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ITU-T Focus Group on Disaster Relief Systems, Network Resilience and Recovery

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Technical Report on Telecommunications and Disaster Mitigation

Focus Group Technical Report

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The procedures for establishment of focus groups are defined in Recommendation ITU-T A.7. The ITU-T Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR) was established further to ITU-T TSAG agreement at its meeting in Geneva, 10-13 January 2012. ITU-T Study Group 2 is the parent group of FG-DR&NRR.

Deliverables of focus groups can take the form of technical reports, specifications, etc. and aim to provide material for consideration by the parent group or by other relevant groups in its standardization activities. Deliverables of focus groups are not ITU-T Recommendations.

SERIES OF FG-DR&NRR TECHNICAL REPORTS

Technical Report on Telecommunications and Disaster Mitigation

Contents

Preface

This technical report is the first report of the ITU-T Focus Group on Disaster Relief Systems, Network Resilience and Recovery (FG-DR&NRR). It presents a number of case studies of the performance of public telecommunications systems in recent disasters along with a review of the activities concerned with the use of telecommunications for disaster mitigation and the standards that have been developed by various organizations.

1. Introduction

Natural disasters appear to have been increasing in frequency [1]. Figure 1 shows that the number of natural disasters reported to have occurred increased dramatically over the second half of the 20th century. However, it is not all bleak news as there also appears to be a decrease in the number of people reported as being killed in natural disasters over the same period (Figure2), although the numbers of people affected by these disasters (Figure 3) and the associated economic costs (Figure 4) have increased dramatically. Over the last decade 3,852 natural disasters have killed 780,000 and affected 2,000 million people and cost at least US$960,000 million [2].

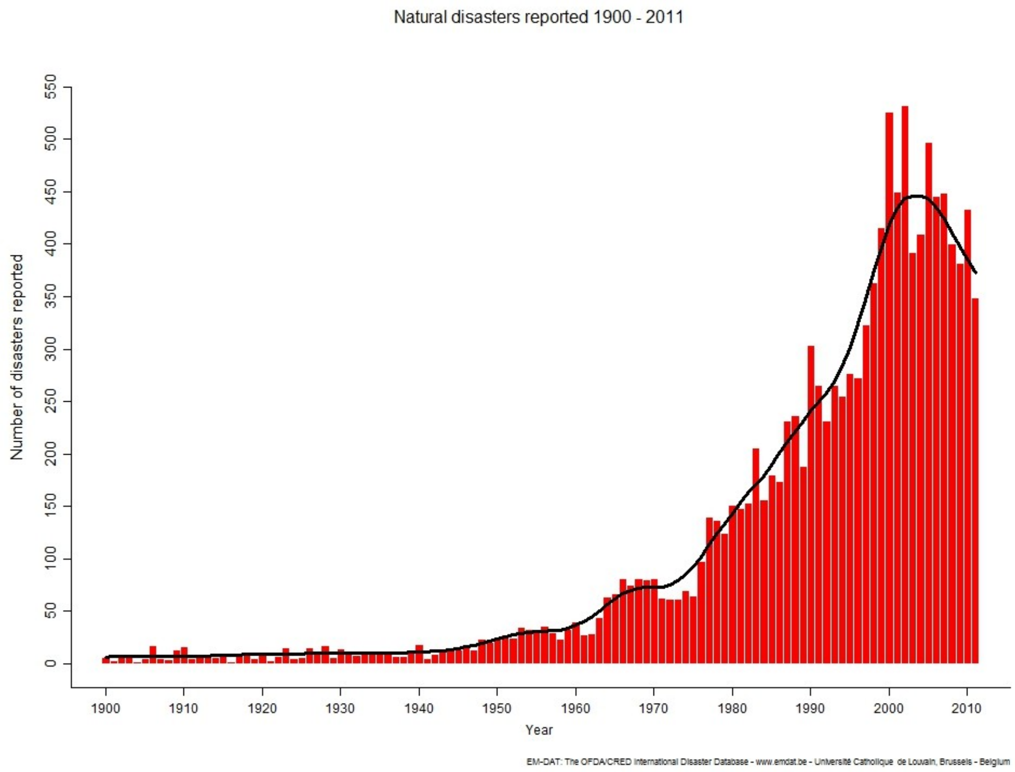

Figure 1. The numbers of natural disasters reported from 1900 to 2011.

