the contrary active devices contain active electronics. A "node" is defined as a point of intervention in the network, e.g. it occurs at each opening or end of a cable jacket. Each node shall be capable of performing its expected function in the network, while exposed to the environment in which it is intended to reside. In order to achieve and to maintain a suitable network performance level the optical nodes should be able to properly store and protect all compatible devices without altering their performance characteristics.

4.1.2.1 Passive optical devices

The main passive optical devices deployed in the outside optical network are shortly indicated in the following.

Optical fibre splices

[For further information see Recommendations ITU-T L.12 and ITU-T G.671]

Splices are critical points in the optical fibre network, as they strongly affect not only the quality of the links, but also their lifetime. In fact, the splice shall ensure high quality and stability of performance with time. High quality in splicing is usually defined as low splice loss and tensile strength near that of the fibre proof test level. Splices shall be stable over the design life of the system under its expected environmental conditions.

A suitable procedure for splicing should be carefully followed in order to obtain reliable splices between optical fibres. This procedure applies both to single fibres or ribbons (mass splicing). All optical fibre splices should be suitable for indoor applications as well as for outdoor environments, when suitably protected in appropriate accessories.

Optical connectors

[For further information see ITU-T Recommendations L.36 and G.671]

Fibre optic connectors provide a method for jointing the ends of two optical fibres. Such a joint is not a permanent one, but it can be opened and closed several times. The optical connectors are required in the points of the network in which it is necessary to have flexibility in terms of network configuration and test access.

Fibre optic connectors have application in all types of network, at the input and output ports of the transmission systems and are also used to connect test equipment and instrumentation.

Optical fibre organizers

[For further information see ITU-T Recommendation L.50]

In a node, the optical fibres are to be properly managed and guided from where a cable or pigtail enters the node, to where it leaves again. A fibre organizer, put inside the node, comprises the whole of the means and features that are intended to guide and store fibres, pigtails, splices, connectors and passive devices inside a node, at any location where they are not protected by the cable sheath.

Moreover the fibre organizer system of a node shall provide features and methods to store fibre excess lengths (over-length) in a reliable and consistent way.

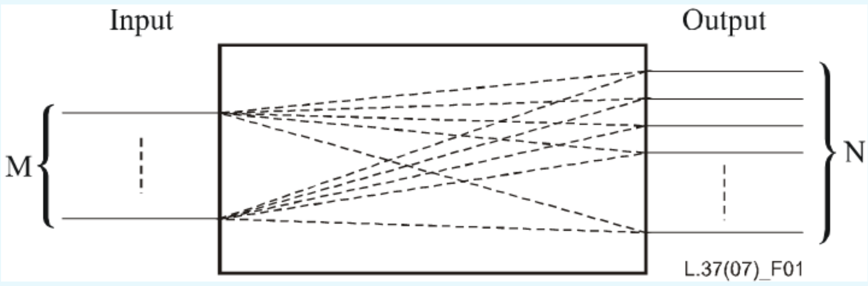
Optical branching devices (including PON splitters)

[For further information see ITU-T Recommendations L.37, L.52 and G.671]

An optical branching component (wavelength non-selective) is a passive component possessing three or more ports, which shares optical power among its ports in a predetermined fashion, without any amplification, switching, or other active modulation.

Optical branching components provide a method for splitting optical signals between M input and N output ports (Figure 4-2). Optical branching components are required when an optical signal has to be split into two or more fibre lines or when several signals coming from different fibre lines have to be mixed in a single fibre line; in general, optical branching components are dividers/combiners of transit signals.

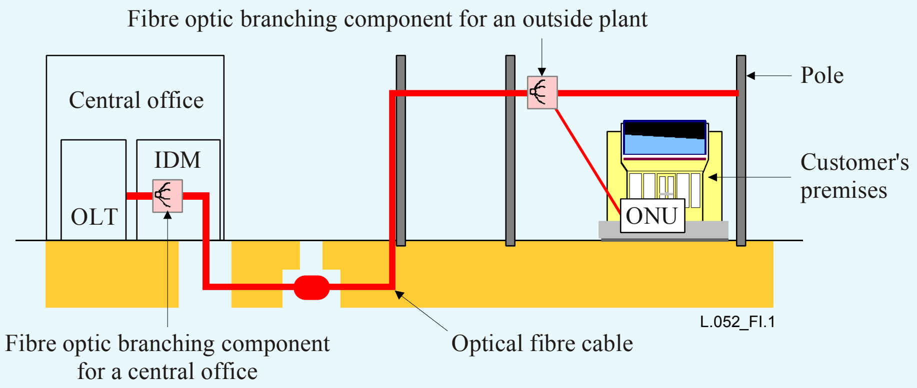
Figure 4-2: Schematic of an MxN branching component



In passive optical networks (PON) with a point-to-multipoint distribution architecture, optical branching components are used to connect an OLT located at a central office to several ONUs located in outside plant or on subscriber premises. The specified values for PONs are 1 input port and X output ports, where X = 4, 8, 16, 32. [For further in formation see Chapter 1]

An example of deployment of branching components both in the central office and in the outside plant of an optical access network is shown in Figure 4-3.

Figure 4-3: Configuration of optical fibre network using a (fibre optic) branching component for a central office and an outside plant



4.1.2.2 Passive optical nodes

Optical nodes for terrestrial applications

[For further information see ITU-T Recommendations L.13 and L.51]

Optical nodes for terrestrial applications properly store and protect all compatible passive devices, such as splices, branching devices and connectors, without altering their performances. Moreover they contain, protect and manage the fibre extra length. A node occurs at each opening or end of a cable sheath. When an optical node resides in an outdoor environment, it is generally contained in a sealed enclosure. This is commonly also referred to as an optical closure, optical cable joint or optical sheath joint. Here the term "optical closure" will be used.

An optical closure comprises a mechanical structure (closure housing) that is attached to the ends of the sheaths joined and a means (organizer) for containing and protecting the fibres and passive optical devices. The term closure housing only refers to the sealed container or box, not including the organizer system. Its main functions are: sealing to the cables, mechanical attachment of the cable and protection of its content.

The optical closure will:

i) restore the integrity of the sheath, including mechanical continuity of strength members when required;

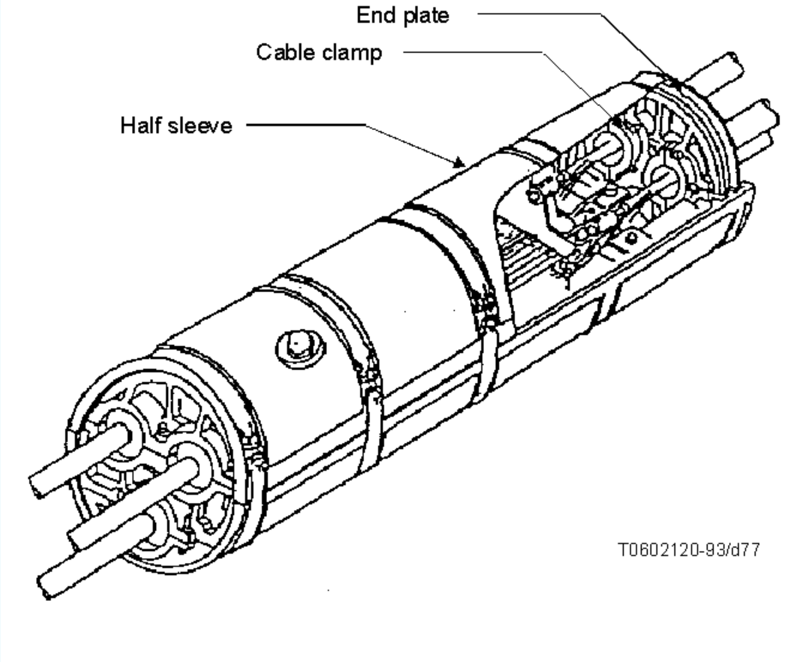
ii) protect the fibres, fibre joints and optical devices from the environment in all types of outdoor plant (aerial, direct buried, in ducts, etc.);

iii) provide for the organization of the fibre joints, passive devices and the storage of fibre overlength

iv) provide electrical bonding and grounding of the metal parts of the sheath and strength members where required.

An example of fibre closure is in Figure 4-4.

Figure 4-4: Example of optical closure



In addition to the node's optical functionality in the network, performance requirements and test severity shall also reflect the environmental conditions to which a passive node is exposed during its lifecycle.

Once installed, optical nodes typically may reside in one of the basic environments indicated in Table 4-1:

Table 4-1 – Application environments

Indoor	temperature controlled	IC
	non-temperature controlled	IN
Outdoor	above ground	OA
	at ground level	OG
	under ground (sub-terrain)	OS

Typical values, applicable to passive optical nodes, can be found in Table 4-2.

Table 4-2 – Summary of typical parameters for the basic environmental classes

Exposure ↓	Indoor		Outdoor		
	IC	IN	OA	OG	OS
	Temp controlled	Temp non-controlled	Above ground	Ground level	Underground
Temp Min (°C)	+5	–10	–40	–40	–30
Temp Max (°C)	+40	+60	+65	+65	+60
Solar Radiation	No		Yes	Yes	No
Relative Humidity (max) (%)	93% (decreasing once above 30° C)		100% (occasional/permanent exposure to water possible)		
Precipitation	No		Rain, Snow, etc.	Rain, Snow, etc.	N.A.
Submersion	No (Note 2)		No	No (Note 2)	Yes
Vibration (m/s²)	10-55 Hz 1 m/s² (~0.1 g) (whole system) 5 m/s² (~0.5 g) (components)		5-500 Hz 10 m/s² (~1 g) (due to e.g., traffic, wind, etc.)		
Chemical	Negligible (Note 1)		Atmospheric	Atmospheric + Soil (base only)	Soil/waterborne
Biological	Negligible		Atmospheric	Atmospheric + Soil (base only)	Soil/ waterborne
NOTE 1 – In areas where corrosive atmospheres can be expected (marine and coastal areas, industrial areas, urban pollution), increased corrosion protection may be requested as an additional requirement. NOTE 2 – If accidental flooding may occur, e.g., in vaults or basements, this is to be added as a conditional requirement. This will also correspond to a higher IP rating according to IEC 60529.					

NOTE – For further information on the environmental conditions see Section 4.1.3.2 of this Chapter 4 “Protection of the active devices and nodes”.

Optical nodes for submarine applications

[For further information see Recommendation ITU-T G.977].

There are two passive nodes that are specific to submarine cables: the submarine repeater housing and the branching unit.

– The submarine repeater housing is the mechanical piece-part of a repeater.

  A submarine repeater is equipment that essentially includes one or more regenerators or amplifiers and associated devices.

  Submarine repeater housing must be designed to allow operation, laying, recovery, and re-laying in large depths with no degradation in mechanical, electrical and optical performance.

  Technical requirements for submarine repeater housings are as follows:

  - The internal unit. Inside the repeater housing, the internal unit can contain several power feed modules and OFA (optical fibre amplifiers) pairs to amplify in both directions optical signals from one or several fibre pairs;
  - Corrosion protection. The external housing of an OSR (optical submarine repeater) should be designed to not suffer from corrosion due to sea water;
  - Water pressure resistance. The submarine repeater housing must be designed to support large pressure strengths in deep sea water;

- High-voltage insulation. High-voltage insulation is required between the repeater housing and the internal unit to ensure repeater operations;
- Thermal management. Heat generated by the electronic components inside the OSR may be dissipated sufficiently via thermal conduction with the repeater housing;
- Repeater housing sealing. The repeater must be provided with a protection against water and gas ingress, both directly from the surrounding sea and from axial cable leakage resulting from a cable break close to the repeater;
- Ambient atmosphere control. Reliability and proper operation of components may require a controlled internal atmosphere regarding relative humidity or any expected gas that may be generated inside the repeater.

– The branching unit (BU) is an optical node in which it is possible to interconnect three cable (and not only two, as in terrestrial closures), allowing a complete connectibility among the cables (Figure 4-5).

Figure 4-5: Example of branching unit

With the use of the branching units it is possible to interconnect three landing points (three terminal stations) with only one submarine cable. The deployment of two BU on the same cable widens the number of landing points that can be reached with the same submarine cable.

Technical requirements for a branching unit housing are very similar to those of a submarine repeater housing.

4.1.3 Active optical devices and nodes

4.1.3.1 Active optical devices

The main active devices deployed in the outside optical network are shortly indicated in the following.

ONU: Optical Network Unit is a device that transforms incoming optical signals into electronics at a suitable place of the access network in order to connect the optical access network to a part of the metallic network. (see also Chapter 1).

DSLAM: Digital Subscriber Line Access Multiplexer (DSLAM) equipment collects the data from many modem ports and aggregates their voice and data traffic into one complex composite "signal" via multiplexing.

xDSL Terminal: a Digital Subscriber Line terminal provide for the transmission of asymmetric and symmetric aggregate data rates up to tens of Mbit/s on twisted metallic pairs. xDSL is an access technology that exploits the existing infrastructure of copper wires that were originally deployed for the telephone service.

Reach Extender: XG-PON (XGbit – Passive Optical Networks) often needs to increase both overall fibre length and overall splitting ratio. This can be obtained through an active extension node placed in the middle of the optical network, generally indicated as reach extender.

4.1.3.2 Protection of the active optical devices and nodes

[For further information see ITU-T Recommendation L.70]

In order to obtain maximum reliability at a minimal cost, network electronics are generally centralized in locations with controlled environments. This is also typical in the initial layout of copper networks for plain old telephone service (POTS). However, with the increasing demand for connections and bandwidth, operators often face the need to apply active electronics at remote locations. These active nodes cannot always be located inside building but also in the outside plants.

Active network nodes in outside plant have a number of characteristics that make their design and maintenance more complex than that of passive nodes:

- active nodes perform a transformation between input and output signal;
- active nodes require electrical powering;
- active nodes dissipate heat.

The following elements should be considered when applying network electronics in outside plant locations (both in above ground and in underground applications):

- environmental protection and related sealing requirements;
- mechanical protection;
- thermal management;
- electrical powering;
- safety and environmental aspects;
- maintenance aspects.

Environmental conditions

Once installed, optical nodes typically may reside in one of the basic environments quoted in Table 4-1.

Table 4-1: Application environments

Indoor [(1)]	temperature controlled	IC
	non-temperature controlled	IN
Outdoor	above ground	OA
	at ground level	OG
	underground (sub-terrain)	OS
[(1)] "Indoor" is intended as in sheltered locations, hunters, street cabinets, etc.		

The five basic environmental classes indicated in Table 4-1 cover the majority of the applications around the globe and can be described as follows:

i) IC: Indoor temperature controlled

- inside buildings protected by a roof and walls all around, heating or air-conditioning available;
- contact with chemical and biological contaminants is negligible, e.g., inside central offices, some remote network buildings/houses, residential buildings.

ii) IN: Indoor non-temperature controlled

– inside buildings protected by a roof and walls all around, no heating or air-conditioning available;

– contact with chemical and biological contaminants is negligible, e.g., cable vaults, basements, remote network buildings/houses, inside garages, warehouses, homes.

iii) OA: Outdoor above ground

– all outdoor non-sheltered locations, above ground level;

– no other sources of heat or extreme temperatures than the surrounding air or solar radiation;

– exposed to contaminants and dust that may occur in the atmosphere in rural, city or industrial areas, e.g., wall mounted, pole mounted, strand mounted nodes.

iv) OG: Outdoor ground level

– outdoor, standing on the ground, perhaps with a base that resides partially below the ground; this class may also apply to outdoor, wall mounted products that are close to ground level;

– exposed to contaminants and dust that may occur in the atmosphere in rural, city or industrial areas. The base of the product may be permanently in contact with soil, biological and chemical contaminants that occur at or just below ground or street-level, e.g., along roads, pavements and railroads.

v) OS: Outdoor underground (Sub-terrain)

– outdoor below ground level;

– exposed to soil or water-borne contaminants, including organic and inorganic agents related to the presence of roads and traffic, e.g., in manholes, handholes or direct buried.

Table 4-2 summarizes the typical parameters for the five basic environmental classes. related to the active nodes.

Table 4-2: Summary of typical parameters for the outdoor environmental classes

Exposure ↓	Outdoor		
	OA	OG	OS
	Above ground	Ground level	Underground
T_{air} Min (°C) (Note 3)	–40	–40	–30
T_{air} Max (°C) (Note 3)	+45	+45	+45
Solar radiation	Yes (up to 1120 watt/m²)		No
Relative humidity (max) (%)	100% (occasional/permanent exposure to water possible)		
Precipitation	Rain, snow, etc.	Rain, snow, etc.	NA
Submersion	No	No (Note 2)	Yes
Vibration	5-500 Hz 10 m/s² (~1g) (due to, e.g., traffic, wind, etc.)		
Chemical	Atmospheric (Note 1)	Atmospheric soil (base only) (Note 1)	Soil/waterborne

Exposure ↓	Outdoor		
	OA	OG	OS
	Above ground	Ground level	Underground
Biological	Atmospheric	Atmospheric soil (base only)	Soil/waterborne
NOTE 1 – In areas where corrosive atmospheres can be expected (marine and coastal areas, industrial areas, urban pollution), increased corrosion protection may be requested as an additional requirement. NOTE 2 – If accidental flooding may occur, this is to be added as a conditional requirement. This will also correspond to a higher IP rating according to [IEC 60529]. NOTE 3 – For active nodes, air temperature (as measured in a thermometer hut) is to be considered separate from solar radiation effects. For passive nodes, these effects are generally combined, resulting in a higher maximum temperature for the node.			

Special environmental conditions

– Extreme: any environment for which at least one of the environmental parameters exceeds the boundaries of the five basic environmental classes as specified above: e.g., more extreme temperature excursions;

– Additional requirements: in specific cases, extra constraints may be required on top of the conditions of one of the basic environmental classes (e.g., bullet resistance, accidental flooding, etc.). This is not included under the term "extreme" conditions. For these occasions, additional requirements or tests can be added on top of the test program of the basic environmental class.

  This a non-exclusive list of potential additional requirements. limited to those related to natural disasters:

  - Accidental flooding above ground;
  - Earthquake resistance;
  - Freeze-thaw resistance.

Sealing against ingress of solids and fluids

For nodes above or at ground level (OA and OG), the minimum recommended protection level against ingress of objects and water is International Protection 55 according to Specification IEC 60529 (protected against dust and resistant to jets of water).

For nodes at ground level (OG), it is recommended to provide a separation plate with cable entrance seals to avoid intrusion of dirt, water, rodents or insects via the bottom.

For nodes below ground level (OS), the recommended sealing level is IP 68 according to Specification IEC 60529 (suitable for permanent submersion). Required submersion depth should be at least 1 m above the top of the enclosure, but may be more if applied in deep manholes (in this case, the maximum required submersion depth is to be agreed explicitly between user and supplier in order to obtain proper sealing performance and structural strength).

Mechanical protection

The enclosure should be resistant to the mechanical loads and influences that it may encounter in the outdoor environment.

For nodes above or at ground level (OA and OG):

– a minimum recommended protection level against impact of IK 10 according to [IEC 62262];

– the enclosures, including fixation system, should resist loads induced by wind.

For underground nodes (OS):

– Enclosure should be resistant to accidental impact from above.

– Enclosure should be resistant to a static load on top equivalent to the weight of at least one installer.

– Node should be resistant to vibration and shock.

– Cables must be properly attached to resist axial tension, flexure and torsion loads that may occur during typical installation and maintenance.

Thermal management

The temperature inside the enclosure (T_{inside}) must be kept within the operational temperature range of the electronics.

Thermal model

The temperature inside an above ground active enclosure (Figure 4-6) will be determined by a number of factors:

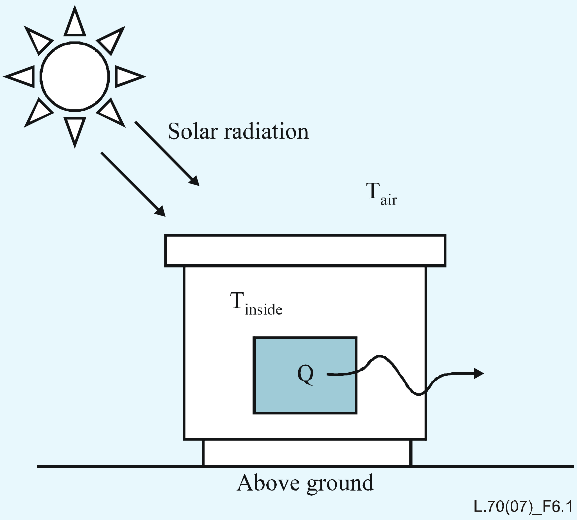
– the air temperature of the environment (T_{air}) (as measured in a thermometer hut);

– solar radiation;

– the heat dissipated by the electronics (Q);

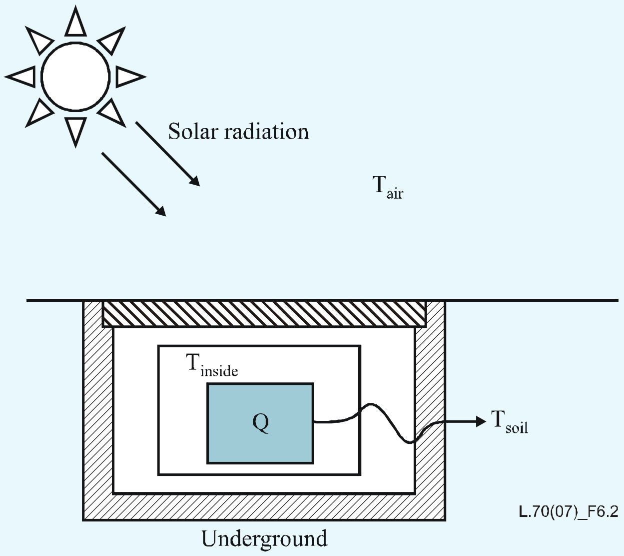
– the construction of the enclosure.

Figure 4-6: Above ground active node



For underground nodes (Figure 4-7), a similar model is applicable, however, there will be no direct solar exposure to the enclosure, while the dissipated heat is transferred via the hand-hole and the surrounding soil.

Figure 4-7: Underground active node



Operational temperature range of the electronics

Electronic equipment is typically qualified to an operational temperature range of 0°C to +40°C, corresponding to an indoor controlled environment. Applying this type of equipment in outdoor enclosures would require extensive climatic control provisions, increasing initial investment as well as operational cost.

For outdoor applications, it is recommended to use "temperature-hardened equipment" with an operational temperature range of at least –40°C to +65°C, unless there is a different agreement between a manufacturer and a user.

Enclosure design

The thermal design of the enclosure for active equipment should be selected, taking into account operational temperature, climate and amount of heat to be dissipated as well as economical aspects such as initial investment and operating cost. Therefore, it is recommended to observe the following parameters:

– minimize the effect of solar radiation on internal temperature;

– minimize the extra power required for thermal management;

– consider a modular approach that allows scope to increase cooling capacity when upgrading to more powerful equipment;

– minimize the need for maintenance due to thermal management features.

The most common thermal designs of enclosures for active electronics are described in Annexes 4A2 and 4A3.

4.1.3.3 Electric power supply for active optical nodes

[For further information see ITU-T Recommendation L.44]

Some intermediate equipment (e.g. repeaters) needing a power supply had existed before optical fibres were installed. At that time, electrical power had been mainly supplied from the central office by using a superimposition technique or by having insulated communication and power conductors in the same cable.

After optical fibres were introduced, many kinds of optical/electrical equipment which require a power supply system were installed into a telecommunication network, in order to increase capacity. The problem is that optical fibre cannot be used to directly transmit electrical power.

As a consequence power is supplied by one of three ways:

– to feed power from the central office by using metallic wires. To connect the power supply between the central office and the equipment, individual metallic cables or cables with both fibres and copper conductors may be used;

– to use a local power supply. In this method, one power supply provides power to all the equipment located within its area by using metallic cables or cables with both fibres and copper conductors. The numbers of equipment that can be supported in this way may be from two to several tens;

– each equipment has its own power supply.

This section deals with the methods of the power feeding and back-up systems.

Power supply methods

In order to select a power supply method, telecommunication companies should consider:

1) the outage rate of commercial power suppliers;

2) the cost when using commercial power suppliers;

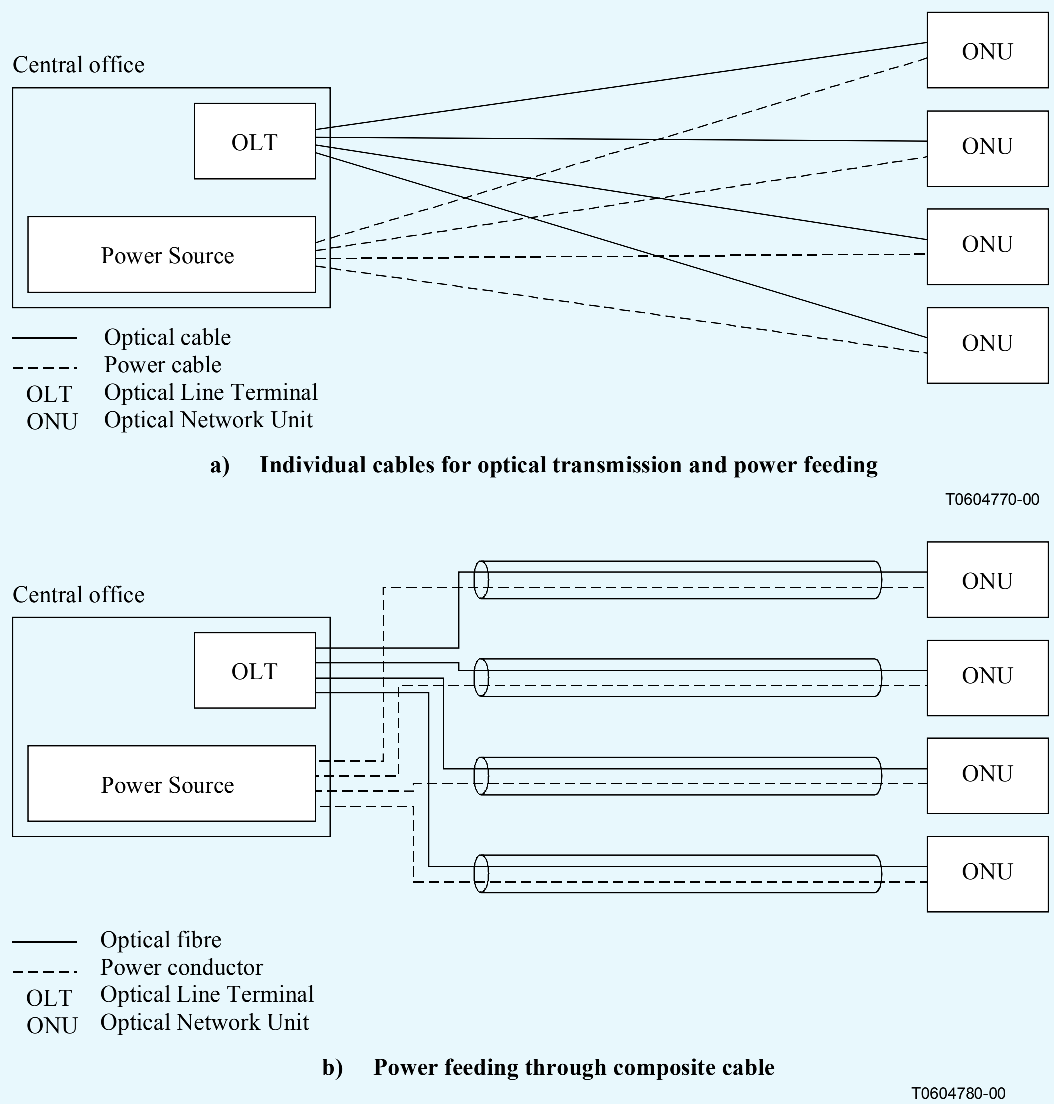
3) the time to repair power source failure.

Based on the suitability of the electric power supplies in each country, telecommunication companies should select a power supply method from the following.

– Power supply from central office

When optical transmission is used, the basic structure of power supplies from the central office is shown in Figure 4-8. The power source is located in the central office. Power is fed by power cables or composite cables (power conductors and optical fibres). This method allows telecommunication companies to control the quality of electrical power (that is, those technical issues covering the stability of the current, voltage and frequency, and the outage rate). However, the telecommunication companies then have the duty to operate and manage power networks.

Figure 4-8: Structure of power supply from central office

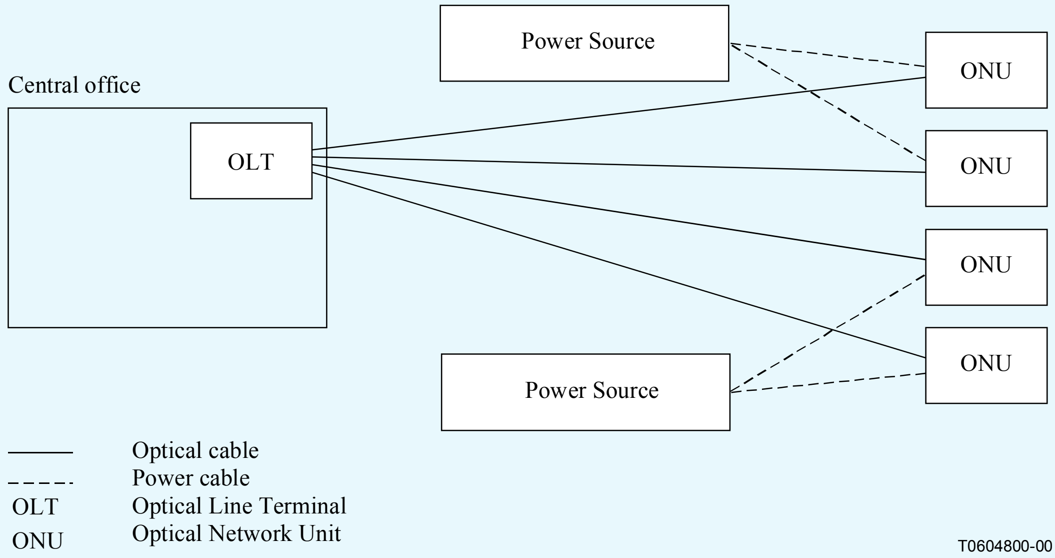


– Local power supply

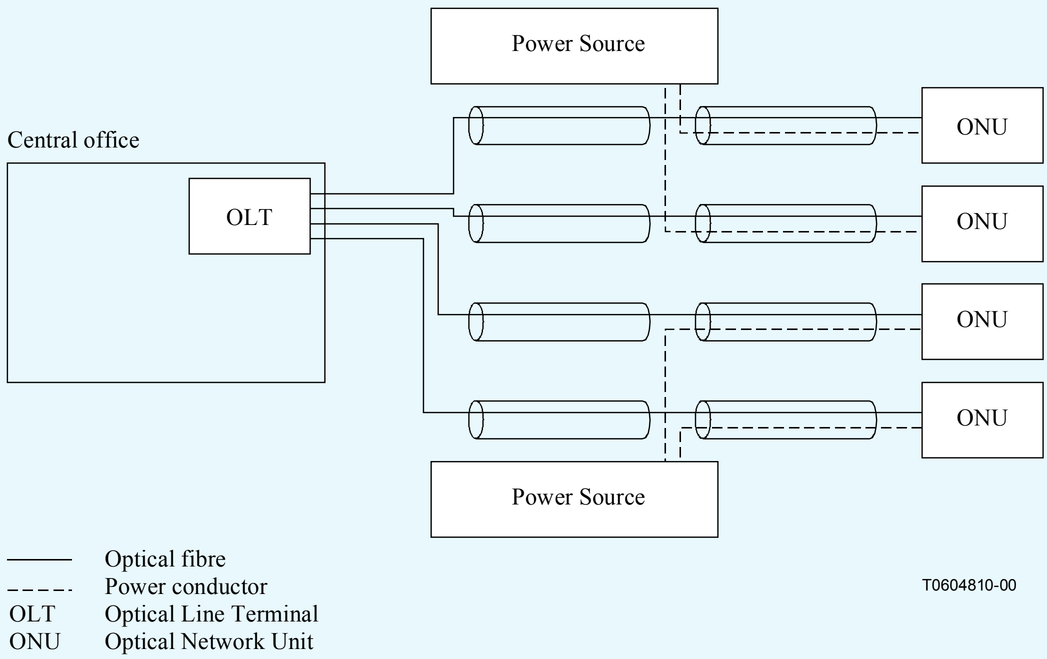
Using optical transmission, the basic structure of local power supplies is shown in Figure 4-9. Power sources are set up near the ONU locations. Power can be supplied to several ONUs from each power source. The number of ONUs which are covered by one power source is dependent upon supplied power from the power source, the power consumption of ONUs and the power losses in the power cables. Power is fed by power cables or composite cables (combined power and communication cables).

To control the local power supplies, monitoring systems or alarm systems are set up in the central office in order to obtain information about the condition of the power sources. Usually, the duty to operate and manage the power sources belongs to telecommunication company. However, when the power sources are located in the customer premises, then customers may operate and manage the power sources themselves. The supply of electrical power from other customers' power sources should be avoided.

Figure 4-9: Structure of local power supply



a) Individual cables for optical transmission and power feeding

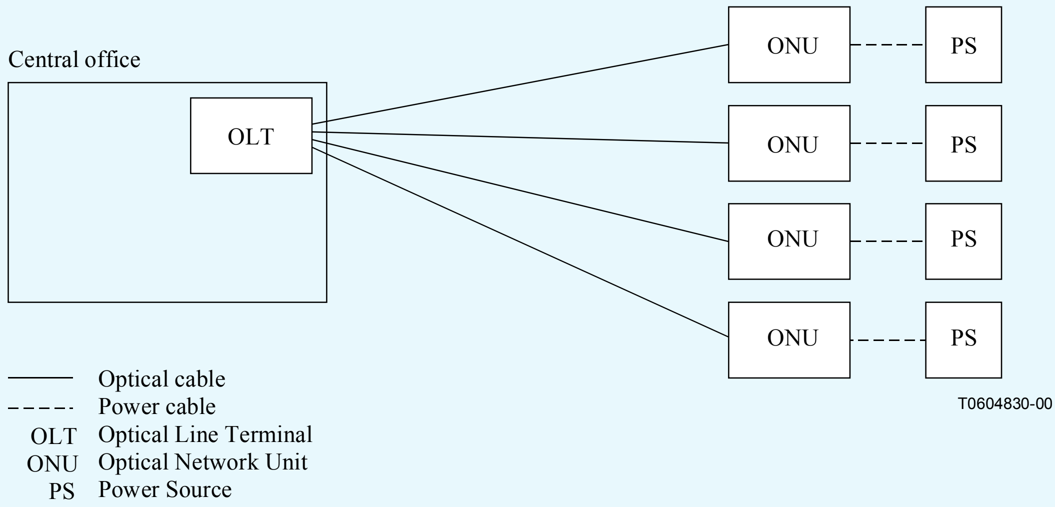


b) Power feeding through composite cable

– Individual power supply

The basic configuration of this method is shown in Figure 4-10. Electrical power is fed to each Optical Network Unit (ONU) from each power source. Usually, the duty to operate and manage the power source belongs to the customers.

Figure 4-10: Individual power supply



Power sources for usual operation

In order to select a power source for usual operation, the following should be considered:

1) capacity;

2) stability of power feeding;

3) quality of electrical power;

4) operating cost.

– Power company

Where the electrical power is supplied by a power company, a telecommunication company should condition the electrical power in order for it to be suitable for the telecommunication equipment. When conditioning electrical power, a telecommunication company should consider the power quality supplied by a power company. Poor power quality may affect the quality of transmission or in the worst case damage telecommunication equipment.

In order to design a backup system, a telecommunication company should know the outage rate of the power supply.

NOTE – A separation (disconnection) point (e.g. switch) in the cabinets is provided in order to separate the competence of power and telecommunication companies as well as to allow safe maintenance of the telecommunication equipment.

– Generator

Where the electrical power is produced by a generator, a telecommunication company should condition the electrical power in order for it to be suitable for the telecommunication equipment. When conditioning electrical power, a telecommunication company should consider the power quality produced by a generator. Poor power quality may affect the quality of transmission, or may damage telecommunication equipment in the worst case.

In order to design a backup system, a telecommunication company should know the failure rate (such as MTBF) of the generator.

– Battery

When using batteries, a telecommunication company may condition the electrical power in order for it to be suitable for the telecommunication equipment. In this case, the capacity of a battery is most important. Use of a battery for equipment with high power consumption should be carefully evaluated.

Power sources for backup

In order to select a power source for backup operation consideration should be given to the following:

1) backup duration;

2) time to start backup system;

3) lifetime;

4) outage rate of power source for usual operation;

5) operating cost.

– Generator

When a generator is used for a backup system, the most critical issue is time to start-up. Usually, some time is required in order to stabilize the electrical power when starting a generator. Therefore, this method is not suitable for systems which require quick recovery. Backup duration is determined by the amount of stored fuel. The power quality produced by a generator should be considered. Poor power quality may affect the quality of transmission or in the worst case may damage the telecommunication equipment.

– Battery

A battery can supply high quality electrical power rapidly. Therefore, it is suitable for powering a backup system which requires a quick recovery. However, backup duration and lifetime is relatively short. Therefore, when designing backup systems with batteries, the following should be considered:

1) outage rate of usual power source;

2) time to repair the failed power source;

3) time to change batteries.

4.1.4 Infrastructures for the outside optical plants

[For further information see ITU-T Handbook "Optical Fibres, Cables and Systems", Chapter 3]

Optical fibres must be protected from excessive strains, produced axially or in bending, during installation and various methods are available to do this. The aim of all installation methods and systems should be to install the cable with the conductors in, as near as possible, a strain free condition, ready for splicing.

Attention is to be given on the fact that methods and practices used in the handling of cables during installation can, without producing any immediately evident physical damage or transmission loss, affect their long term transmission characteristics.

Moreover the optical cables are to be protected during their useful life from the outside environment. At this purpose they are very frequently laid in suitable infrastructures. The most widespread types of these infrastructures are shortly described in the following.

4.1.4.1 Underground ducts/conduits

[There are no ITU-T Recommendation specifically dealing with the construction of ducts. only as an example it can be said that the subject is dealt in http://plasticpipe.org/pdf/chapter14.pdf]

Applications

The general purpose of a conduit, or duct, is to provide a clear, protected pathway for a cable, or for smaller conduits, sometimes called inner-ducts. Advances in cable technologies, as well as the expense of repairing sensitive cable materials like optical fibre cable, have driven preferences for protective conduit over that of direct burial. Plastic (PVC, PE) conduits provide mechanical protection to fragile cable materials like optical fibres, as well as protection from moisture or chemicals and even, in some cases, animals. Furthermore, the permanent pathway provided by conduit also facilitates replacement projects or future installations of additional cable or duct.

Plastic conduits can be installed below ground by a variety of methods, including open trench (Figure 4-11), trenchless technique (see ITU-T Recommendation L.38), mini-trench technique (see ITU-T Recommendation L.48), etc.. Also, its flexibility and availability in continuous coiled lengths facilitates installation into existing conduits or ducts as inner-duct. In addition conduit provides many above ground or aerial options. Flexible conduit can be wound onto reels, does not require manufactured bends, and can be easily navigated around unexpected obstructions (in the ground or within existing ducts), simplifying installation. The few joints that are required can be made reliably through a number of options.

Design considerations

Determination of a conduit dimensions begins with the largest cable, or group of cables or inner-ducts, intended for occupancy. From a functional viewpoint, selection of diameter can be broken down into the following general considerations:

– The inside diameter of the conduit is determined by the cable diameter and placement method (pulling or air-assisted pushing).
– Pulling cables into underground conduits requires sufficient free clearance and is typically further distinguished by the type of cables, in particular if there are long lengths of cable.
– Long pulling lengths require low volume fill, i.e. 36% max.
– Short pulling lengths may be filled up to 53%
– Push-blow installation methods for long length fiber cables utilize higher volume fills, i.e. up to 70% max.
– Innerducts are smaller diameter conduits, intended for placement into larger conduits or casings. Their purpose is to subdivide the larger conduit space into discrete continuous pathways for incorporation of fiber optic cables. Diameters of conduits and innerducts are often specially designed to maximize the conduit fill.

Conduit and duct products come in a wide range of sizes, e.g. spanning 5 mm to 600 mm. The standard dimension ratio, SDR, of a conduit is defined as the ratio of the average conduit diameter divided by the minimum wall thickness. Wall thickness typically ranges between SDR 9 to SDR 17. (Larger SDR numbers indicate a thinner wall thickness.) Determination of the wall thickness becomes a function of either the method by which the conduit is placed, or the nature of environmental stresses that it will be exposed to over the service life.

Loads are applied to conduits both by the environment that they are placed into and by the placement means under which they are installed; the chief difference being the duration over which the load is applied. For example, a common means to install multiple conduits is to directly plow them into the ground using either a railroad plow or tractor-drawn plow. During this installation process, a certain amount of bending and tensile stress is encountered over a rather short period of time (only seconds to minutes). Whereas, after the plow cavity collapses about the conduit, the ground continues to settle upon stones that may be pressing directly against the conduit, thus setting up a long-term compressive load. For this application there is a requirement for both long-term and short-term moduli to assess the deflection resistance.

Types of installation

There are several below ground installations methods:

– Open Trench/Continuous Trenching

– Direct Plow

– Conduit Network Pulling (inner-ducts)

Moreover there is the above ground aerial installation method. There are many applications for aerial conduit, which include but are not limited to road crossings, rail crossings, trolley line crossings, and water crossings.

Joining methods

Conduit can be joined by a variety of thermal and mechanical methods. Since conduit does not experience any long-term internal pressure and acts only as a pathway for the telecommunication cables, the owner of the system may be tempted to neglect the importance of specifying effective couplings. However, an integral part of any conduit system is the type and quality of joining method used. Proper engineering design of a system will consider the type and effectiveness of these joining techniques. The owner of the conduit system should be aware that there are joint performance considerations that affect the system's reliability well beyond initial installation. Some of those might include:

– Pull out resistance, both at installation and over time due to thermal contraction/expansion, must be considered.

– Pressure leak rates, for "blow-in" installations. Consideration must be given to how much leakage can be tolerated without reducing the distance the cable can consistently be moved through the conduit.

– Infiltration leakage, allowing water and/or silt to enter the conduit over time, can create obstacles for cable installation and repair or cause water freeze compression of fiber optic cables.

– Corrosion resistance is important as conduit systems are often buried in soils exposed to and containing alkali, fertilizers, and ice-thawing chemicals, insecticides, herbicides and acids.

– Cold temperature brittleness resistance is required to avoid problems with installation and long-term performance in colder climates.

Figure 4-11: Ducts laid in a trench

The condition and geometry of duct routes is of great importance for the installation of the cables. Where the infrastructure includes ducts in poor condition, contains excessive curvature, includes ducts already containing cables or access points with abrupt changes of direction, the maximum pull distance will be reduced accordingly.

4.1.4.2 Tunnels

[For further information see ITU-T Recommendation L.11]

Duct tunnels are constructions containing one or generally more ducts belonging to different networks. Tunnels which can be inspected (inspectable tunnels) include one or more gangways for initial assembly work and for subsequent control, maintenance and repair operations.

Tunnels may contain ducts belonging to the following types of networks:

– collective antennas;

– telecommunications;

– electricity;

– gas;

– water;

– district heating;

– ducted transport (e.g. pneumatic tubes);

– drainage water.

Tunnel routing must take into account the structure of networks and their levels of priority.

The transport ducts of different networks do not generally follow the same itinerary, since neither the production units (e.g., power plants, pumping stations or telephone exchanges) nor the transit points from transport to primary distribution coincide. On the other hand, in densely populated areas, primary and secondary distribution ducts often do follow the same itineraries, so that it is advisable to run tunnels under arteries containing primary and secondary distribution ducts.

Tunnels and trenches

Several factors should be taken into account when opting between trenches and tunnels. Some of them are listed in the following.

– Distribution security

A high level of distribution security will depend on the following factors:

- durability of material and joints;
- rapid location of damage when it occurs, easy access and minimum repair times;
- low exposure to outside effects (e.g. damage caused by third parties or by earthquakes).

Ducts laid in tunnels generally offer high durability and a low risk of deterioration. They may be repaired rapidly.

– Economic considerations

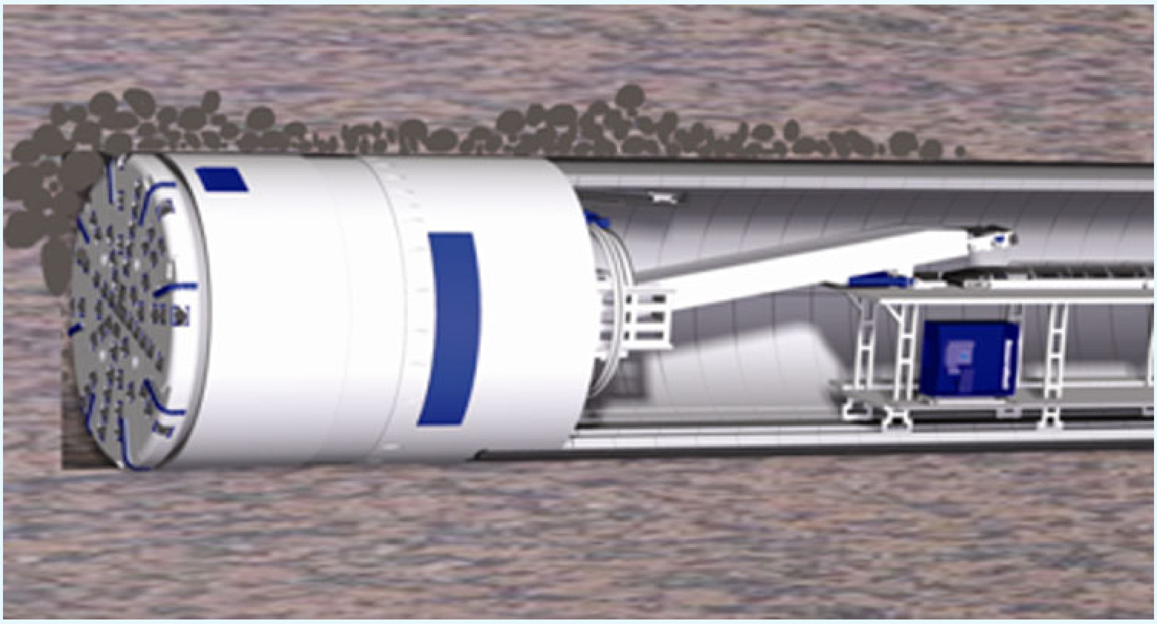
Economic considerations should include not only the cost of constructing and maintaining tunnels, but also the savings which will arise in the future from avoiding the secondary effects of buried ducts. By secondary effects are meant the effects produced on local inhabitants, local activities, vehicle traffic and the environment in general by the installation, malfunction, repair and maintenance of ducts.

– Types of tunnels

There are two basic different cross section features of tunnels: open cut (Figure 4-12) and shield cable (Figure 4-13). The cable tunnel has higher reliability due to their higher rigidity compared by buried pipes. Shield tunnel has highest reliability due to deep construction compared with open cut cable tunnel without any effects of liquefaction and ground settlement.

Figure 4-12: Open-cut tunnel

Figure 4-13: Shield tunnel



General requirements

Some general requirements applicable to tunnels, when used for telecommunication cables, are listed in the following.

– Distances from power lines

Minimum distances from main ducts should be applied.

– Protection against thermal load

Since telecommunications cables are vulnerable to thermal load, thermal conditions in tunnels must be taken into account. This applies especially for optical cables.

– Protection against mechanical forces

Suitable shields may be used to protect cables against mechanical effects such as vibrations or impacts.

– Protection against outside effects

Plastic-covered cables may be protected against rodents with fibre glass or aramid-fibre shielding.

Contractable cable joints may provide protection against earthquakes.

– Bends

Since cable curvature is limited, layout plans must take account of permitted curvature radii.

– Specialized work

Since work has to be done relatively frequently on telecommunication installations, particularly on sleeves, sufficient working space should be provided (e.g. alcoves or chambers).

Safety plans

Tables 4-4 and 4-5 show a model of a safety plan in the operational phase, with an indication of possible preventive measures. The rules applicable to the construction of a tunnel should be established in the light of the safety plan.

Table 4-4: Safety plan against outside risks

Risk	Consequences	Level of risk	Security requirement	Possible preventive measures
Seismic tremors	Duct bursts, particularly at transit point from tunnel to ground	Variable possibility according to regions Substantial effects	Continued operation of all ducts	Tremor-resistant fixtures Special design of duct exit points
Incoming water from outside	Possibility of drowning Damage to duct	Rare	Distribution security	Protection against flood water
Unstable ground Foundation	Duct bursts, particularly at transit point from tunnel to ground	Foreseeable effects	Same as for load-bearing structure	Consolidation of foundation ground

Table 4-5: Safety plan for risks inherent in tunnel ducts

Description of risks		Consequence	Level of risk	Security required	Possible preventive measures		
Network	**Risk**				**At source**	**During Construction**	**In service**
Water	Tunnel flooding due to duct burst	Possibility of drowing Damaged ducts	Rare Personal risk and little material damage	For persons, same as for load-bearing structures	Careful design and construction of installation	Strong fixtures Automatic Valves Effective water drainage system All pipes to be secured against upward pressure	Regular checks for possible leaks Corrosion Checks Alarm system (with floater switch)
Drainage Water (I)	Partial flooding	Damage to ducts	Rare, Little material damage	Limitation of material damage	Ducts to placed above the highest water level		
Drainage Water (II)	Complete flooding of tunnel	Physical injury and material damage	Rare	For persons, same as for load-bearing structures	Leakproof and lockable access points and inspection holes	Ducts to be secured against upward pressure	

Figures 4-14 and 4-15 show an example of circular and rectangular tunnel cross-sections respectively. They show how the available space can be divided among the different networks.

Construction

The main requirements to be considered in the construction of tunnels are listed in the following.

– Permanent loads

Permanent loads should be indicated in the operating plan.

– Lifting

All ducts should, generally speaking, be secured against lifting forces.

– Seismic effects

All ducts brackets, supports and cable racks should be able to resist the effects of seismic forces, in accordance with national standards.

– Explosions

The ducts and other contents of a tunnel may be strongly shaken by explosions. If the safety plan shows that essential ducts may be exposed to such overloading, it should be ensured that the operation of such ducts is not affected by breakage or deformation and that no movement may occur which might wrench essential supply ducts off their supports or allow them to collide against tunnel walls or other part of the construction. Such risks may be avoided with the introduction of shockproof ties and an appropriate arrangement of ducts.

– Protection against corrosion

It is important to protect supports and ties against corrosion in view of the long life of installations.

– Transit points between tunnels and open ground

At points where ducts transit between tunnels and open ground, due account should be taken to relative movements which may occur between the two types of environment. Tunnel exit points should be as leakproof as possible, so as to avoid the penetration of gas or water in the tunnel.

– Flood alarm systems

Flood alarm systems should include floater switches placed at low points and in drainage wells, with additional floaters on different levels, thus setting off successive alarms.

Figure 4-14: Example of circular cross-section

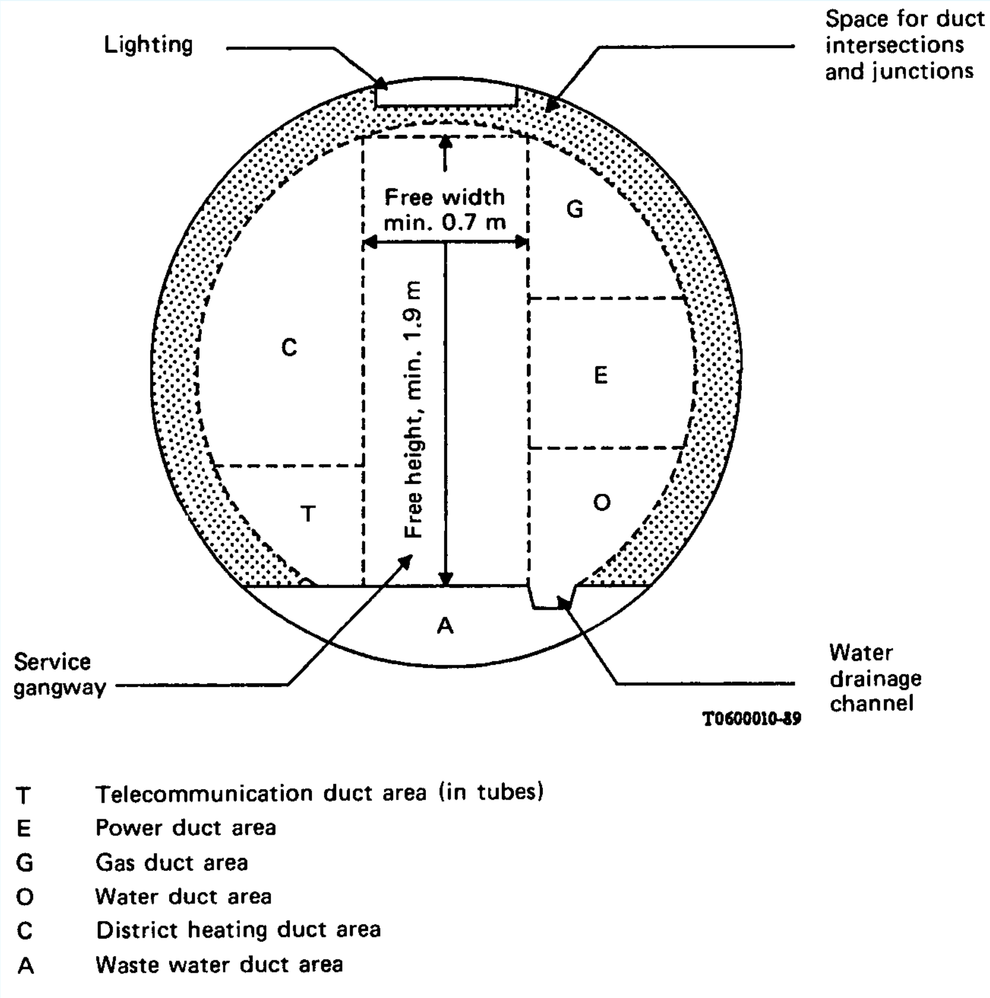
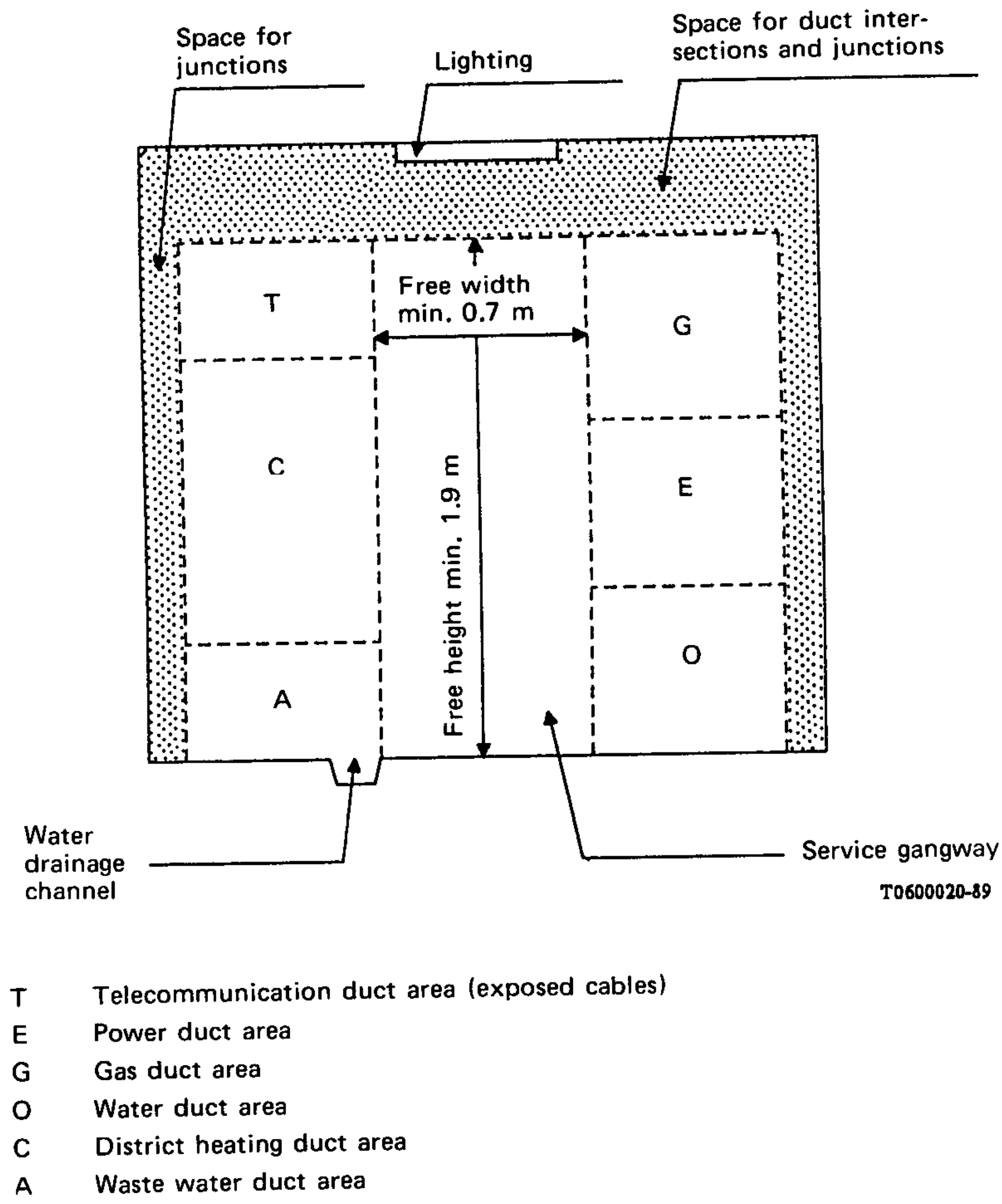


Figure 4-15: Example of rectangular cross-section



4.1.4.3 Telecommunication poles, suspension wires and guy-lines for aerial cables

[For further information see ITU-T Recommendation L.89]

Pole routes are vulnerable to disasters involving water penetration, high winds, earthquakes, snow, etc. Any disaster causing just one of the poles on the route to fall down, or the cable to be cut even at one point, will disrupt the circuit. Restoring service may take days especially if the roads are inaccessible.

This section describes the general requirements for suspension wires, telecommunication poles and guy-lines that support aerial cables for optical access networks. In Annex 4A1 there are the main design guidelines for these infrastructures.

The main characteristics of the aerial cable infrastructure

The intent of such an infrastructure is to support outdoor cables that will be attached by lashings, clips, or similar mechanisms. Self-supporting cables, while not specifically addressed by this Section, have the same issues applicable to their installation. Loads applied to the infrastructures are also indicated.

Suspension wires, telecommunication poles and guy-lines that support aerial optical fibre cables are important facilities for providing broadband services. An appropriate design is needed to maintain the reliability of these facilities and services. Moreover, they are big facilities installed at a high position, and so they should be managed in a way that ensures sufficient safety. To realize these requirements, a design is needed that carefully considers facility strength.

Definitions

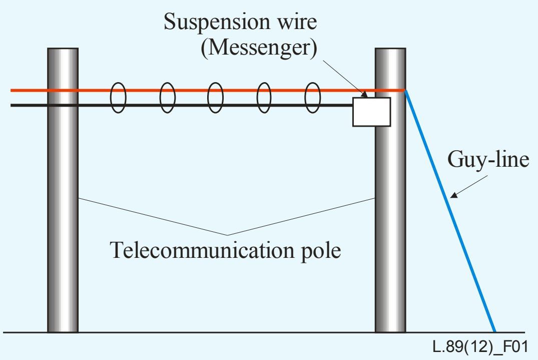
– Guy-line is a wire installed to prevent poles collapsing as a result of tension imbalances that occur during or after cable installation. One end of the guy-line is fixed to the pole and the other end is fixed to the ground by a guy anchor.

– Messenger is an alternative term for suspension wire.

– Suspension wire is a wire that is installed in advance between telecommunication poles from which aerial optical cables are suspended. It supports a tension applying to non-self-supporting aerial optical cables.

– The aerial infrastructure consists of a suspension wire (messenger), a telecommunication pole, a guy-line, as shown in Figure 4-16, and the optical fibre cables for aerial applications.

Figure 4-16: Aerial infrastructure



The general requirements for aerial infrastructure design are shown in the following.

Classification of site conditions

Ideally, aerial infrastructure is designed in accordance with the conditions of each individual site. However, designing on such an individual basis raises capital expenditure (CAPEX). Therefore, a certain level of design standardization is necessary to simplify the design and construction process, in order to reduce CAPEX. As one example of this standardization, site conditions may be classified based on wind loading, ice loading and/or soil property. Network operators should carefully investigate the site conditions so that the site can be correctly classified.

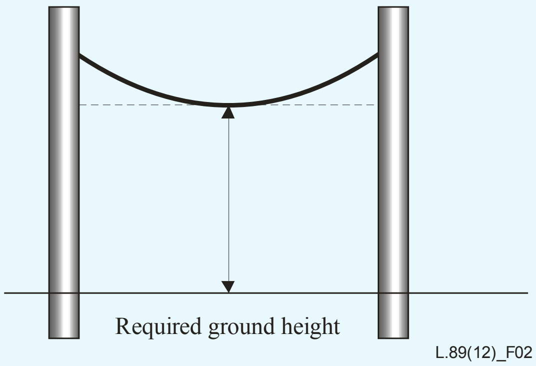
Safety and economic considerations

Aerial infrastructure consists of large facilities that are installed high above the ground. So, it is recommended that telecommunication companies carefully consider safety and avoid any accidental destruction to aerial infrastructure by employing a design with sufficient strength and protection against lightning. Note that telecommunication companies should also consider reducing CAPEX while maintaining safety.

Management of ground height and offset distance

It is recommended that aerial infrastructure (including cables shown in [ITU-T L.26], [ITU T L.58] and [ITU-T L.87]) has sufficient ground height to prevent any component from being a traffic barrier and to eliminate risks to people and other constructions (Figure 4-17). The ground height shall be evaluated in wind-free conditions. An offset distance that is as great as possible should be established between optical fibre cables and electrical cables to achieve safety and workability. In general, ground height and offset distances are defined by regulations, and so telecommunication companies shall follow these regulations when designing aerial infrastructure.

Figure 4-17: Ground height



Loads applied to aerial infrastructure

Aerial infrastructure should be designed in accordance with the loads applied to them to maintain their reliability and safety. In particular, telecommunication companies should carefully consider wind loading, suspension wire tension and vertical load. These loads must include the weight of the cable(s) which are expected to be supported by the suspension wire.

The design criteria based on the above requirements are in Annex 4A1.

4.1.4.4 Street cabinets

[For further information see ITU-T Recommendations L.70, L.71 and L.oxcon (under preparation)]

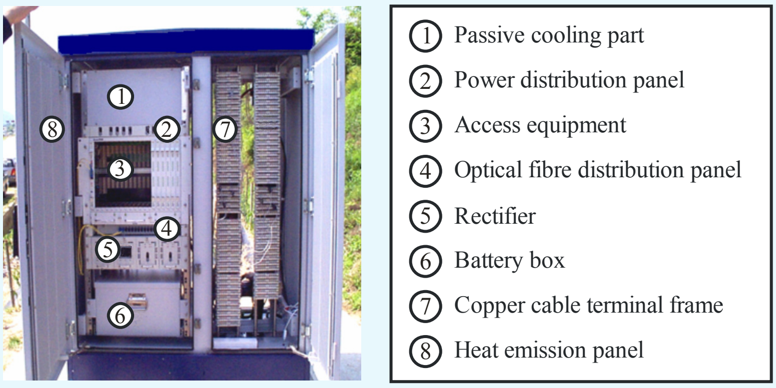
Street cabinets accommodate passive and active optical devices and can be configured only for fibres, for a combination of copper and fibre, for splices, and passive optical splitters. Example of street cabinets for the broadband access network are shown in Figures 4-18 and 4-19.

The outdoor cabinets should be installed considering the size of the cabinet, occupation area and the risk of flood damage. Also, it can be considered whether to purchase or rent the place to install outdoor cabinets. A series of these processes can minimize the OPEX for environmental damage or moving of cabinets in future. As for the power supply for active equipment (e.g., ONU or remote xDSL) deployed in street cabinets see Section 4.5.

Figure 4-18: Example of cabinet for broadband services

L.71(08)_FI.1

Figure 4-19: Example of the structure of a cabinet for broadband services



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4.1.4.5 Manholes and Handholes

[Guide to Post-Earthquake Investigation of Lifelines, ASCI]

[http://books.google.it/books?id=Zi6vvZDbDH0C&pg=SA14-PA19&lpg=SA14-PA19&dq=Manholes+and+handholes&source=bl&ots=5PSqY3RYM9&sig=ZUF4cZqXW1y9dsMyx_jIZI1N6sk&hl=it&sa=X&ei=93qxUb-6HcGUhQfgmYFw&ved=0CG4Q6AEwCg#v=onepage&q=Manholes%20and%20handholes&f=false]

Manholes and handholes are means to branch the cables and protect the splice joints from the environment (Figure 4-20). They also allow service people to add or to repair cables in the network. Cables can be easily added between manholes by stringing the new cable through the conduits. Handholes are used for direct buried cables and cables entering a building. As the name implies, handholes are much smaller than manholes.

The majority of manholes and handholes are concrete structures buried underground. The size of the manholes is dependent of the amount of cables and repeaters for the location. Recently some operators have used some fiberglass construction; these manholes are lighter in weight and easier to handle than concrete.

All manholes and handholes are required to be water tight. Therefore, cables entering or exiting a manhole or a handhole have to be sealed. Normally, cables in a manhole are tied to shelves away from the manhole floor so that they cannot be damaged by water when water leaks into the manhole. It is common practice to inspect manholes for water after a major rain storm and pump them out where necessary.

Figure 4-20: Protection system for extra length cable in handholes

4.2 Maintenance aspects

[For further information see ITU-T Recommendations L.omtl, L.73, L.74, L.88, G.979]

An optical fibre line testing system is essential for reducing maintenance costs and improving service reliability in optical fibre networks. The system requirements described in this Section, for sake of brevity, is limited to deal with some maintenance aspects of optical cables for trunk lines and of active optical nodes.

4.2.1 Maintenance aspects of optical trunk systems

NOTE – An optical trunk line is a part of the optical fibre cable network that is located between two central offices.

Data communication traffic in both access networks and optical trunk lines is rapidly increasing. Therefore, the optical fibre cable for trunk lines is becoming increasingly important because of its large transmission capacity. The fundamental requirements for optical fibre cable maintenance support, monitoring and testing systems for optical trunk lines are as follows:

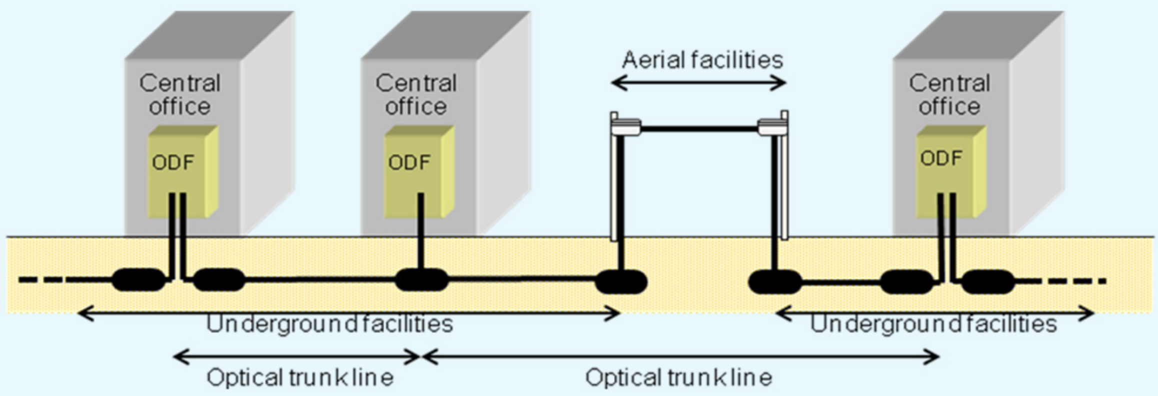
- An optical fibre cable maintenance support, monitoring and testing system must perform the maintenance work described in [ITU-T L.25] efficiently.
- An optical fibre cable maintenance support, monitoring and testing system should provide the surveillance, testing and control functions listed in [ITU-T L.40] to meet the system specifications for optical fibres or fibre-optic components even when applied to optical trunk lines.

– It must be safe for network operators to handle the optical fibre cables, cords and fibre-optic components of the optical fibre cable maintenance support, monitoring and testing system. Network operator safety must be in accordance with [ITU-T G.664], [IEC 60825-1] and [IEC 60825-2].

Maintenance aspects of optical trunk line

Figure 4-21 shows a typical configuration of an optical trunk line. In general, an optical trunk line has a long transmission distance and must have a low attenuation. Therefore, the fibre-optic devices that are inserted in the communication lines for testing must also have a low insertion loss. In addition, test equipment must provide highly accurate measurements because of the importance of the optical trunk line. Specific requirements and functions for trunk lines are described below.

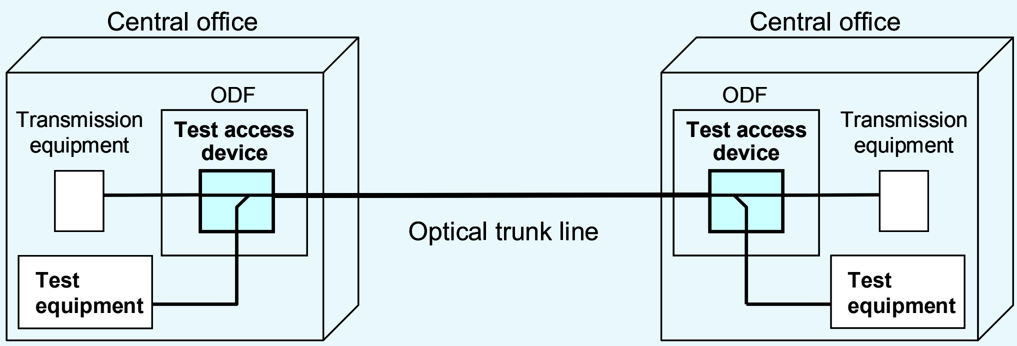
Figure 4-21: Typical configuration of an optical trunk line



There are several ways to implement the maintenance functions described in [ITU-T L.40] and in [ITU-T G.667]for testing an optical fibre cable, the optical loss and the optical power of optical signals. Optical fibre cable maintenance systems should have optical branching devices for test light insertion (e.g., an optical coupler). The branching device for test use should have a low insertion loss in both the communication and test ports when we assume a long distance trunk line. Therefore, wavelength selective couplers or WDM couplers would appear to be efficient devices for testing. Also, the optical branching device should have a wide wavelength range for communication signals when the optical trunk lines accommodate services using WDM transmission systems.

When the length of an optical trunk line cable exceeds the measurable range of the test equipment, branching devices must be inserted at both ends of the optical trunk line for bidirectional testing. A typical configuration of the optical trunk line with test access devices is shown in Figure 4-22.

Figure 4-22: Typical configuration of an optical trunk line with test access devices



4.2.2 Maintenance aspects of active nodes

[For further information see ITU-T Recommendation L.70]

In general, remote active nodes require more maintenance effort than passive outdoor nodes or active equipment in central offices. The main reasons for the more intensive maintenance are:

– limited lifetime of the equipment and moving parts (e.g., fans);

– potential pollution of ventilation systems;

– temperature excursions that have a negative effect on the lifetime of equipment and batteries;

– damage (accidental or intentional).

Compared to centralized electronics, the cost per maintenance intervention will be higher due to the required travel time. In order to minimize the need for maintenance interventions, the following design features and practices are recommended:

– minimum lifetime of fan and equipment should be five years;

– avoid forced ventilation when possible;

– apply multiple fans in parallel (redundancy);

– mount air intake of ventilation systems away from the ground to reduce risk of pollution (e.g., in the "roof" of the enclosure);

– apply air filter types with a minimum need for maintenance or replacement;

– avoid the application of active cooling ("chillers") unless absolutely necessary;

– minimize the need for intervention related to the powering of the node (e.g., resetting of safety switches or fuses, meter reading, battery breakdown, etc.);

– apply a maintenance plan (e.g., annual, bi-annual, etc.) to execute a number of standard activities that will prevent sudden breakdown due to deterioration of the node (e.g., battery replacement, filter replacement, fan replacement, cleaning, etc.);

– apply remote monitoring of critical parameters such as internal temperature, humidity level, fan status, open door contacts, etc.

4.3 Natural disasters management

[For further information see ITU-T Recommendations L.92 and L.81]

4.3.1 Earthquakes

Outside plant facilities may be damaged during earthquakes. Telecommunication services may be lost because of damage to underground conduits, aerial cables, etc. Therefore it is necessary to perform an initial evaluation of the earthquake hazard and outside plant facilities vulnerability. In addition seismic design standards for outside plant facilities are needed to improve their earthquake performance.

4.3.1.1 Damages to the outside plants

Duct /conduits

When conduit is damaged, water can penetrate into the closure and small flaws in cables will eventually allow water to enter and degrade cable performance. PVC ducts can be damaged by ground deformation caused by an earthquake.

The following countermeasures using ducts with flexibilities to relative displacements are effective.

i) Sliding joint for general ducts

The joint structure is changed from a screw type to a sliding type to improve flexibility of a range of a motion (Figure 4-23(2)).

ii) Sliding joint for manhole ducts (duct sleeve)

This is a sleeve for a duct connecting to a manhole, which also acts as a sliding joint (Figure 4-23(1)).

iii) Sliding joint with a stopper

This is used near a bridge section and in a liquescent ground. The stopper embedded in the joint limits excess movement of ducts (Figure 4-23(3)).

iv) Flexible building access duct

This is used for connecting a handhole and a customer’s building and absorbing large relative displacements (Figure 4-23(6)).

Poles/guy lines of aerial cables

Poles (concrete poles and steel poles) have several failure modes: falling, sinking, and breaking. Poles fall to the ground when the bearing capacity of foundation is weak. In liquefied soils, poles sink into the soil. Poles can also be broken at the weakest point. The failure of the pole is attributed to ground motions or to being pulled over when an adjacent pole fails. Appropriate countermeasures should be applied according to these failure modes.

Terrestrial cables

Terrestrial cables are one of the important infrastructures and have to meet a set of requirements. These requirements are intended to protect the cables from the hostile outside plant environment including earthquakes. It is recommended that cables should have good seismic performance. It is desirable that cables have enough length at manholes so as not to be cut due to ground settlement by earthquake.

Tunnels

Cable tunnels are designed to withstand a large scale earthquake based on a sufficient strength design, and so cables inside tunnels are not damaged. However, water leakage and flooding occur at connections. So following countermeasures are developed.

(1) Flexible joint for open-cut tunnel

This is used to prevent a damage caused by relative displacements at the attachment point of the open-cut tunnel between a building and a vertical shaft (see Figure 4-23 (5)).

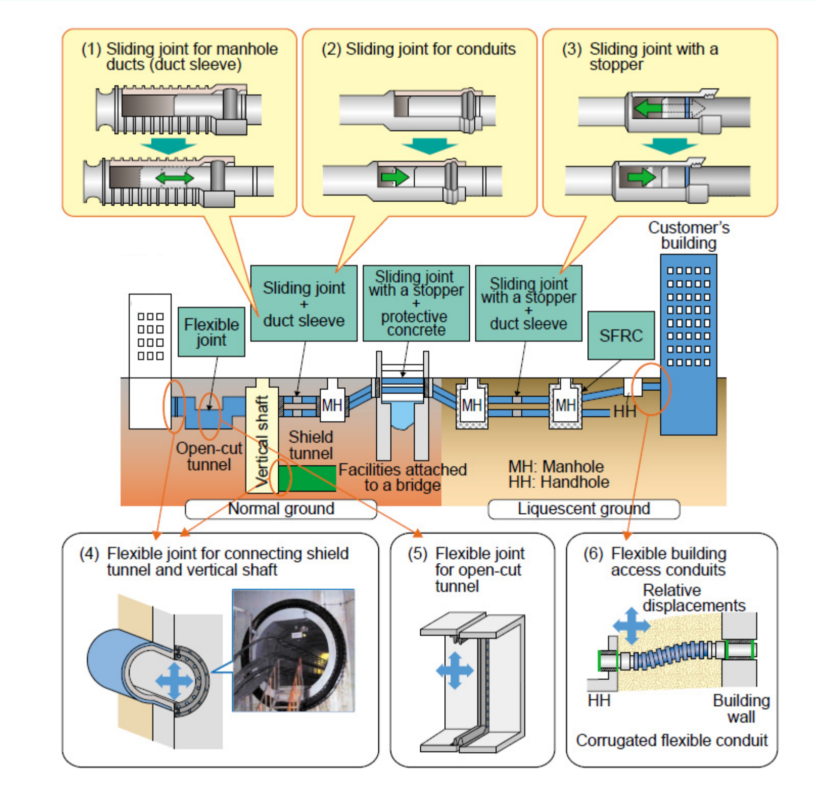
(2) Flexible joint for connection between a shield tunnel and a vertical shaft

This is used to maintain connections between the shield tunnel and the vertical shaft (see Figure 4.1(4)).

[For further information see "Research on reliability assessment of buried Telecommunication facilities during earthquakes"

[http://www.bhrc.ac.ir/Portal/LinkClick.aspx?fileticket=lOD8ZaSB9xw%3D&tabid=562]

Figure 4-23: Japanese experience of earthquake countermeasure for underground facilities



Manholes/handholes

Manholes and handholes are also critical components of outside plant facilities because they are usually damaged during earthquakes. Manholes are damaged when[17] soil liquefaction occurs. The soil around the manhole liquefies and loses its shear strength, and as a result, the manhole can sink or float, breaking conduits connected to the manhole.

[17] Soil liquefaction is a phenomenon whereby a soil loses strength and stiffness during an earthquake, causing it to behave like a liquid. Surface-supported structures have settled several feet below grade, and buried tanks have floated to the surface.

Bridges

As countermeasure to earthquake, bridges have a quake absorbing structure. When an earthquake occurs, a bridge will oscillate in all directions (360 °) owing to the structure. This behavior of the bridge prevents the failure of the bridge. However, on the other hands such flexible structure of the bridge requires the flexible range of motion to conventional ducts put on the bridge. Therefore, it is insufficient to take into account oscillation in only the forward direction as the countermeasure of ducts put on the bridge. Considerations should be focused on more flexible connection technologies for ducts.

4.3.1.2 Possible measures to face earthquakes

Mitigation measures:

– Observe earthquake-resistance design standards and building codes;

– Restrict installation in active earthquake faults;

– Increasing strength of materials which are used in outside plant facilities.

Preparedness measures:

– Rubber joints for cable tunnels, liquefaction countermeasures on manhole, extendable joints for ducts and seismic simulations;

– Installation of vibration controlling or mitigating systems.

Response measures:

– Installation of structural health monitoring systems.

4.3.2 Tsunami

A tsunami consists of a series of sea waves and is usually caused by massive submarine earthquake. Central offices and outside plant facilities in coastal areas may suffer serious damage. It takes a long time to repair damaged telecommunication services at central offices due to the wide variety of specialized equipment typically installed there. There is a need to design alternate trunk cable routes that can be used to sustain telecommunication services when a large portion of the trunk network is degraded.

4.3.2.1 Damages to the outside plants

It is important to prevent water damage in cable tunnels, in submarine cables, in manholes, in handholes, to the power supplies and to have backup power supplies available for use during power supply failures.

4.3.2.2 Possible measures to face tsunami

Preventive mitigation measures:

– Locating central offices and cable routes on higher ground;

– Strengthening trunk line backup systems by subdividing physical network loops;

– Laying cables with ducts under riverbed rather than installing cables along bridges near the mouths of rivers;

– Ensuring an electrical power supply, for example, by establishing duplication using a multiple electrical distribution route and an emergency electrical generation system.

4.3.3 Flood/Flash floods

4.3.3.1 Damages to the outside plants

Outside plant facilities are also damaged by floods.

– Water can enter manholes, handholes, which can cause telecommunication equipment to break down. Therefore, manholes and handholes are required to be water tight. Cables entering or exiting a manhole or handhole have to be sealed. Cables in a manhole should be tied to shelves away from the manhole floor to avoid damage by water when water leaks into a manhole.

– Tunnels: in the cable tunnels, waterproof doors and water pumps should be provided.

– Cables: liquid can penetrate into cables.

4.3.3.2 Possible measures to face floods

Preventive mitigation measures:

– Restrict installation in potential flood zones;

– Installing concrete structures at the site in which ground settlement may be expected due to heavy rains;

– Installing retaining structures or guardrails between outside plant facilities and steep slopes.

Preparedness measures:

– Installation of waterproof doors and water pumps;

– Sealing the ends of the plastic tubes (at the manholes/pits of our underground infrastructure) with foam filler;

– Installing drainage pumps in cable tunnels and installing flood walls in cable tunnels.

Response measures:

– Submersion detection modules and cable tunnel management systems;

– Installation of early-warning systems.

4.3.4 Strong wind (hurricanes/tornados/typhoons/wind storms)

Outside plant facilities may be affected by strong winds, and there is always a risk of loss of telecommunication services.

4.3.4.1 Damages to the outside plants

Telecommunication poles should be braced and guyed to withstand maximum expected wind velocities and optical cables should be installed to resist damage due to wind-driven vibration.

The following damages are possible:

i) falling telecommunication poles;

ii) physical damage to aerial structures;

iii) disconnection of aerial cables.

4.3.4.2 Possible measures to face strong winds

Mitigation measures:

– Observe design criteria for protection against strong winds.

Preparedness measures:

– Installation of supports (i.e. struts, guy line or stay wires);

– Bracing poles alternatively with steel wires when the expected wind speed exceeds 40 m/s;

– Using bracing between poles in windy locations;

– Using vibration dampers to protect cables.

Table 4-6 shows some examples of maximum wind pressure loads allowed to act on vertical profile area.

Table 4-6: Wind pressure loads

Facilities	Wind pressure loads per vertical profile area (kg/m2)
Wooden poles, concrete poles	80
Steel poles	80
Towers	170
Cables	100

4.3.5 Landslides

4.3.5.1 Damages to the outside plants

Typical damages of the landslides are the destruction of underground ducts and the failure of retaining structures.

4.3.5.2 Possible measures to face landslides

Mitigation measures:

– Restrict installation in potential landslide zones;

– Keeping away from landslide-prone areas;

– Increasing the slope's stability.

Preparedness measures

– Periodic inspection;

– Installation of monitoring systems, and monitoring by measurement.

Response measurements:

– Installation of early-warning systems

4.3.6 Forest fires

4.3.6.1 Damages to the outside plants

Typical damages of forest fires are burned down telecommunication poles and disconnection of aerial cables.

4.3.6.2 Possible measures to face forest fires

Mitigation measures:

– Using fire breaks (isolating clean land strips-mostly in the rural area).

Preparedness measures:

– Protecting outside plant facilities with non-flammable or fire-retarding materials;

– Using non-flammable materials in cable structures.

Response measurements:

– Installation of early-warning systems.

4.3.7 Severe cold, snow, ice or heat

4.3.7.1 Damages to the outside plants

Severe atmospheric conditions can impact all the types of telecommunication equipment.

4.3.7.2 Possible measures to face severe cold, snow, ice or heat

Mitigation measures:

– Outside plant facilities that are installed at sites where there is extreme heat or cold should be provisioned with adequate countermeasures in order to operate with stability;

– Outside plant facilities that are installed at the site or environment where its temperature difference is excessive should be provisioned with adequate countermeasures in order to operate with stability.

Preparedness measures:

– A manhole cover for snow covered areas and installing tubes for antifreeze in ducts.

[TBD]ry analysis method.

4.4 Disaster monitoring systems for outside plant facilities

[For further information see Recommendations ITU-T L.81, L.25, L.40 and L.53]

[For the aspects related to active monitoring of the transmission equipment see also ITU-T G.697].

This Section:

– describes typical emergency management for outside plant facilities;

– describes monitoring systems for outside plant facilities using wireless or wired network;

– provides an overview of disaster monitoring systems for outside plant facilities;

– provides design considerations for disaster monitoring systems for outside plant facilities.

Definitions

– disaster: Disasters are characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it. Disasters often result in great damage, loss, or destruction.

– early warning: The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response.

– emergency: An emergency is a sudden, urgent, usually unexpected occurrence or event requiring immediate action.

– structural health monitoring (SHM): The process of continuously monitoring the status of a structure to detect damage.

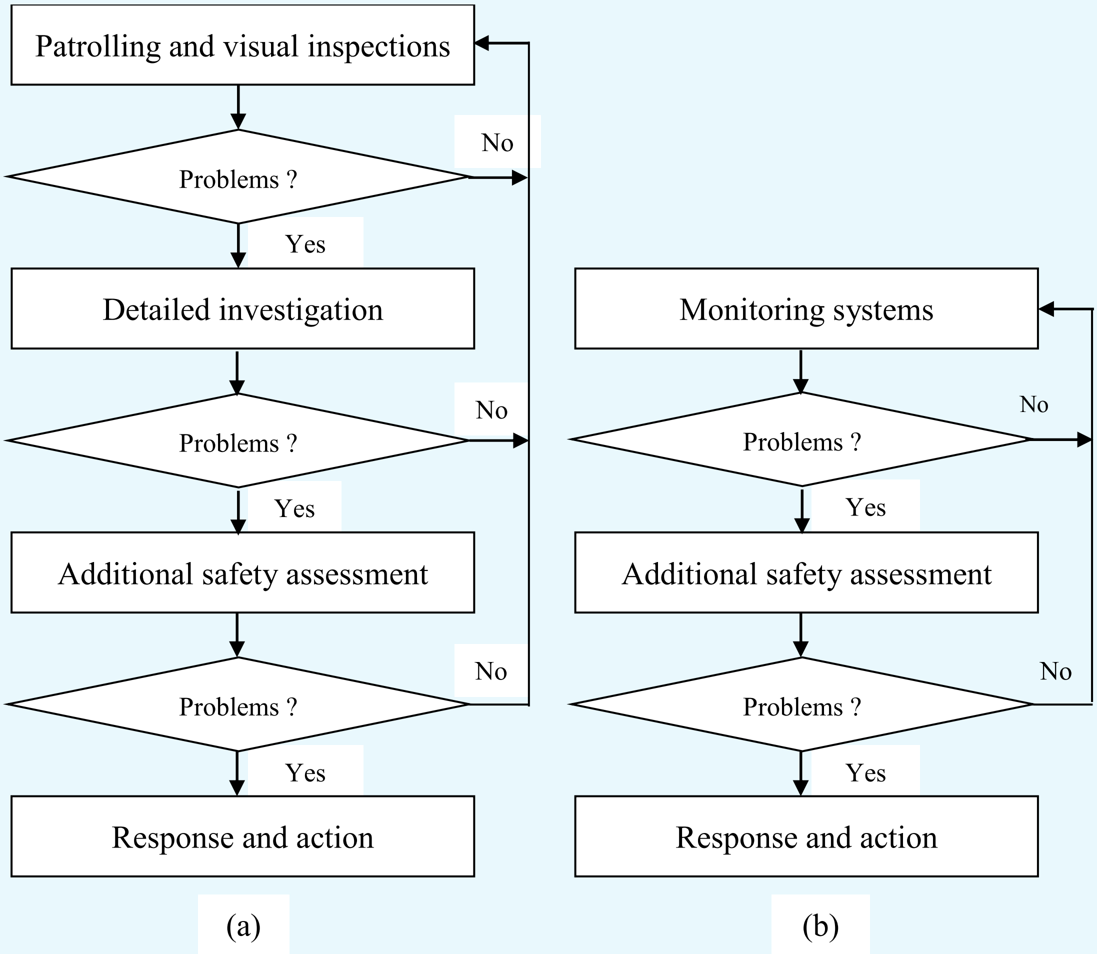
– wireless sensor network (WSN): A wireless network consists of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations.