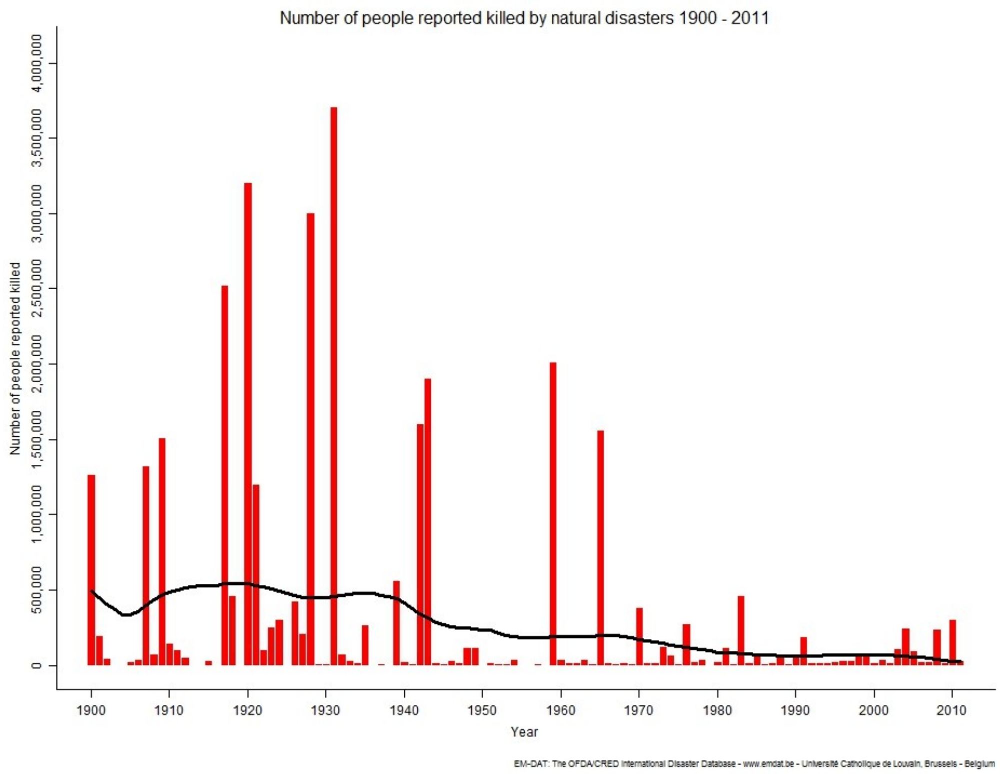

Figure 2. The numbers of people reported as being killed by natural disasters 1900 – 2011.

Some of the peaks shown in Figure 2 correspond to particularly devastating disasters such as the:

- 1931 flooding of the Yellow and Yangtze rivers in China that led to the deaths of almost 4 million people;
- 1970 Bhola cyclone in the Ganges Delta of Bangladesh that killed about 500,000;
- 1976 Tangshan (China) earthquake with approximately 240,000 fatalities
- 2004 Indian Ocean tsunami,
- 2008 Cyclone Nargis that affected Myanmar and the Sichuan earthquake in China; and
- 2010 Haiti earthquake.

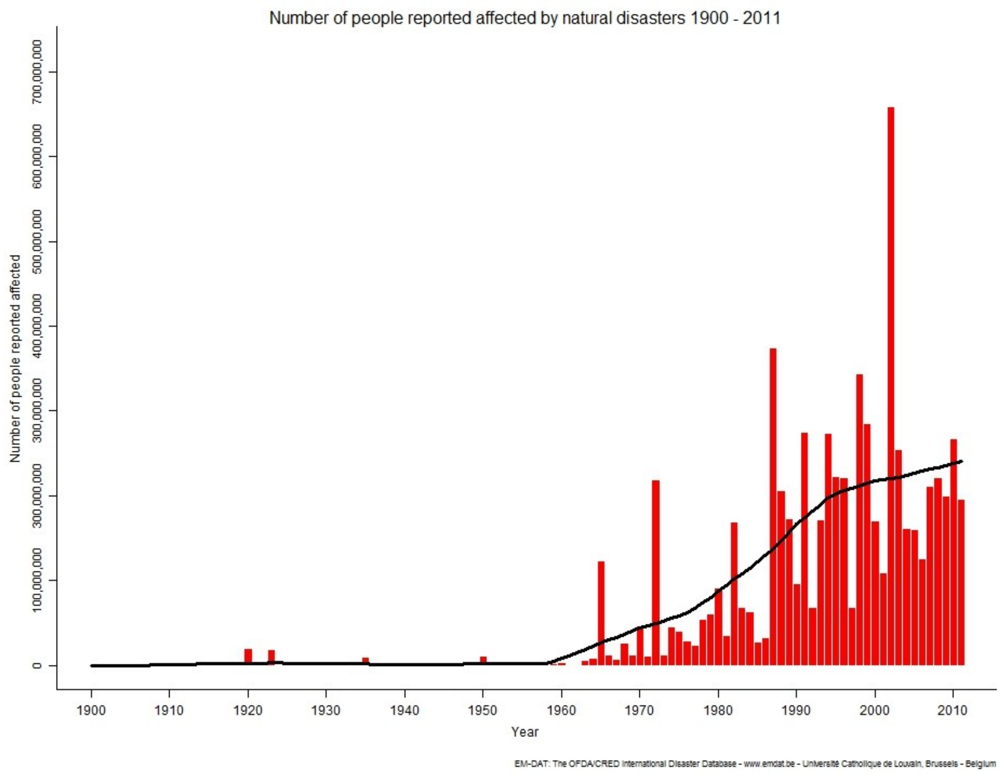

Figure 3. The numbers of people affected by natural disasters 1900-2011.

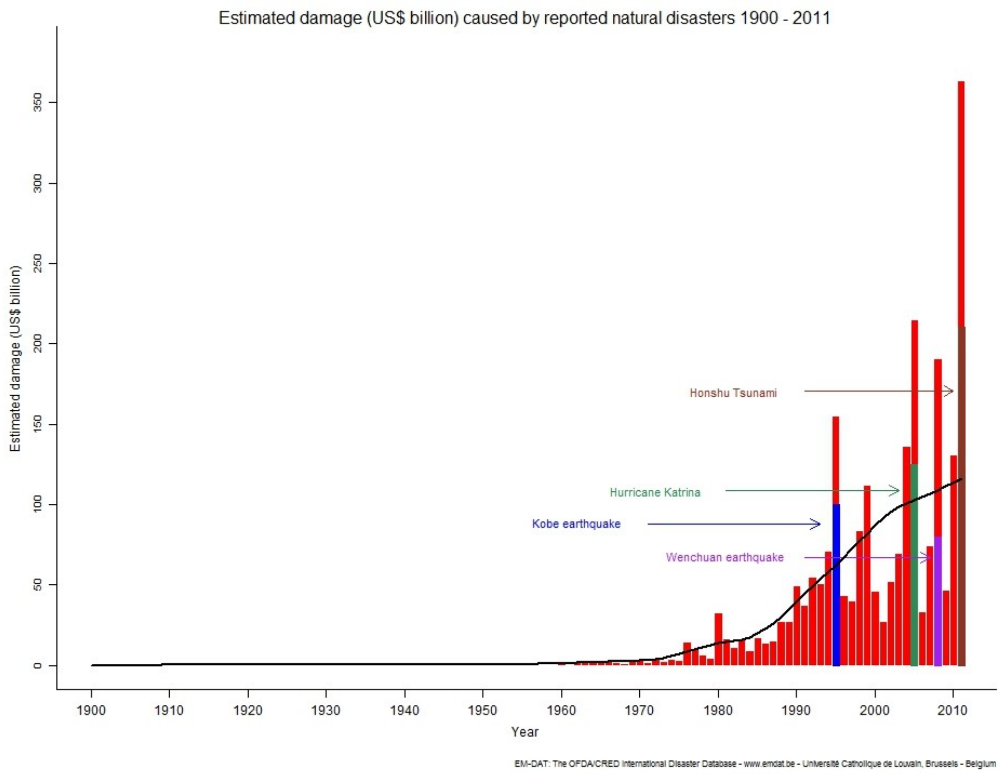

Figure 4. The estimated economic costs of damage caused by natural disasters 1900 – 2011.