4.4.1 Manually operated monitoring systems

Manually operated monitoring procedures for outside plant facilities are described in Figure 4-24 a). Patrolling and visual inspections are carried out by facility member staffs, and a detailed investigation follows when any defects are detected. If critical factors which may cause an accident are detected at this stage, additional safety assessment is carried out.

As shown in Figure 4-24 (b), monitoring systems by sensor network omit some of these stages, and thus make it labour-saving and efficient to maintain the outside plant facilities. In addition, monitoring systems allow facility member staffs to quickly find critical data that ensure outside plant facilities operate 24 hours a day.

Figure 4-24: Monitoring flow diagram: (a) manually operated monitoring method; (b) monitoring systems



4.4.2 Monitoring system for outside plant facilities

The objective of the monitoring system is to detect defects in an early stage, and to deliver warning messages to disaster managers rapidly when the defects are not tolerant. These activities can be performed by persons, but it may cost much time and effort when the structures or facilities to be monitored are big and spatially scattered over a wide area. In addition, small defects that may cause great disasters are apt to be overlooked by only manual inspection. Therefore, it is required to establish more sophisticated countermeasures such as an early-warning monitoring system.

General requirements

It is recommended that the monitoring system for outside plant facilities be:

– designed to carry out proper response action rapidly in the emergency;

– implemented by reliable, stable and proven technology not to give a false alarm;

– operated in real-time or near real-time manner;

– designed to provide alerting without delay for facility staff members;

– tested and verified before application and regularly checked.

Wired/wireless systems

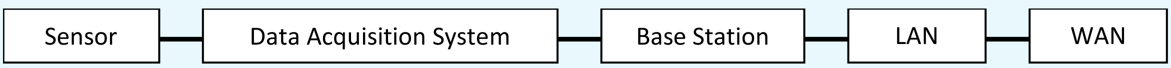
Monitoring system for outside plant facilities is to sense the physical or environmental conditions by sensors, and then to notify facility staff members through the way of wired or wireless system. Comparisons between wired and wireless systems are presented in Table 4-7. Wired system is recommended when a higher reliability is required.

Table 4-7: Comparisons between wired and wireless system

Type	Advantages	Disadvantages
Wired system	– stable and proven technology.	– involves many long lengths of cable to cover the large spatial distances; – expensive to install; – cables can fail due to exposure to the environment or potential damage during extreme events; – long cables result in sensor signal degradation.
Wireless system	– no cables are required for data transfer; – system setup and maintenance cost can be remarkably reduced; – in the case of partial system failure, the rest of the system is capable of performing its task independently.	– power and communication bandwidth available on the node are very limited; – each node has restricted battery life.

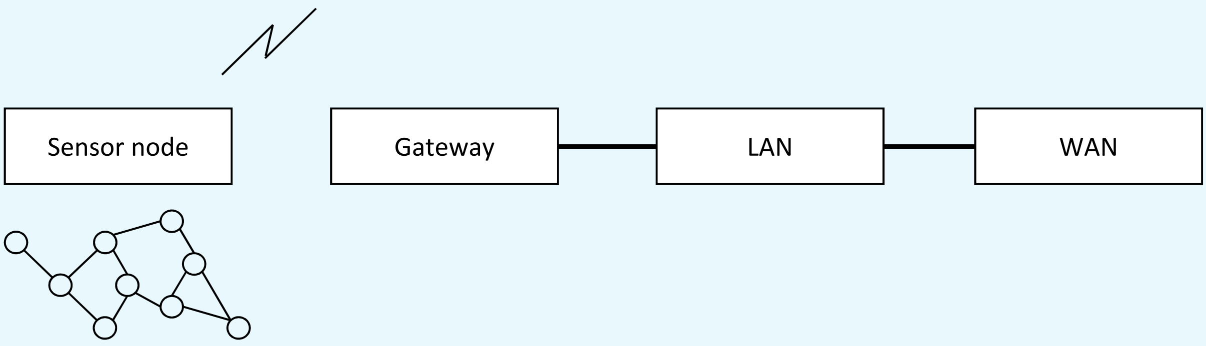
In a wired system, the sensor is generally hard-wired to a data acquisition system which is linked to the base station (Gateway) by a cable. An example of network configuration using Ethernet is shown in Figure 4-25.

Figure 4-25: Example of network configuration (wired system)



In a wireless system, the sensed data are sent to a gateway (Base Station) via radio. Radio frequencies, power and protocols vary greatly among different systems. Some of the wireless systems available are GSM, WiFi, Bluetooth, and ZigBee, etc. The type of wireless systems to be used depends upon factors such as frequency, data rate, range, and monitoring characteristics, etc. Typical network configuration is shown in Figure 4-26. A sensor node is a basic unit which is composed of sensing, processing, communication, and a power unit. Communication between gateway and LAN will be via wired or wireless.

Figure 4-26: Typical network configuration (wireless system)



Sensors

Parameters to be sensed in the monitoring system are deformation, angle, vibration, and temperature, etc. Typical sensors and their applications are presented in Table 4-8.

Table 4-8: Typical sensors for outside plant facilities

Parameters	Sensors	Descriptions	Applications
Deformation	• Crack gage, Convergence gage, Strain gage	• To monitor changing distances between two points	• Monitoring crack width of building, cable tunnel, and manhole
	• Fibre-optic sensor	• To monitor changing distances between two points • Optical fibre Bragg grating (FBG)	• Monitoring deformation of civil infrastructures such as buildings, slopes, tunnels, underground pipes, etc.
	• Probe extensometer	• To monitor the changing distance between two or more points along a common axis	• Monitoring ground movement and settlement
	• Inclinometer	• To monitor the changing vertical deformations along a common axis	• Landslide detection
Angle	• Tiltmeter	• To monitor the change in inclination (rotation) of points	• Monitoring earth retaining wall • Detecting inclination of telecommunication pole or tower
Vibration	• Accelerometers	• To monitor dynamic response, either harmonic (e.g., vibration) or transient (e.g., earthquake)	• Monitoring office vibration by traffic or earthquake
Temperature	• Thermometer	• To monitor temperature	• Monitoring temperature in server rack

Parameters	Sensors	Descriptions	Applications
Water level	• Piezometer	• To monitor water level and/or water pressure	• Flood detection in telephone office or cable tunnel
Security	• Motion detector	• To detect motion	• Detecting intruder to secure restricted area

There are two types of communication models: a pull model and a push model. A pull model requests sensed data periodically in a certain time interval. A push model proactively transmits sensed data only when an event exceeds a predetermined level. It is recommended that a push model be used for a disaster monitoring system.

4.4.3 Application of monitoring systems on outside plant facilities using WSN

[Korean experiences in ITU-T Recommendation L.81]

Design considerations on the deployment of WSN (Wireless Sensor Network) monitoring system are presented in Table 4-9.

Table 4-9: Design considerations

Items	Descriptions
Network topology	– In WSN, there are star and tree (mesh) network topologies. Network topology affects network characteristics such as latency, robustness, and capacity.
Power supply	– WSN can be easily deployed to the sites even where the infrastructures such as communication and electricity are not installed. But the battery which provides sensor node with depletable energy, and thus power unit is one of the most important components to be considered.
Threshold	– Monitoring system performs early warning. Real-time data gathered by WSN are analysed and alarm is issued if the data exceed prescribed thresholds. – If the threshold is set too low, there will be too many false warnings, so that genuine warnings will not be heeded. On the contrary, if the threshold is set too high, the event which may cause accidents will be missed. – This activation threshold should be set case by case for outside plant facilities.
Sampling rate	– Sampling rate determines how often sampling can take place. A faster sampling rate acquires more data in a given time, and therefore often forms a better representation of the original signal. – For example, earthquake monitoring needs at least 200 Hz data sampling rate, whereas, in the case of temperature or humidity sensing, several samples per day may be enough.

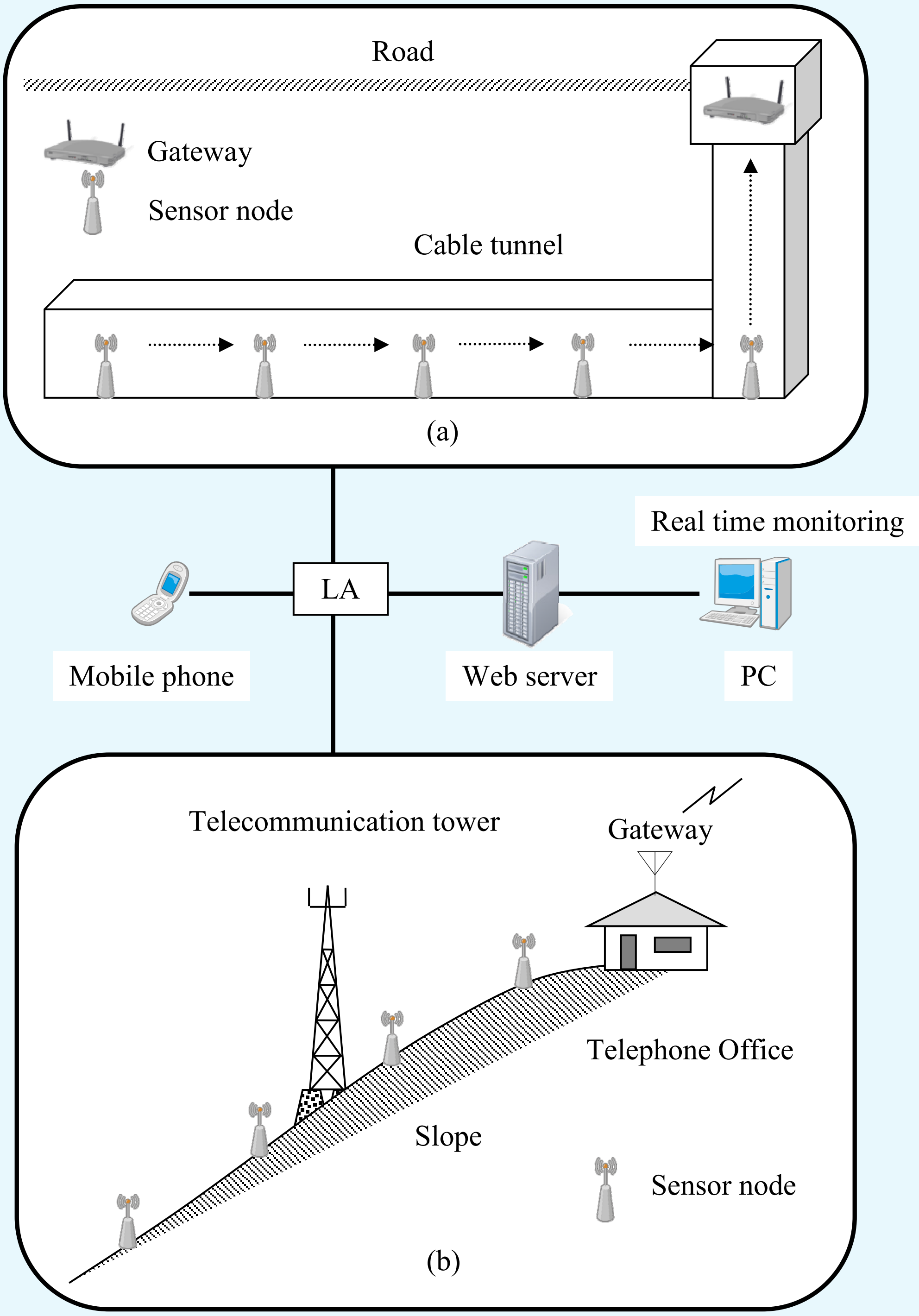
Cable tunnel monitoring

We deployed the cable tunnel monitoring system using WSN. Fire, flood, vibration, temperature and intruder monitoring are performed by sensor nodes, and sensed data are transmitted to the gateway by wireless communication. Data are displayed on a web browser through the Internet, and a facility staff member is notified automatically when an event exceeds the warning level. Schematic drawing of this system is shown in Figure 4-27 (a).

Landslide monitoring

In the case of outside plant facilities on or near steep terrain, landslides are one of the most significant natural hazards. Slope angle and ground vibration are measured every minute, and these data are transmitted to a server computer via radio. Schematic drawing of this system is shown in Figure 4-27 (b).

Figure 4-27: Schematic drawing of monitoring systems: (a) cable tunnel monitoring system; (b) landslide monitoring system



Annex 4A1: General criteria for the design of an aerial cable infrastructure

[For further information see ITU-T Recommendation L.89]

4A1.1 Loads applied to aerial infrastructures

Aerial infrastructure should be designed in accordance with the loads applied to them to maintain their reliability and safety. In particular, telecommunication companies should carefully consider wind loading, suspension wire tension and vertical load, as shown in Figure 4A1-1. These loads must include the weight of the cable(s) which are expected to be supported by the suspension wire.

Wind loading

The wind load peaks when the wind blows at right angles to an aerial infrastructure (Figure 4A1-1). At that time, the wind load T_w [N] can be obtained by the following equation.

$$T_w = \frac{1}{2}\rho C_D V_w^2 S$$

where ρ, C_D, V_w and S are the air density, the drag coefficient of the infrastructure determined by wind tunnel testing, the wind velocity and the profile area of the cable and the suspension wire, respectively. Note that ice accretion to the cable and suspension wire may increase in their profile area.

Suspension wire tension

The suspension wire tension is the load supported by suspension wire. The suspension wire tension T [N] can be obtained with the following equation.

$$T = \frac{WL^2}{8d}$$

where L is a span length. d is a sag and has an inverse ratio to T. In terms of the ground height, a smaller sag is desirable, but this increases suspension wire tension as shown in Figure 4A1-2, and so an aerial infrastructure with greater mechanical strength is required. Therefore, telecommunication companies should design the sag and the suspension wire tension so that they are in balance. As shown in Figure 4A1-3 , W is the load imposed by the sum of the wind load and the cable weight. Note that the resultant load W [N/m] should be defined as the value per unit length. So, it is given by:

$$W = \sqrt{w^2 + \left(\frac{T_w}{D}\right)^2}$$

where w and D are an aggregate of cable and suspension wire weights per unit length and aggregate of cable and wire diameters, respectively. Note that the suspension wire tension reaches its maximum value at its minimum temperature because metal contracts as the temperature falls. Ice loading should be included in cable weight. Ice loading guidelines are generally established by local, regional, or national authorities. Different ice density values for radial and rime ice may be used depending upon local conditions.

Vertical load

This is load applied to a telecommunication pole vertically. Typical vertical loads are as follows:

– weight of telecommunication pole;

– weight of snow and ice adhering to telecommunication pole;

– vertical component of guy-line tension;

– weight of workers and tools.

It is recommended for telecommunication companies to consider maximum vertical load when designing telecommunication poles.

Figure 4A1-1: Wind load, suspension wire tension and vertical load

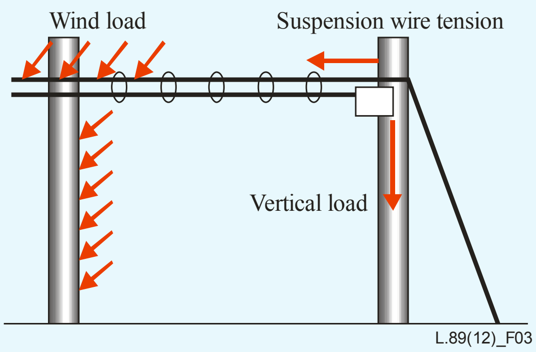


Figure 4A1-2: Relationship between suspension wire tension and sag

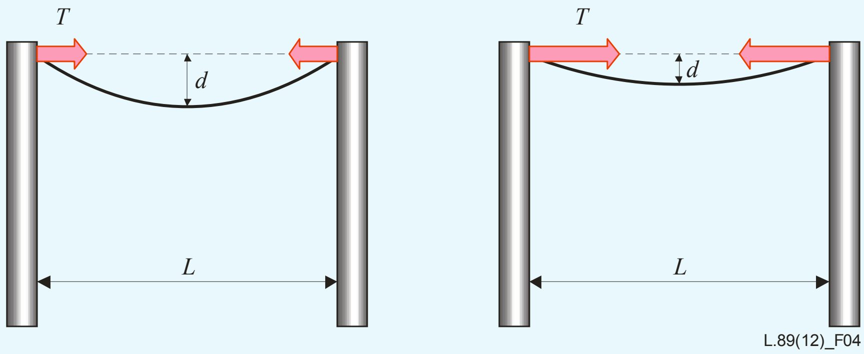
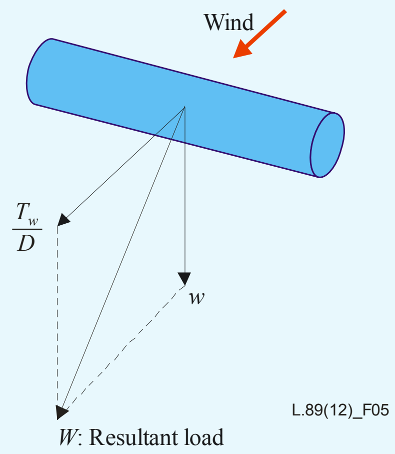


Figure 4A1-3: Resultant load applied to a suspension wire



4A1.2 Design of suspension wires

Materials

It is recommended that stranded steel wire be used as suspension wire. Anticorrosive material, e.g., aluminium-coated steel or zinc-coated steel, should be used for the suspension wire in areas with a corrosion risk. Typical corrosion risk areas are as follows:

– Near the coast; corrosion by salt breeze.

– Industrial and mining areas; corrosion by sulphur dioxide gas.

– Hot springs (warm water found in a volcanic location) and volcanic areas; corrosion by hydrogen sulphite.

Selection of suspension wire type

It is recommended for telecommunication companies to select the suspension wire in accordance with the specifications of the aerial cables that it supports. When a future expansion plan for optical cables becomes clear, telecommunication companies may employ the suspension wire that conforms to their plan in advance. The applicable type of suspension wire should be decided carefully based on its tensile strength, calculated suspension wire tension and safety margin.

Sag

The sag of a suspension wire reaches its maximum value at the maximum temperature or under the maximum weather loading. So, it is recommended for telecommunication companies to carefully consider the temperature conditions at the installation site.

4A1.3 Design of telecommunication poles

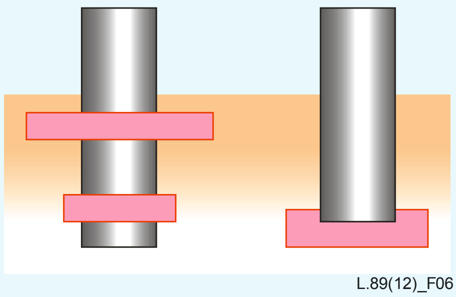
Materials

Telecommunication poles should be made of steel, reinforced concrete or wood.

– Embedded depth

The embedded depth of the pole shall be decided in accordance with the subsurface condition of the ground and the material of the pole to prevent poles from collapsing. A greater embedded depth shall be employed for soft ground such as a paddy field area, an embanked zone and peat soil. The use of a pole anchor is also effective for coping with such ground conditions (Figure 4A1-4). The method for evaluating a telecommunication pole's foundation is described in [ITU-T L.88].

Figure 4A1-4: Example of pole anchor



Pole length

The pole length is limited by the ground height defined by regulations. So, the pole length should be designed to satisfy the required ground height whenever the sag (temperature) reaches its maximum value. At that time, the embedded depth and the surplus length should also be considered.

Classification

Telecommunication poles are typically classified based on their purpose as follows (Figure 4A1-5):

– intermediate pole;

– corner pole;

– terminal pole.

The intermediate pole is located midway in the rectilinear cable region. The intermediate pole is affected by wind loads acting on it, wires and cables. So, guy-lines should be installed on both sides of the intermediate pole. The installation interval of the guy-line should be decided in accordance with the wind load at the site. It is recommended that two side guy-lines be installed every two poles as long as the site condition permits it when the wind load is classified at the highest level.

A corner pole is installed at a bent section of an aerial optical cable line. This corner pole is affected by the resultant load of angular bidirectional suspension wire tensions. So, it is recommended that a guy-line be installed on one side. Note that there is no need to use a guy-line when the suspension wire tension is sufficiently small.

The terminal pole is located at the start and end points of cable lines, and is affected by unbalanced suspension wire tension. So, it is recommended that a terminal guy-line be installed. Note that there is no need to use a guy-line when the suspension wire tension is sufficiently small.

4A1.4 Design of guy-lines

Configuration

A guy-line consists of an upper and a lower part. The upper part of the guy-line (i.e., upper guy-line) is attached to telecommunication poles. The lower part of the guy-line (i.e., guy anchor) is buried to exploit the bearing capacity of the soil.

Installation angle of upper guy-lines

The installation angle, which is formed by the pole and the upper guy-lines, may be more than 25 degrees.

Classification of upper guy-lines

Upper guy-lines are typically classified based on their purpose as follows (Figure 4A1-5):

– terminal guy-line;

– one side guy-line;

– two side guy-line.

Terminal guy-lines are attached to terminal poles, and should be installed parallel to optical cables. If the allowable strength of the single guy-line is insufficient, two guy-lines can be used. One side guy-lines are attached to the corner poles. One side guy-lines should be installed in the direction bisecting the corner angle. Two side guy-lines are mainly attached to the intermediate poles. Two side guy-lines should be installed every two poles when the wind load is classified at the highest level.

Classification of guy anchors

Guy anchors are typically classified according to their purpose as follows (Figure 4A1-6):

– piton anchor;

– block anchor;

– spiky bolt anchor.

The piton anchor, which is a spiky steel piton driven into the ground, is used in most cases except when the installation is on rock or when the driving action might damage existing underground installations or facilities. When it cannot be used, the next choice is the block anchor. The guy-line is held in place by an anchor block formed on site by pouring concrete into a hole, which is then refilled and compacted. However, this also cannot be installed on rock. For an installation on rock, a shallow hole is drilled and a spiky bolt is inserted and mortared in place.

Figure 4A1-5: Classification of telecommunication pole and upper guy-line

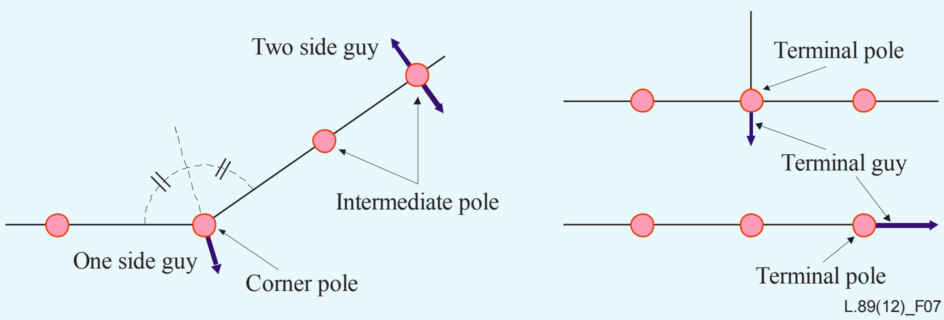
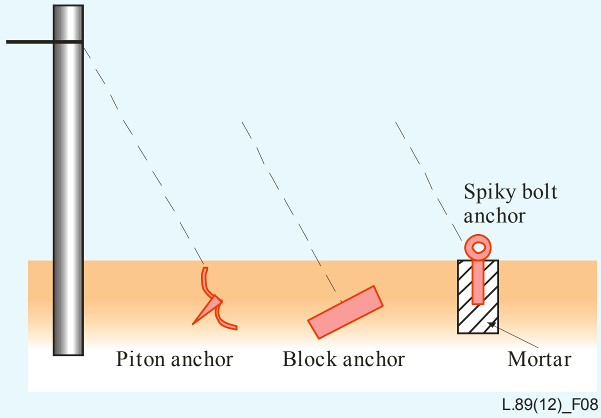


Figure 4A1-6: Classification of guy anchors



Annex 4A2: Thermal design of above ground enclosures

[For further information see ITU-T Recommendation L.70]

The most typical designs for thermal management of above ground outdoor enclosures are listed in this appendix, with their typical properties. The thermal design of the enclosure is to be chosen as a function of various parameters such as:

– surrounding environment and climate;

– dissipated power level of the equipment;

– maximum operating temperature of the equipment;

– size of the enclosure;

– future expandability;

– power consumption;

– etc.

4A2.1 Single wall, natural convection

The most simple enclosure type for housing active electronics would be a single wall box or cabinet, without any specific features for thermal management. Heat is transferred via natural convection along the inside and outside of the enclosure walls (Figure 4A2-1).

The outer walls are exposed to solar radiation and a significant amount of solar energy is transferred to the inside of the closure, increasing temperature.

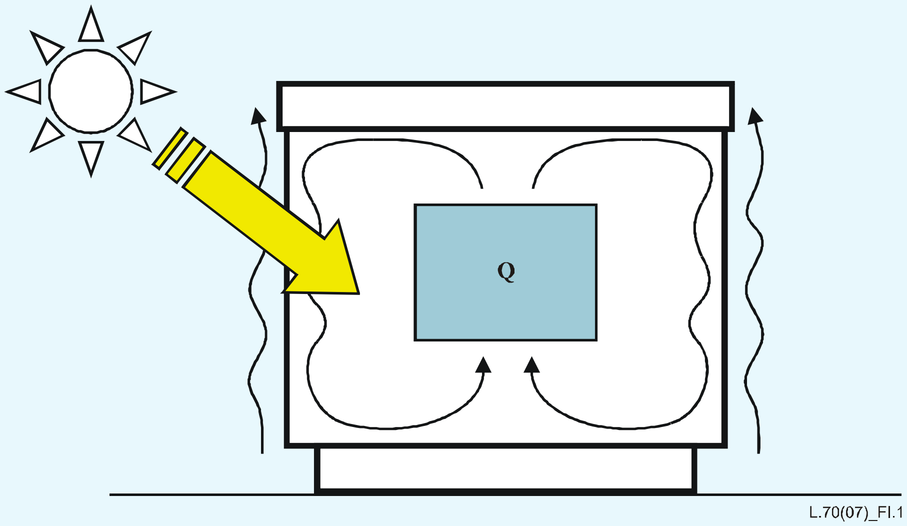
This cooling method does not require extra energy and is maintenance-free.

Internal temperature will rise at least 15-20°C above external air temperature.

NOTE – "At least" means that on a day with intense sunshine, the temperature inside the enclosure will be 15°C or more above the temperature of the surrounding air, even if thermal dissipation inside the enclosure is minimal. E.g., in a passive single wall cabinet, the temperature will rise to about 55°C while the surrounding air is at 40°C.

Due to poor thermal management properties, this design is not recommended for active nodes.

Figure 4A2-1: Single wall, natural convection



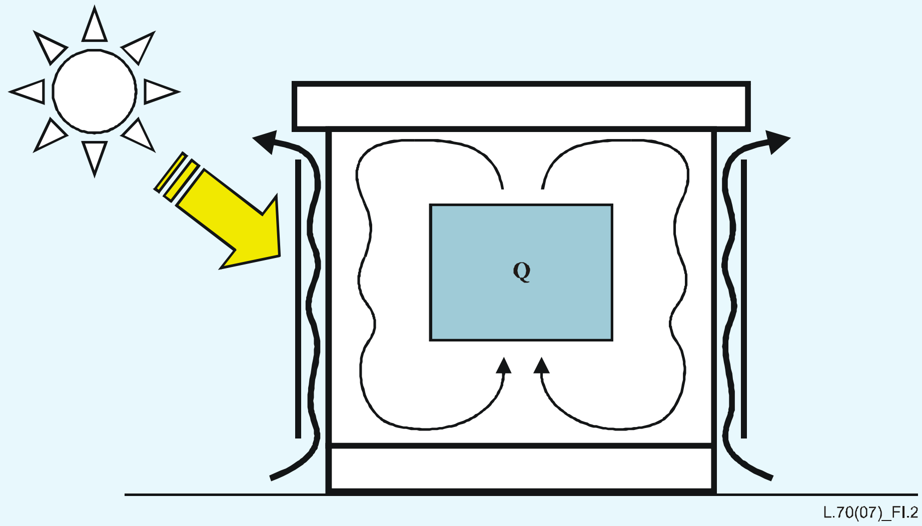
4A2.2 Vented dual wall, natural convection

By applying a double wall construction, the effect of solar load on internal temperature can be reduced. The space between the inner and outer wall must be vented in order to evacuate both the heat generated by solar radiation as well as by the equipment by natural convection (Figure 4A2-2). When properly dimensioned, a "chimney-effect" will be created, increasing effectiveness of the cooling.

This enclosure design combines the advantages of effective thermal management at a low operating expense (no extra energy for cooling and virtually maintenance free).

Internal temperature will be at least 7-8°C above external air temperature.

Figure 4A2-2: Dual wall, natural convection



4A2.3 Forced convection

Increasing airspeed and airflow will make heat transfer to the environment even more effective.

Inside the enclosure, this may be obtained by fans, separate from or integrated into the electronics units. Outside, air can be forced through the dual wall construction. Preferably, the air is circulated top-down, to avoid aspiration of dirt or sand particles from the ground (Figure 4A2-3).

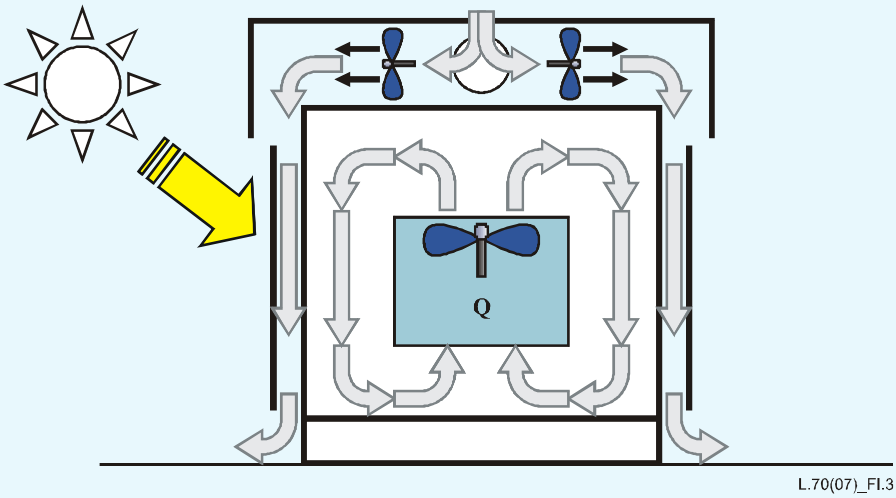
The extra fans in the enclosure will require about 10-20% extra electrical power, on top of the energy to operate the actual equipment.

Recommended fan lifetime is at least five years to minimize fan maintenance.

Fan speed may be regulated as a function of internal temperature. This would increase fan lifetime and decrease power consumption.

Internal temperature will be at least 7-8°C above external air temperature.

Figure 4A2-3: Dual wall, forced convection



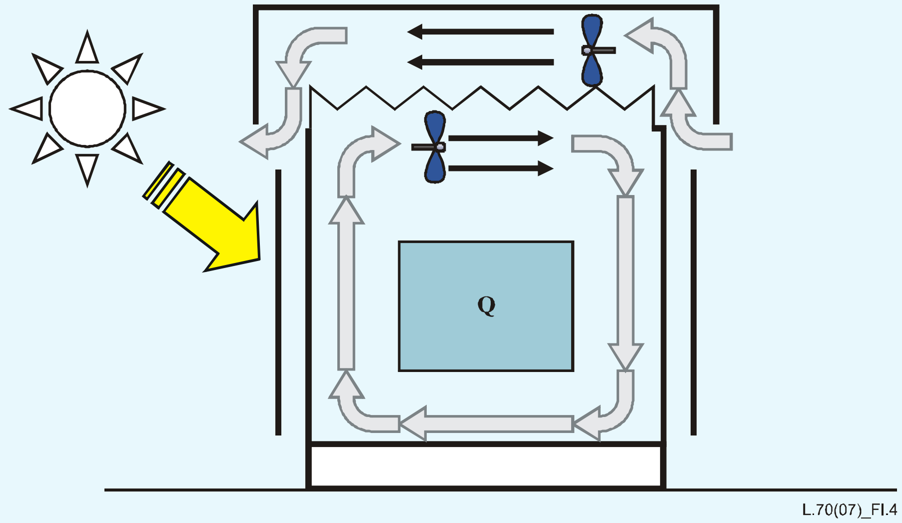
4A2.4 Air-to-air heat exchangers

Cooling by forced convection can still be improved by applying heat exchanger elements. Heat exchangers increase the effective contact surface for cooling (Figure 4A2-4).

The fans of the heat exchanger will typically require 15-30% extra electrical power for cooling.

Heat exchangers should respect the IP 55 sealing level to avoid exchange of external air and intrusion of dust or moisture into the enclosure. The external circuit of the heat exchanger should be designed to minimize dust or dirt build up, that would result in early deterioration of cooling capacity and the related need for maintenance.

Figure 4A2-4: Dual wall, heat exchanger



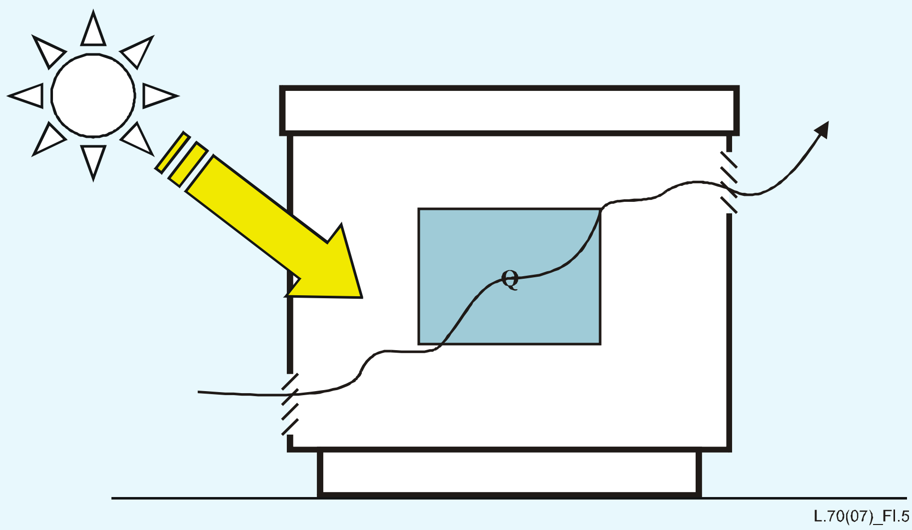
4A2.5 Natural and forced ventilation

For the cases described in clauses 4A2.1 to 4A2.4, the air is constantly re-circulating inside the enclosure. The heat is transferred from the air inside to the air outside through the walls of the enclosure.

By blowing external air directly into the enclosure, a more effective heat transfer can be achieved, resulting in a smaller temperature difference compared to the external air (Figure 4A2-5).

Ventilation by free convection is sometimes applied to improve heat transfer in single wall cabinets; however, it is difficult to achieve a proper sealing level for this method. Adding sealing filters would obstruct the rather weak airflow. Therefore, this layout is not recommended for active nodes.

Figure 4A2-5: Single wall, ventilation by natural convection



The most appropriate method for cooling by ventilation is the use of fans and filters. This is the combination of a fan, driving the external air in and out of the enclosure, with a filter system that prevents intrusion of dust, insects and liquid water. Filter design with minimal need for regular cleaning or replacement is recommended (Figure 4A2-6).

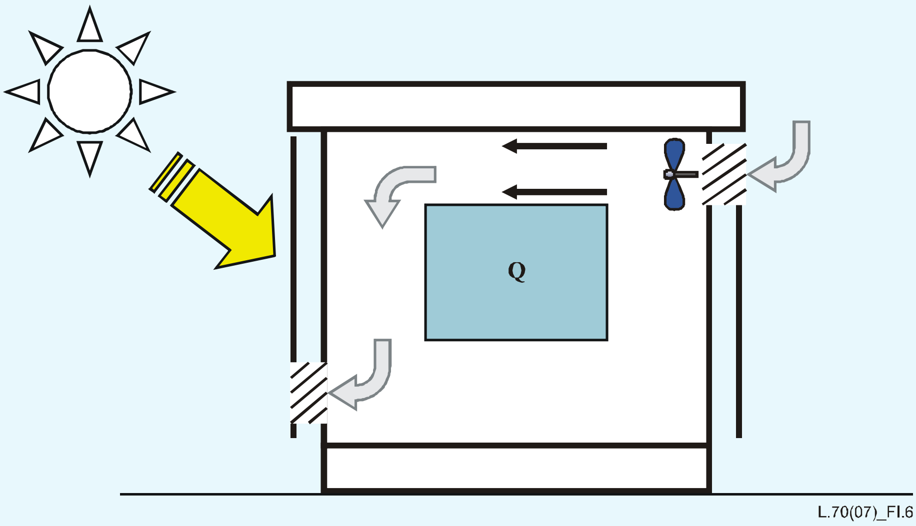
Even when applying IP 55 filters, the air flow will contain water vapour.

Sufficient resistance to corrosion of the equipment is also to be considered.

Filter fans will require about 10-30% of extra electrical power for cooling.

Internal temperature will be at least 3-5°C above external air temperature.

Figure 4A2-6:f Dual wall, forced ventilation (filter fans)



4A2.6 Active cooling ("chillers")

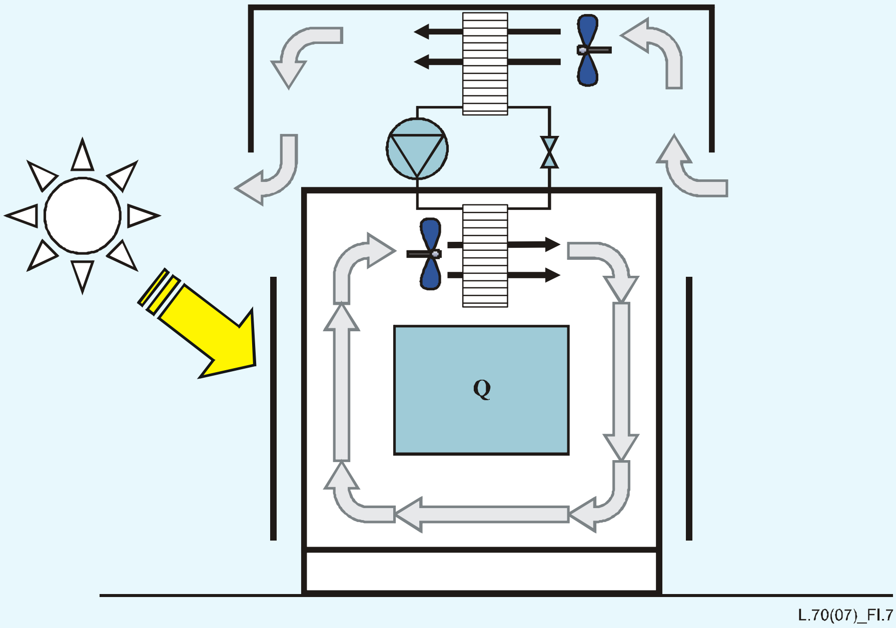
All above methods move heat from the warmer interior to the cooler environment. The temperature inside the enclosure will always be higher than the surrounding air. For certain types of equipment, e.g., when using indoor equipment, it may be required to maintain operating temperatures below the maximum ambient air temperature (Figure 4A2-7). This can only be obtained by applying active cooling devices (chillers). These devices are able to "pump" heat from a cooler to a warmer environment (as in a refrigerator or air conditioner).

About 40-70% of extra electrical power is required to power the cooling unit and its fans. These units will also require more space and more frequent maintenance than the above solutions.

Practically, active cooling is therefore only recommended for specific applications, in extreme conditions or in very large nodes, where the investment and operating expense can be shared over a large number of subscriber lines (operating cost to be compared to a small building).

Internal temperature can be maintained up to 20°C or more below external air temperature.

Figure 4A2-7: Active cooling



4A2.7 Heaters

In some cases, it is recommended not only to manage the maximum temperature but also the minimum temperature range inside an enclosure:

– maintain minimum operating temperature of the equipment (operating temperature ranges for equipment starting at 0°C are still very common);

– obtain minimum temperature before (cold) start of the equipment;

– avoid condensation inside the enclosure.

Annex 4A3: Thermal properties of underground enclosures

This appendix lists the most typical designs for thermal management of underground outdoor enclosures, with their typical properties. Here, only designs are considered that have no above ground elements.

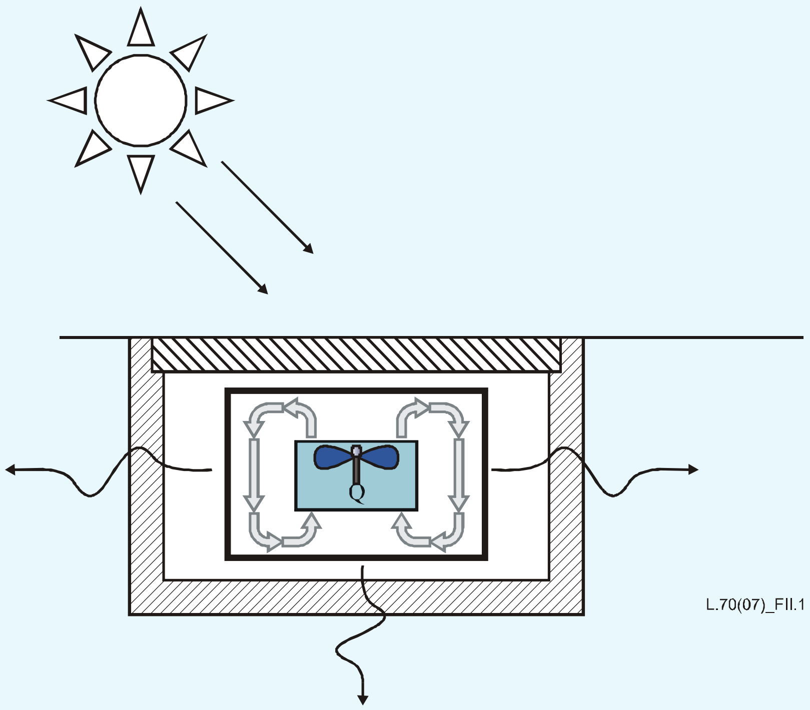
4A3.1 Free or forced convection inside

The most simple design for an underground active node is to store the node in a single wall, sealed enclosure inside a hand- or manhole. Air inside the enclosure will circulate due to natural or forced convection. Fans are often an integrated feature of the electronic equipment (Figure 4A3-1).