Natural disasters impact developing and developed countries in different ways with greater numbers of people being killed and affected in developing countries and greater economic costs being experienced by developed countries. This reflects the greater investment in infrastructure in developed countries and also their ability, based on strong institutions, to minimize casualties. Whether a natural hazard results in a disaster is at least partly determined by whether authorities have taken action to prevent or respond in an appropriate manner to hazardous natural phenomena. “Risk is a function of the hazards to which a community is exposed and the vulnerabilities of that community. However, that risk is modified by the level of the local preparedness or capacity of the community as risk.” [3]

$$\text{Risk} \propto \frac{\text{Hazard x Vulnerability}}{\text{Capacity}}$$

Table 1 shows the numbers of people killed and affected by disasters and the economic costs of disasters by region according to the level of economic development, between 1991 and 2005.

Region	**Number killed**	**Number affected**	**Economic damages (2005 US$ 10^9)**
OECD	61,918	37,723,852	714.61
CEE & CIS	10,412	25,848,223	50.35
Developing countries	630,106	3,035,655,591	379.15
Least developed countries	254,739	368,673,811	22.61
Countries not classified	3,327	2,261,484	26.22
Total	**960,502**	**3,470,162,961**	**1192.95**

Table 1. Numbers of people reported killed and affected by disasters and reported economic damages by level of development, 1991 – 2005 [4].

Earthquakes and storms are, of course, a natural part of the behaviour of the earth-system but climate change resulting from human activities is also causing an increasing number of disasters. It has been estimated that 300,000 people are dying annually due to environmental degradation, drought and flooding brought about by extreme weather conditions, with some 325 million people being affected [5]. Environmental degradation is increasing hunger, disease and poverty and in some instances causing human displacement and posing a threat to political stability.

Natural disasters cause significant displacement of people. More than 36 million people were displaced by sudden-onset natural disasters in 2008, of which over 20 million were displaced due to climate-related disasters [6].

The global estimates for newly displaced people are given in Table 2.

Type of disaster	2008	2009	2010	2011
Weather	20.3	15.2	38.3	13.8
Geophysical	15.8	1.5	4.0	1.1
Total	**36.1**	**16.7**	**42.3**	**14.9**

Table 2. Global estimates of newly displaced people - 2008 – 2011 (millions) [7].

Disasters are most commonly caused by flooding. 182 floods, 83 storms, 29 extreme temperature events, 25 landslides, 23 earthquakes (including tsunamis), 14 droughts, 7 wild fires, 6 volcanic eruptions and 4 avalanches were reported in 2010 [4]. Figure 5 shows the number of natural disasters classified according to type between 1900 and 2011.

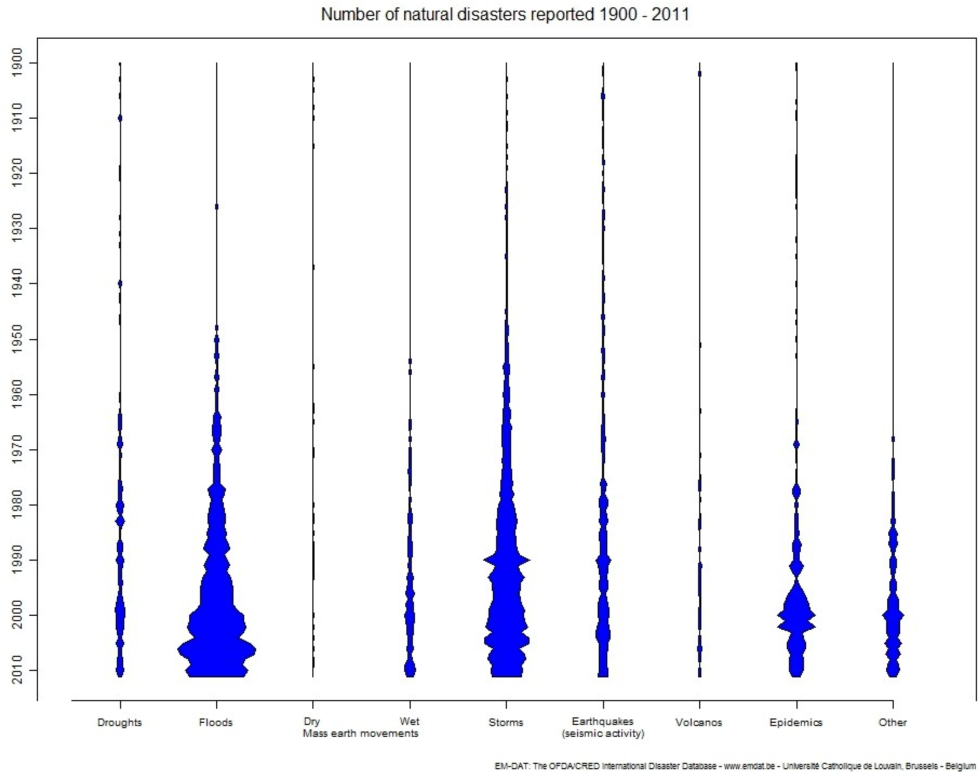

Figure 5. The number of natural disasters, 1900 – 2011, classified according to type.

90% of the 7500 disasters occurring between 1980 and 2007, accounting for 71% of casualties and 78% of economic losses were caused by weather-related hazards such as droughts, floods, windstorms, tropical cyclones, storm surges, extreme temperatures, land slides and wild fires, or by health epidemics and insect infestations directly linked to meteorological and hydrological conditions (see Figure 6) [8].

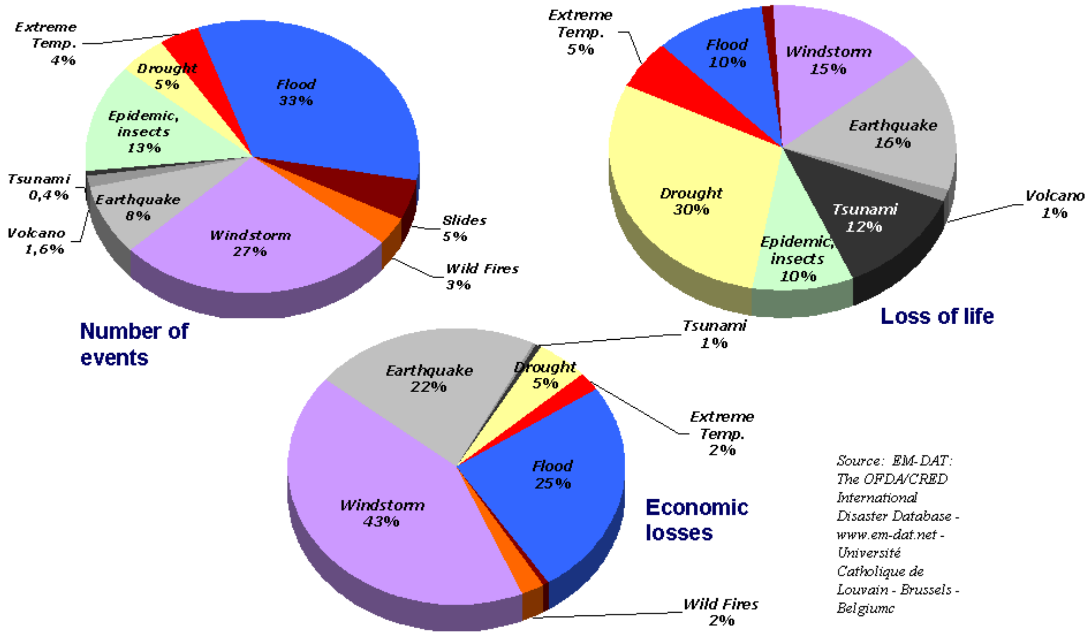

Figure 6. The causes of disasters and their impact in terms of fatalities and economic losses, 1980 – 2007 [8].

The trends in economic loss and loss of life in the past decades due to natural hazards are shown in Figure 7.