The heat is transferred through the walls of the enclosure to the air inside the manhole, and then further to the walls of the hand-hole into the surrounding soil.

In case the manhole fills up with water (partially or completely), the heat will be transferred through convection in the water. In this mode, heat transfer is more effective than in a dry manhole.

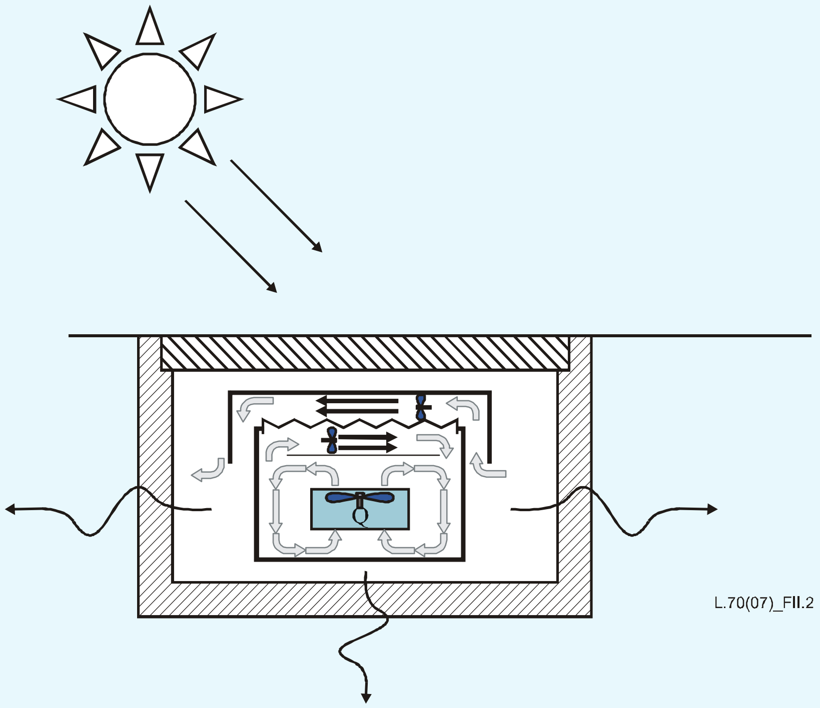
Figure 4A3-1: Forced convection inside



4A2.2 Heat exchanger

If more or better heat transfer is desired, a heat exchanger may be added. More effective heat transfer is obtained by higher airspeeds and increased contact surface area. The forced convection on the outside of the enclosure will also increase airspeeds in the hand-hole, with a positive effect on heat transfer (Figure 4A3-2). The heat exchanger design should maintain the IP 68 sealing level of the enclosure. External fans should be protected or even shut down when the hand-hole fills with water.

Figure 4A3-2: Heat exchanger



Bibliography

The bibliography is indicated at the beginning of each section.

Chapter 5

Outside plant of land fixed/mobile wireless systems to be deployed in disaster areas: design and implementation

5 Introduction

This Chapter provides guidance on design and implementation of radio systems (HF and microwave links) and of Base Transceiver Stations (cellular service).

5.1 High Frequency radio systems

[For further information see ITU-R F.1610, http://www.itu.int/rec/R-REC-F.1610/en]

5.1.1 General

High operational flexibility, easy maintenance of equipment make High Frequency (3-30 MHz) system techniques very useful in world communications; this is particularly emphasized in the case of large geographical areas with low density of telecommunications traffic. When the need for a new communications capability between two or more points is first envisioned, and HF radio link is suggested as a possible solution, a feasibility study is required to analyse and define the whole system.

This study will verify that HF radio link is the appropriate means of communication for the set of system requirements pending, based on a comparison of technical and operational alternatives, and that the economic aspects for the new HF system are compelling.

The system designer must select a site having adequate access roads, water and electrical power supply, fuel for generators, telephone service, post office, medical facilities, and adequate housing and shopping areas for site personnel. In the vast majority of cases, the radio site will be located near a city or large town, and the support considerations mentioned above, will normally be available. But in a few cases obtaining these services may require special logistics effort.

If the site is a new one, then an equipment building/control facility must be constructed to house the equipment and to provide a place for the site's personnel to operate. If the site is an existing one, then it may be necessary to construct additional rooms for the site building(s) to house the new capability.

The HF system requires a.c. power, from the local power company grid, to run the HF equipment, and site to provide support for equipment such as heating, ventilation, and air-conditioning. If the site is an existing one, this power may be already provided, but in many cases the power distribution system may have to be upgraded with larger transformers, and additional circuit breakers. The engineering plan may also call for the installation of an auxiliary power source, such as a gasoline- or diesel-powered electrical power generator for emergency use.

5.1.2 System analysis and design

The steps to system engineering a typical HF radio system might include the following three levels of planning:

– the first is an analysis of the requirements for the communications system, to establish that the use of HF radio is suitable;

– the second level of planning is to develop estimated data to substantiate project funding requests and approvals;

– lastly, the third level of planning is the detailed engineering analysis.

In this Handbook only the third item is of interest. As for the two others, reference should be made to ITU-R Recommendation F.1610.

5.1.3 Tentative site selection

The selection of an HF radio site requires a detailed analysis of the physical surroundings in which the radio site must function. Above all, the site chosen must be technically adequate. Specifically, the engineer must consider the site's noise environment, ground conductivity, the obstacles in the foreground, and things such as buildings or mountains nearby that would obstruct the received or transmitted signals. Secondary considerations include ease of construction, access to utilities (water, electrical power, etc.) and access to the site.

5.1.4 Site/field surveys

The primary technical objectives for a good HF radio site are to obtain the maximum S/N at the receiver site and maximum effective power radiated in the desired direction from the transmitter site. Site topography affects the signal radiated from the transmitting site and signal arrival at the receiver site. The presence of natural and man-made noise detracts from the ability to obtain a good S/N at receiver sites. Desirable ground constants improve the performance of both transmit and receive antennas. These and other factors which enter into the selection of HF sites often involve compromises and trade-offs between economy, availability, and convenience.

5.1.4.1 Topography

The technically ideal HF radio site requires a broad expanse of flat, treeless land away from natural and man-made obstacles. Terrain flatness is necessary for uniform ground reflection of the antenna radiation. Obstacles may mask portions of the signal-radiation path at transmit and receive sites.

Site terrain features

The nature of the terrain in front of an antenna has a significant influence on the vertical radiation pattern. A good antenna site will have a smooth reflection zone and will be free of obstacles that may block the radiation path.

– Reflection zone: The reflection zone is the area directly in front of the antenna that is required for the reflection of the ground-reflected component of the sky wave signal. The surface of the reflection zone should not have any abrupt changes in elevation greater than 10% of the antenna height nor a slope greater than 10% in any direction. Surface irregularities in the area should be limited to 0.1 wavelength in height at the highest operating frequency. The reflection zone at fixed sites and wherever else practicable should be cleared of all trees and brush. A low ground cover of grass, clover, or similar growth should be maintained for erosion control.

– Obstacles: In the direction of propagation, any substantial obstruction (such as a terrain mass, man-made structures, and trees) should subtend a vertical angle less than one-half of the angle between the horizontal and the lower 3 dB point of the required take-off angle. At potential HF sites where obstructions are likely to be encountered, a manually plotted site azimuth-elevation profile should be made. Elevation profile records are also useful for future planning in the event of expansion.

Land area requirements

The area required for an HF site depends upon the size and number of antennas, the spacing between antennas, the clearance required for ground reflection, and the clearance required avoiding mutual coupling. In addition to known initial plans, space should usually be set aside for unspecified future antenna field expansion. Sites may vary from a minimum of a few hectares for a small site to up to 30 hectares for a medium-sized site.

5.1.4.2 Radio transmitting station site choice

Two essential technical factors may influence the site choice for the installation of a radio transmitting station:

– availability of an expanse of flat land, clear from natural and artificial encumbrances over the whole horizon, for the antenna installation;

– possibility of easy utilization of the existing main networks for the transmitter power supply.

5.1.4.3 Radio receiving station site choice

A good quality reception and ease of operating can be attained with a site having the following:

– considerable ground space, possibly a square surface, both for allowing an optimal installation of directional antennas at a suitable distance (for diversity reception 200-300 m) and for obtaining a minimum beam as a safety guarantee against mechanical encumbrances and neighbourhood electrical interferences;

– level ground configuration, so as to install an antenna array having a regular electric behaviour;

– a clear, unobstructed view of the horizon around the antenna, for an elevation angle of less than 40°;

– man-made noise negligible with respect to atmospheric noise;

– no buildings, high voltage lines or other radio electric interference sources nearby;

– possibility of easy utilization of existing main networks for receiver power supply.

Environmental RF noise receiving station site

For reliable reception of weak signals from distant stations, the receiving antennas must be located in an electromagnetically quiet area relatively free from man-made noise. At HF, there are three major sources of RF noise: galactic, atmospheric, and man-made. The latter is of chief concern since it is the only source over which some control can be exercised. At many locations the noise from power lines dominates in the lower part of the HF band. Ignition noise from motor vehicles tends to predominate over power-line noise in the upper part of the HF band. Any strong, nearby source can be dominant in controlling the noise environment.

Site separation

Radio transmitters located within several kilometres of a receiving station may create serious interference due to harmonics or co-channel operation. In addition, intermodulation products may be generated in receivers due to intense radio energy fields from nearby transmitters even when operated on widely separated frequencies. Radio receiver and transmitter sites must be isolated from each other, from other radio facilities, and from heavily travelled highways, cities, and industrial areas. Exceptions are sometimes required for small sites where antennas may be as close as 300 m from each other. Transmitters with less than about 1 kW of transmitting power can be co-located with receivers if special attention is given to frequency selection. The use of RF filters may be necessary at collocated sites.

Earth constants

Resistivity and conductivity of the earth and the relative dielectric constant at the HF site should be considered during site selection. The resistivity of the earth affects the quality of the earth electrode grounding system. Good conductivity of the earth increases the range of ground wave propagation and lowers the take-off angle of sky wave signals, thereby increasing their range. Ground conductivity is difficult to measure accurately. However, it may be estimated by the nature of the terrain.

General site requirements

In addition to the technical factors, other important features of a general nature should be considered when selecting HF sites, are availability, suitability, accessibility and security:

– Availability

Land which meets the flatness criteria of an HF site is generally prime construction land or agricultural land. When this land is acquired, the area required even in small sites, can be very expensive. In fact, land acquisition may be the single greatest expense in the project. Therefore, the site selector should always consider the use of existing facilities. The least expensive siting of an HF installation is to use and expand an existing HF site.

– Suitability

The general suitability of a potential site is dependent upon the magnitude of construction required for site development, implementation, and maintenance of facilities. The existence and capacity of nearby utilities such as electrical power, water, gas, and sewage disposal are important factors in site selection. Information relating to geological conditions such as soil and drainage data, wind and weather data (including icing conditions), and seismic activity should be gathered and considered. Soil and drainage data should be available from the supporting facility engineer. Wind and weather data are available from area weather stations**,** while records on seismic activity are usually available from the geological survey or from a nearby university geophysics department.

– Accessibility

Access to HF sites should be supported by the existence of adjacent roads and highways leading to the site. Conditions such as slopes, constrictions, curves, overhead and side clearances, surfacing, turnouts, and weight limitations on bridges and culverts should allow transportation of equipment during installation as well as during support operation and maintenance after installation. The facility engineer should be consulted about existing road conditions or for new road construction.

– Security

HF radio site selection should consider provision for fences, area lighting, guard and alarm systems and proximity to other facilities.

Site survey procedures

Site surveys are conducted for the purpose of determining the technical and general suitability of land for an HF transmitting or receiving site. Each survey will have unique requirements for the number and size of transmitters, number of receivers, and the land and topography requirements for antennas. The process of selection of a site for a radio transmitting or receiving facility involves three distinct steps:

– Step 1: Entails map studies, ownership studies, logistics studies, and long range planning to select several tentative candidate areas.

– Step 2: Consists of teams who conduct preliminary site surveys to gather general site information of all the likely candidate areas. From the general site information, the list of candidate sites is then reduced to a potential few.

– Step 3: Involves survey teams who visit one or more of the final sites selected. The teams will gather detailed information which will be analysed to determine the adequacy of the site or sites. From this information, a decision is made as to the best site to use for the facility.

5.1.5 Typical power plants layout

Generator power installations of 100 kW output power or less may be integrated into the operations building complex, but ideally are installed in a separate building near the operations building. Power building should be of well-bonded metal construction with fuel storage facilities. Fuel storage may be in above ground tanks near the power building, but ideally should be buried and located with a trench at least 10 m from the power building.

5.1.6 System test

After the ... be foundnk or a photosAfter the Afinstallation of the HF radio system, the system test and evaluation plan must be implemented. Possible areas of interest of this Handbook might include:

Power considerations:

– adequate power for all operations, including emergency conditions;

– clean power with only minor noise and fluctuations.

Review site security plan:

– physical security adequate on all parameters;

– no hazardous conditions left from construction or implementation;

– network security is functioning.

5.2 Microwave radio links

[For further information on microwave radio links see Chapter 1]

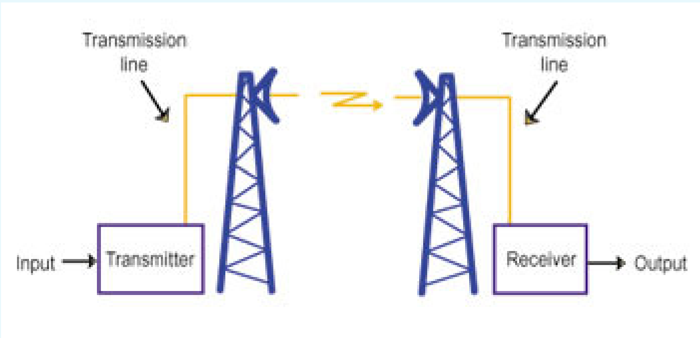
5.2.1 General characteristics

The basic components required for operating a microwave link are transmitter, receiver and antennas. Transmitter functions typically include multiplexing, encoding, modulation, up-conversion from baseband or intermediate frequency (IF) to radio frequency (RF), power amplification, and filtering for spectrum control. Receiver functions include RF filtering, down-conversion from RF to IF, amplification at IF, equalization, demodulation, decoding, and demultiplexing. To achieve point-to-point radio links, antennas are placed on a tower or other tall structure at sufficient height to provide a direct, unobstructed line-of-sight (LOS) path between the transmitter and receiver sites (Figure 5-1).

The design of microwave radio systems involves engineering of the path to evaluate the effects of propagation on performance, development of a frequency allocation plan, and proper selection of radio and link components. This design process must ensure that outage requirements are met on a per link and system basis.

Various phenomena associated with propagation, such as multipath fading and interference, affect microwave radio performance. As a consequence the modes of propagation between two radio antennas may include not only a direct, line-of-sight (LOS) path, but also a ground or surface wave that parallels the earth's surface, a sky wave from signal components reflected off the troposphere or ionosphere, a ground reflected path, and a path diffracted from an obstacle in the terrain. The presence and utility of these modes depend on the link geometry, both distance and terrain between the two antennas, and the operating frequency. For frequencies in the microwave (~ 2-30 GHz) band, the LOS propagation mode is the predominant mode available for use; the other modes may cause interference with the stronger LOS path. Line-of-sight links are limited in distance by the curvature of the earth, obstacles along the path, and free-space loss. Average distances for conservatively designed LOS links are 40 to 50 km, although distances up to 150 km have been used. A link between two stations not in LOS can be realized through an intermediate radio repeater station.

Figure 5-1: Line of sight propagation



5.2.2 Antennas

Various types of antenna have been used in the network's history. At first, prime-focus parabolic reflectors were used. In about 1960, dual-band horn antennas (Figure 5-2) started to be used widely, and a few of these survive to the present day. They began to go out of fashion at the end of the 1960s, when types of parabolic antenna with an improved performance became available.

Figure 5-2: Horn antennas

5.2.3 Infrastructures

[For further information see next Section dealing with BTS]

To operate properly, a microwave antenna must be located high atop a microwave tower. Placing these antennas on towers allows microwave signals to be sent longer distances that would be possible otherwise. This is because there cannot be any structures, including mountains or large buildings, directly between the two antennas. Only when this has been achieved data can travel through the microwave system.

There are many types of towers. Some of them are quoted in the following.

Steel lattice

The steel lattice is the most widespread form of construction. It provides great strength, low weight, wind resistance and economy in the use of materials. Lattices of triangular cross-section are most common, and square lattices are also widely used. As shown in Figure 5-3 many antennas can be installed on the same tower..

Tubular steel

Guyed masts are sometimes also constructed out of steel tubes. This construction type has the advantage that cables and other components can be protected from weather inside the tube and the structure may look more clean. These masts are mainly used for FM-/TV-broadcasting.

NOTE – The terms "mast" and "tower" are often used interchangeably. However, in structural engineering terms, a tower is a self-supporting structure, while a mast is held up by stays or guys. Mast tend to be cheaper to build, but require an extended area surrounding them to accommodate the guys wires. Towers are more commonly used in cities where land is in short supply.

Reinforced concrete

Reinforced concrete towers are relatively expensive to build, but provide a high degree of mechanical rigidity in strong winds, where is required.

Fibreglass and other composite materials

Fibreglass poles are occasionally used for low-power non-directional beacons or medium-wave broadcast transmitters. Carbon fibre monopoles and towers have traditionally been too expensive but recent developments in the way the carbon fibre tow is spun have resulted in solutions that offer strengths similar or exceeding steel for a fraction of the weight - now allowing monopole and towers to be built in locations that were too expensive or difficult to access with the heavy lifting equipment that is needed for steel structure.

Wood

There are fewer wooden towers now than in the past.

Shorter masts may consist of a self-supporting or guyed wooden pole, similar to a telegraph pole.

Figure 5-3: Relay towers (Frazier Mountain, Southern California)

5.3 Base Transceiver Stations for cellular service

[For further information on BTSs see Chapter 1]

5.3.1 General

A cell site is a term used to describe a site where antennas and electronic communications equipment are placed, usually on a radio mast, tower or other high place, to create a cell (or adjacent cells) in a cellular network. The elevated structure typically supports antennas, and one or more sets of transmitter/receivers transceivers, digital signal processors, control electronics, primary and backup electrical power sources, and sheltering (Figure 5-4).

A cell site is sometimes called a "cell tower", even if the cell site antennas are mounted on a building rather than a tower (Figure 5-5). In GSM networks, the technically used term is Base Transceiver Station (BTS), but frequently also the term "base station" is used. The term "base station site" might better reflect the increasing co-location of multiple mobile operators, and therefore multiple base stations, at a single site. Depending on an operator's technology, even a site hosting just a single mobile operator may house multiple base stations, each to serve a different air interface technology (CDMA2000 or GSM, for example).

Figure 5-4: A steel structure decorated with colored glass, in Piazza Matteotti, Treviso, Italy

Figure 5-5: Cell site placed atop an existing building

Design criteria for the infrastructures related to Base Transceiver Stations, i.e. lattices, poles, and poles on existing structures, are dealt with in this Section.

5.3.2 General characteristics of Base Transceiver Stations (BTS)

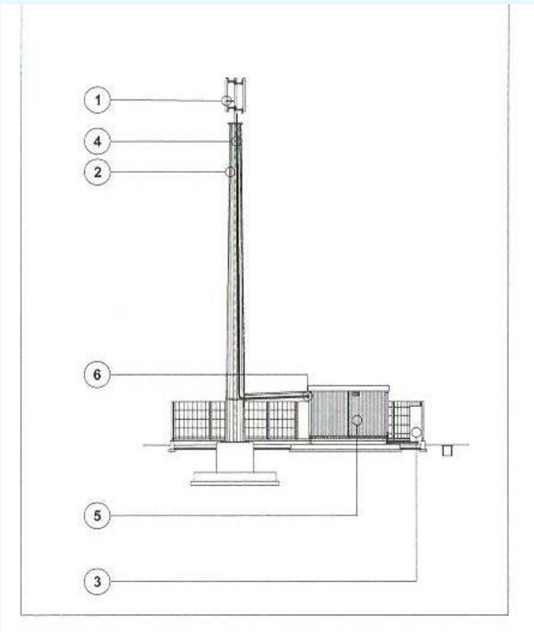
5.3.1.1 Types of BTS

A typical Base Transceiver Station (BTS) is generally composed of a system of antennas, which receive and transmit the radio signal and by some equipment.

The antennas are maintained in the orientation and at the height elevation necessary to ensure the radio coverage of project by suitable structures, referred to as antenna supporting structures that, depending on the type of site, can be classified as follows:

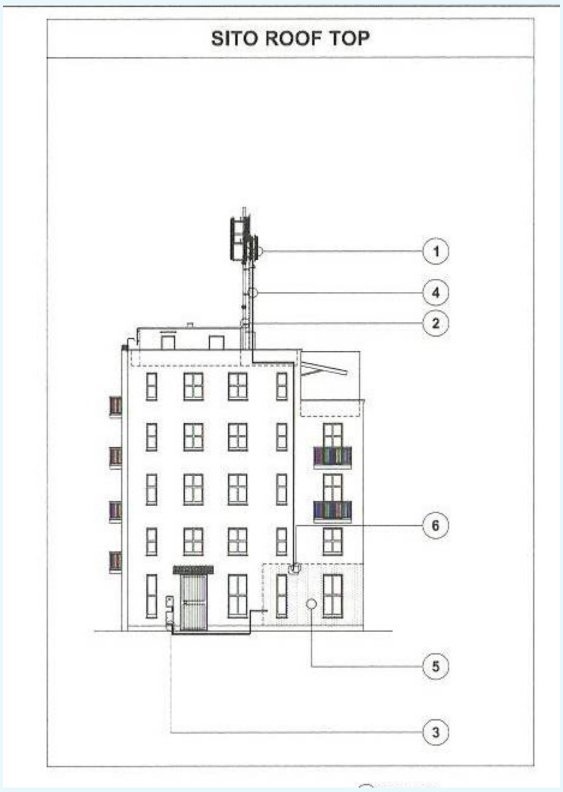
– Raw Land: is the so-called site on the ground, that is, where the station is constituted by a pole or a lattice with foundations on the ground. These structures may have heights up to 30 meters (sometimes even superior) where antennas and satellite dishes are positioned (Figure 5-6);

Figure 5-6: Raw Land structures



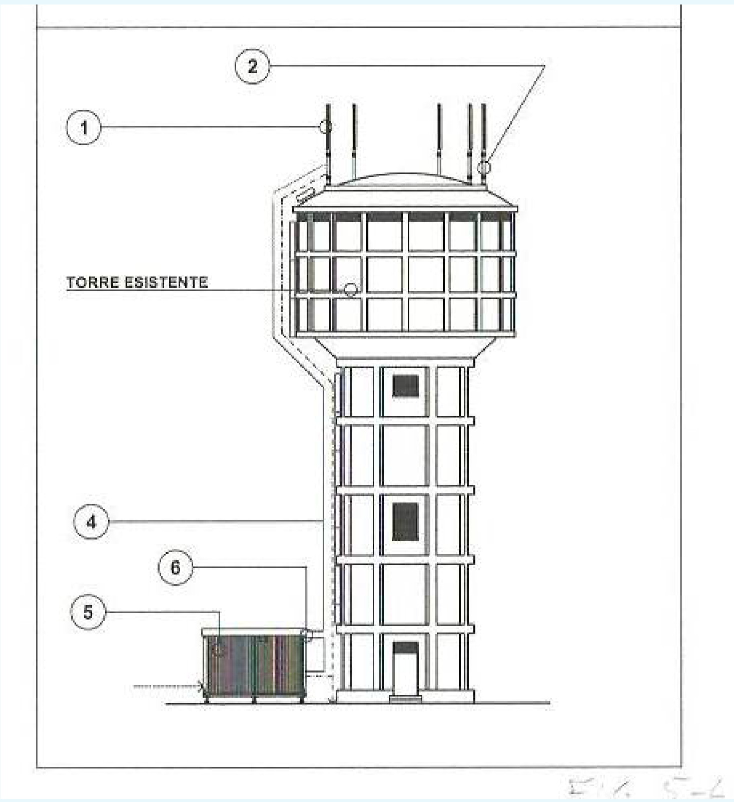
– Roof Top: consists of a pole (a steel pole small compared to that of the sites Raw Land) as support for antennas, anchored or clamped on structures on the roof of a building. This type of site is often found in urban centers (Figure 5-7);

Figure 5-7: Roof Top structures



– Co-located: in this case the antennas are installed on poles, lattices or towers where are already radio equipment (with its antennas) of different feature and functionality (Figure 5-8).

Figure 5-8: Co-located structures



The equipment are housed in premises specially prepared which may be of prefabricated type (shelter) or derived from the adaptation of existing environments (indoor). Alternatively the equipment can be inserted into appropriate outside cabinets, suitably made at this purpose.

The equipment can be of two types:

– ”conventional” equipment, directly connected to the antennas by coaxial cables.

– "splitted" equipment, consisting of a main unit connected via fiber optic cables to remote units placed at bottom of the pole. The remote units are then connected to antennas using coaxial cables.

The "splitted" equipment are compact and can be allocated in limited spaces.

The radio base station is connected to the power network and to the telecommunication network.

5.3.2.2 Characteristics of the sites

The spaces devoted to the BTSs must ensure the functionality of the equipment, of the antennas and of all the operations related to their maintenance. As a consequence different areas are necessary for the base stations depending of the types of equipment. Some examples are the following:

i) Conventional equipment:

  – area for urban sites: 15 m^2;

  – area for rural sites: 50 m^2.

ii) Splitted equipment:

– area for urban sites: 10 m^2;

– area for rural sites: 30-40 m^2.

The internal height of the areas are usually at least 2.40 m.

5.3.2.3 Security aspects

The Base Transceiver Stations, as regards both the equipment and the antennas, should be located in a dedicated area, so as to avoid any interference and risk of vandalism. In particular the space should be protected from possible interference and mechanical damage (shocks). In order to ensure no accessibility, the stations should be equipped with fences and other protections that prevent or mitigate risks to do so. Moreover the equipment should be protected from the risk of contact with water and moisture and from the risk of fire. The room for equipment should ensure a minimum fire resistance in accordance with the requirements provided by the specific agencies (Fire Brigade, etc.) in relation to the characteristics of the site (intended use of the building, etc.). For the antennas it should always be possible to identify a dedicated area, inside of which it is not allowed access to anyone other than maintenance workers.

5.3.3 Design criteria for the BTS infrastructures

The infrastructure of BTS must be compliant with the relevant local regulations. In particular it is necessary to take all the measures of prevention and protection, collective and individual, to ensure the security, to eliminate or to reduce to a minimum the risks relating to the operations to be carried out and to avoid damage to persons and property.

Some of the materials frequently used for realizing support for the antennas of the BTSs are the following:

– Steel lattice

The steel lattice is the most widespread form of construction. It provides great strength, low weight, wind resistance, and economy in the use of materials. Lattices of triangular cross-section are most common. Square lattices are also widely used.

– Tubular steel

Guyed masts are sometimes also constructed out of steel tubes. This construction type has the advantage that cables and other components can be protected from weather inside the tube and consequently the structure may look cleaner. These masts are mainly used for FM-TV broadcasting.

– Reinforced concrete

Reinforced concrete towers are relatively expensive to build, but provide a high degree of mechanical rigidity in strong winds. This can be important when antennas with narrow beamwidths are used, such as those used for microwave point-to-point links, and when to the structure is to be occupied by people.

– Wood

There are fewer wooden towers now than in the past. Many of them were built in a situation of a shortage of steel. Most of them have since been demolished.

As said above, depending on the type of site it is possible to distinguish the following antenna supporting structures:

– lattices;

– poles;

– support structures for the antennas placed on existing buildings.

5.3.4 Lattices

5.3.4.1 General

The lattices, with square cross-section and shape of a truncated pyramid, are structures formed by loose elements to be assembled on site by means of bolted joints.

The lattices often have nominal modular heights, with a pitch of 5 meters from 15 meters above ground level. By way of example the nominal heights sometimes used are the following: 15, 20, 25, 30, 35, 40 m. The lattices can be based on reference types 15, 25 and 35 m and then be super-elevated in the following manner:

– tower of 15 m to 20 m.

– tower of 25 meters to 30 m.

– tower of 35 meters to 40 m.

The above example refers to lattices which can be super-elevated by a module 5 meters without having to carry out works of reinforcement.

5.3.4.2 Actions acting on the lattice

Actions to be taken into account in a lattice design are the following:

– Permanent actions "P" (Permanent):
  - weight of structural steel;
  - weight of the antennas for the cellular service;
  - weight of the parabolic antennas for the microwave radio links;
  - weight of the accessories (ladders, rack carrying cables, etc.).

– Variable action "W" (Wind)

Actions arising from wind should be considered taking into account the size of the antennas, cables, support structures, ladder lifts, etc..

In the case of presence of ice the areas of the elements should be increased (e.g. 15%).

– Variable action "S" (Snow)

Actions related to the presence of the snow should be considered.

– Variable action "I" (Ice)

Actions related to the presence of ice should be considered. As an example it can be assumed the presence of a sleeve of ice of 12.5 mm, uniformly distributed on the structure (specific weight 700 kg/m^3).

– Variable action "M" (Maintenance)

Actions related to the maintenance should also be considered. As an example, in the case of normal situations a vertical overload of 200 daN/m^2 can be considered on working and rest balconies.

– Seismic action "E" (Earthquakes)

Seismic actions related to the site of installation of the lattice should be considered.

5.3.4.3 Limit states

The infrastructures and the structural components should be designed and constructed so as to permit the intended use in an economically sustainable way and with the level of security required. The safety and performance of an infrastructure should be in relation to the limit states that may occur during its nominal life. Limit state is a condition beyond which the infrastructure no longer meets the needs for which it was designed. Generally “Ultimate Limit States” and “Service Limit States” are considered.

The main Ultimate Limit States to be verified are the following:

– Limit State of Equilibrium, in order to control the equilibrium of the structure and its parts throughout its nominal life, including the construction and repair phases;

– Limit State of Collapse, corresponding to the reaching of the yield point or the ultimate strains of the material (excessive deformation of a section, of a member or of a link) or the formation of a collapse mechanism, or the onset of phenomena of instability of equilibrium in the elements or components in the structure as a whole;

– Limit State of Fatigue, controlling stress changes induced by repeated loading.

The main Service Limit States to be verified are:

– Limit states of Deformation and Displacement, in order to avoid deformations and displacements that can compromise the efficient use of the structure and its contents;

– Limit State of Vibration, in order to ensure that the sensations perceived by users ensure acceptable levels of comfort and the getting over of which might be an indication of poor strength and/or an indicator of possible damage in secondary elements;

– Limit State of local Plasticization, in order to avoid plastic deformations that can generate irreversible deformation and unacceptable.

NOTE – The criteria for the verification of the Limit States are outside the scope of this Handbook.

5.3.5 Poles

5.3.5.1 General

Poles supporting cellular antennas are generally deployed in sites of rural type. The pole structures can be of two types:

– Flanged poles. The flanged poles are made from constant circular section tubes, connected by flanged joints and bolted;

– Polygonal poles. The poles are constituted by truncated cone sections welded longitudinally. The mounting of the segments forming each pole must be done on site by overlapping and dap jointed in order to ensure the minimum values of overlap.

Suitable support elements for the cellular antennas will be mounted on these poles. On the poles are also installed ladders lifts in order to allow an easy maintenance of cellular antennas.

The poles, whether flanged or polygonal, usually have nominal modular heights. As an example, with a pitch 6 meters the nominal heights could be: 12, 18, 24, 30, 36 m.

The poles, whether flanged or polygonal, can be of two types, depending on the applied loads:

– type "light" or "slim";

– type "heavy" or "with rings" which make possible to install more cellular antennas and additional parabolic dishes.

5.3.5.2 Actions acting on the pole

See Section 5.3.4.2.

5.3.5.3 Limit states

See Section 5.3.4.3.

5.3.6 Structures for the support of antennas on existing buildings

5.3.6.1 General

Antennas supporting structures for cellular systems can be also placed on existing buildings/sites, such as:

– civil buildings.

– industrial buildings.

– chimneys.

The necessary works are related to the specific conditions of the building/site. Therefore planning should be done case by case, always keeping in mind the necessity to reduce the structural weight and the visual impact of the new structures. The added structures will generally consist of poles supporting the new antennas suitably fixed to existing structures.

The conditions and the resilience of existing structures should be accurately checked before proceeding with the final design. In particular, it is necessary to check and verify the following:

– No evident defects in design and implementation;

– Previous actions, even exceptional, the effects of which are not fully manifest;

– Degradation and/or significant changes compared to initial situation.

5.3.6.2 Actions affecting the structure

See Section 5.3.4.2.

5.3.6.3 Limit States

See Section 5.3.4.3.

5.3.7 Design criteria of lattice steel structures resistant to wind and seismic loads (Korean experience)

[For further information see ITU-T Recommendation L.92]

Towers are lattice steel structures which are used to support telecommunication cables. The design criteria for towers include both seismic and wind loads, but wind loads usually control the design. Earthquake resistance design for towers can be substituted by wind resistance design, if wind load is proved to be greater than earthquake load. On building supported towers the dynamic amplification introduced by the building should be evaluated. Though wind loads usually control tower design, earthquake performance evaluation is explicitly considered.

Outside plant facilities that are constructed on the ground should have earthquake-resistance performance by applying a ground response spectrum. A ground response spectrum use design parameters of building structure criteria. Outside plant facilities that are constructed on the building should have earthquake-resistance performance for a floor response spectrum. Towers should comply with the extra-first class of earthquake-resistance design. Outside plant facilities should comply with the first class of earthquake-resistance design. Wind loads are applied to tower design when wind loads are larger than earthquake loads. It is recommended that earthquake-resistance performance should be evaluated (Tables 5-1 and 5-2).

Table 5-1: Earthquake resistant design facilities

		Facilities	Remarks
Towers	Building roof	Towers for backbone network; Wireless base transceiver station.	If wind loads are larger than earthquake loads, earthquake-resistance design is not considered.
	Ground	Towers for backbone network; Wireless base transceiver station.	If wind loads are larger than earthquake loads, earthquake-resistance design is not considered.

[TBD]ry analysis method.

Table 5-2: Earthquake resistant class

		Facilities	Remarks
Towers	Building roof	Towers for backbone network; Wireless base transceiver station.	To be designed using roof response spectrum or floor response spectrum; To be designed by extra-first class criteria;
	Ground	Towers for backbone network; Wireless base transceiver station.	To be designed by extra-first class criteria (KBC2005)

5.4 Power plants for BTSs

[For further information see "Power systems considerations for cell tower applications", Wissam Balshe, http://www.cumminspower.com/www/literature/technicalpapers/PT-9019-Cell-Tower-Applications-en.pdf]

Experts in Asia and South America are estimating the wireless market to grow about 7–10% every year for the next five years. Over 50 million additional wireless subscribers are expected in Africa alone over the next two years. This means that more than 75,000 new off-grid telecommunications cell towers will be built in developing countries during the next two years. Most of these cell towers will need generator sets, either for emergency backup in urban areas or as the prime source of power in remote locations. This section examines some of the factors to be considered in designing and configuring these generator sets.

NOTE – A power (electrical) grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas. They are usually quite large to take advantage of the economies of scale. The electric power which is generated is stepped up to a higher voltage at which it connects to the transmission network.

5.4.1 The reliability of the grid

Because the power grid is not always reliable in many parts of the world, just extending the grid will not answer the need of additional BTSs. Concerns about the reliability of the grid are especially common in rural regions of developing countries. But these concerns apply to the grid in many urban areas as well. Many so-called "standby" generator sets installed at urban cell towers are in fact running for several hours every day.

With the sustained rise of global energy prices, the fuel costs of running these diesel, natural gas or propane generators are a major piece of the Total Cost of Ownership (TCO) for these cell towers. For example, the fuel cost (as a percentage of TCO) could be as high as 64% for a typical 12 kW diesel generator running for about eight hours per day. This cost is driving many telecom cell tower operators to consider other power system options, which are covered in Section 5.4.4.5.

5.4.2 Power system configuration for cell towers

Power requirements for base transceiver stations vary widely depending on a number of factors:

– Is the site indoor or outdoor?

– Is the location urban or rural?

– In which region is the site?

In light of these variables, it is unrealistic to create one load profile for all cell tower power system configurations. A couple of alternative configurations are shown in the following:

– One generator set or two. Most cell tower operators in North America and Europe use one diesel-fueled generator for emergency backup to the main utility power. But in developing countries and prime power markets, two generators are typically used: one running continuously and alternating with the other generator set weekly, or whatever interval the automatic transfer switch (ATS) is set to use.

– Air conditioning units play a major role in determining the size of the generator set needed in indoor base stations, because most indoor BTS loads require air conditioning during the summer. Typically there will be two air conditioning units: a primary and a secondary unit. It is rare, however, for both air conditioning units to run at the same time, so in sizing the generator set, the engineer should assume it will start and operate only one unit at a time. For outdoor applications, there is no requirement for air conditioning, hence no need to supply a large alternator to meet the starting requirements of air conditioning units. A smaller generator set can be used.

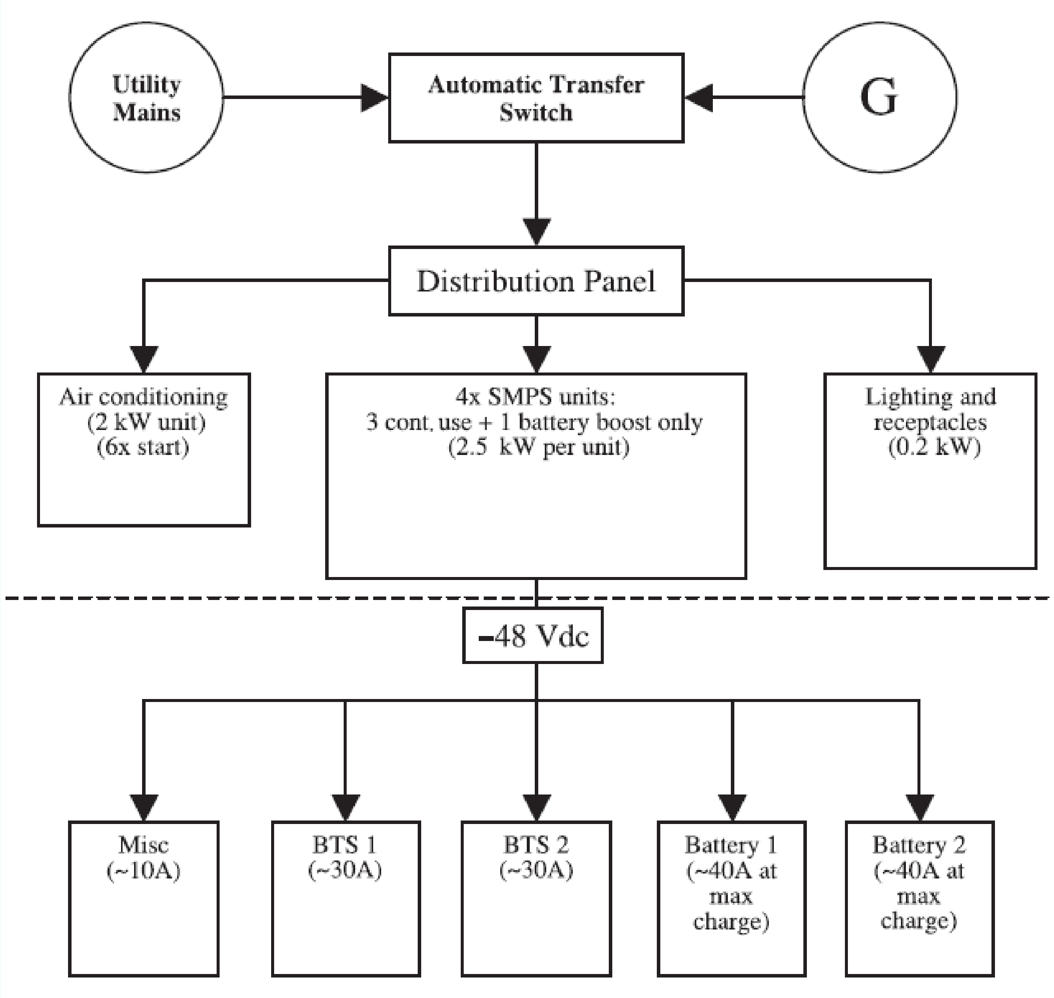
5.4.3 Design aspects

5.4.3.1 General layout

The differences in the size of transceivers, ambient environmental conditions, type of rectifiers and inverters used in the Switch Mode Power Supply (SMPS), number and size of batteries, and other factors (such as maximum allowable fuel tank size limit or design for future load expansion) are the major variables that need to be considered when selecting the generator set and power system configuration for the cell tower.

At the same time, there are certain loads that every base transceiver station will use. These loads are pictured in Figure 5-9, which shows a typical one-line electrical layout for a base station employing a 12 kW (15 kVA) generator set that would meet the demands of a cell tower in most regions.

Figure 5-9: General layout of a power plant for BTSs



As it can be seen, the load consists mainly of microwave radio equipment and other housekeeping loads such as lighting and air conditioning units. The actual BTS load used on the cell tower is powered via the SMPS, which is the direct current (DC) power plant.

5.4.3.2 48V and -48V

Although other voltages are possible, most radio transceiver loads used in telecom base stations run on a –48V DC bus. This practice originated in the early days of telephony, when 48V DC was found to be suitably high for long telephone lines, but low enough to prevent serious injury from touching the telephone wires. Consequently, most electrical safety regulations consider DC voltage lower than 50V to be a safe low-voltage circuit. It is also practical, because this voltage is easily supplied from standard valve regulated lead acid (VRLA) batteries by connecting four 12V batteries (like those used in cars) in series, making it a simple system.

The positive grounded or -48V system is another survivor from earlier industry practice. Negative voltage on the line was found to be superior to positive voltage in preventing electrochemical reactions from destroying copper cables if they happen to get wet. Negative voltage also protects against sulphation on battery terminals. Sulphation, the buildup of crystals of lead sulphate, is the leading cause of early battery failure.

5.4.3.3 Alarms

There are shutdown alarms and warning alarms on the generator set. The shutdown alarms include over-speed, overvoltage, overcurrent, under-voltage, high engine temperature, overcrank, low oil pressure, and circuit breaker trip. The warning alarms notify the operator of the following:

– Loss of fuel pressure and fuel level (important because of vandalism and theft concerns in many remote locations);

– Low battery bus voltage;

– Start switch not in auto;

– Remote/manual start;

– Engine oil temperature.

Alarms can also be linked to other parameters that can help the operator flag any potential problems that could lead to the generator set shutting down, and potentially dropping its loads.

5.4.3.4 Design factors: sizing the generator and alternator

The first thing power system designers need to address is size. They need to know the total steady-state requirements of all the equipment on the cell tower that will be powered by the generator set, and then match it with the right alternator to supply the locked rotor amp (LRA) requirements for starting the air conditioning units in the BTS room (for indoor installations). It's important to note that the LRA could be as high as *6 times* the rated full load amp (FLA) output of 3-phase motors, and up to *12 times* the FLA for single-phase motors.

Similarly, the alternator also needs to meet the steady state reactive power requirements of all other loads in the BTS. This requirement explains why the alternator is typically oversized by about 150-200% of the actual kW needed to power the cell tower.

5.4.3.5 Other factors to consider

There are other technical considerations to keep in mind when selecting the generator set.

– For BTS stations located in residential locations, a quiet generator set is required. This can be achieved by housing the generator set in a sound-attenuation enclosure.

– For rural and remote locations, the generator should have at least eight input/output dry contacts and relays for remote monitoring devices, as well as an oversized fuel tank and fuel pressure sensors.

– For <u>sandy</u> and <u>dusty</u> environments, heavy-duty air filters should be used.

– For <u>wet</u> and <u>humid</u> environments, specify aluminium enclosures and anti-condensation heaters to prevent insulation failures and short circuits between the windings in the alternator stator.

– For <u>cold climates</u>, engine block and oil heaters are required, especially for standby applications.

5.4.4 Industry trends

Certain trends in the telecom industry have a direct impact on generator set power requirements for cell towers. In particular many telecommunication equipment vendors are making considerable investments in the development of more efficient equipment to reduce the capital expenses (capex) and operating expenses (opex) associated with standby power systems. The main developments in progress are listed in the following.

5.4.4.1 No air conditioning

Radio transceivers are being designed to handle high ambient temperatures, in order to eliminate air conditioning in the cell tower BTS shelter. The impact of this trend is substantial, because air conditioning more than doubles the size of generators needed for steady state operation.

For example, in a typical cell tower, the BTS load itself requires only about 2 to 3 kW, but up to 12 kW generator sets are being used to meet the occasional peak power requirements for starting air conditioning units. Therefore, as the use of the high ambient radio equipment increases, the size of the generator set required to power future telecom cell towers will be reduced substantially.

5.4.4.2 Energy-efficient radio equipment

In addition to the reduction in the starting power requirements from eliminating air conditioning units, the steady-state power requirements are also being reduced. To cut capital and operating costs, telecom companies are investing heavily in the development of more energy-efficient radio equipment to reduce the total power consumption and hence, the size of the generator set and ATS (Automatic Transfer Switch) required for the BTS station. This trend will lower the initial capital cost, and with smaller generator sets, will also reduce the operating (mainly fuel) costs of cell towers.

5.4.4.3 Building materials

To have an energy-efficient cell tower does not always require investing in new technologies for BTS equipment. Some telecom operators are switching to simpler cell tower designs. For example, the shelter traditionally was built from brick and concrete, but now many operators are using high-thermal-efficiency plastic, which reduces the energy costs for operating cell towers. All these new design considerations and technology improvements in BTS equipment and shelters are dropping the generator size needed for telecom cell towers from 12 kW to about 5 kW.

5.4.4.4 Policy changes and shared equipment

Certain trends in the telecom space are driven by public policy, which may have a direct impact on the power requirements of cell towers. For example, in many developing countries, governments are requiring the use of backup power at telecom sites due to the critical nature of their service during a national catastrophe. However, they are also requiring providers to share towers and equipment to reduce the number of towers and their environmental impact. Accordingly, multiple operators are entering into agreements to share infrastructure and support equipment such as the tower itself, shelters, generators and accessories, thereby reducing costs substantially. Third parties are also taking advantage of this trend, building cell towers and leasing space on them to multiple operators. These towers have separate radio equipment for each operator, but still share one generator.

This trend of sharing towers by different operators is reducing the number of cell towers needed to cover a region or network, but it is also increasing the size of the generators needed to run these towers. This increase in generator size is also being driven by the increased demand for 3G and 4G data services used by smartphones.

5.4.4.5 Alternative energy sources and DC generators

Finally, in response to government subsidies and fuel cost savings, telecom prime power markets are utilizing more renewable energy solutions to power their cell towers. Some towers are powered by wind turbines or photovoltaic (PV) solar cells, especially for small load sites (less than 2 kW). Other solutions use natural gas or variable-speed DC generator sets for better fuel economy and efficiency.

However, due to the variability in wind speed across the globe, wind-only solutions are likely to be restricted to locations with abundant wind resources such as coastal and mountainous regions. The efficiency of PV is still an issue, and solar cells are more expensive than conventional power generators, hence less economical for large sites. Until green power sources become more economical and efficient, telecom operators will continue to use traditional generators to power their cell towers, but many will start combining the generator with wind and solar cell power sources.

5.4.5 Conclusions of the power plants for BTSs

There are no universal features recommended for all generator sets used in telecommunication cell tower applications, because requirements and duty ratings vary from region to region. In general, for standby applications in urban areas connected to a reliable utility grid, standard generator set features as required by local codes and regulations should be sufficient. In other words, there is nothing unique about a standby generator set used in such telecom cell tower applications. However, when specifying generator sets for prime duty applications, such as those used in remote cell tower applications and some urban sites in developing countries, an oversized fuel tank with fuel alarm sensors, and 8–10 dry contacts and relays for remote monitoring are recommended. A fuel-efficient engine, or the use of batteries to supply the BTS load for a few minutes of power interruption or during peak demand, will save fuel costs substantially, and lower the operating costs of running the cell tower.

In the next 5 to 10 years, telecom equipment manufacturers will continue to reduce the power consumption of BTS equipment. This trend will mean smaller generator sets. Manufacturers will continue to explore hybrid power systems that use renewable energy sources or batteries running in parallel with generator sets. Some generator set manufacturers will start developing DC or variable-speed generators to meet the increased fuel-efficiency requirements of cell tower sites. Most manufacturers, however, will continue to supply synchronous-speed AC generators with oversized alternators to meet the starting power requirements of air conditioning units, but these generators will be driven by smaller and more fuel-efficient diesel engines.

Bibliography

Bibliography is indicated under the title of the various subjects.

Chapter 6

Outside plant of satellite systems to be deployed in natural disaster areas: design and implementation

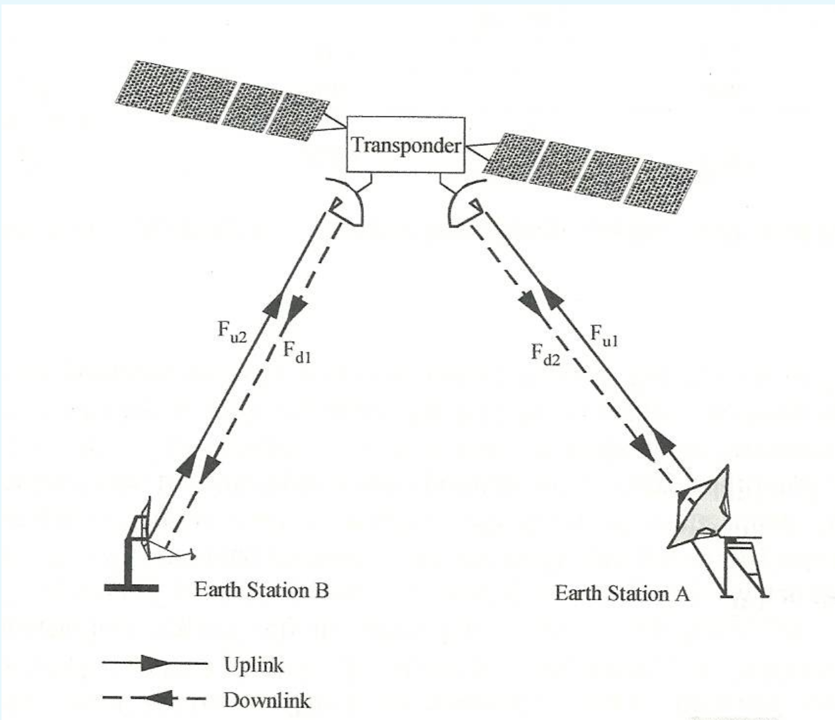
NOTE – Fixed and Transportable and portable VSAT earth stations are dealt with in Chapter 7

6 Introduction

[For further information see "Handbook on satellite communications", Wiley-ITU]

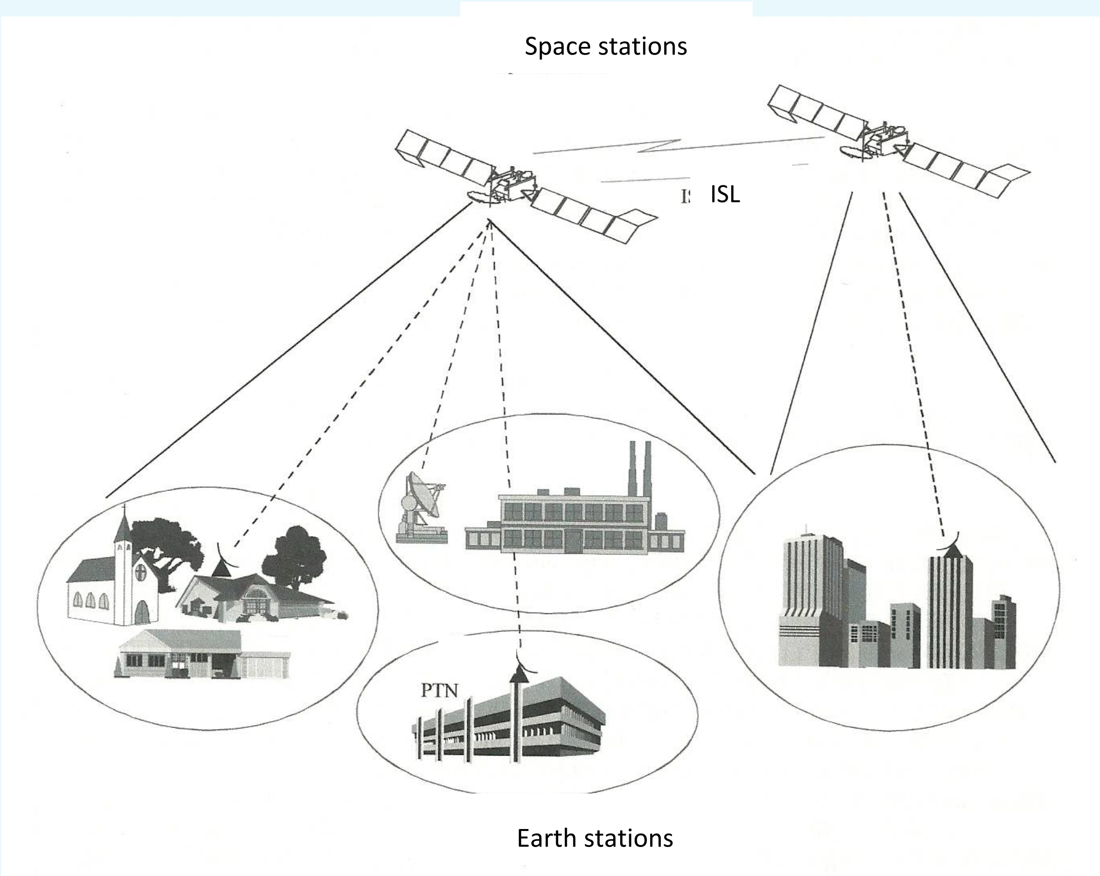
A set of space stations and earth stations working together to provide radiocommunications is called a satellite system (Figure 6-1). There are three main types of satellite services: Fixed Satellite Services (FSS), Mobile Satellite Services (MSS) and Broadcasting Satellite Services (BSS).

Figure 6-1: The basic satellite link



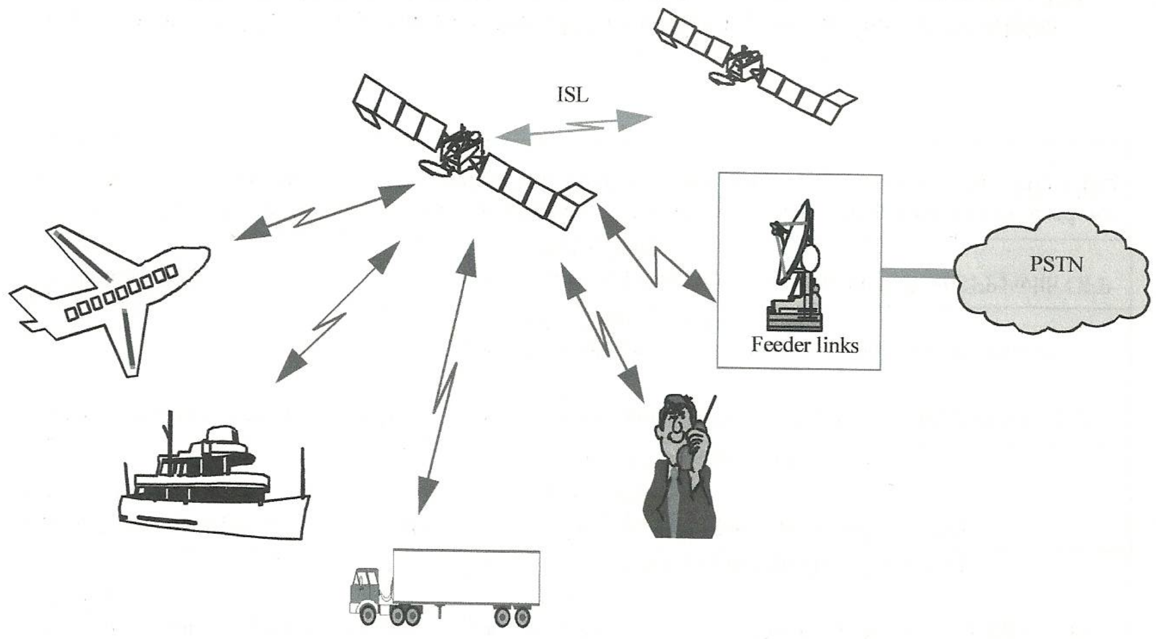
The FSS is a radiocommunications service between given positions on the Earth's surface when one or more satellites are used. The stations located at given positions on the Earth's surface are called earth stations of the FSS. The given position may be a specified fixed point or any fixed point within specified areas. Stations located on board the satellites, mainly consisting of the satellite transponders and associated antennas, are called space stations of the FSS (Figure 6-2).

Figure 6-2: Generic illustration of FSS



Mobile-satellite service (MSS) is a radiocommunications service between mobile earth stations and one or more space stations, or between mobile earth stations by means of one or more space stations (Figure 6-3). This includes maritime, aeronautical and land MSSs. Note that, in some modern systems the earth stations may consist of very small, even hand-held, terminals.

Figure 6-3: Generic illustration of mobile-satellite services



(A possible inter-satellite link (ISL) with another satellite is represented)

PSTN: public switched telephone network

Broadcasting-satellite service (BSS) is a radiocommunications service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public using very small receiving antennas (Television Receive only, TVROs). The satellites implemented for the BSS are often called direct broadcast satellites (DBSs). The TVROs needed for BSS reception should be smaller than the ones needed for operation in the FSS. The direct reception shall encompass both individual reception (DTH) and community reception (CATV and SMATV) (Figure 6-4).

During times of natural disaster, civil disturbance or serious accidents, normal terrestrial-based communication facilities are frequently overloaded, temporarily disrupted or destroyed. The availability of satellite communication facilities ensures that one element of the system remains isolated from terrestrial-based disruptions, i.e. the satellite or space segment. Through the deployment of small transportable earth terminals to the emergency location, communications can be established and the process of restoring the necessary services (communications, aid, food/water distribution, etc.) assisted. [See also Chapter 7]

A typical satellite communication includes the following elements:

i) space segment: one or several spacecraft (satellites) with in-orbit spare capability;

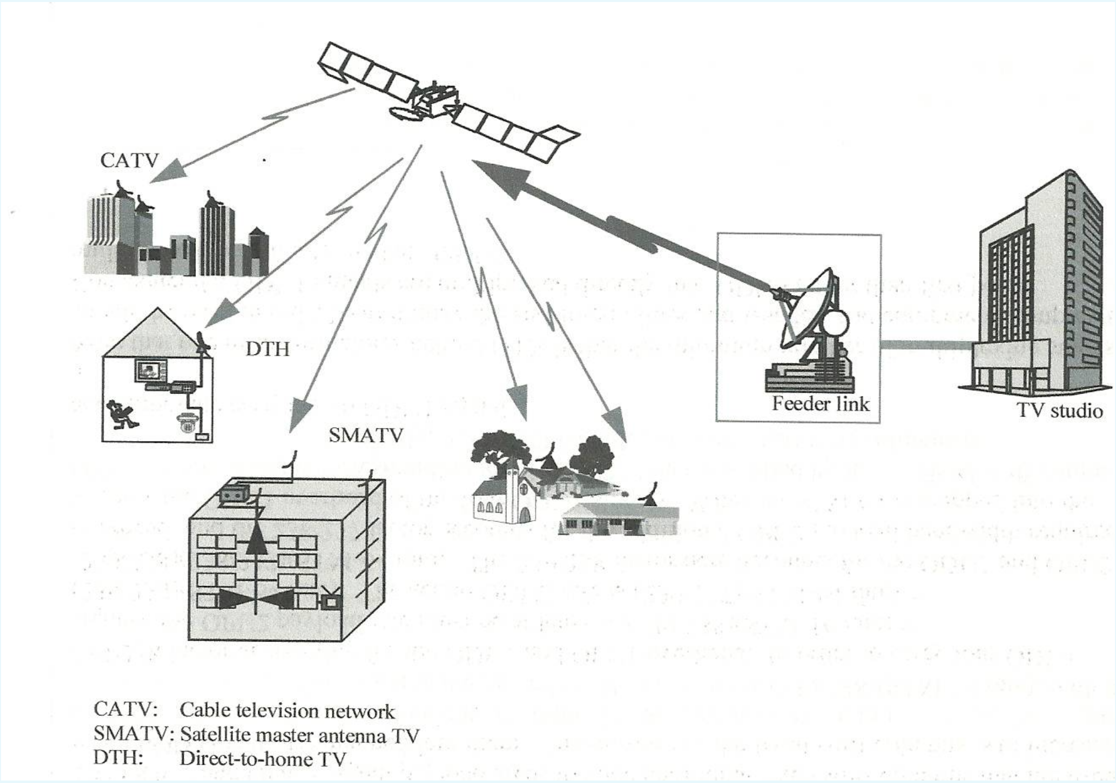
ii) earth station for communications: a system may include a great variety of earth stations;

iii) terrestrial distribution: from the earth station the signal is carried to the customers' premises through a terrestrial transmission medium;

iv) power supply plants: most of the terrestrial facilities, including the earth stations, require a backup power system in case of commercial power failure.

The satellites are outside the scope of this Handbook because they are not impacted by the natural hazards. The terrestrial distribution realized by terrestrial distribution medium is dealt with in Chapters 4 and 5. Therefore the attention of this Chapter 6 will be focused on the earth stations and on the power supply plants.

Figure 6-4: Generic illustration of broadcasting-satellite services



6.1 The earth segment

The earth segment is the term given to that part of a communication-satellite system which is constituted by the earth stations used for transmitting and receiving the traffic signals of all kinds to and from the satellites, and which form the interface with the terrestrial networks.

An earth station includes all the terminal equipment of a satellite link. Its role is equivalent to that of a terminal radio-relay station. Earth stations generally consist of the following six main items:

- the transmitting and receiving antenna, with a diameter ranging from 50 cm (or even less in some new systems) to more than 16 m. Large antennas are usually equipped with an automatic tracking device which keeps them constantly pointed to the satellite; medium-sized antennas may have simple tracking devices (e.g. step-track), while small antennas generally have no tracking device and although normally fixed, can usually be pointed manually;
- the receiver system, with a sensitive, low noise amplifier front-end having a noise temperature ranging from about 30 K, or even less, to several hundred K;
- the transmitter, with power ranging from a few watts to several kilowatts, depending on the type of signals to be transmitted and on the traffic;
- the modulation, demodulation and frequency translation units;
- the signal processing units;

- the interface units for interconnecting with terrestrial networks (with terrestrial equipment or directly with user equipment and/or terminal).

The size of this equipment varies considerably according to the station capacity.

Planning of the earth segment would involve the following main steps:

- collection of service requirements and traffic matrix, finalization of transmission plan taking into consideration the specified space segment characteristics;
- preparation of the overall definition for the ground segment;
- finalization of earth-station equipment specification, preparation of request-for-proposals for ground segment, evaluation of RFP and ordering of equipment;
- selection of earth-station sites and electromagnetic compatibility (EMC) survey;
- notification and frequency clearance for selected sites;
- preparation of plans for building and award of contract for building construction;
- ordering of water, electric supplies and power plant.

6.2 Configuration and general characteristics of earth stations

6.2.1 Configuration, block diagrams and main functions

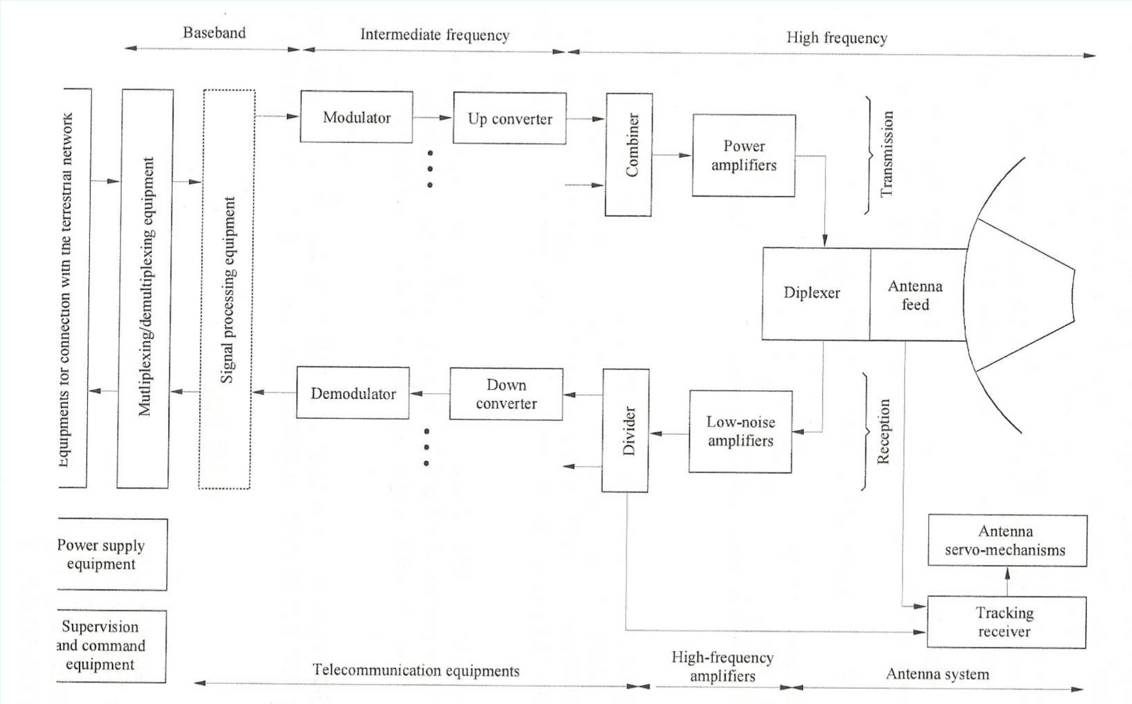
As said above, the earth station is the transmission and reception terminal of a telecommunication link via satellite. The general configuration of an earth station is not substantially different from that of a radio-relay terminal, but the very large free-space attenuation (about 200 dB) undergone by the carrier radio waves on their path between the station and satellite (up to 36 000 km) usually requires the main subsystems of an earth station to have a much higher performance level than those of a radio relay terminal.

The general operational diagram of an earth station is shown in Figure 6-5, where it is possible to see the following main subsystems:

- the antenna system; (*)
- the receiver amplifiers (low-noise);
- the transmitter amplifiers (power);
- the telecommunication equipment (frequency converters and modems);
- the multiplexing/demultiplexing equipment;
- the equipment for connection with the terrestrial network; (*)
- the auxiliary equipment;
- the power-supply equipment; (*)

  (*) These subsystems are of interest of this Handbook and will be described in the following sections.

Figure 6-5: General operational diagram of an earth station



To achieve the required availability, the practice of providing equipment redundancy is widely used.

In fact, an earth station with multiple access links comprises two categories of subsystems, i.e. those which are common to all RF links and those which are specific to a particular link.

The first category includes primarily the antenna system, the receive low noise amplifiers and the transmitter power amplifiers. Low noise amplifiers and power amplifiers are usually backed up by hot, automatically switched, stand-by units. On the contrary, the antenna system (feed, tracking device, mechanical structure, drive and servo-controlled mechanism) cannot generally be provided with redundant units and great care must be applied to its design and construction in order to guarantee a very long MTTF (mean time to failures). Note also that power supply equipment is often designed for uninterruptible operation.

The second category may include telecommunication equipment, multiplex units, etc. when the configuration of the station, the link distribution and also the MTTF of the units allows it, those subsystems may possibly be provided with one-for-n type redundancy, i.e. with a single stand-by unit (also possibly automatically switched) common to n (identical) active units.

6.2.1.1 The antenna

The antenna, with a diameter which may vary between about 33 m and 3 m or even smaller, is the most conspicuous and often the most impressive subsystem of an earth station.

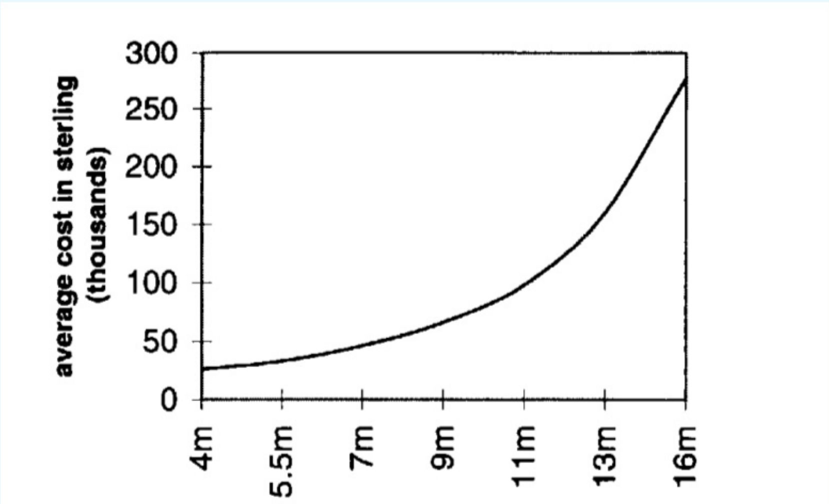
The antennas of earth stations are common to transmission and reception. The antenna beam must remain pointed towards the satellite under all environmental operational conditions and irrespective of the residual movements of the satellite.

Types of earth station for 6/4 GHz and 14/11-12 GHz bands are often classified according to the size of their antennas:

- large stations: antennas dimension more than 15 m;
- medium-sized stations: antennas of approximately 15 m to 7 m;
- small stations: antennas of 7 m to 3 m or less;
- micro-stations for VSAT (very small aperture terminal): 4 m to 0.7 m. [See Chapter 7]

The price rises steadily as the antenna diameter increases, owing to the increased amount of steel and aluminium. As well as the diameter increasing the amount of structural material required, the design wind-speed also has a key impact on cost (Figure 6-6). The graph shows costs for standard wind-speed antennas (e.g. 180 km/h) survival. An antenna designed to operate in locations subject to higher wind-speeds or hurricanes must have a significantly stronger and hence more expensive structure. Some antennas are designed to survive during high-wind periods in a stow position, to lessen the effect of the wind. In addition, the larger antennas will probably include more complex tracking arrangements.

Figure 6-6: Average cost against antenna diameter: C-band



6.2.1.2 Connection to the terrestrial network

For telecommunication services, the earth station is usually connected to the terrestrial network through a switching centre. This may be a transit centre in the case of international stations and large or medium-sized stations in national systems, or possibly a subscriber exchange in the case of small local stations within national networks. The specific equipment usually required for such a connection is a terrestrial link between the earth station and the switching centre. Generally it may use an optical or coaxial cable. However, where the geographical conditions make it necessary, radio-relay links are also used. [For these subjects see Chapters 4 and 5]

6.2.1.3 Power supply equipment

The satisfactory operation and service continuity of an earth station depends on the correct design of its electric power supply. There are two main sources of power:

- the main power supply, with stand-by capability;
- the uninterrupted power supply (UPS).

In addition, an auxiliary low voltage (24 V or 48 V) d.c. source may be required to supply certain automatic equipment.

The main power supply distribution network is via the station transformer unit. It is backed up by an independent generating set (or better still by two sets with 1 + 1 redundancy) driven by a fast-start (5 to 10 s) diesel engine. This generator, which for large stations would have a power of usually about 250 kVA, supplies the whole station, including the antenna motors, lighting and air conditioning. Maintaining the stand-by generator and keeping a stock of diesel fuel is one of the basic tasks in the management of the station.

The purpose of the Uninterrupted Power Supply, which receives its primary energy from the main power supply, is to provide a constant high-quality power supply (stable voltage and frequency with no significant transients), while the stand-by sets are starting up following a power cut in the distribution network. This source supplies all the electronic equipment. For a large station the power would be roughly from 50 to 100 kVA, most of which (80% to 90%) is required for the high-power amplifiers.

The three most common Uninterrupted Power Supply systems are:

- alternator motors with an inertia flywheel. The flywheel provides reserve mechanical energy which continues to drive the alternator while the diesel motors are starting up;
- alternator converter systems. In this case the reserve energy is provided by accumulator batteries. The batteries, which are kept charged by the main power supply (via rectifiers), feed an alternator which constitutes the uninterrupted source;
- static converter systems in which the alternator mentioned above is replaced by a solid-state a.c. generating unit using thyristor bridges. This is the most commonly used system at present.

The converter systems described above require a large set of electric batteries. The size of the unit depends on the installed power of the uninterrupted source but also, and most importantly, on the duration of autonomy required (permissible duration of interruption of the general source). This duration usually ranges from a few minutes to half an hour.

Clearly, if there is no adequate and reliable local electricity network, the power supply equipment may be designed quite differently. It might, for instance, be based entirely on diesel generating sets with built-in redundancy and switching systems guaranteeing continuous operation. It is often the case for small stations that no electricity supply is available and that the station must operate without technical staff. Here the engineer must endeavor to design low consumption equipment, if possible completely solid state, which can operate without ancillaries (air conditioners, etc.) in all local environmental conditions. Power supply systems should be provided that requires the least possible maintenance and replenishment (fuel, etc.). Solar power units are particularly suitable and can generally be used for power consumption not exceeding 500 W.

6.2.2 General infrastructure

The general infrastructure of an earth station includes all premises, buildings and civil engineering works. Its size obviously depends on the type of station.

6.2.2.1 Large earth stations (mainly for international applications)

Although INTELSAT is no longer the only global international operator, INTELSAT standards are typical examples of international earth stations.

Seven standard types of earth stations are normally admitted for operation in the "INTELSAT global system", though other types ("non-standard") may be taken into consideration (at least for provisional operation) on a case-by-case basis. INTELSAT's earth stations standards (IESSs) define seven types of stations as Standards A, B, C, D, E, F, and G, each of them is cost-effective for a specific type/capacity of traffic. The characteristics of these stations can be taken as a basis for the design of the relevant infrastructure.

6.2.2.2 Medium-sized stations (mainly for regional and domestic applications)

A number of earth-station types are available for regional or domestic applications. The selection of a specific type depends on the general system operation and on satellite communications payload performance characteristics.

For medium-sized stations, which require less equipment and consume less power than large stations, the infrastructure can be designed more simply and economically. It may be advantageous for ready-wired prefabricated buildings to be delivered to the site.

6.2.2.3 Small stations

The term "small earth station" should be taken in a broader sense and should include a wide variety of earth stations implemented in the FSS (at 6/4 GHz, 14/10-12 GHz, 30/20 GHz) in the framework of GSO (Geostationary) or non-GSO satellite systems. In fact, this sector of the earth segment is, at the moment, in very rapid evolution in terms of technical progress and market evolution. Also small earth stations can be characterized by their technical features.

In terms of applications and services, small earth stations can be characterized by their proximity to the users. In consequence, they are generally used as access communication systems, by permitting connection to public or private communication networks or to shared information or computer means.

As concerns the earth station construction, small earth stations are characterized by a compact equipment assembly, all equipment being generally contained, either in a shelter near the antenna, or even in two "boxes", the first one (the "outdoor unit") or ODU comprising the main parts of the radio equipment) being located in the antenna system and the other one (the "indoor unit" or IDU comprising the signal processing and the interfacing equipment) being inside the user premises. Ultimately, in the case of very small terminals, the complete equipment could form a single unit;

6.3 General construction of main earth stations

When a decision has to be made as to a suitable location for an earth station, a number of physical considerations have to be taken into account. Typical of these are the external temperature and humidity, rainfall, snow etc., likely wind conditions, particularly corrosive atmospheric conditions, and the likelihood of earthquakes etc. The effects of some of these can be minimized by careful site selection, but other considerations may well outweigh these possible actions. Availability of sufficient space to locate the equipment, transportation to the site (e.g. good road access) and reliable electric power at the site must also be considered.

Large satellite earth stations are usually located in low-lying areas that are shielded from terrestrial RF interference by low hills surrounding the area. They are generally operating with significant traffic capacities and are equipped with medium or large antennas (typically 10 m to 18 m, but possibly even more) and are implemented with relatively large, manned, buildings. The case of small stations used in domestic or business operations (e.g. VSATs) is quite different and it is not included in this section. [See Chapter 7]

NOTE – Up to the eighties, the INTELSAT specifications for Standard A earth stations (G/T ≥ 40.7 dBi at 4 GHz) asked the use of very large antennas (up to 33 m diameter). Since then specifications have been relaxed (G/T ≥ 35.0 dBi at 4GHz) to permit the utilization of smaller, less expensive Standard A antennas. However, older stations remain operating with those previous very large antennas.

Large and medium earth stations often include within the station proper, a terrestrial microwave link connecting the station to the central area it is serving.

The earth station should be designed to provide shelter and a suitable internal environment for the telecommunications equipment, control and monitoring equipment, the station support equipment and the personnel operating the station. The basic components are:

- the civil works necessary to provide shelter and a working environment;
- the power supply providing the energy to the electronic equipment and the building services;
- the antenna system (antenna civil works).

All descriptions given in this section are to be considered only as representative of current trends in technology. In fact, project engineers and designers should, in each particular case, consider fully the local conditions and comply with the regulations, standards and requirements which are locally in force as concerns environment, construction, security, human engineering, etc.

6.3.1 Civil works

The design of a satellite earth station has to cater for the following main features:

- antenna;
- telecommunication equipment;
- power supply equipment;
- mechanical equipment (heating, ventilating and air-conditioning);
- administration;
- station support services.

Additional supplementary features that should be considered are:

- access roads and parking;
- security;
- water supply and treatment;
- fire protection system;
- power entrance;
- terrestrial link telecommunication facilities.

The characteristics of the areas designated for the above features will depend upon the type of station being considered and are given below.

6.3.1.1 Large multi-antenna earth stations

In a station with several antennas, each antenna is erected on a separate building which houses the equipment directly associated with it (low-noise amplifiers, tracking receiver, power amplifier and sometimes frequency converters). A central operations building, common to all the antennas, contains the actual telecommunication and operating equipment, some of which may be shared (e.g. supervisory and command equipment) or multi-purpose (e.g. the transmission and reception chains may be assigned to the various antennas according to requirements).

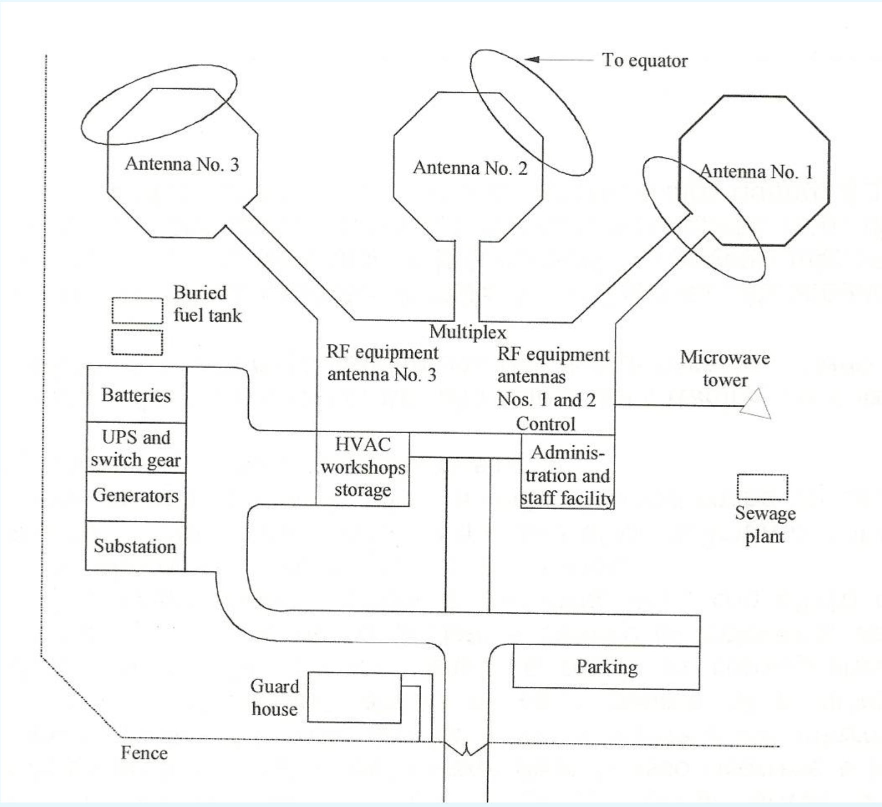
Microwave (waveguide) or intermediate frequency (coaxial cable) links, called inter-facility links, are used to connect the equipment in the antenna buildings to the equipment in the main building. The general infrastructure of a large multi-antenna station can account for a high proportion of the total cost of the centre: between 20% and 50%, or even more if additional installations and premises are necessary, as is frequently the case (conference rooms, staff accommodation, etc.). Construction costs should also cover the general preparation of the site and access (roads, etc.), supply networks (electricity, air conditioning, fluids, etc.) and miscellaneous fittings (grounding, internal communications, fire prevention, drainage, etc.).

The main features mentioned previously, apart from the antennas, should be housed in discrete areas (individual areas isolated from their neighbours by fire-resistant walls, door openings, etc.) with a central building so located as to provide the shortest possible inter-facility links between the telecommunications equipment room and the antennas. Figure 6-7 shows the layout of a typical multi-antenna station.

The location, height and orientation of the various buildings, structures and antennas should be such that no obstacles obstruct the radiation of the antennas wherever they are pointed during operations.

The main building should be designed to withstand the severest seismic shocks anticipated in the locality. After such a shock the building should have suffered only superficial damage and its support and communications systems should continue to maintain service.

Figure 6-7: Layout of typical large multi-antenna station



Telecommunication equipment area

The telecommunications equipment should be housed in a discrete area having adequate floor-to-ceiling height to permit the use of overhead inter-rack cabling. Elevated air-conditioning ducts are usually installed in the space provided between the concrete ceiling and a false ceiling.

Alternatively, the area should have a technical elevated floor (computer type) with sufficient under floor depth (0.6 m) to provide space for air-conditioning ducts and for inter-rack wiring, including power distribution cabling.

The environment of the area should be controlled to meet the requirements specified by the equipment suppliers. The air-conditioning equipment should be of sufficient capacity to adequately meet all heating/cooling loads and have ample redundancy to allow for individual unit failure.

Power supply equipment area

The power supply equipment (i.e. transformers, switchgear, uninterruptible power supply (UPS), stand-by generators, d.c. power supplies, etc.) should be housed in a discrete area somewhat adjacent to the telecommunications equipment room. This area should have amply resistant fire walls to prevent the spread of combustion to and from the other areas. The stand-by generators, batteries, switchgear and UPS should be housed in separate interconnected rooms within the area.

Self-closing, anti-panic, fire-resistant doors should be used throughout and all cable routes through walls or under-floor should be sealed with fire-resistant materials to prevent the spread of combustion. Sound-absorbing materials should be used in the construction of the generator room, particularly if this is the only source of continuous electrical power. If possible this room should be cooled by outside ambient air using natural convection or fans. The generator control equipment should, if possible, be housed in an adjacent room with a sound-proof window between rooms.

The battery room should have adequate ventilation to disperse hydrogen fumes. Adequate curbs, sloping floors and a cesspool for removing and retrieving accidental spillage should be provided.

The floor and lower part of the walls should be protected with anti-acid paint. For security reasons, the battery room should also be equipped with a shower/eye douche.

The d.c. power and uninterruptible power supply (UPS) rooms should be air-conditioned. The use of heat pumps in the UPS room is recommended if other station support areas required heating in the winter months as the excess heat from this equipment can thus be utilized.

The power supply area should be laid out so that the d.c. power and UPS rooms are as close as possible to the electronic equipment room to avoid long power cable runs.

An adequate underground reservoir for fuel oil of sufficient size to meet the needs of the station's power generating equipment, should be provided. The reservoir should consist of two or more interconnected tanks linked by dual fuel lines, valves, etc. to dual daytanks located in the generator room. All fuel lines should be equipped with fusible link stop valves at their entry to the generator room.

Mechanical equipment (heating, ventilating and air-conditioning)

The mechanical equipment (heating, ventilating, air-conditioning, HVAC) should have a separate area adjacent to the power equipment area with fire-resistant walls, doors, etc. The type of HVAC system will depend on the location of the station. It is usual for large stations to have heat exchangers (cooling towers) with a central circulating plant using either chilled water or water at a controlled temperature to individual air-conditioning units or heat pumps distributed throughout the station.

If heating is required in the winter season, the use of heat pumps between the UPS room, the electronic equipment room and the station support areas should be considered. The excess heat from UPS and equipment can thus be utilized.

The design of the building envelope (walls, roof, windows, etc.) should include a study of the local climatic conditions and environmental requirements of the station to determine the optimum design of both the envelope and mechanical system. Natural (free) cooling should be used whenever possible and consideration should be given to energy-reducing features to improve the building energy efficiency.

The cooling of the microwave HPAs should be carried out by means of either an air-cooled system or a water-cooled system depending on the size of the microwave tube that is used.

In the case of an air-cooled system, cooling of the HPA should be by means of outside air connected directly to the intakes and exhausts of the individual units by insulated ducts. Supplementary fans should be considered to assist the flow of cooling air and to overcome duct friction. In climates with large variations of seasonal temperatures the intake and exhaust ducts should be interconnected and the hot exhaust air mixed with the cold outside air by means of modulating duct dampers to give the required intake temperatures at the HPA inlet.

In the case of a water-cooled system, de-ionized pure water should be used for cooling the HPA in order to prevent blockages of the water paths in the collector and to provide low water conductivity. It is also necessary to keep the amount of diluted oxygen absorbed in the water flow as small as possible to avoid oxidization. Materials such as copper, brass and stainless steel are commonly used for water path. However, recently, water-cooled systems are seldom used.

Administration and station support area

The administration and station support areas can be combined in one discrete area or be in two separate discrete areas. The area should contain the offices (manager, supervisors, clerical staff), the staff personnel facilities (lunchroom, lockers, toilets, classroom/conference room, etc.), receiving, storage/warehouse area and mechanical and electronic workshops.