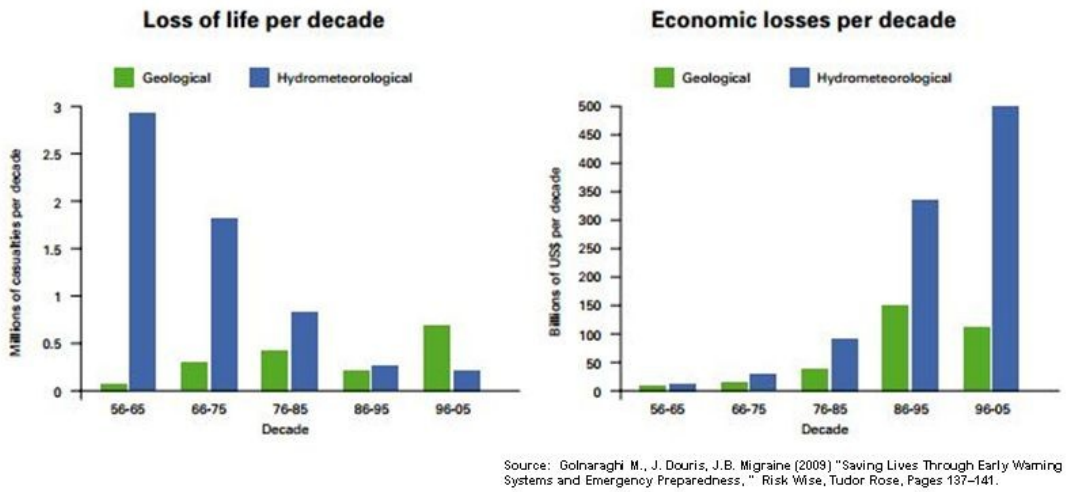

Figure 7. Trends in economic loss and loss of life in the past decades due to natural hazards [8].

Hazards are not only environmental but also technological and societal. The World Health Organization has classified hazards as follows [9]:

- Natural
  - e.g. Earthquake, landslide, tsunami, cyclones, flood, drought.
- Biological
  - e.g. Disease epidemics (such as SARS, influenza and cholera), pest infestations.
- Technological
  - e.g. chemicals, radiological agents, transport accidents.
- Societal
  - e.g. Conflicts, acts of terrorism, population displacement.

The World Health Organization notes that a study in Latin America found that that there were 20 disasters that were not recorded for each of those recorded in global disaster databases and that the cumulative impact on the poor of these local disasters was greater than any one major event.

The International Federation of Red Cross and Red Crescent Societies has estimated that some 10,000 people were killed and 500,000 affected by chemical, biological, radiological or nuclear disasters between 2000 and 2011 [10]. The Chernobyl nuclear accident in 1986 affected some 8 million people.

Telecommunications plays a critical role in environmental monitoring, dissemination of warnings, and in the coordination of relief operations. The three sectors of the ITU - the Radiocommunication, Development and Standardisation Bureaus have been active in producing technical specifications for emergency telecommunication systems, promoting the use of telecommunications for disaster mitigation and providing assistance in emergencies. The ITU-D produced a “Handbook on Disaster Communications” in 2001 and updated this with a “Handbook on Emergency Telecommunications” in 2005. This handbook discusses the organizational and regulatory frameworks for emergency telecommunications, reviews various telecommunications network technologies and presents appropriate radiocommunication technologies for disaster relief. The ITU-R published a Special Supplement on “Emergency and Disaster relief” in 2006 that describes ITU-R Study Group activities and reproduces all of the ITU-R texts concerning radiocommunications for emergency and disaster relief, including Radio Regulation texts, ITU-R Recommendations and Reports. In 2007 a “Compendium of ITU’s work on Emergency Telecommunications” was published which incorporates the ITU-D and ITU-R handbooks and also includes a section on the activities of the ITU-T and copies of relevant ITU-T Recommendations. This compendium, therefore, includes the text of all ITU-R and ITU-T Recommendations concerned with emergency telecommunications and disaster relief that were available at that time.

The focus of this report is on the use, resilience and recovery of public telecommunication network infrastructures during disasters. Chapter 2 describes a number of recent disasters, both natural and manmade, and presents information on the performance of public telecommunication systems under stress. This is followed by a consideration of the requirements for public telecommunication networks in disaster relief and network resilience and recovery. There then follow chapters on international disaster relief initiatives and on the work of the ITU related to this topic. ITU-T Recommendations in particular are reviewed as are the activities concerning emergency telecommunications of other standardization organizations and telecommunications industry forums.