Supplementary features

Apart from the preceding main features the following supplementary features should also be considered:

- access roads and parking: access to the station, particularly during the construction stage when large heavy structural components of the antenna have to be transported, must be reviewed. Adequacy of the road bed, bridges, tunnels, etc. must be determined and corrections made where necessary. Turning areas for delivery vehicles and space for parking should be allowed.
- water supply and treatment: investigations should be undertaken before the site has been selected to ascertain the availability of potable water, or water requiring the minimum amount of treatment, adjacent to the site. The availability of this water will have a direct bearing on the design of the HVAC system, the stand-by generator cooling as well as the personal needs of the station staff. If wells have to be drilled, their capacity should be determined for all seasons of the year and a redundant system should be provided to cater for failure or maintenance of pumps and equipment.

  An adequate sewage system should be provided. This system should be connected to a main line system or consist of a septic tank with drainage field.
- fire protection system: the buildings should be protected by a zone-designated fire protection alarm system including local fire detectors. In equipment areas the protection system could consist of an automatic release of CO_2 gas. A portable system, associated with proper alarm announcement, could be sufficient in attended areas.

  Where the stations are located in heavily-wooded areas, a clear space to act as a fire break should be maintained between the buildings and foliage.

  A water hydrant system connected to a reservoir of sufficient capacity and with pumping facilities to maintain an adequate flow of fire-fighting water should be considered.
- power entrance: if a high voltage or commercial power source is available it should be fed via dual cables (underground and/or overhead) to a high voltage substation which can be located within the main building or exterior to it. The exterior substation should be protected by a 2.5 m chain link or equivalent type fence.
- terrestrial link telecommunication facilities: provision should be made for providing terrestrial telecommunication facilities from the station. Protected space should be provided for the electronic equipment and, if required, the location of a terrestrial microwave transmission tower should be determined so as not to interfere with the operation of the main antennas. If communication is by cable then an adequate duct or burial system should be provided.

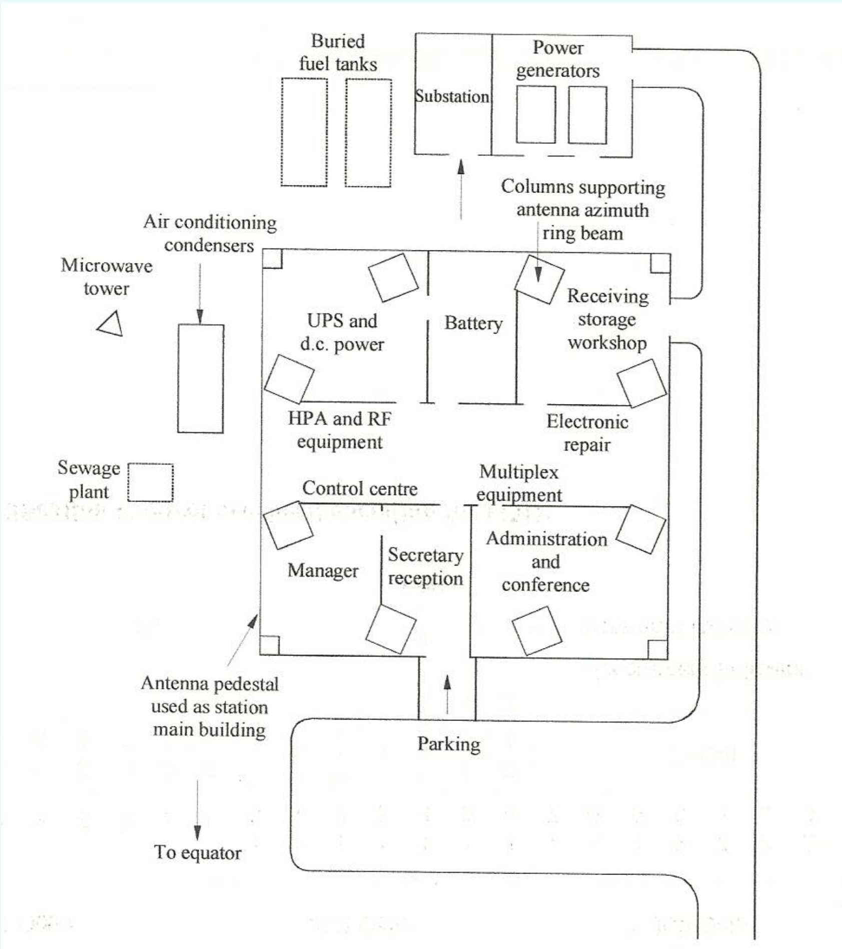
6.3.1.2 Large single-antenna earth stations

In a station with a single antenna all the equipment may be installed in one building located under the antenna (apart from the power supply equipment which for sound-proofing reasons is usually housed in its own building). In this way the general infrastructure is particularly compact and economical.

This type of station is assumed to have a maximum of one antenna only, the antenna pedestal acting as the central building (Figure 6-8). The main features (antenna, telecommunication equipment, power supply, administration and support services) as given for a multi-antenna station apply equally for this type of station. The characteristics and locations of all the above quoted features should be followed, except for the following:

- mechanical equipment (HVAC): for a station of this size a separate HVAC room may not be necessary. A split unit (internal evaporator, external condenser) system should be considered for the conditioned areas with individual fan coil (evaporator) air handling units plus back-up units in each area. The condenser units should be outside and adjacent to the pedestal in an area with an adequate wind flow. The air handling units can be provided with a heating coil if seasonal changes necessitate the use of heating in the winter months.
- power generating equipment: the stand-by generators and their control equipment should be housed in a separate building some distance from the antenna. This building should be cooled by natural and/or mechanical (fans) air flow using ambient outside air. Ventilation openings should be provided with automatic louvers that will close in the event of a fire, the generators and fans should shut off automatically in this event and fire extinguishing devices should be provided. The requirement for an underground fuel reservoir remains as before.

Figure 6-8: Layout of typical large single-antenna station



6.3.1.3 Medium-sized earth stations

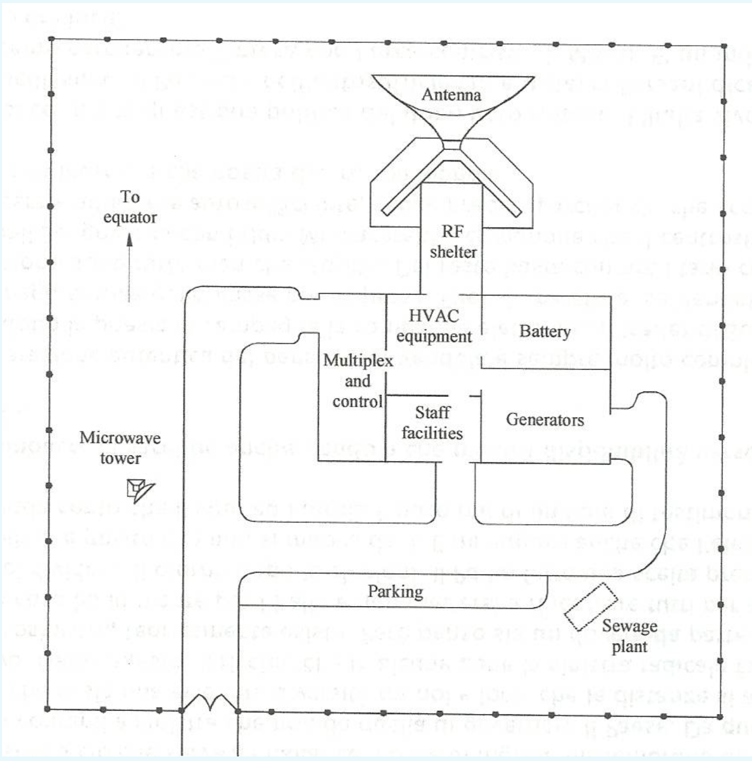
The stations considered in this subsection are domestic network type stations with a single medium-sized antenna (10-15 m). The main features detailed previously apply in general but modifications and omissions can be tolerated depending on the reliability required for this type of station (Figure 6-9).

The construction of a medium-sized station consists basically of the antenna, a radio equipment shelter and a main building. The 10-15 m antennas are usually of the limited motion variety consisting of the reflecting surface mounted on an Az-El mechanism fabricated from medium steel sections. The radio equipment shelter should be an abutment from the main building located between the support members of the antenna pedestal thus bringing the RF equipment and LNAs as close to the antenna feed as possible. The RF shelter should be well-constructed and transportable, having a removable chassis, thus permitting the RF equipment to be assembled and tested at the manufacturer's premises and transported to site ready for operation with a minimum of field labour.

The main building can be constructed of local material on a concrete slab or be of the steel frame type with a prefabricated hung panel which can be readily transported and assembled on site.

The supplementary features (access roads, parking, fire protection, etc.) as given for a multi-antenna station apply equally for this type of station.

Figure 6-9: Layout of typical medium single-antenna station



6.3.2 Power system

The power system should be designed to deliver the electrical power which is required for the communications equipment, the buildings services and auxiliary facilities.

The requirements are as follows:

- critical loads: high power amplifiers, telecommunications equipment, multiplex equipment, etc. Critical loads are normally supplied through the battery bank of the uninterruptible power supply system (UPS);
- essential loads: antenna servo system, antenna anti-icing, air-conditioning, ventilation, lighting, etc. Essential loads are normally supplied by a commercial power line and, in case of its failure, by a stand-by motor/generator at the station;
- non-essential loads: external lighting. Non-essential loads are normally supplied by a commercial power line only.

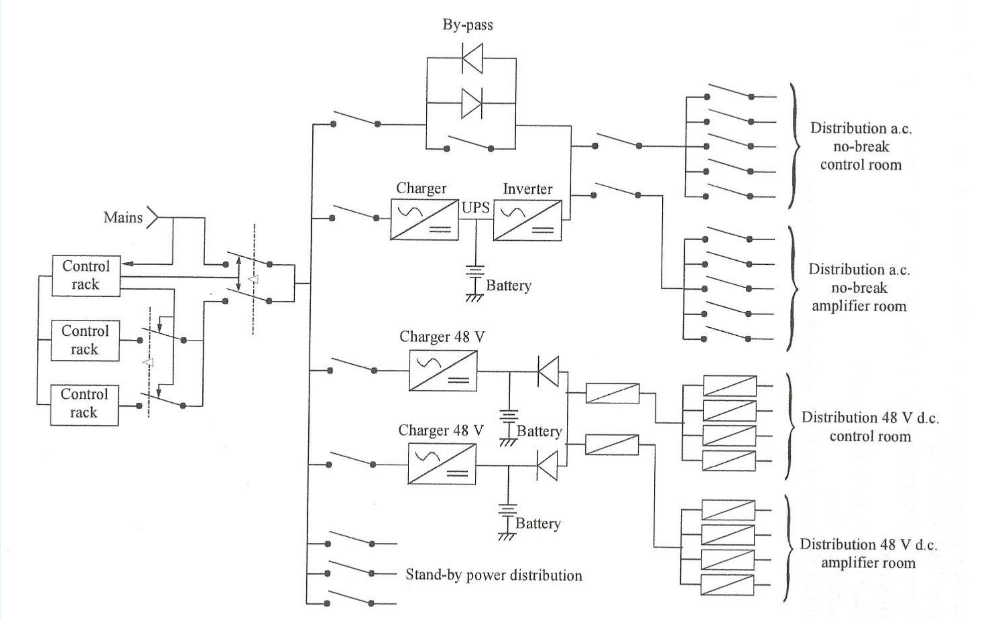
The main power subsystems are as follows:

- the power entrance facility; including the high voltage feed and transformer substation with high voltage protection;
- the a.c. power distribution; including switchgear, metering, low voltage distribution panel boards with integral low voltage protection;
- the emergency stand-by generator(s); including related auxiliary equipment and control facilities;
- the uninterruptible power supply (UPS); including rectifier, inverter and battery bank;
- the d.c. power supplies; including rectifiers, battery banks and associated distribution;
- the station grounding facilities.

A block diagram of a typical power system is shown in Figure 6-10.

The characteristics of the subsystems indicated above will depend upon the type of station being considered as given below.

Figure 6-10: Typical block diagram of a power system



6.3.2.1 Power systems for large earth stations

The main design criteria for large multi-antenna earth stations and large single-antenna stations are listed below:

i) The initial point of entry of the power supply system should be connected to a dual HV feeder each having an independent fused or circuit breaker protection fed from a common utility or commercial power source. The incoming feed to each fuse or circuit breaker should be equipped with lightning arrestors. Two main power transformers should be used to step down the incoming voltage. The transformers should have star (Y) secondary windings with the neutral grounded at the transformer and connected to the station ground. An isolated neutral can also be used (depending on local regulations). The transformers should be rated so that either transformer is capable of feeding the station load. It is preferable to utilize both transformers to feed the station via separate input circuit breakers for additional redundancy.

ii) The main switchgear should incorporate at least two main bus circuits to permit the essential loads to be separated from the non-essential loads. The bus configuration should also provide diversity of operation in that the routing of power may be derived from either or both transformers without paralleling the transformer outputs. Metering and protection facilities should be provided. Coordinated selective trip facilities are of prime importance. Coordinated ground fault protection is recommended on all three-phase circuit breakers. An isolated generator bus should be provided to permit testing of the stand-by generators. Use of a tie breaker and a dummy load feeder breaker facilitate generator operation. The rating of the main bus circuits should allow for future growth. Switchgear control power should be fed from an independent d.c. power supply backed up by batteries.

The requirement for voltage regulation is primarily dependent on the quality of the commercial power source. The majority of the station equipment will operate on the nominal voltage within ± 10%. If the required voltage tolerance cannot be met by the commercial power source, voltage regulators should be provided. Power factor correction should be incorporated in the distribution facilities; however the amount of correction required should depend upon the cost saving in operation versus the installation cost.

iii) Emergency stand-by generators are required to back up at least the essential loads. The rating of the diesel generators can be based on stand-by use but the sets must be capable of continuous use at the stand-by rating. The location of the site above sea level and the ambient temperature coupled with the choice of radiator are of prime importance in determining the continuous output capability. The requirement for multiple diesel generators is dependent on the availability and reliability of the commercial power source. The advantages of utilizing more than one stand-by generator set are numerous and if multiple sets are used, synchronizing facilities should be provided to parallel the sets. The fuel system should include dual electric transfer pumps to keep the day tanks full. The generator output voltage regulation should be ± 2% for steady-state conditions for no load to full load and the frequency regulation should be ± 1% for the same steady-state conditions.

The use of an electronic voltage regulator and an electronic governor is recommended. The generator and/or voltage regulator should incorporate an exciter current boost circuit to prevent exciter field collapse during short circuit conditions, to ensure circuit breaker fault clearing.

iv) Uninterruptible power supply systems (UPS) may employ rotary or static generation. The preferred scheme utilizes a static inverter which under normal conditions feeds the critical a.c. loads of the station and provides total isolation from commercial power interruptions and line disturbances including voltage or frequency excursions. The system employs a rectifier charger to supply current to a d.c. bus which feeds a battery and an inverter. An automatic transfer switch is used to transfer the critical load from the UPS to the UPS bus in the case of an inverter failure. The use of a static transfer switch for this function is preferable over an electromechanical type switch in cases where computer equipment is being fed. The rectifier should incorporate a delayed start and a current control facility to coordinate and limit power inrush to the working bus upon restoration of a.c. input power. The system should also incorporate adjustable output current limit facilities, the capability to parallel with additional future UPS modules and a d.c. logic power supply backed up by a separate battery. The UPS battery should be of long lifetime type (lead antimony, lead calcium, nickel cadmium).

v) d.c. power supplies consisting of rectifier chargers feeding a battery bank and its associated distribution via circuit breakers or fuses are required to feed communications equipment. The use of multiple conservatively-rated rectifier chargers suitable for load sharing is recommended. The battery bank should have local disconnect facilities with cable protection. The bank should consist of two sets of cells in parallel to permit isolation of one set for maintenance.

vi) Station grounding facilities should be provided as follows:

- An important requirement of station grounding is to maintain an equal potential across all portions of the system and the equipment to which it is connected, particularly during electrical power faults and strokes of lightning. In order to distribute the ground throughout the station, a perimeter ground system is used. This consists of a large diameter conductor (about 10 mm copper wire) buried adjacent to the walls of the building with conductors connected at intervals to the perimeter conductor and carried to the interior where they are connected to an interior copper bus bar. The bus extends internally around the building walls of rooms where equipment requires grounding. The extension of the perimeter ground to the antenna and the transformer substation is normally done using two buried ground conductors. All ground connections should utilize a cad-welded process. Ground rods are normally driven in adjacent to the perimeter conductor and connected to it. The number of ground rods required will depend upon soil conductivity.

- The antenna grounding is of special concern with regard to lightning protection. Antenna structure grounding down leads should be welded to the antenna perimeter ground with a ground rod at the same point. If the overall ground resistance is poor, consideration should be given to utilizing deep earth electrode grounds around the antenna with connections to the perimeter ground. The nature of the soil conditions determines the methods which must be used to achieve a low-resistance ground. A design goal of 5 Ω should be used.

- In an area which is predominantly rocky and soil conductivity is low, it may be necessary to utilize deep earth electrodes to meet the design goal of 5 Ω.

6.3.2.2 Power systems for medium-sized stations

Power supply subsystem characteristics for domestic network type stations are listed below:

i) the initial point of entry of the power supply system should use a single high voltage fused disconnect switch feeding a step-down transformer. The transformer secondary star (Y) point should be connected to the station ground;

ii) the switchgear could consist of a Circuit Breaker Panel board (CDP) with dual bus circuits to permit essential loads to be separated from non-essential loads. The bus configuration should also permit feeding a dummy load from the stand-by generator while the working bus is fed from the commercial power source;

iii) the characteristics of the uninterruptible power supply system are essentially the same as those used on large earth-station complexes;

iv) the characteristics of the emergency stand-by generator system are essentially the same as those used on large earth-station complexes. However, less emphasis should be given to the use of redundant or multiple diesel generator sets;

v) the characteristics of the d.c. power supply system are the same as those used on large earth station complexes;

vi) the characteristics of the station ground system are essentially the same as those used on large earth-station complexes.

6.3.3 Antenna system (antenna civil works)

The civil works associated with the antenna are described below.

Two types of antennas are here again considered in this section: large antennas (>15 m) used in high traffic capacity earth stations and medium-sized antennas (15 m to 10 m) used in domestic network stations.

The pointing accuracies of the antennas require that the antenna should be built on ground with stable soil conditions. The soil should be analyzed in depth to determine the actual condition on which the foundations are to be laid. These analyses are usually conducted by the antenna supplier/erector and the type of foundation is determined after a study of the soil report.

The foundation must be designed to meet the operational and survival loads imposed by the antenna, the support structure and the pedestal. These include wind loads, gravitational loads and seismic loads.

6.3.3.1 Large antennas civil works

Most large antennas are mounted on an azimuth-over-elevation (Az-El) mechanical assembly of the wheel and track type. In this design, a large diameter circular rail supports the mechanical assembly and allows its rotation in azimuth, while the horizontal stresses are transmitted to a central bearing. The foundation pedestal can consist of eight columns of reinforced concrete supporting the azimuth rail tied to four columns supporting the central bearing (pintle), connected by radial beams and a top slab. The pedestal can also consist of a continuous polygonal concrete shell with a self-bearing dome-shaped roofing embedded in the circular beam, the pintle being included in this roofing. In this latter case the foundation is an integral part of the antenna building.

As the diameter of the azimuth rail ring is about 15 m to 18 m for large (30 m) antennas, the area under the top slab or the roofing is an ideal place to locate RF equipment. The internal construction and finish of this area should follow the general guidelines previously given for the main building.

The antenna foundation and pedestal should have a good drainage system which is capable of gathering and dispersing storm-water captured by the antenna and support structure.

6.3.3.2 Medium-sized antennas civil works

Medium-sized antennas (10-15 m) are generally mounted on limited motion assemblies (Az-El or X-Y type) attached to a fixed support structure secured directly to the foundation by means of embedded anchor bolts.

The foundation should be designed after completion of a soil analysis. In general, it consists of footings or of a raft with piles tied in the upper part by groundsels, the whole being constructed in reinforced concrete. The foundation should have a sufficient mass, conveniently distributed to compensate for the winds, gravitational and seismic loads imposed by the antenna. A less stringent soil condition can thus be tolerated.

Small footings should also be provided for supporting an electronic equipment shelter situated, if possible, between the rear legs of the antenna support structure.

6.4 Maintenance

Now that the earth station is ready to go into operation it is imperative that a correctly formulated plan is in existence for keeping it in operation. To this end, supplies of spare parts must be available as well as sufficient test equipment for routine maintenance and fault finding. Maintenance instructions must be prepared for all equipment and systems as well as charts showing recommended maintenance intervals. Maintenance records, when well kept, can be an excellent indication of fault trends leading to early diagnosis of problem areas and timely corrective action. Staff must be available with the necessary skills to carry out this maintenance either on a round-the-clock attendance basis or a call-out basis for unattended sites. Full training will be required to ensure that maintenance staff are familiar with the equipment. The standby/redundancy philosophy for the earth station is a key factor here.

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Chapter 7

Outside plants of transportable fixed wireless terrestrial systems and VSAT earth stations: design and implementation

7 Introduction

This Chapter deals with the outside plants of two types of systems which can be rapidly deployed: transportable fixed wireless terrestrial systems and VSAT earth stations.

7.1 Transportable fixed wireless terrestrial systems

[For further information see ITU-R Recommendation 1105, http://www.itu.int/md/R12-WP5C-C-0171/enhttp://www.itu.int/md/R12-WP5C-C-0171/en]

Transportable fixed wireless equipment may be used for relief operation of either radio or cable links and may involve multi-hop applications with digital and analogue equipment. These systems may be operated in locations with differing terrain and in differing climatic zones, uncontrolled environmental conditions and/or unstable power sources.

It can be also effective to equip both a transportable mobile backhaul link and a transportable mobile base station in a vehicle and carry it to the disaster hit area when the mobile backhaul link and the base station for normal operation are both damaged by a disaster;

7.1.1 Types of transportable wireless systems

Some types of these fixed wireless systems (FWS) are shown in Table 7-1.

Table 7-1: Types of transportable wireless systems for disaster mitigation and relief operations

Type	Feature	Application
A	A simple wireless link which can be established rapidly for telephone communication with a governmental or international headquarters	(1) (2)
B	One or more local networks which connect a communications centre and up to about 10 or 20 end-user stations with telephone links	(1)
C	A telephone link for between about 6 and 120 channels or a data link up to the 6.3/8 Mbit/s over a line-of-sight or near line-of-sight path	(1) (2)
D	A telephone link between 12 and 480 channels or a data link up to 34/45 Mbit/s over a line-of-sight or obstacle [or trans-horizon path]	(2)
E	A high-capacity telephone link (more than 480 channels) or high-speed data link up to STM-1	(2)
Application (1): For devastated areas. Application (2): For breaks in transmission links. Application (3): For mitigation of disaster effects.		

Transportable fixed wireless systems listed in Table 7-1 could also be used for the access link to a base station in mobile communications that are operating in disaster relief and emergency situations.

7.1.2 System characteristics

For each type of system in Table 7-1, the channel capacities, frequency bands and path distances given in Table 7-2 are suitable.

Table 7-2: Basic characteristics

System type	Capacity	Example frequency bands[1]	Transmission path distance
A	1-2 channels	HF (2-10 MHz)	Up to 250 km and beyond
B	Local network with 10-20 outstations (several channels)	VHF (50-88 MHz) (150-174 MHz) UHF (335-470 MHz)	Up to a few km
C	From 6 to 120 channels 1.5/2 or 6.3/8 Mbit/s	UHF (335-470 MHz) (1.4-1.6 GHz) SHF (7-8 GHz) (10.5-10.68 GHz)	Up to 100 km
D	From 12 to 480 channels 1.5/2, 6.3/8, 4 x 6.3/8 Mbit/s or 34/45 Mbit/s	UHF (800-1 000 MHz) (1.7-2.7 GHz) SHF (4.2-5 GHz)	Line-of-sight or obstructed paths
E	960-2 700 channels STM-0 (52 Mbit/s) or STM-1 (155 Mbit/s)	SHF (4.4-5 GHz) (7.1-8.5 GHz) (10.5-10.68 GHz) (10.7-11.7 GHz) (11.7-13.2 GHz) (14.4-15.23 GHz) (17.85-17.97/18.6-18.72 GHz) (23 GHz)	Up to several tens of km

STM: Synchronous transfer mode.
[1] Many parts of these bands are shared with satellite services.

7.1.3 Engineering principles

7.1.3.1 Low-capacity links (Type A system)

HF transportable equipment for 1 or 2 channels should employ only solid-state components and should be designed to switch off the transmitters when not in use, <u>in order</u> <u>to conserve battery power</u>, and to reduce the potential of interference.

As an example, a solid-state 100 W single-sideband terminal in a band between, say, 2 and 8 MHz operated with a whip antenna, could have a range of <u>up to 250 km</u>. Simplex operation (transmitter and receiver employing the same frequency) with a frequency synthesizer to ensure a wide and rapid choice of frequency when interference occurs and to facilitate setting-up in an emergency, can give up to <u>24 h operation from a relatively small battery</u> (assuming that use of the transmitter is not excessive). The <u>battery can be charged from a vehicle generator</u> and all units can be hand-carried over rough country.

7.1.3.2 Local radio networks (Type B system)

Radio networks of Type B are envisaged as local centres with single-channel radiocommunication with 10 to 20 out-stations, operating on VHF or UHF up to about 470 MHz. Single-channel and multi-channel equipment similar to types used in the land mobile service could be used.

7.1.3.3 Links up to 120 channels or 6.3/8 Mbit/s (Type C system)

Equipment which is suitable for transportation by road, railway or helicopter is available. Such equipment, together with power supply equipment, can be easily and quickly installed and put into service. The equipment capacity is from about 1.5/2 to 6.3/8 Mbit/s, depending on the requirements, the topography and other factors.

d.c. operated equipment or a.c. powered equipment automatically switchable to d.c. is preferred. It can be associated with light-weight, high gain Yagi or grid antennas, giving a range of up to 100 km line-of-sight, but capable of accepting some obstruction from trees on shorter paths. Simply erected guyed or telescopic poles which can be rotated from ground level are to be preferred.

7.1.3.4 Links up to 480 channels or 34/45 Mbit/s (Type D system)

Equipment which is suitable for transportation by road or railway or by helicopter is available. Such equipment, together with power supply equipment, can be easily and quickly installed and put into service. The equipment capacity is from about 12 to 480 telephone channels, depending on the requirements, the topography and other factors. The use of receivers with low noise factors and with special demodulators and of diversity reception, enables the size of the antennas, the transmitter power and the size of the power supply equipment, to be smaller than those often used for conventional trans-horizon installations.

In line-of-sight or partially obstructed path conditions, transportable equipment with similar fast deployment capability but with transmission capacities of up to 34/45 Mbit/s is available.

d.c. operated equipment or a.c. powered equipment automatically switchable to d.c. is preferred. It can be associated with light-weight grid or flat panel antennas, giving a range of line-of-sight, but capable of accepting some obstruction from trees on shorter paths. Simply erected guyed or telescopic poles which can be rotated from ground level are to be preferred.

7.1.3.5 High-capacity links (Type E system)

For higher frequency bands and capacities of 960 telephone channels or STM-0 and above, it is recommended that the radio-frequency equipment is integrated directly to the antennas. For transportable equipment, preference should be given to equipment in which reflectors of diameter less than about 2 m are available. Because IF interconnection at repeaters is a desirable feature, an IF interconnection should be possible between the radio-frequency heads.

However, since the equipment which is to be bypassed in an emergency or for temporary use will most likely be at ground level, the control cable should bring the IF to the control unit at ground level. The antennas of systems used for relief operations are likely to be smaller than those of fixed microwave links and it is therefore important that the output power of the transmitters should be as high as possible and the noise factor of receivers should be as low as possible. Battery operated equipment is preferable: 12 V and/or 24 V supplies are appropriate if the batteries are to be rechargeable from the dynamos or alternators of any vehicles which are available.

An alternative arrangement would be to house the equipment in a number of containers. These would not only facilitate the transport of the equipment but each container could provide facilities for rapidly installing a number of transmitters and receivers. The maximum number of transceivers to be housed in any one container would depend on the dimensions and maximum weight adopted, allowing for transport by helicopter, aeroplane or any other means of transport. Furthermore, it is preferable to take into consideration equipment operating with ordinary commercial power supplies. Fixed wireless systems generally require line-of-sight operation. For digital fixed wireless systems, the interface should be based on the primary rate (2 Mbit/s (E1) or 1.5 Mbit/s (T1)) or 155.52 Mbit/s (STM-1).

7.1.3.6 Vehicle-mounted use of transportable FS equipment (Type D or E system) in combination with transportable mobile base stations

One of the main usages of FWS (Fixed Wireless System) is for mobile backhaul link, which also can be constructed using a cable system such as optical fibre.

In a widespread disaster, not only an access link to a base station (using whether FWS or a cable system) but also a mobile base station may be damaged and become unusable. Therefore, both a portable FWS backhaul link and a portable mobile base station should be mounted on a vehicle so that both equipment would be easily interconnected at the disaster hit area. Such an operating condition makes it possible to restore the telecommunication infrastructure effectively and to provide the service to end-users quickly.

As an example, the vehicle-mounted disaster relief operation system developed for the above purpose is provided in the next section.

7.1.4 Specifications for vehicle-mounted use of transportable FS equipment in combination with a mobile base station for disaster relief operation

The transportable FWS uses the different frequency bands, i.e. some of the example frequency bands in Table 7-2 (row E), depending on the interference condition and/or the transmission distance needed in the disaster hit area. In particular, the upper 4 GHz and 18 GHz band systems are light weight and small in size. Therefore they are easy to install on a vehicle and easy to use. The main specifications of these systems are shown in Table 7-3.

The main specifications of the transportable mobile base station to be interconnected to the transportable FWS are shown in Table 7-4. The overall conceptual diagram of such system is shown in Figure 7-1.

Table 7-3: Main specifications of transportable FWS for vehicle-mounted use for disaster relief operation

Frequency band (*)	Capacity	Interface	Antenna type	Transmission distance
Upper 4 GHz band (4.92-5.0 GHz)	7-35 Mbit/s	100BASE-TX (**)	36 cm flat panel	10 km
18 GHz band (17.85-17.97/ 18.6-18.72 GHz)	155.52 Mbit/s	STM-1	0.4-1.2 m diameter dish	3.5 km

(*) The RF channel is selected within the assigned frequency band.
(**) Connected to the MPX (multiplexer) via Ether/ATM convertor.

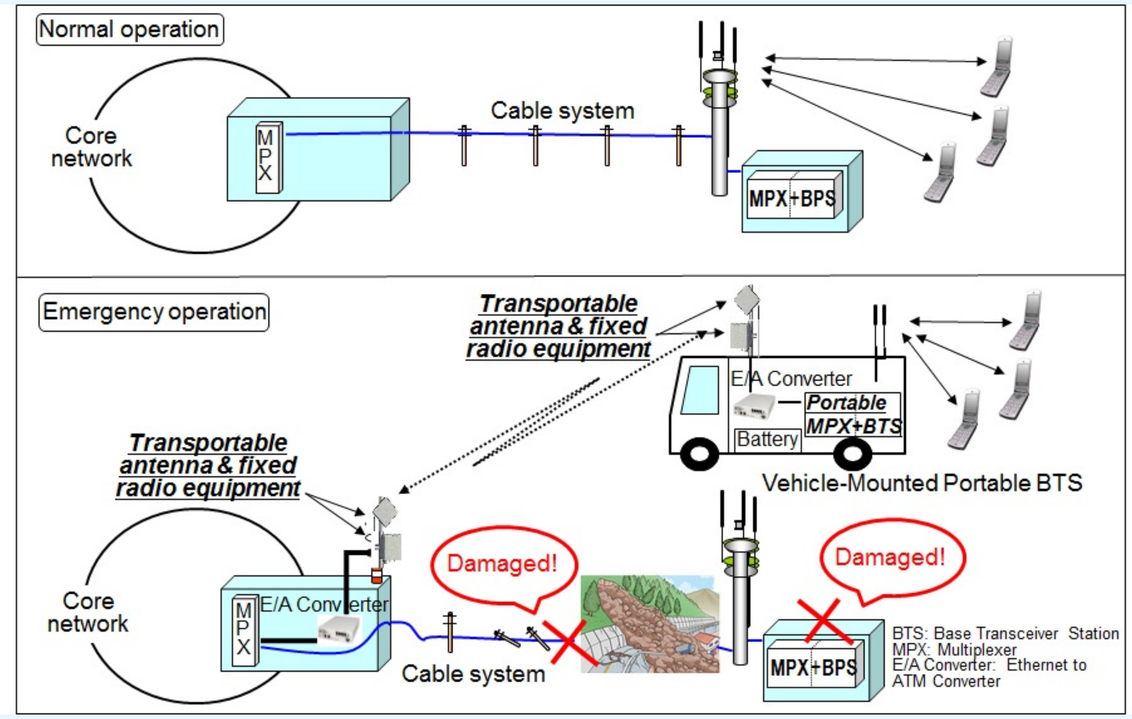
Table 7-4: Example parameters of transportable mobile base station for vehicle-mounted use for disaster relief operation

Frequency band	Bandwidth (Carrier number)	Antenna type
800 MHz (830-845/875-890 MHz), 2 GHz (1 940-1 960/2 130-2 150 MHz)	15 MHz (3 carriers)(*), 20 MHz (4 carriers)(*)	Corner reflector (40 cm × 3 7cm), Corner reflector (23 cm × 42cm) (**)

(*) The bandwidth of 1 carrier is 5 MHz.
(**) Maximum aperture.

Figure 7-1 shows the conceptual diagram of the vehicle-mounted disaster relief operation system for the upper 4 GHz band.

Figure 7-1: Conceptual diagram of the vehicle-mounted disaster relief operation system for the upper 4 GHz band



7.2 Transportable VSAT earth stations

[For further information see Report ITU-R S.2151 and “Handbook on satellite communications” Wiley-ITU]

The term "Very Small Aperture Terminal", or simply "VSAT" was introduced in the eighties to designate small earth stations generally implemented in the framework of "VSAT systems" (or "VSAT networks") used for private corporate communications.

Very Small Aperture Terminal, is a two-way satellite earth station with a dish antenna that is smaller than 3 meters. The majority of VSAT antennas range from 75 cm to 1.2 m. Data rates typically range from 56 kbit/s up to 4 Mbit/s. VSATs access satellite(s) in geosynchronous orbit to relay data from small “remote” earth stations (terminals) to other terminals (in mesh topology) or master earth station "hubs" (in star topology).

VSATs designed for fixed installation are used to transmit narrowband data (point of sale transactions such as credit card, polling or RFID data, etc.), or broadband data (for the provision of satellite Internet access to remote locations, VoIP or video). VSAT networks can also support basic telecommunications infrastructure restoration requirements including the Public Switched Telephone Network (PSTN). Fixed VSAT (remote) earth stations are generally directly installed on users' premises and unattended. Their location density may be high.

VSATs are also frequently used to meet emergency telecommunications requirements and for this use so-called "transportable" systems (including vehicle-mounted and hand-carried earth stations) have been designed. Also transportable VSATs can offer high-speed Internet connections, that are independent of the telecommunication terrestrial system infrastructure, to re-establish voice, data and video connectivity. In particular VSAT networks can provide for restoration of wireless cellular nodes and WiMAX WAN (Wide Area Network) networks for public and private first responders networks. Dishes for disaster relief and recovery are often smaller to allow for rapid transportation to, and installation at, the disaster area. VSATs for this application should be quickly made operational with no special tools or test equipment for installation.

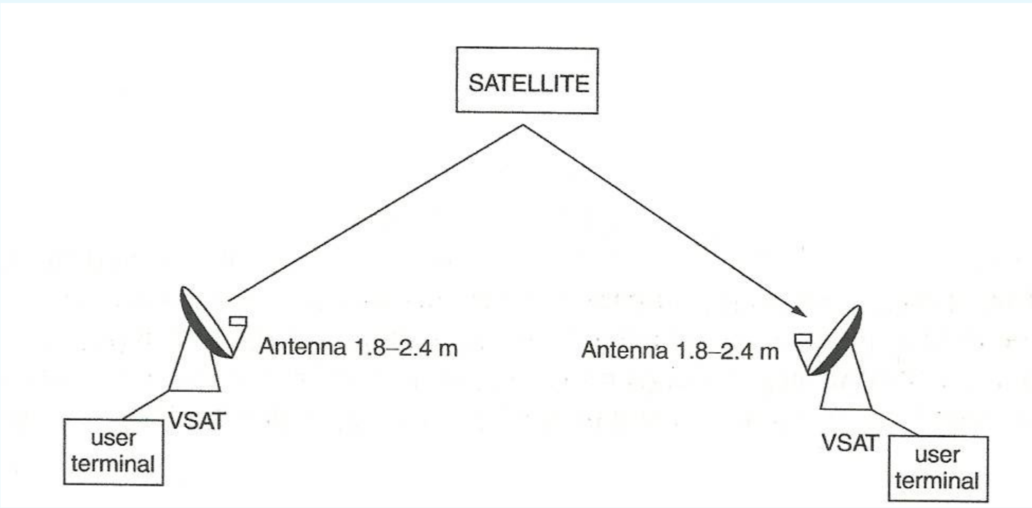
7.2.1 VSAT network architecture and requirements

VSAT earth stations are usually implemented to form closed networks for dedicated applications either for information broadcasting (receive only VSATs) or for information exchange (transmit/receive VSATs).

VSAT networks can be designed and managed in accordance with two architectures:

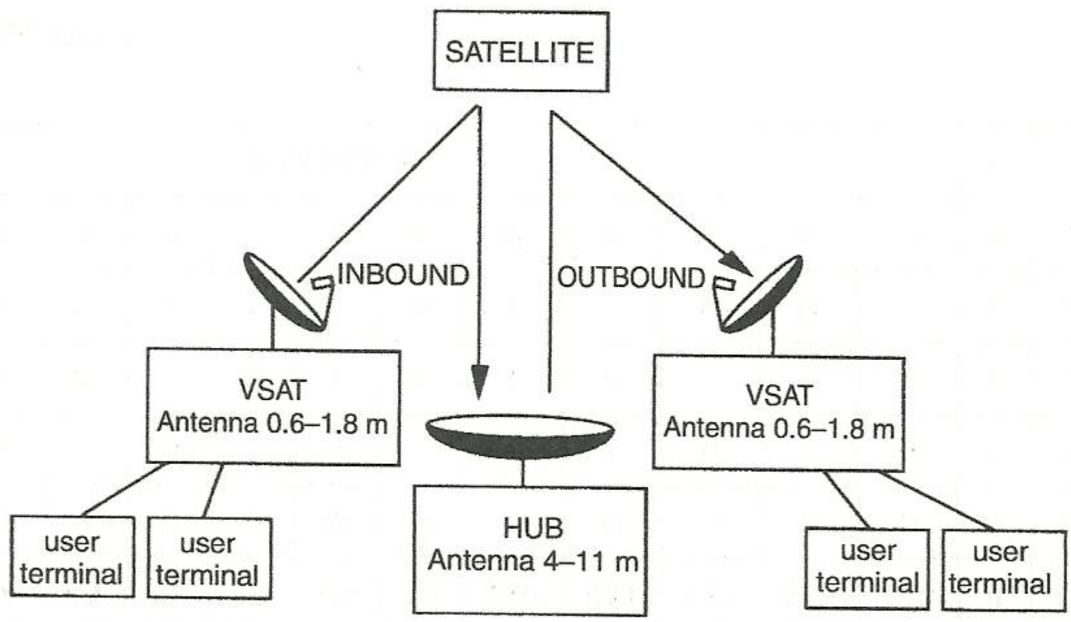
– a mesh architecture characterized by a direct link among the earth stations (Figure 7-2);

Figure 7-2: User terminal connectivity within meshed VSAT networks



– a star architecture in which a central earth station, usually called the "hub", is linked to a large number of geographically dispersed remote. In most applications the hub is connected, possibly through terrestrial lines, to a host computer. The block diagram of a star architecture is shown in Figure 7-3.

Figure 7-3: User terminal connectivity using the hub as a relay in star shaped networks



The basic telecommunication architecture for relief operations should be composed of a link connecting the disaster area and designated relief centres, supporting basic telecommunication services comprising at least telephony, any kind of data (IP, datagrams, facsimile), and video.

For relief operations, due to the essential requirement of having small antennas, it is preferable to operate the network in the 14/12 GHz band or even in the 30/20 GHz band. Although the bands such as 6/4 GHz require larger antennas, they are also suitable depending on conditions of transmission and coverage of satellite resources. In order to avoid interference, it should be taken into account that some bands are shared with terrestrial services.

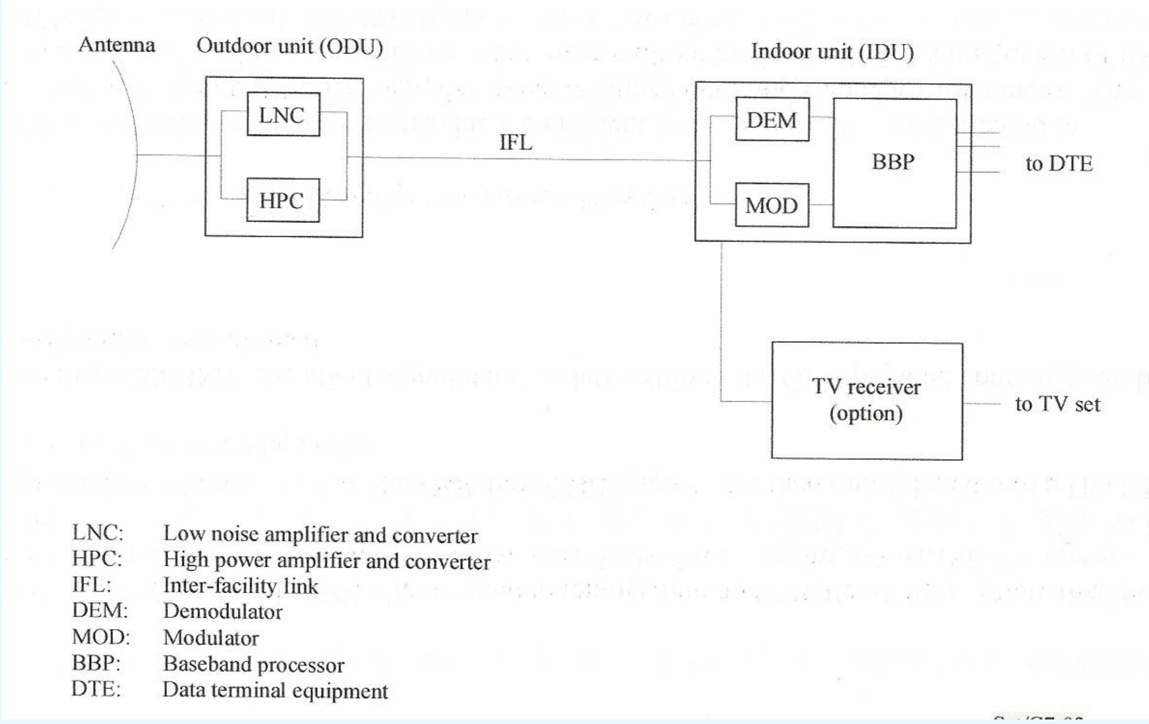
VSAT networks should offer suitable quality of service. In case the network is shared with customers having non-urgent needs, the emergency operations should have absolute priority which means a "pre-emption" class of service. A fully private network, with reserved frequency bands and facilities, could be desirable.