2. Case studies

2.1 Japan - the 2011 earthquake and tsunami[1]

2.1.1 Overview

At 05.46 UTC on 11March 2011 an earthquake registering 9.0 Mw occurred in the Pacific Ocean with an epicenter 130km east of Sendai City in northern Japan. Tsunami waves reaching 40 metres in height hit the shoreline and in places reached 10 Km inland. It was the greatest earthquake in Japan's history and caused incredible damage. Approximately 19,000 lives were lost and the cost of damages estimated at US$ 210 billion. About 370,000 houses were destroyed, nuclear power plants were severely damaged and power, water and gas supplies were cut. Approximately 1.2 million fixed telephone lines and 15,000 mobile base stations were unusable and 80% of these breakdowns in both cases were caused by widespread and prolonged power outages [13]. In May 2012 no nuclear reactors were generating power in a country that needs to import 84% of its energy. Some 30% of Japan's electricity needs were previously met by nuclear power and there were plans to increase this proportion to at least 40% by 2017 [14]. Energy efficiency and alternative energy sources (it is worth noting that wind turbines, even those in the path of tsunami, were not destroyed) are now at the top of the national agenda, as is building a resilient telecommunications infrastructure.

2.1.2 Damage to the telecommunications infrastructure

Fixed and mobile telephony services were severely impacted. NTT East's fixed network suffered damage that resulted in 385 buildings being out-of-service, 90 transmission routes were broken and 6,300 km of coastal aerial cables and 65,000 utility poles washed away or otherwise damaged. Aerial facilities fared much worse than those underground with a damage rate of 0.3% for underground facilities compared with 7.9% for aerial facilities [13]. The earthquake itself caused little damage and the tsunami destroyed outside plant and flooded buildings to account for about 20% of the damage but 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. Approximately 1.9 million fixed communications lines were affected which amounts to about 8% of lines in the area.

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[1] This section is based on information provided by the Japan Meteorological Agency and the Ministry of Internal Affairs and Communications Study Group on Maintaining Communications Capabilities during Major Natural Disasters and other Emergency Situations – Final Report December 2011 [11] and the MIC-ITU Symposium on Disaster Communications - March 2012 [12].

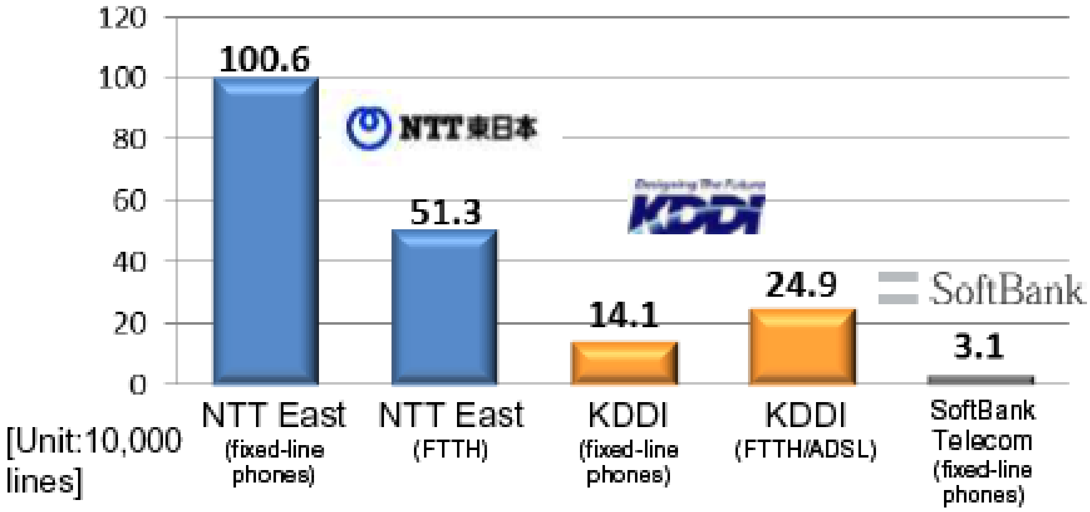


Figure 8. Maximum number of damaged fixed lines [13]

Congestion caused by the surge in call attempts to verify people's safety or to let people know of one's own safety, resulted in usage restrictions being applied to 80 to 90% of telephone calls. The number of call attempts is shown in Figure 9 and the levels of restriction applied in Figure 10.