When the number of operational earth stations is large, a network control based on Demand Assignment Multiple Access (DAMA) may be necessary.

7.2.2 VSAT earth stations characteristics

A VSAT remote earth station (fixed, vehicle-mounted, hand-carried) is functionally divided into three major elements: the antenna, the outdoor unit (ODU) and the indoor unit (IDU). The typical configuration of a VSAT is shown in Figure 7-4. All three components are compact and designed for low cost mass production. This section mainly describes the configuration of VSATs for 14/12 GHz band operation. The configuration for 6/4 GHz band operation is similar except for the antenna and RF circuit.

Figure 7-4: Typical configuration of a VSAT



Small offset parabolic antennas with typically 1 to 2 meter diameters are widely used. The ODU typically contains RF electronics such as a low noise converter (a low noise amplifier with a down converter) and a high power converter (a high power amplifier with an up converter) in a compact weather-proof housing with an integrated antenna feed horn, and is installed behind the antenna focal point. The antenna with the ODU can be installed very easily on the roof top, on the wall, or in the car park of the user's office buildings, where the user data terminals are located.

The IDU typically contains an IF circuit, a modem and a baseband signal processor. Sometimes the modulator circuits are contained in the ODU instead of in the IDU. The IDU is usually installed near the user data terminals and connected to them directly through the standard data communication interface. Usually an optional TV receiver can be connected to the IDU to receive TV signals transmitted by another transponder of the same satellite. The ODU and the IDU are connected by inter-facility link (IFL) cable(s). The IDU can be separated from the ODU by as much as 100 m to 300 m.

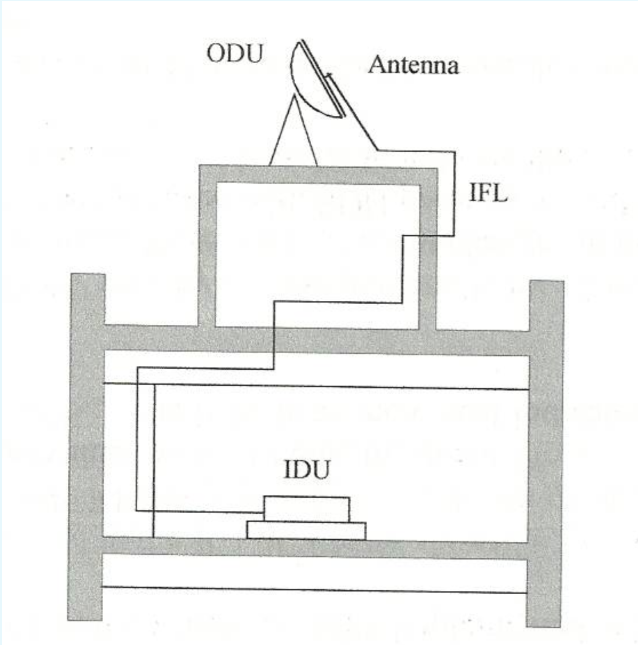
A typical installation layout of the VSAT is shown in Figure 7-5. Consideration should be given to safety aspects to protect the VSATs earth stations, such as tolerance to high winds, avoidance of electrical shock, lightning protection, and protection from radio-frequency radiation hazards.

Typical values adopted for wind speed and deicing in VSAT station are the following:

– Wind speed: operation 75 to 100 km/h survival 210 km/h;

– Deicing Electric (optional) or passive (hydrophobic coating).

Figure 7-5: Typical installation of a VSAT



VSATs should also include control and monitoring equipment, terminal equipment (including facsimile and telephones) and support facilities.

In order to best support requirements for disaster telecommunications management, VSATs solutions should be evaluated based on size, ease of installation and transportation, weight of materials, and frequency and bandwidth requirements.

As a result of an example of link budget calculation based on the assumption that a small earth station (a fixed VSAT, a "vehicle-mounted" earth station or a "hand-carried" earth station) operating in the disaster area communicates with a hub earth station equipped with a larger antenna, the diameters of the antennas are indicated in Tables 7-5 and 7-6:

Table 7-5: Remote earth station antennas

Frequency band (GHz)	6/4		14/12		30/20	
Antenna diameter	2.5 m	5.0 m	1.2 m	3.0 m	1.2 m	2.4 m

Table 7-6: HUB earth station antennas

Frequency (GHz)	6/4	14/12	30/20
Antenna diameter	18 m	7.6 m	4.7 m

From this example of the link budget calculation it appears the antenna diameter of a small earth station (in particular vehicle-mounted or hand-carried) is assumed to be 2.5 m or 5 m for the 6/4 GHz band and 1.2 m or 3 m for the 14/12 GHz band and 1.2 m or 2.4 m for the 30/20 GHz band.

For 14/12 GHz and 30/20 GHz stations, smaller diameter antennas (such as 45 cm and 75 cm) may be used if appropriate measures are adopted. However Radio Regulations (RR) including the off-axis limitation should be considered when using those antennas. The use of small antennas may not allow meeting the off-axis emission criteria, therefore the earth station transmit power should be reduced in order to avoid the interference to adjacent satellites and other services.

Considering that one of the major requirements for the antenna is ease of erection and transportation, the antenna reflector could consist of several panels made of light material such as fibre reinforced plastic or aluminium alloy. A manual or automatic pointing system may be provided commensurate with weight and power consumption,

7.2.3 Additional requirements for transportable earth stations

Efforts have been made to decrease the size and to improve transportability of earth stations so as to facilitate use of satellite services for many applications. For emergency applications, it is desirable that fixed, vehicle-mounted and hand-carried VSATs earth stations, with access to an existing satellite system, should be available for an easy transportation to, and installation at, the disaster area. This allows the occasional or temporary use of these earth stations for relief operations anywhere a disaster might occur.

Examples of transportable earth station realizations are in Section 7.2.4.

It is also desirable that the system relies on widespread standards so that equipment is readily available, interoperability is ensured and reliability is ensured. For the smooth operation of earth stations in the event of a disaster, regular training for potential operators and preparatory maintenance of the equipment is essential. Particularly, special attention should be given to the inclusion of autonomous battery or power systems.

7.2.3.1 Requirements for vehicle mounted VSATs

An earth station in which all the necessary equipment is installed in a vehicle, e.g. a four-wheel drive van, permits operation within 10 minutes of arrival including all necessary actions such as antenna direction adjustments.

7.2.3.2 Requirements for hand-carried VSATs

A hand-carried earth station is disassembled prior to transportation and quickly reassembled at the site within approximately 15 to 30 min. All the equipment, including shelters, should be capable of being packaged into units of weight which can be handled by a few persons. The size and weight of the equipment normally allow it to be carried by hand by one or two persons, and the containers are within the limit of the International Air Transport Association (IATA) checked luggage regulations, if transported by air. It is also possible to carry the equipment by helicopters.

Total weight of this type of earth station including power generator and antenna assembly is reported to be as low as 150 kg, but 200 kg is more usual. This is readily attainable with present-day technology. The allowable size and weight specifications of the various aircraft should be consulted during the design of satellite terminals for disaster relief telecommunications.

Some characteristics of small transportable earth stations in the 14/12 GHz band are shown in Table 7-7.

Table 7-7: Characteristics of transportable earth stations for the 14/12 GHz band

Type of transportation	Air transportable
Antenna diameter (m)	1.2~21.8
RF bandwidth (MHz)	20~30
Total weight	200~275 kg
Package: • Total dimensions (m) • Total number • Max. weight (kg)	 <2 8~13 20~45
Capacity of engine generator (kvA)	0.9~93
Required number of persons	1~3

7.2.4 Example of transportable earth station characteristics (from Japan)

Examples of small transportable earth stations for use with Japanese communication satellites in the 14/12 GHz band are shown in Table 7-8.

Table 7-8: Examples of small transportable earth stations for the 14/12 GHz band

Example No.	1	2	3	4[(1)]	5	6
Type of transportation	Vehicle equipped					
Antenna diameter (m)	2.6 × 2.4	1.8	1.2	1.8	0.9	1.5 × 1.35
e.i.r.p. (dBW)	72	70	62.5	65.1-71.2 (95-400 W)[(2)]	54-64 (20-200 W)[(2)]	72 (400 W)[(2)]
RF bandwidth (MHz)	24-27	20-30	30	1.4-60 Mbit/s	64 kbit/s-60 Mbit/s	1.4-60 Mbit/s
Total weight	6.4 tons	6.0 tons	2.5 tons	250 kg[(3)]	70 kg[(4)]	210 kg
Package: – Total dimensions (m) – Total number – Max. weight (kg)	 – – –	 – – –	 – – –	 2.62 × 1.95 × 0.88 – < 345 kg	 1.2 × 1.1 × 0.4 m 1 –	 2.37 × 1.53 × 0.45 1 –
Capacity of engine generator or power consumption	7.5 kVA	10 kVA	5 kVA	~ 4 100 W	~ 4 100 W	~ 4 100 W
Required number of persons	1-2	1-2	1-2	1	1	1

Example No.	7	8	9	10	11	12	13	14	15
Type of transportation	Air transportable								
Antenna diameter (m)	1.8	1.4	1.2	0.75	0.9	0.9 × 0.66	1	0.9	0.9 × 0.66
e.i.r.p. (dBW)	70	64.9	62.5	42.5	44.0	51.7	55	66	51.7
RF bandwidth (MHz)	20-30	30	30	Up to 0.5	Up to 0.5	2	6	64 k ~ 60 Mbit/s	64 k ~ 4 Mbit/s
Total weight (kg)	275	250	200	131	141	100	110	130	39
Package:									
– Total dimensions (m)	2	2	2	1	1.2	–	–	1 × 0.6 × 1.2	70 × 47 × 31 (cm)
– Total number	10	13	8	5	5	–	–	3(5)	1
– Max. weight (kg)	45	34	20	37	37	–	–	< 43 kg	39 kg
Capacity of engine generator or power consumption	3 kVA	0.9-1.3 kVA	1.0 kVA	< 370 W	< 370 W	< 2 kVA	< 2 kVA	~ 4 100 W	750 W
Required number of persons	2-3	2-3	1-2	1-2	1-2	2	3	1	1

(1) Flyaway.
(2) The amplifier size is selectable for the purpose.
(3) Total weight does not include the weight of the car.
(4) Without amplifier.
(5) There are three packages; the sizes are 72 × 60 × 26 (cm), 51 × 29 × 40 (cm) and 100 × 60 × 40 (cm) respectively.

Also several types of 30/20 GHz small transportable earth stations, which can be transported by a truck or a helicopter, have been manufactured and operated satisfactorily in Japan.

Examples of small transportable earth stations for operation at 30/20 GHz are shown in Table 7-9.

Table 7-9: Examples of small transportable earth stations for the 30/20 GHz band

Operating frequency (GHz)	Total weight (tons)	Power requirement (kVA)	Antenna		Maximum e.i.r.p. (dBW)	*G/T* (dB/K)	Type of modulation	Total setting-up time (h)	Normal location of earth station
			Diameter (m)	Type					
30/20	5.8	12	2.7	Cassegrain	76	27	FM (colour TV 1 channel)[(1)] or FDM-FM (132 telephone channels)	1	On a truck
	2	9	3	Cassegrain [(2)]	79.8	27.9	FM (colour TV 1 channel)[(1)] and ADPCM-BPSK-SCPC (3 telephone channels)	1	On the ground
	1	1[(3)]	2	Cassegrain	56.3	20.4	ADM-QPSK-SCPC (1 telephone channel)	1.5	On the ground
	3.5[(4)]	< 8.5	1.4	Offset Cassegrain	68	20	Digital-TV (3 voice channels are multiplexed)[(1)] or 1 voice channel	> 1	On a van/SUV
	0.7	3	1	Cassegrain	59.9	15.2	FM-SCPC (1 telephone channel) or DM-QPSK-SCPC (1 telephone channel)	1	On a truck

(1) One-way.
(2) The reflector is divided into three sections.
(3) Excluding power for air conditioning.
(4) Include vehicle.

7.2.5 Examples of VSAT emergency networks

7.2.5.1 Example of an emergency network in Italy using the 14/12 GHz band

An emergency satellite network has been designed and implemented in Italy for operation in the 14/12.5 GHz frequency band via a EUTELSAT transponder. This dedicated network, which is based on the use of wholly digital techniques, provides emergency voice and data circuits and a time shared compressed video channel for relief operations and environmental data collection. The network architecture is based on a dual sub-networking star configuration, for the two services. The ground segment is composed of:

i) a master common hub station for the two star networks, which is a fixed-earth station having a 9 m antenna and a 80 W transmitter;

ii) a small number of transportable earth stations, having antennas of 2.2 m and 110 W transmitters;

iii) a number of fixed data transmission platforms with 1.8 m dishes and 2 W solid state power amplifier transmitters.

The transportable earth stations are mounted on a lorry, but if necessary, can also be loaded in a cargo helicopter for fast transportation. They are equipped with two sets of equipment each containing one 16 kbit/s (vocoder) voice channel and one facsimile channel at 2.5 kbit/s. These earth stations which are also able to transmit a compressed video channel at 2.048 Mbit/s, are remotely controlled by the master station. The major features of this *ad hoc* emergency network are summarized in Table 7-10.

Table 7-10: Example of an emergency satellite radiocommunication network operating at 14/12 GHz

Station designation	Antenna diameter (m)	Primary power requirement (kVA)	Service capability
Master	9.0	15.0	12 × 16 kbit/s (vocoder) voice channels
			12 × 2.4 kbit/s facsimile channels 1 × 2.048 Mbit/s video channel
Peripherals (transportable)	2.2	2.0	2 × 16 kbit/s (vocoder) voice channels 2 × 2.4 kbit/s facsimile channels
			1 × 2.048 Mbit/s video channel
Unattended platforms	1.8	0.15	1 × 1.2 kbit/s data transmission channel

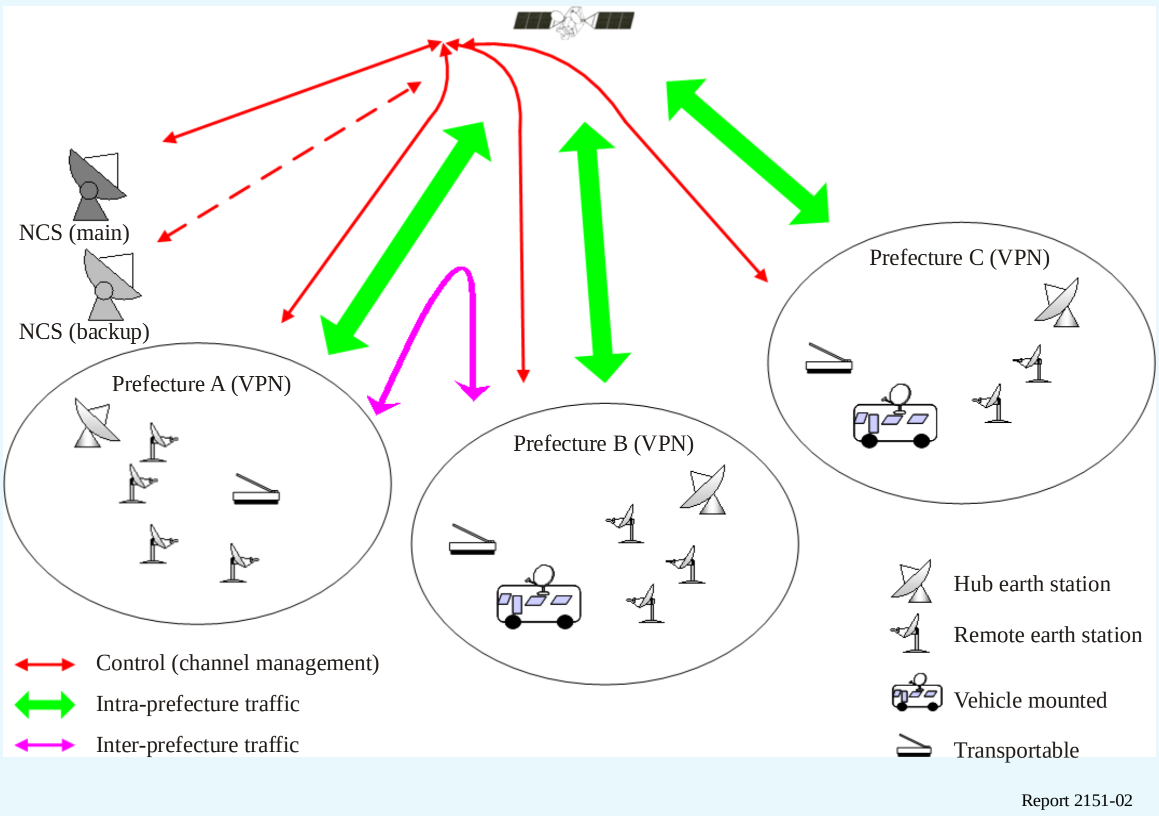
7.2.5.2 Example of an emergency network in Japan using the 14/12 GHz band

In Japan, there is a satellite network operating in the 14/12.5 GHz frequency band mainly for the purpose of emergency radiocommunications that accommodates more than 4 700 earth stations including VSATs located at municipal offices and fire departments, transportable earth stations and vehicle-mounted earth stations. The network provides voice, facsimile, announcement (simplex), video transmission and high-speed IP data transmission.

As shown in Figure 7-6, the network is based on DAMA, so that satellite channels can be efficiently shared by as many as 5 000 earth stations. An earth station asks the Network Coordination Station (NCS) for the assignment of traffic channels such as voice, facsimile and IP transmission prior to its radiocommunication with other earth stations. Note that there are two NCSs, main and backup, in the network.

The network is designed to have a multi-star topology where each prefecture (note that Japan consists of 47 prefectures) configures an independent sub-network so that the principal office of the prefecture can be the hub of emergency radiocommunications in the case of an event. By virtue of the closed-group network, the satellite resources can be controlled by the NCS depending on urgency of events. For instance, the NCS can provide priorities for radiocommunications originated from a particular prefecture where an emergency event occurs over routine radiocommunications in other prefectures. The network also provides inter-prefecture radiocommunications if any.

Figure 7-6: Configuration of the emergency network



In order to help telecommunications from/to an area damaged by disasters, the development of smaller user earth stations with high performance is under way. Typical parameters of such earth stations are listed in Table 7-11. There are two types of vehicle-mounted earth stations. Type-A earth station is designed to transmit full motion picture based on MPEG-2 (i.e. 6 Mbit/s) and provide a voice circuit simultaneously available during video transmission. The earth station is to be mounted on a relatively large vehicle such as “Wagon” type. On the other hand, a type-B earth station is designed to transmit a low rate limited-motion picture by MPEG-4/IP (i.e. 1 Mbit/s) with a voice circuit switchable with video transmission. The earth station is to be mounted on a smaller vehicle such as “Land-cruiser” type. Similar to type-B vehicle-mounted earth stations, the transportable earth station is designed to transmit a low rate limited-motion picture by MPEG-4/IP with a voice circuit switchable with video transmission. Its video transmission rate is only 256 kbit/s.

Table 7-11: Parameters of the vehicle-mounted and transportable earth station

Parameters	Vehicle-mounted earth station		Transportable earth station
	Type-A	Type-B	
Description	– Full-motion pictures based on MPEG-2 – Simultaneous voice circuit	– IP-based low-rate motion picture based on MPEG-4 – Voice circuit switchable with the video circuit	– IP-based low-rate motion picture based on MPEG-4 – Voice circuit switchable with the video circuit
Antenna diameter	1.5 m (offset parabola)	75 cm (offset parabola)	1 m (Flat array)
Number of channels and transmission rate	Video: 1 channel (6 Mbit/s, MPEG2) Voice/IP: 1 channel	Video: 1 channel (1 Mbit/s, IP) Voice/IP: 1 channel	Video: 1 channel (256 kbit/s, IP) Voice/IP: 1 channel
Type of vehicle	Wagon type	Land-cruiser type	N/A

7.2.5.3 Example of an emergency network in South-East Asia using the 14/12 GHz band

An agency in South-East Asia has set up an end-to-end broadband VSAT system to improve the broadband telecommunication between its offices and enhance the e-risk management policy.

The satellite network interconnects the headquarters (redounded) with:

– 13 national offices;

– 25 county offices;

– 72 villages;

– 12 emergency vehicles.

Based on IP, it offers all the common services of an intranet such as access to web and FTP servers, electronic messaging and content distribution in multicast, e.g. streaming. In addition, it offers broadband applications relevant for crisis management (e-risks services suite): videoconferencing, collaborative working and voice-over-IP.

In normal situations, the system carries up to 8 Mbit/s:

– 2 Mbit/s shared by all voice radiocommunications;

– 3 Mbit/s for central data exchanges;

– 3 Mbit/s for data shared by other data exchanges.

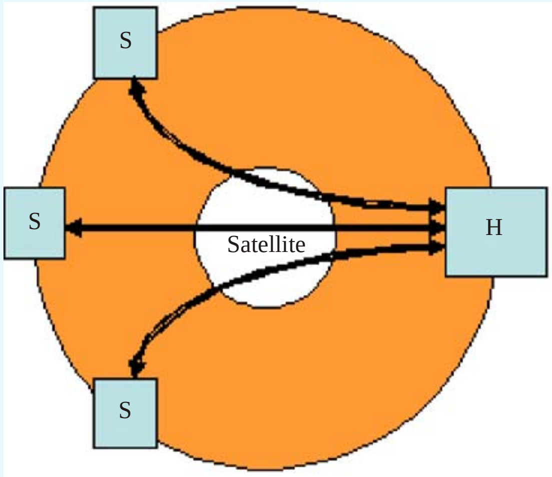
In crisis situations, the system carries up to 21 Mbit/s:

– 12 Mbit/s for two video streams;

– 9 Mbit/s for up to 16 videoconference terminals.

The topology chosen is the star topology (as opposed to the mesh one) with a hub installed at the headquarters and satellite terminals installed at the remote sites listed above (Figure 7-7).

Figure 7-7: Star topology



This topology is the best suited to services such as videoconferencing since they are by nature point-to-multipoint with a multipoint control unit located at the hub. This one also enables access to the Internet by means of a broadband access server. It shall be located abroad from the place of the disaster and therefore there is less constraint on the facilities; for example, the antenna can be as large as necessary.

The network operates in 14/12 GHz band (the 14 GHz band for the uplinks; the 12 GHz band for the downlinks). 14/12 GHz band antennas are smaller and lighter, which eases the use and the transportation of material. The terminals are state-of-the-art with a diameter ranging from 0.6 m to 1.2 m; the diameter is chosen so as to optimize the trade-off between the signal-to-noise ratio and the ease of transportation. The RF subsystem of remote terminals is specified in the norm as the outdoor unit.

The satellite access technology on the return link is fixed multi-frequency time division multiple access (fixed MF-TDMA). Fixed MF-TDMA allows a group of satellite terminals to communicate with the hub using a set of carrier frequencies of equal bandwidth while the time is divided into slots of equal duration. The network control centre at the hub will allocate to each active satellite terminal series of bursts, each defined by a frequency, a bandwidth, a start time and a duration.

Satellites terminals can be controlled from the hub, they can be configured, faults can be detected and software can be downloaded.

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Chapter 8

Risk assessment and cost/effectiveness analysis for the mitigation activities of the hazards effects

8 Introduction

Hazards, emergency and disasters threaten many areas of the world. Whether it is a natural disaster or a technological accident, risk management should put systems in place to prevent and reduce losses and damages. The following management strategy is known to reduce risk:

– hazard risk assessment analysis;

– mitigation strategy;

– cost/effectiveness analysis.

The first step is to prepare a hazard risk assessment analysis for the area of interest that means to identify hazards, to estimate their intensity and likelihoods, to evaluate their consequences. This is the subject of Section 8.1.

The second step is to develop a management strategy suitable to face the hazard. As already known, a hazard management strategy is based on four activities: hazard mitigation, emergency preparedness, emergency response and disaster recovery. Mitigation and preparedness take place before disasters strike. Response and recovery activities tale place after the disasters have occurred. The objective of this Handbook is mainly to look at the design criteria of the telecommunication outside plants in areas particularly exposed to natural disasters. This means that among the four above quoted activities, the attention is focused on hazard mitigation. It is clear that actions devoted to apply more stringent design criteria in order to better face future hazards can also be taken during the disaster recovery phase (e.g. during the reconstruction of the damaged plants). However for sake of simplicity reference is mainly made in this Chapter to the mitigation phase. This is the subject of section 8.2.

The third and last step is a cost/effectiveness analysis (incurred costs/achievable benefits) of the mitigation actions. This is the subject of section 8.3.

8.1 Hazard risk assessment analysis

[For further information see Bibliography]

Hazard risk assessment is the process through which the threat posed in the area of interest by each identified hazard is investigated. Risk is evaluated in two steps. The first is hazard identification, and description (intensity and probability). The second is the evaluation of the hazard consequences. Together these two factors inform us of how concerned we should be about the existence of a hazard. Generally, high-likelihood/high-consequence hazards are of great concern, while low likelihood/low-consequence hazards are of least concern, and all of the others full in between.

8.1.1 Hazard identification and description

Hazard identification, as the name suggest, is the process through which all hazards that have or could affect an area of interest are identified and described. This is done through a number of methods, including historical study, brainstorming, scientific analysis and subject matter expertise. For example, historical data for the past hundred years show that residents who live on the Atlantic and Gulf coast of the US are exposed to hurricanes, while people who live on the Pacific Northwest and the Hawaii are exposed to volcanoes. To be comprehensive, a hazards risk assessment effort must look not at each hazard individually and irrespective of the others, but rather at the entire hazards portfolio as interconnected and as each hazard having an influence on the effects and risks of the others.

Hazard description, or profiling as it is also called, is a further step, where the particular characteristics of the specific natural hazard, possibly impacting the studied area, is defined.

Each hazard has the following significant characteristics:

– the *intensity* of the hazard, which is generally defined in accordance with a recognized category/scale;

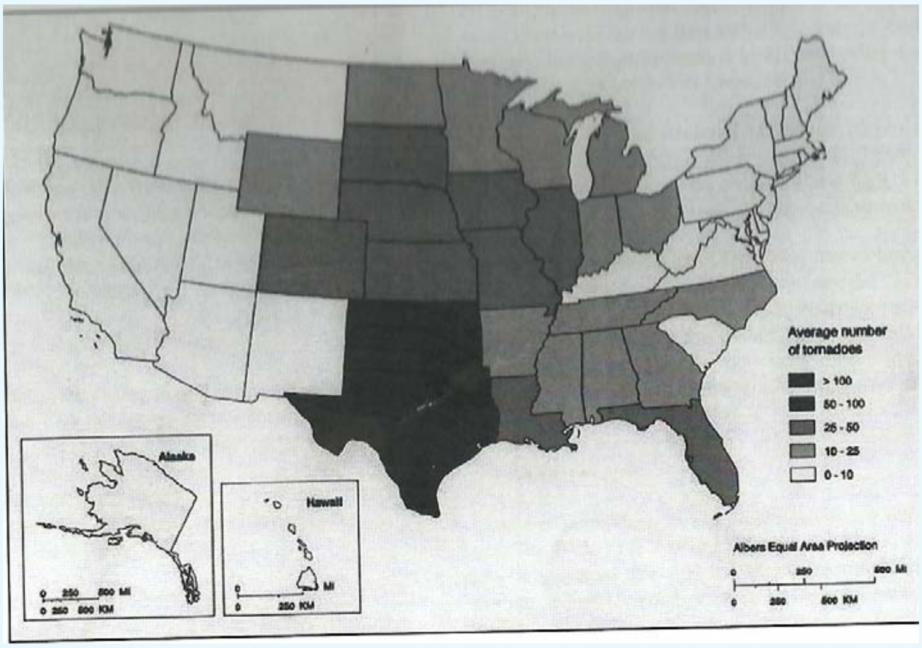
– the size of the geographical area affected by disaster impacts;

– the duration of impact, which is the length of time the disaster impact persists;

– the *probability* of occurrence.

In order to carry out hazard description there are many useful sources of information that can be used. As an example related to the US, one source is the set of maps contained in FEMA Multi Hazard Identification and Risk assessment, as those shown in Figures 8-1 and 8-2.

Figure 8-1: Average annual number of tornadoes per state in the period 1953-1993

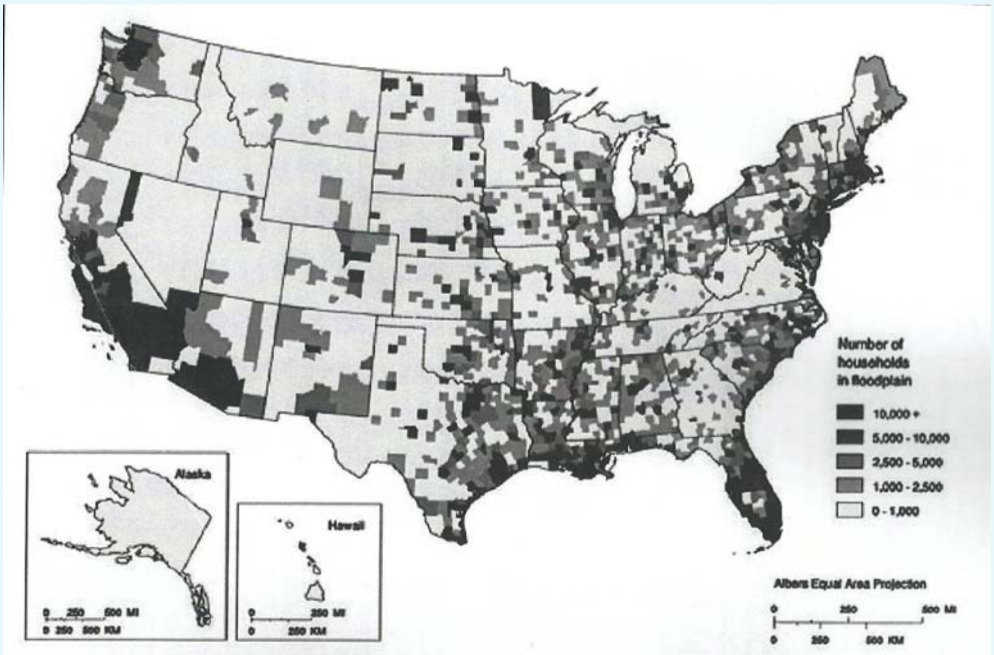


This source describes exposure to most natural hazards. These maps of natural hazards exposures can be supplemented visiting several Web site, including those belonging to the same FEMA (www.fema.gov), U.S. Geological Survey (www.usgs.gov), and National Weather Service (www.nws.noaa.gov).

However even if these maps provide a good start toward assessing the potential impact of disasters, they have some limitations:

– many of these maps are designed to compare the relative risk of large areas. This information does not tell which zones within the area of interest are most likely to be struck by a disaster. For example, a coastal region might be exposed to hurricanes, but only a small area is exposed to significant damage. Smaller scale maps are needed to assess exposure of limited areas;

Figure 8-2: Geographic distribution by county of households in the United States in the 1-percent-annual-chance floodplain



– these maps vary in the amount of information they provide. For example, hurricane maps identify areas that will be hit by category 1-5 hurricanes. However these maps do not provide with the probability of each category of hurricane striking the area of interest. By contrast, other earthquake maps give the probability that an earthquake will exceed a given intensity. Some maps tell which areas in a city contain buildings that are the most likely to collapse. However within each of these areas, each building probability of collapse must be assessed by structural engineers;

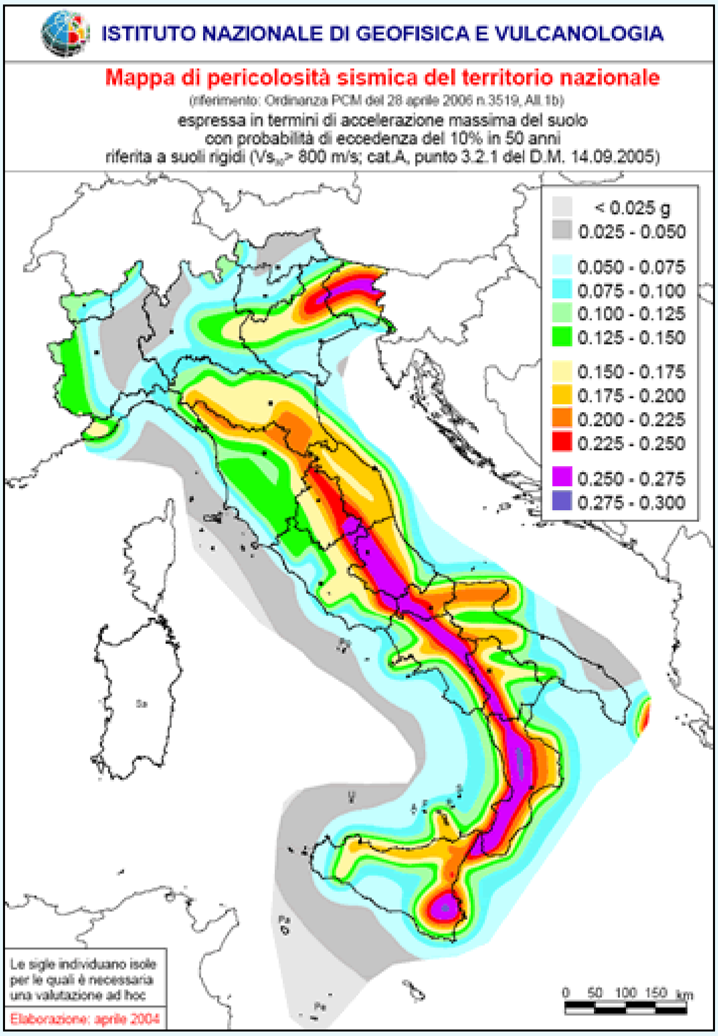
– these maps often lack important information about the relative risk of different hazards. In deciding how to allocate the available resources, it is necessary to know what is the likelihood of a flood in comparison to a tornado and to an earthquake;

– in many cases it is only possible to categorize disaster impact as high, medium or low. This provide only a rough estimate for determining which hazards need the most attention. Considering that some emergency management measures are hazard specific, the possibility of ranking hazards in the area of interest can help to allocate resources to get the biggest reduction in likely casualties and damage.

An example of natural hazards exposures is in Figure 8-3 which shows the map of seismic hazard of the Italian territory expressed as maximum acceleration of the soil with a 10% probability of exceeding the indicated values in 50 years.

An example of evaluating seismic performance of outside facilities is in Annex 8A1.

Figure 8-3: Map of seismic hazard in Italy (http://zonesismiche.mi.ingv.it/mappa_ps_apr04/italia.html)



8.1.2 Hazard consequences and methodologies for their evaluation

The evaluation of the hazard consequences is performed in order to determine the relative seriousness of hazard risks that have been identified and assessed. Using the procedures just listed to identify the hazards that threaten the area of interest, in order to determine their consequences, emergency managers will have to gather all of the information necessary to determine how these risks compare one to another. For this reason, by the time the risk evaluation process begins, each hazard must have been identified, described, mapped and analyzed according to its likelihood of occurrence.

It is also to be taken into account that a given hazard agent may initiate a number of different threats. For, example, hurricanes can cause casualties and damages through wind, rain, storm surge, and inland flooding. Volcanoes produce ash fall, explosive eruptions, lava flows, mudflows and floods, and forest fires. For this reason, by the time the risk evaluation process begins, each hazard must have been identified, described, mapped and analyzed according to its intensity and likelihood of occurrence.

Hazards consequences can be evaluated in the frame of a Hazard Vulnerability Analysis (HVA) study, which mainly looks at the following factors: physical vulnerability and social vulnerability.

The *physical vulnerability* is the human, agricultural, structural susceptibility to damage or injury from disasters and can be measured in casualties and damages.

The *social vulnerability* is the lack of psychological, social, economic and political resources to cope with disaster impacts.. This vulnerability includes effects which can develop over a long period of time and can be difficult to assess.

Complete information on the above quoted vulnerability is unlikely to be available. This might seem to be a negative view of the usefulness of HVAs, but it is not. Rather it simply recognizes the current limitations of HVA technology and the resources which can be devoted to this activity. However, it is still possible to do a good job without extremely precise data. This is because it could be sufficient to collect enough information to decide how much money to spend in different activities. That is, it could be sufficient to collect enough HVA data to decide how to allocate resources among hazard mitigation, emergency preparedness, emergency response and disaster recovery. After the relative threat from different types of hazard has been assessed, it is necessary to verify if these different types of hazard might have the same disaster demands. For example, hurricanes and inland floods might have different probability of occurrence but they require similar emergency responses such evacuation. Consequently some investments will help to prepare for multiple hazards.

The evaluation of the hazard consequences is so important because all communities face a range of natural and technological hazards, each of which requires a different degree of mitigation and risk reduction. Moreover, most communities have a range of competing budgetary pressures and are therefore unable to fully mitigate all hazard risks. The goal, as a result, is to lower the number of deaths, injuries, and damage to property and to the environment, associated with hazards, to an acceptable degree, so they must ensure them the greatest results overall.

There are various approaches to developing a study of the possible hazard consequences, ranging from qualitative to quantitative, as well as several computer-based models that have been developed for individual hazards such as earthquakes, floods, hurricanes, and landslides. The validity and utility of any risk assessment is defined by the quality and availably of data. Emergency managers must rely on a range of sources to develop accurate determinations of the possible consequences, despite the fact that these factors are constantly changing as a result of increased development, access to new information, changes in climates and community characteristics and many other factors which can complicate the equations.

Rather than relying on specific mathematical calculations to determine exact values, qualitative systems limit the possible values to a smaller defined range (typically five to seven values) into which each hazard is more easily placed. For example, it may be difficult to calculate the rate of return for an ice storm in the specific year, but it is much more possible to determine whether that storm will occur once or more every year or once every two or ten years. Qualitative systems are not exact, but they facilitate a process that might otherwise be too difficult or time-consuming and therefore disregarded. In the United States, Australia and New Zealand, for instance, various qualitative assessment systems have been developed to measure possible consequence values. Some examples of quantitative assessment methods are pointed out in the following.

8.1.2.1 Hazard US-Multi Hazard (HAZUS-MH)

Hazard US-Multi Hazard (AZUS-MH) is a computer program that predicts losses from earthquakes, floods and hurricane winds. The program estimates casualties, damage and economic losses. Further information about AZUS-MH is available at www.fema.gov/hazus.

8.1.2.2 Risk matrix approach

Each region is unique because of such factors as climate, geography, and development. Therefore the risks associated with hazards in each region are also relatively unique. Depending on the corresponding needs for risk assessment and associated costs, different levels of risk management can be conducted. In the risk matrix approach, both the frequency of occurrence and the magnitude (severity) of a hazard are given as qualitative measure that permits the prioritization of risk among multiple hazards.

Criteria for frequency categorization might include:

- High frequency: events that occur more frequently than once in 10 years (>10^{-1}/yr);
- Moderate frequency: events that occur from once in 10 years to once in 100 years (10^{-1} to 10^{-2}/yr);
- Low frequency: events that occur from once in 100 years to once in 1,000 years (10^{-2} to 10^{-3}/yr);
- Very low frequency: events that occur less frequently than once in 1,000 years (<10^{-3}/yr).

Criteria for severity categorization might include an examination of the potential for fatalities, injuries, property damage, business interruption, and environmental and economic impacts, rated in categories ranging from catastrophic to minor:

- Class A: High-risk condition with highest priority for mitigation and contingency planning (immediate action). Examples of losses: death or fatal injury, complete shutdown of facilities and critical services for more than one month, more than 50 percent of the property located in affected area is severely damaged;
- Class B: Moderate-to-high-risk condition with risk addressed by mitigation and contingency planning (prompt action). Examples of losses: permanent disability, severe injury or illness, complete shutdown of facilities and critical services for more than 2 weeks, more than 25 percent of the property located in the affected area is severely damaged;
- Class C: Risk condition sufficiently high to give consideration for further mitigation and planning (planned action). Examples of losses: injury or illness not resulting in disability, complete shutdown of facilities and critical services for more than one week, more than 10 percent of the property located in the affected area is severely damaged;
- Class D: Low-risk condition with additional mitigation contingency planning (advisory in nature). Examples of losses: treatable first aid injury, complete shutdown of facilities and critical services for more than 24 hours, no more than 1 percent of property located in the affected area is severely damaged.

To prepare risk analysis, emergency managers create a graph that represent risk frequency (likelihood) and severity (consequences) on the x- and y- axes, with the highest of both falling in the upper right quadrant and the lowest in the bottom left. If a quantitative system has been used, the defined values selected for each of the two risk factors are transferred into this matrix (Table 8-1). Otherwise, if qualitative representation of likelihood and consequences have been used, the minimum and maximum of all hazards analyzed represent the high and low limits of the two graph axes. Then all of the hazards are plotted into this matrix together, thereby providing a visual illustration of a community or country's hazard risks in relation to one another. Using the results of the risk matrix, a prioritized ranking of the risks is created. This list becomes the basis of the final step, which is the treatment of the identified hazard risks.

Table 8-1: Example of risk matrix

		Severity			
Frequency		**Minor**	**Serious**	**Extensive**	**Catastrophic**
	High	C	B	A	A
	Moderate	C	B	B	A
	Low	D	C	B	B
	Very low	D	D	C	C

8.1.2.3 Composite Exposure Indicator

Another approach to assess the risk from a given hazard based on several indicator variables is the Composite Exposure Indicator (CEI) method. The output of this approach is a ranking of the potential losses in a given region or area for single or multiple hazards. Actual losses are not estimated because the approach does not include a relationship between exposure and losses, and economic data are not used. However the approach could be extended to provide estimates of losses.

Using databases provided by FEMA, 14 variables are quantified for 3,140 counties in the United States. The variables and their units of measure are expressed as densities (number or length per square mile). The variables were chosen because they are readily available and indicative of exposure and potential damage from hazards. The approach is flexible and the list of indicator variables could be modified easily. Table 8-2 shows an application to the telecommunication outside plants.

Table 8-2: The Outside plants in an area natural disaster-prone

Type of outside plants	Number in the area	Characteristics	Degree of protection	Spare/redundancies	Fuel/power autonomy

CEI values are a measure of exposure of each type of outside plant to the considered hazard. Larger CEI values imply that more plants are exposed to potential damages from the considered natural hazard.

8.2 Mitigation activities for the protection of the TLC outside plants

[For further information see Bibliography]

Mitigation strategies can be classified in different ways. One of the most common is the distinction between structural and nonstructural mitigation. The most common examples of structural mitigation are dams, levees, seawalls, and other permanent barriers that prevent floodwater from reaching protected areas. Nonstructural mitigation includes activities as purchasing undeveloped floodplains and dedicating them to open space, installing window shutters for buildings located on hurricane-prone coastlines, etc.

However, the above classification of mitigation activities is still vague, so that a more precise classification was developed by FEMA based on five categories: hazard source control, community protection works, land-use practices, building construction practices and building contents protection.

– *Hazard source control* does not work for natural disasters, but there are some exceptions. Wildfire hazard can be controlled by limiting fuel loads in woodlands and controlling ignition sources. Flood hazard can be controlled by maintaining ground cover that decreases runoff by causing rainfall to infiltrate the soil.

– *Community protection works* are most commonly used to divert flood water pass areas that are located in flood plains. They can also be used to provide protection from other types of water flows such as tsunami and hurricane storm surge. Finally, community protection can protect against two types of geophysical hazards: landslides and volcanic lava flows. The four major types of flood control works are the following: i) channelization which is the process of deepening and straightening stream channels; ii) dams which are elevated barriers sited across a streambed for increasing surface storage of floodwater in reservoirs upstream from them; iii) levees which are elevated barriers placed along the streambed for limiting stream flow to the floodway; iv) floodwalls which are built of strong materials such as concrete. They are more expensive than levees, but they are also stronger.

– *Land-use practices* are defined by the ways people use the land. These include woodlands, farmland, residential, commercial and industrial structures and infrastructure facilities. The local government can influence land-use practices through the use of risk communication, incentives and sanctions.

– *Building construction practices.* Property owners can change their construction practices voluntarily because of risk communication or incentives. They can also change involuntarily because of building code requirements.

– *Building contents protection.* For most hazards, protecting buildings from damage also protects the content from harm.

As well known, this Handbook deals with telecommunication outside plants which are cables, conduits, ducts, poles, towers, antennas, repeaters, repeater huts, and other equipment located between a demarcation point in a switching facility and a demarcation point in another switching facility or customer premises.

These means that, strictly speaking, the above five general categories of mitigation activities are out of the scope of this Handbook. However, it is clear that the mitigation actions taken under these categories could in some cases reduce the amount of hazard on the TLC outside plants.

The design criteria able to mitigate the direct impact of the natural disasters on the TLC outside plants are dealt with in Chapters 4, 5, 6, and 7 and there is nothing to add in this chapter.

8.3 Cost/effectiveness analysis of mitigation actions

[For further information see Bibliography]

Several possible mitigation actions have been described in this Handbook in view of reducing hazard consequences. This section deals with the problem how these actions can be justified and approved from the economical point of view.

8.3.1 Cost evaluation of mitigation activities

The first issue is the evaluation of the cost of the possible mitigation actions. The cost is different in each of the following cases:

i) the mitigation actions are implemented on the existing outside plants;

ii) the mitigation actions are adopted for the replacing of plants destroyed by a natural disaster;

iii) the mitigation actions are applied in the realization of new plants.

In general the cost incurred in these three cases is different. Focusing the attention on the iii) case, which is the main objective of the Handbook, the following relations apply:

- C_N : Cost of an outside plant realized with a "normal" requirements;
- C_E : Cost of an outside plant realized with "more severe" requirements;
- $C_D = C_E - C_N$ Difference between "more severe" and "normal" costs.

As an example let us see the following case:

i) the plant has been realized with "normal" requirements and the disaster does not happen: no money has been lost for a "more severe" design of the plant and no damage has occurred.

ii) the plant has been realized with "normal" requirements and the disaster happens: some money (C_R) is necessary for the repair or an amount of money (C_E or C_N) is necessary for the replacement of the plant. Moreover damages have been suffered.

iii) the plant has been realized with "more severe" requirements and the disaster does not happen: an amount of money equal to C_D has been lost, but no damage has been suffered.

iv) the plant has been realized with "more severe" requirements and the disaster happens: an amount of money (C_D) has been necessary, but no damage has been suffered (hopefully).

These four situations are summarized in Table 8-8.

Table 8-8: Impact of the mitigation activities

	The disaster does not happen		The disaster happens	
Design criteria	**Cost**	**Damages**	**Cost**	**Damages**
Normal	No cost	No	C_N or C_E or C_R	Yes
More severe	C_D	No	C_D	No

From this elementary exercise, it is clear that an evaluation of the damages due to the disaster is a key element in order to take a decision on the adoption of the mitigation activities and of the relative costs.

8.3.2 The damages from a disaster

As said above, the *physical impact* of a disaster is measured in terms of deaths, injuries and property damage. These losses are the most obvious and rather easily measured. The *social impact* which includes psychosocial, demographic, economic and political effects develops over a long period of time and can be difficult to assess.

8.3.2.1 Physical impact

The physical impact of a disaster can be measured in casualties and damages:

– Human vulnerability. Humans are vulnerable to extreme of temperature and pressure. These environmental conditions can cause death, injury and illness.

– Agricultural vulnerability. Like humans, agricultural plants and animals can also be hurt by hazards. However agricultural vulnerability is more complex than human vulnerability because there are more spaces. Each species has its own response.

– Structural vulnerability. Buildings are damaged or destroyed by hazards. The design and materials used in constructions determines the level of vulnerability. The construction of most buildings is governed by building codes intended to protect occupants from structural collapse. However the buildings do not necessarily provide protection from extreme wind, seismic, hydraulic loads.

In ranking the disasters, hurricanes can cause the most fatalities. Worldwide data from 1947-1980 show:

– Hurricanes produced 499.000 deaths
– Earthquakes produced 450.000 deaths
– Floods produced 194.000 deaths

8.3.2.2 Economic impact

Leaving aside the psychosocial and demographic impacts in the analysis of the social impacts, let us consider only the economic impact. Telecommunication outside plants damages can be measured by the cost of repair or replacement.

In addition to direct economic losses, there are indirect losses that arise from business interruption. An earthquake in the community might have left a company's buildings, equipment and raw materials undamaged. However if electric power has been lost, workers will not be able to operate the machinery and produce the goods the company sells. to stay in business. Business interruption can be also be caused by the loss of other infrastructures such as fuel, water, sewer, telecommunications and transportations.

8.3.3 Cost/benefits from mitigation actions

As said above, it is rather difficult to make a precise assessment of the cost/benefits related to the implementation of a telecommunication outside plant designed on the basis of "more severe" criteria in order to improve its resistance to a specific natural disaster, which could impact the area. However, some tools, also operating on PC (e.g. FEMA), allow estimation with an accuracy related to the precision of the available data (e.g. extension of the area, type of hazard, its intensity, its probability, estimation of casualties and damages).

In any case an evaluation of the cost/benefits is always necessary in order to have risk mitigation programs approved and implemented. Otherwise despite the best technical knowledge, historic occurrence and media attention, very often it is not recognized that TLC plants are vulnerable. Some of the reasons are denial of the risk, costs and lack of funding and taking on the risk. Recognition requires action and it could have economic consequences as business decide to locate elsewhere if they find the area is at risk. Some people are willing to try to beat the odds, but if a disaster strikes, they know someone will help them out. Gradually, however, such attitudes are changing. Potential liability issues are making responsible more aware, media attention to disasters has brought public pressure and the government have provided both incentives for and penalties for not, taking actions.

Moreover, as previously mentioned, mitigation provides long-term benefits, while very often people tend to focus on short-term rewards. Without a good risk and vulnerability analysis, it is very difficult to decide to spend money on mitigation activities. Data on vulnerability of telecommunication plants are necessary to lobby for more money. Emergency management must compete with other needs such as new TLC services, new TLC systems, etc.. In these cases, the Hazard Vulnerability Analysis (HVA) should be specific enough to persuade others that an increase will benefit the community and the telecom operators. This is not a trivial problem. Emergency management must lobby for money to solve *future* problems. TLC services and TLC network planners tend to be more successful because they request money to solve *current* problems.

Annex 8A1: Example of evaluating seismic performance of outside plant facilities (Japan experience)

[For further information see Bibliography 4]

It is necessary to evaluate outside plant facilities in terms of the possibility of them suffering damage and to execute appropriate countermeasures according to priority assessment with a limited budget.

Figure 8A1-1 shows an example of an algorithm for evaluating the seismic performance of underground facilities. It can evaluate their earthquake resistance based on 1) information about the facilities (available from various in-house shared databases), the ground (detailed geological data about Japan) and earthquakes (magnitude, epicentre, depth, etc.) and 2) the probability of damage estimated from historical damage data.

By performing simulations, we can predict the seismic intensity and potential liquefaction areas, and utilize this information to make an effective plan for updating facilities taking account of the importance of communication lines. The results help us in making plans for surveying damage and undertaking effective restoration work after an earthquake (Figure 8A1-2).

Figure 8A1-1: Algorithm for evaluating seismic performance of underground facilities

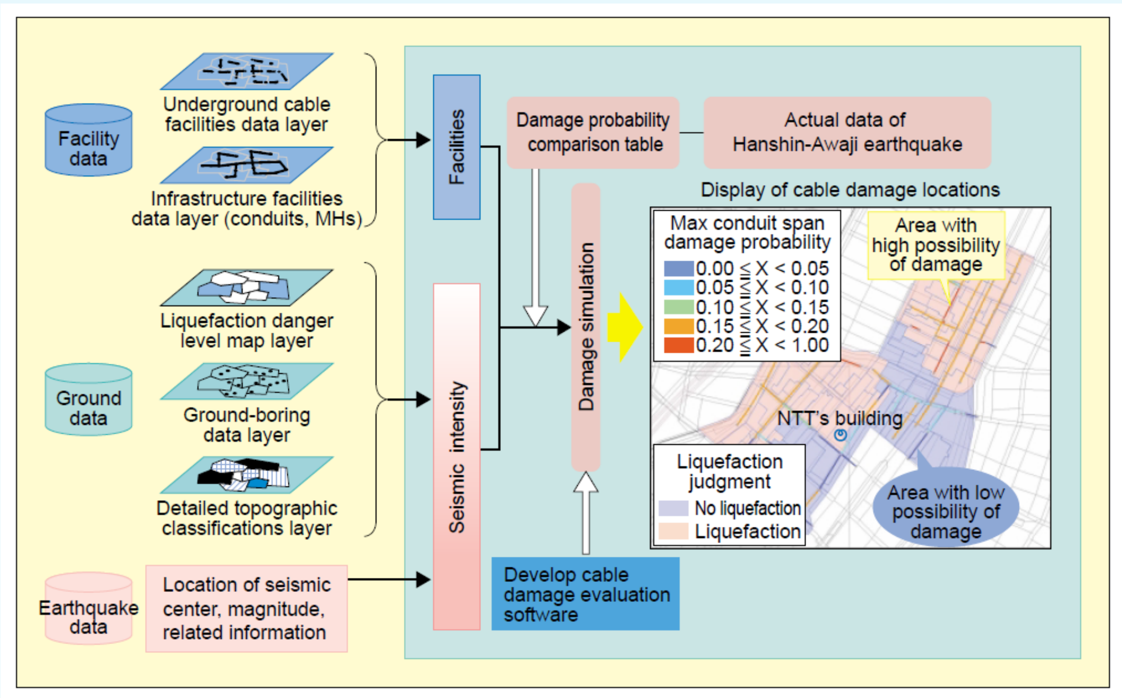
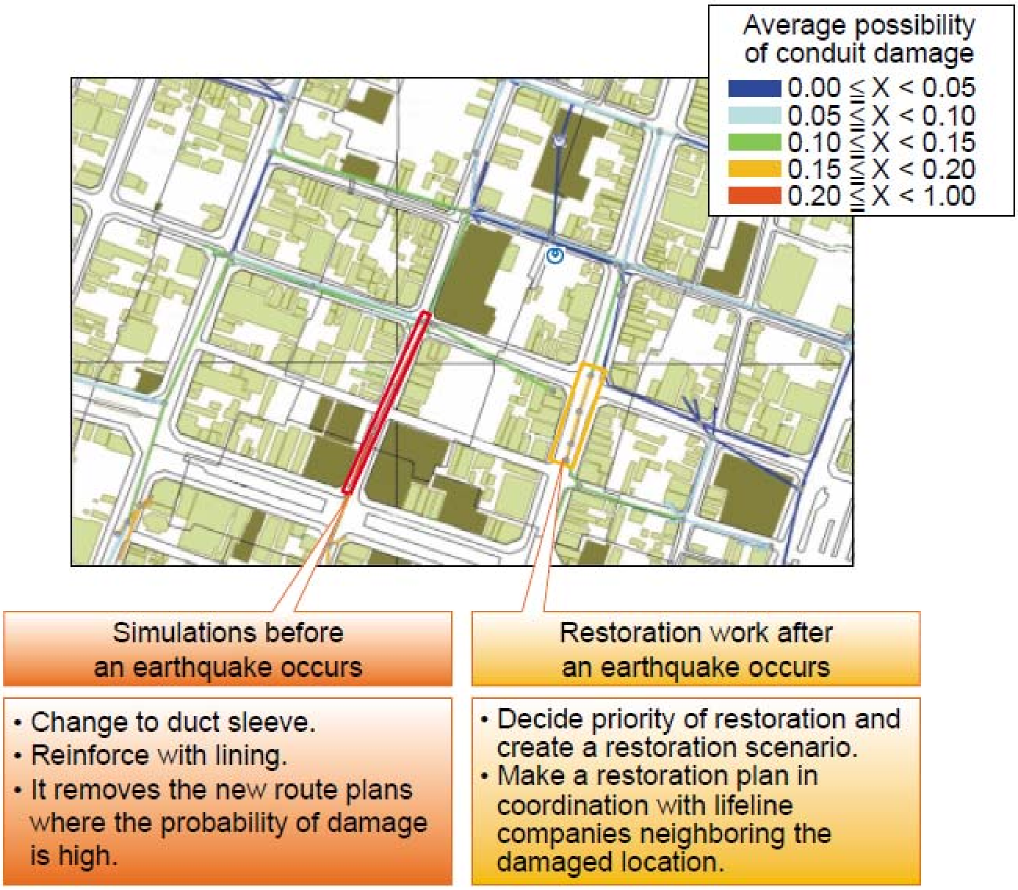


Figure 8A1-2: Example interpretation of simulation results



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Chapter 9

Emergency telecommunication plans with a focus on the outside plants

9 Introduction

In a disaster, communications is one of, if not the, primary tool in recovery. Therefore, having a communication system that is both reliable (i.e. able to withstand unusual and unexpected situations) and resilient (i.e. able to recover quickly when service is interrupted by unusual situations) is a key element in responding to disasters.

Fortunately, disasters are relatively rare events, and this leads to a tendency to put off planning for them. There are enough things that warrant attention in daily operations about without preparing for something that rarely happens. This philosophy works for some things but not for telecommunications networks. The vital role that communications plays in our everyday lives and especially in disaster situations makes preparation and practice essential. Because of the key role that communications plays in personal lives, commerce and government, National Emergency Telecommunication Plans (NEPT) for dealing with a disaster need to be established long before it happens.

A NEPT should be based on specific disaster management activities which can be grouped into the following four phases:

i) Mitigation (Prevention): Activities that actually eliminate or reduce the probability/effects of a disaster (for example, designing buildings resistant to earthquakes).

ii) Preparedness: Activities prior to disasters that are used to support the prevention of, mitigation of, response to, and recovery from disasters. In this phase, plans are developed to save lives and minimize disaster damage (for example installing early warning systems).

iii) Response: Activities following a disaster. These activities are designed to provide emergency assistance for victims, to stabilize the situation and to reduce the probability of secondary damage.

iv) Recovery: Activities necessary to return all systems to normal or better (for example, rebuilding destroyed property, or the repair of other essential infrastructure).

This Chapter gives a glance to the possible actions for mitigation (Section 9.1), Preparedness (Section 9.2) and Response (Section 9.3). Section 9.4 is dedicated to the preparation of a National Emergency Telecommunication Plan., based on the practical application of the above activities.

9.1 Actions for Mitigation

Communications systems are constantly under attack from nature (e.g., hurricane, flood, earthquake) and from humans, either intentionally (e.g., vandalism) or unintentionally (e.g., work errors, overloads). These are referred to as hazards. It is practically impossible for communications operators to be prepared for the next specific hazard with which they will be attacked. Fortunately, while operators may not know the next threat that they will be assailed with, they can know the vulnerabilities of their systems, and take steps to guard those.

A hazard can only have an impact on a system if it exploits an intrinsic vulnerability of that system. As an example, the need for power is an intrinsic vulnerability of communications systems, so that outages can occur by affecting the power on those systems. Operators may not know what form the hazard on power may take, but they know they need power and can take steps (e.g., dual power feeds, back-up batteries, emergency generators) to protect the power to the system, thereby mitigating the vulnerability. By examining the vulnerabilities of a system and protecting it, the operator can be prepared to face the hazard in whatever particular variation it comes in.

9.1.1 Telecommunication networks and their vulnerability

Telecommunication networks are based on a vulnerable infrastructure. The exchanges are interconnected by cable connections or radio links. The knowledge of the vulnerability of the various parts of this infrastructure allows us to determine the capacity to resist the hazards and to take measures to reduce this vulnerability.

- Switching exchanges

The switching exchanges are exposed to the risks of flood, fire, collapse further to the hazards of diverse natures (earthquake, landslide, volcanic eruption, etc.), of breakdown on the system power supply, blocking because of the overload of networks further to a sudden increase of the traffic.

In the implementation of exchanges, measures must be taken to reduce their vulnerabilities to these various risks.

- Local loop in wired network

The local loop, the connection between the local exchange and the residence of the subscriber, is generally a copper cable; in numerous places, these telephone lines are cables suspended from poles. Their routes are vulnerable in the disasters caused by violent winds, snow and earthquakes.

- Metropolitan and long haul networks

Metropolitan and long haul links are connections which group hundreds or thousands of circuits by the process of multiplexing. According to the necessary capacity and to the distance between the concerned cities, these connections can be by radio links, by copper and optical fibre cables. When the links are realized by cable, these cables are generally laid underground.

Whatever is the type of connection (cable or radio link), the vulnerability can be reduced by the implementation of protection links. However, the continuity of the service widely depends on the available protection capacities. In certain countries, there is a progressive decrease of the redundant capacities, these having been sold by operators subjected to a strong competition. When a connection breaks down, the protection links has no sufficient capacity to support the interrupted traffic. For that reason, it is necessary that sufficient spare capacity is maintained.

- Mobile Network

When the mobile telecommunications network is not damaged by a disaster, it is an essential tool for its management.

The mobile networks are less vulnerable in disasters, because the connections are wireless and the network is disrupted only if exchanges and base telephone stations are affected by the hazard.

- Satellite Network

Considering their positions in respect to the surface of the earth, satellites are protected from natural hazards. The earth stations are the only component of the satellite systems which are vulnerable to the natural disasters. Therefore satellite links constitute an important element for the emergency telecommunications.

9.1.2 Evaluation of the vulnerability of the telecommunication systems

Communication systems can be described by eight basic ingredients; power, environment, hardware, software, network, payload, human, and policy. Using these eight ingredients, a system owner can study its system, identify their vulnerabilities, and to devise measures to protect these vulnerabilities. The eight ingredient framework has been used by various teams to help define the system under study, its vulnerabilities, and the corresponding countermeasures needed to protect these vulnerabilities.

In the United States, the communications industry, under the auspices of the Federal Communications Commission (FCC) has developed a set of Best Practices that provide guidance, based on industry expertise and experience, on making communications more reliable and resilient. In other words Best Practices are intended to help prevent communications outages from occurring (*reliability*) and to speed recovery from outages should they occur (*resiliency*).

The Best Practices can be accessed on the ATIS web site (http://www.atis.org/bestpractices) or on the FCC web site (https://www.fcc.gov/nors/outage/bestpractice/BestPractice.cfm). Best Practices cover five general areas: Network Reliability and Interoperability, Disaster Recovery and Mutual Aid, Public Safety, Physical Security, and Cyber Security. A key characteristic of a Best Practice is that it is not just a good idea – it has been implemented by at least one company and has been judged to be a Best Practice by the other companies involved, even though they themselves may not have implemented it. Best Practices are not intended to be requirements. Each Best Practice must be evaluated by a person knowledgeable in the specific area covered, and implemented only if it makes sense for a company's individual set of circumstances.

The European Network and Information Security Agency (ENISA) have also established a set of practices aimed at things such as information sharing and emergency preparedness exercises. (http://www.enisa.europa.eu/act/res/policies/good-practices-1) .

9.1.3 Possible actions for strengthening telecommunication networks

As an example of the possible actions for strengthening telecommunication networks, the following can be quoted:

- land use restrictions (zoning) in order to limit people's intrusion/building's construction into the flood plain;
- definition of building codes, architecture and design criteria, and soils and landscaping considerations for the construction of new buildings resisting to earthquakes.

Other examples of the actions which can be taken for strengthening the telecommunication networks/plants are given in Annex 9A1.

Moreover Chapters 4, 5 and 6 of this Handbook are devoted to the description of the design criteria of the telecommunication outside plants, with a particular attention to those criteria able to improve the resistance of the plants to the natural disasters.

9.2 Actions for Preparedness

Disaster preparedness for communications systems has several components. The most important are listed in the following:

- typology of the disasters which have had an impact on the country in the past (Section 9.2.1;
- mutual aid agreements (Section 9.2.2);
- signature of agreements of mutual assistance or partnership between involved organizations (Section 9.2.3);
- spare emergency equipment (Section 9.2.4);

– training of the staff involved in emergency telecommunications and simulation exercises (Section 9.2.5);

– realization of systems of alert and of plan of alert.

9.2.1 Typology of the natural disasters which have had impact one the country in the past

An example of the typology of natural disasters in a country is shown in Annex 9A2.

9.2.2 Mutual aid agreements

Disasters, especially natural disasters, are often geographically contained, even though it might be a wide spread area. Because of this, communications companies in the same area are all likely faced with disaster recovery and may not be in a position to provide assistance to one another. To deal with this, companies should consider establishing mutual aid agreements with other operators, possibly in different areas of the country or even in different countries, as part of their disaster recovery plan. These companies may not have been impacted by the event and may be in better position to provide equipment or personnel to assist with the restoration.

What is a formal mutual aid agreement? It is an expression of intent to work together, *if both sides agree at the time*, and can spell out financial and legal agreements that have been established in a controlled negotiation rather than in the heat of the moment during a disaster. A key point is that a mutual aid agreement *does not* obligate either side to provide assistance or to accept it. It simply establishes the ground rules that will be used if both agree to implement it. In the United States, a mutual aid template has been established that is used as the foundation for mutual aid agreements by many network operators. It identifies some of the types of aid that might be considered, including equipment, vehicles, network capacity, and personnel, and calls out many of the legal and financial considerations that might be addressed in a mutual aid agreement.

The United States has experienced a number of well-known communications disaster situations over the past few years, including Hurricanes Katrina and Rita. In these, and in many other cases, mutual aid agreements have demonstrated their value to quickly and efficiently focus the full force of the communications industry on restoring communications services. At the international level, the Tampere Convention, an effort of the ITU, provides a framework for telecommunications assistance in times of disaster.

9.2.3 Plan for priority communications

Another thing to consider in disaster recovery preparation is ensuring that the most urgent calls can be completed. In most disaster situations, the communications network is flooded with a load for which it was not engineered, resulting in a large number of calls that don't complete. This is not acceptable for calls from first responders and those vital to the restoration of various human and communication services. For this reason, it is imperative that a scheme be established to help ensure priority calls are completed at a rate higher than the normal completion rate. In the United States the Government Emergency Telecommunications System (GETS) and Wireless Priority Service (WPS) have been developed and been put in place to address precisely this issue. Both services provide enhanced completion opportunities to those calls identified as priority. The United Kingdom has deployed a wireless priority scheme called Mobile Privileged Access Scheme (MTPAS) as well as a Government Telephone Preference Scheme (GTPS), Australia has a Wireless Priority Service System, and an effort is underway in Spain, supported by the European Commission, to look at ways of addressing Priority Communications on Public Mobile Networks (PCPMN) in crisis situations. All currently deployed schemes have drawbacks, and a country considering deploying such a capability would be wise to examine these systems to avoid the pitfalls each has experienced. When creating and deploying a means of addressing priority calling, strong consideration should be given to the interface such a system would have with other countries. Disaster recovery often involves contacting vendors or other support organizations in different countries, and a priority communications system that doesn't span national borders will not provide the full potential that it should.

9.2.4 Emergency equipment

Spare emergency equipment is necessary for being used in the natural disaster areas in order to substitute the damaged equipment and/or to complement the existing ones. The type, the number and the distribution of emergency equipment on the national territory is one of the tasks of a National Emergency Telecommunication Plan.

Possible spare emergency equipment is the following:

– radio base stations on mobile tracks;

– switching exchanges on mobile tracks;

– back-up batteries;

– emergency generators;

– VSAT terminals;

Thuraya/Iridium/Immarsat/Intelsat phone/terminals.

In the areas hit by the earthquake/tsunami in Japan on 16 March 2011, the ITU deployed 78 Thuraya satellite phones equipped with GPS to facilitate search and rescue efforts along with 13 Iridium satellite phones as well as 37 Inmarsat Broadband Global Area Network terminals. The equipment can be charged by car batteries and were also supplied with solar panels to enable operations during power outages.

The ITU deployed a hybrid of 40 broadband satellite terminals in an effort to restore vital communication links in the aftermath of a tsunami triggered by a 7.7 magnitude earthquake and a volcanic eruption that hit the Indonesian archipelago in two separate incidents.

9.2.6 Training and exercises

Having an emergency plan, which may include mutual aid agreements, it is possible that plan may seldom, if ever, be used, but because disasters are rare events. An organization doesn't know if it has a good, up-to-date emergency plan unless it has been used recently.

Once a disaster occurs is not the time to discover that there are gaps in the emergency plan, that vital contact information has changed, or that critical items haven't been accounted for. Those discoveries should occur during periodic exercises, which should be conducted as realistically as possible. It is far better to discover gaps or errors in a plan under the controlled conditions of an exercise than during an actual event, when errors can be the difference between a successful recovery or an extended outage, between being a key recovery enabler or a recovery impediment, or even between life and death. Exercises are also an opportunity to utilize existing tools. The Database of Frequencies to Be Used in Disaster Relief [ITU-R Resolution 647 (WRC-07)] is one such tool, and ensuring that it contains accurate information and that people know where to find it and how to use it can be woven into exercises.

Emergency exercises aren't free and there is a tendency to reduce or eliminate this type of effort, especially if a disaster hasn't occurred recently and economic conditions are putting pressure on the operator. Having no emergency plan is simply unacceptable, and having an untested plan is only slightly better. When it comes to ensuring a robust and dependable communications infrastructure, nothing pays greater dividends than preparation.

9.3 Actions for the Response in case of a disaster

The Response is the totality of the activities following a disaster. These activities are designed to provide emergency assistance for victims, to stabilize the situation and to reduce the probability of secondary damage.

Response activities are normally in line with Preparedness activities (defined in the NETP) prepared and approved in advance. Those activities are composed of Preparedness arrangements and plans for effective measures to be taken to deal with emergencies and disasters if and when they do occur, to act during or immediately after a disaster, and to be able to manage the consequences of a disaster. This is important to ensure that the public emergency works to support search and rescue operations, emergency medical delivery and the evacuation process so as to minimize suffering and loss of life.

A pro-active approach is imperative. As soon as it becomes apparent that a disaster needs telecommunications equipment and/or expertise, emergency telecommunications planners should immediately initiate the activation of the emergency telecommunications response plan. If necessary, planners should activate their emergency operation centre. Precious time and high costs result from a reactive rather than pro-active stance.

The main activities during the response phase are the following:

– evaluate which are the available telecommunication infrastructures after the disaster;

– allow the availability of the communications between the various involved organizations;

– operate to face the disruptive effects of emergencies on telecommunications services and networks;

– facilitate the operation of international, inter-governmental and telecommunications organizations;

– facilitate the use of the spare telecommunications equipment to ensure the availability of telecommunications according to the emergency requirements;

– facilitate the tasks and the steps of deployment of equipment supplied by national and international organizations;

– facilitate the availability of the new radiofrequency necessary for the response operations;

– facilitate the deployment of the new earth satellite stations and terminals;

– collection of data from the warning systems.

9.4 National Emergency Telecommunication Plan (NETP)

9.4.1 Why a National Emergency Telecommunication Plan (NETP)

The preparation of a National Emergency Telecommunication Plan (NETP) is the necessary completion of the activities listed in the previous Sections.

Preliminary questions to the preparation of a NETP are the following: "which is the value of a NETP?" "Why not wait until something happens, evaluate the situation, and then decide how to react?" There is an old adage that says, "Practice makes perfect." In almost any field of endeavour where people seek to perform at their best, they practice first. Why? Because while practice can't simulate all the things encountered in a game, it helps prepare people to react properly to whatever they may encounter. The same holds true for practicing for disasters.

It is impossible to know what form the next disaster will take, but individuals and organizations can learn how to respond, whatever the conditions, by practicing responding to a variety of disasters. Having completed the planning process, an organization is better able to respond quickly and efficiently to a disaster. They know the steps to take and the contacts to make to begin the recovery effort. With the stakes so high, no communications provider can afford to wait for a disaster to strike before formulating recovery plans.

A NETP consists of all the activities that aim to protect the availability, at any time, of telecommunications systems in the case of the natural disasters. This plan also includes the measures taken to guarantee the availability of telecommunication systems for the institutional structures charged with the protection of the public (Police, fire brigades, emergency medical service, etc.).

A National Emergency Telecommunication Plan is mainly based on:

– the typology of the hazards which have had an impact on the country in the past;
– the data collection concerning the resources available by identifying the infrastructures of essential and critical telecommunications;
– the identification of the vulnerabilities of the critical infrastructures and their protection;
– the reduction of the vulnerabilities of the existing infrastructures;
– the implementation of legislation/regulations which facilitates the provision of the resources of telecommunications for the prevention and the management of the disasters;
– the identification of the various actors of the emergency telecommunications.

The activities carried out within the framework of the National Emergency Telecommunication Plan involve several administrations and companies. None of the institutions involved have the mandate, in its structure, to lead all these activities. The realization of these activities can be effective only through collaboration or a dialogue between the various participants.

To bring these activities to a successful conclusion, it is thus necessary to set up a National Committee for Emergency Telecommunications (NCET) in which all the organizations involved in the emergency telecommunications are represented. The NCET establishes a platform for a dialogue among all the involved organizations in order to facilitate the implementation of the National Emergency Telecommunications Plan.

The National Emergency Telecommunication Plan is part of the National Emergency Plan (NEP) prepared by the National Committee for the Emergency Plans (NCEP).

An example of NEP is shown in Annex 9A3.

9.4.2 Necessary actions to put in place a National Emergency Telecommunication Plan

The necessary actions to put in place a NETP are summarized below.

9.4.2.1 Objective: Adapt the infrastructures of telecommunications to the management of the disasters and the emergencies:

Activities:

– identify the vulnerabilities of the telecommunication networks;
– implement a plan of priority of the calls in the public networks;
– set up an integrated management system of emergency calls and location of appellants;
– set up systems of premature alert;
– set up a system of communication independent from that usable public network by all the participants in case of disaster;
– set up a geographical information system (SIG) of high-risk areas;
– set up monitoring system of the natural phenomena;
– management of frequencies and control of the interferences.

9.4.2.2 Objective: Adapt the legal and statutory framework to the use of Telecommunications for the management of the disasters.

Activities:

– Adapt the legislation and the telecommunication regulation to prevent and to manage the disasters;

– Amend the legislation and the regulations of the management of the disasters to take into account the role of telecommunications.

9.4.2.3 Objective: Make available the necessary equipment

Activities:

– Purchase and maintenance of the emergency equipment.

9.4.2.4 Objective: Coordinate the use of the resources of telecommunications for the management of the disasters

Activities:

– Create a National Committee for the Emergency Telecommunications;

– Set up the National Emergency Telecommunications Plan;

– Sign agreements of mutual assistance or partnership between stakeholders;

– Realize an inventory of the resources of emergency telecommunications.

9.4.2.5 Objective: develop the human resources for the emergency telecommunications

Activities:

– Train the staff of the emergency telecommunications;

– Realize exercises of simulation.

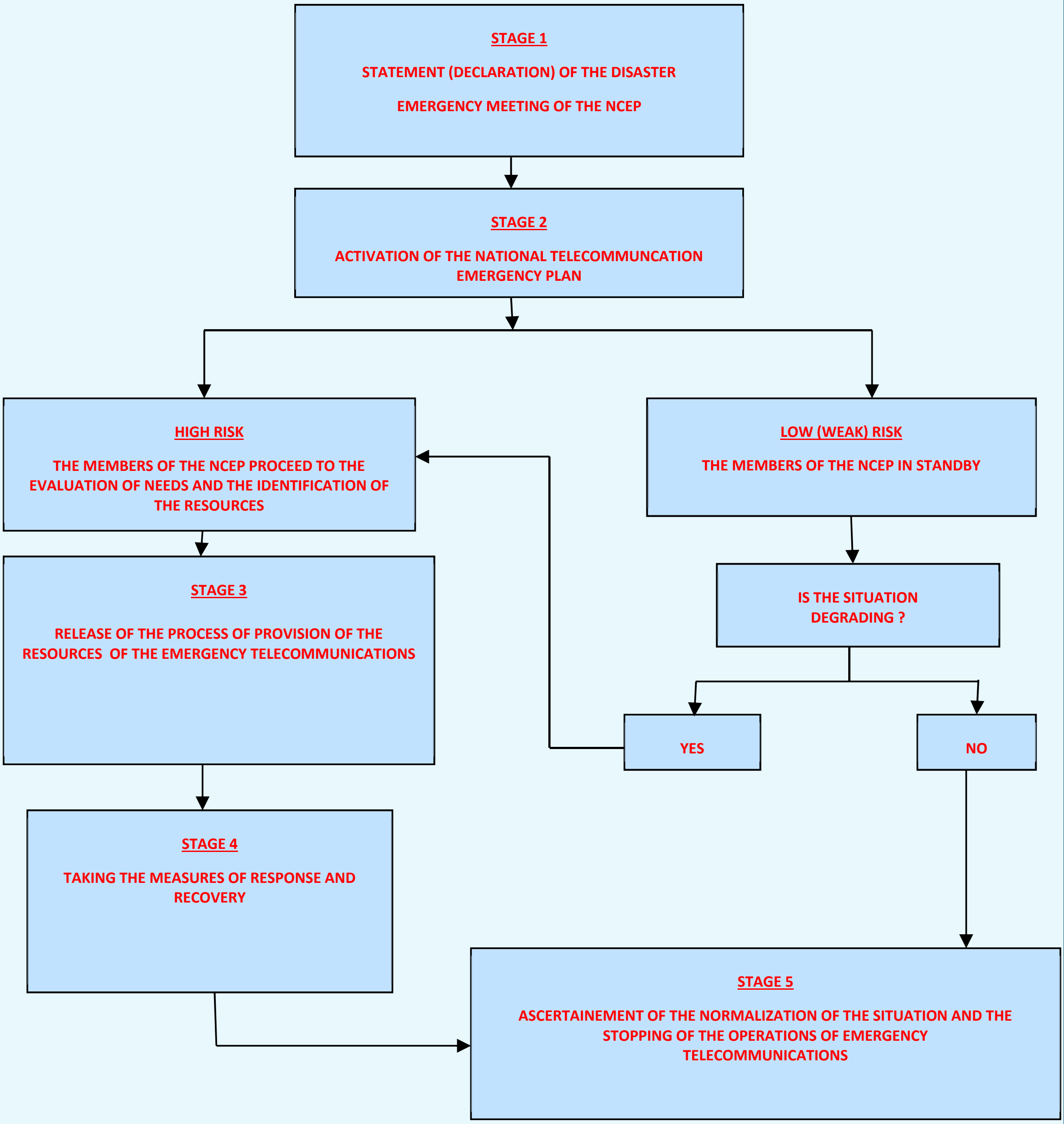
9.4.3 Procedure to implement the National Emergency Telecommunication Plan

As already mentioned, the purpose of a National Emergency Telecommunication Plan is to supply guidelines for the organization and the implementation of the means of telecommunications necessary for the answer to the disasters. It describes the actions to be led to coordinate the stake measure of the resources of telecommunications for the answer to the hazards as well as for the recovery after the disaster. It is based on the legislation and the regulations in force regarding management of the disasters on one hand, and telecommunications on the other hand.

The resources of available telecommunications for the implementation of this plan are the ones belonging to all the organizations involved in the emergency telecommunications. The way to put at disposal the resources of telecommunications for the relief operations in case of emergency is coordinated by the National Emergency Telecommunication Plan which also specifies the responsibilities of the various organizations involved in the emergency telecommunications in the implementation of the above-mentioned plan.

Figure 9-1 shows an example of process for putting in operation a National Emergency Telecommunication Plan.

Figure 9.1: Process for putting in operation a National Emergency Telecommunication Plan



Conclusion

Disasters are rare events, and while some may view management for such events as unnecessary overhead, history has demonstrated that although the possibility of a disaster striking is small, it is not zero. The indisputable importance of communications in today's societies requires a strong commitment to timely restoration in times of disaster. At this purpose a key element is the preparation of a National Emergency Telecommunication Plan.

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Annex 9A1: Actions in Cameroon to reinforce the resistance in the disasters

9A1.1 Strategic actions of the National Emergency Telecommunication Plan in Cameroon

The analysis made on the state of emergency telecommunications in Cameroon highlighted inadequacies in this domain. There are no adequate resources to manage telecommunications when there are disasters on emergency situations. This problem is related to four main causes and numerous primary causes with direct effects in the mismanagement of the disasters, with material losses and human lives.

With regard to what precedes, the following strategic actions have emerged for the National Emergency Telecommunication Plan.

9.A1.1.1 1st Strategic action: building networks, aid services and emergency services

– strengthen the infrastructure, the covering and the functioning of the aid networks and services, of the electric radio services of help and safety of the human life, of the air and maritime radio navigation, of the telecommunication networks of the national safety and the protection of the public, to support and contribute to the works of mitigation of the effects of the disasters;

– strengthen the infrastructure, the covering and the functioning of the electric radio systems assistant to the meteorology, the seismic and volcanic alarm systems, and the systems of detection of the natural phenomena;

– strengthen the infrastructure, the covering and the functioning of the telecommunication networks of the operational entities of the help and the national emergency telecommunication networks, as well as the telecommunications networks of the regional and local committees of management of the disasters, in particular in the high-risk zones;

– strengthen and promote in an appropriate and effective way, the supply of the service of alert and public information, supported by the public telecommunication networks to guarantee the communication between the citizens and the authorities in case of emergency;

– strengthen and promote, in an appropriate and effective way, the supply of the priority service in case of emergency, supported by the public telecommunication networks, to facilitate the communication between the governmental authorities and between the organizations of the first aids.

9A1.1.2 2nd Strategic action: building telecommunication networks and services for the mitigation of disasters

– strengthen the infrastructure, coverage and operation of public networks and promote an appropriate and effective basic public service telecommunications, such as fixed and mobile telephony, to ensure communications during an emergency or a disaster;

– strengthen the infrastructure and operation of broadcasting stations and promote in a timely and effective manner, the provision of public broadcasting service such as radio and television, to ensure the dissemination of information to the public for the prevention of disaster and for relief /disaster recovery after the disaster. This is also to promote the use of spaces for the dissemination of social programs, the proper use of mass media for prevention, relief and recovery;

– strengthen the infrastructure and operation of public telecommunications networks and promote the provision of value added services such as Internet and broadband systems, to facilitate communications in emergencies and disasters;

– strengthen the infrastructure and operation and promote the provision of services of amateur radio and citizens band, to contribute to the disaster management;

– promote and strengthen the network infrastructure of institutional and official state government entities, of the telecommunications networks to support the public service, of the telecommunication networks of strategic economic institutions and of other private networks, to ensure the availability of telecommunications in emergencies, and to protect and preserve the national infrastructure.

9A1.1.3 3rd Strategic action: promoting development of the sector

– promote the development of the entities of the telecommunications sector in order to facilitate the prevention of the disasters, the help in case of disasters and the recovery after the disaster.

Annex 9A2: Natural typology of the disasters in Cameroon

Table 9A2-1 presents the typology of the natural disasters occurred in Cameroon during the last 30 years.

Table 9A2-1: Typology of the natural disasters in Cameroon

Type of disasters	No.	Concerned Regions	Locality and years	Damages
Volcanic Eruptions	2	South West	Buea (Mont Cameroon), 1998 et 1999	300 million damages
Floods	9	Centre, Adamaoua, South West, North, Far-North	Limbe, Garoua, etc.	10 people died, 200 Farming victims, 20 houses destroyed
Landslides	9	South-West, East, South, Center, West and Littoral	Bafaka-Balue 1995, Garoua-boulai 1996 et 1998, Mont Bankolo 1986	10 died, 50 destroyed plantations of cocoa, 180 million FCFA of damages.
Tornados, thunderstorms and lightnings	22	Center, East, North-West, Adamaoua, South, South-West, West, North	Nkolgal (1986), Nguelemendouka (1994), Tignere (1995), Ambam (1995), Garoua (1994), Boumnyeyebel (2000), Dibang (2000), Bamusso (2000), Ebolowa (2004)	2272 victims, 482 destroyed houses, 100 decimated heads of cattle, 54 million FCFA of damages, fields gobbled up in waters.
Fire	20	All Provinces	Marché Mokolo 1999, Mvog-Ada 1995, Edéa 1994, Bafoussam 1999, Sangmelima 1995, Douala 1992, Batouri et Maroua 1995, Nsam Effoulan 1998, Marché de Maroua 2000	Shops and destroyed supermarkets, losses in human lives

Annex 9A3: Organization of the management of the disasters in Cameroon

9A3.1 Management Roles

The "Ministère de l'Administration Territoriale et de la Décentralisation (Direction de la Protection Civile)» is charged with the coordination of the national and international actions in case of disasters in contact. This, of course, with the authorities and the other administrations involved in the management of crisis situations.

Other organizations involved in the management of the disasters are: the "Police Nationale, the "Ministère de la Défense (Gendarmerie et Corps National des Sapeurs Pompiers) », the « Ministère de la Santé Publique (SAMU) », the « Ministère de la Recherche Scientifique et de l'Innovation (IRGM et INC) », the « Croix Rouge Camerounaise », the « Haut Commissariat des Réfugiés (HCR) », the «Fonds des Nations Unies pour l'Enfance (UNICEF) », the « Programme des Nations Unies pour le Développement (PNUD) », the « Organisation Mondiale de la Santé (OMS) », the Fédération Internationale de la Croix Rouge et du Croissant Rouge (FICR) », etc.

The main structures of intervention and management are shown in Figure 9A3-1.

9A3.2 Role of the sector of telecommunications in the management of the disasters

– Ministry of Post and Telecommunications

The Ministry of Post and Telecommunications is responsible for the elaboration and for the implementation of the policy of the Government regarding the telecommunications, the technologies of information and the communication. In this framework several measures have been taken to guarantee the supply of the services of emergency telecommunications in Cameroon. In particular the creation of a department of emergency telecommunications which guides a project concerning the emergency telecommunications.

– Agency of Regulation of the Telecommunications (ART)

The Agency insures on behalf of the State, the regulation, the control and the follow-up of the activities of the operators of the telecommunications sector. In this framework it deals with license applications and prepares the related decisions. Moreover measures are taken to integrate into the technical specifications of the networks operators the requirements necessary for the supply of service of telecommunication emergency, in particular:

- the free emergency calling services (17, 117, 18, 118);
- the commitment of the operators to arrange measures of prevention and mitigation of the effects of the hazards;
- the attribution of authorizations to the radio bands;
- the organization of seminars and conferences to make sensitive and insure a better supply of the service of emergency telecommunications. The Agency has among others missions, the management of the coastal station of Douala to protect and insure the safety of the offshore human lives.

– Operators of the telecommunication networks

The operators of the telecommunication networks are called to collaborate with the Government for the deployment of their networks to guarantee the continuity of service in case of disaster.

– Media

In a general way, in case of disaster, the information is broadcasted on the Television and on the Radio. Several organs of media are involved.

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Printed in Switzerland
Geneva, 2014

01/2014