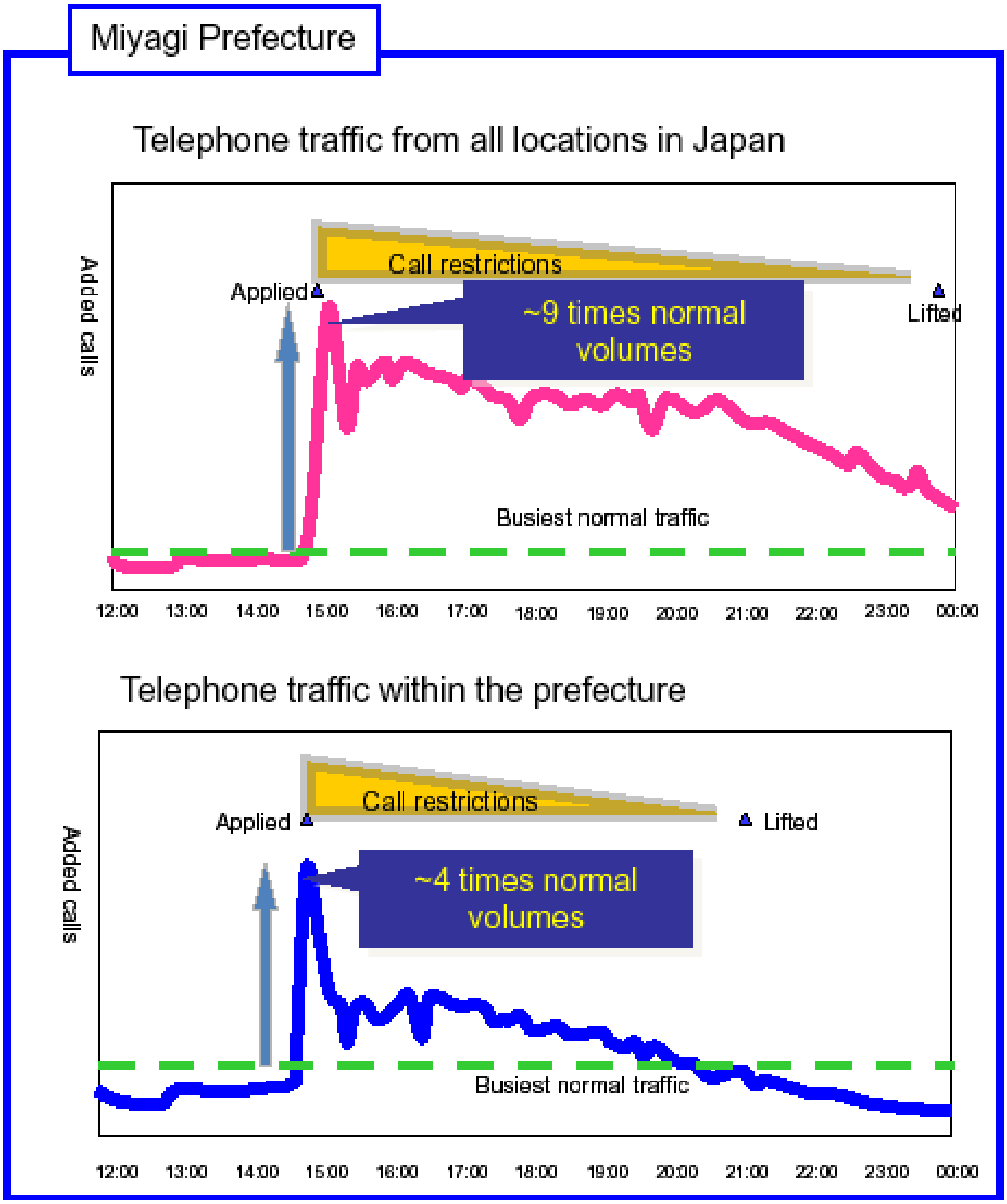


Figure 9. Call volumes in Miyagi Prefecture on March 11 [MIC].

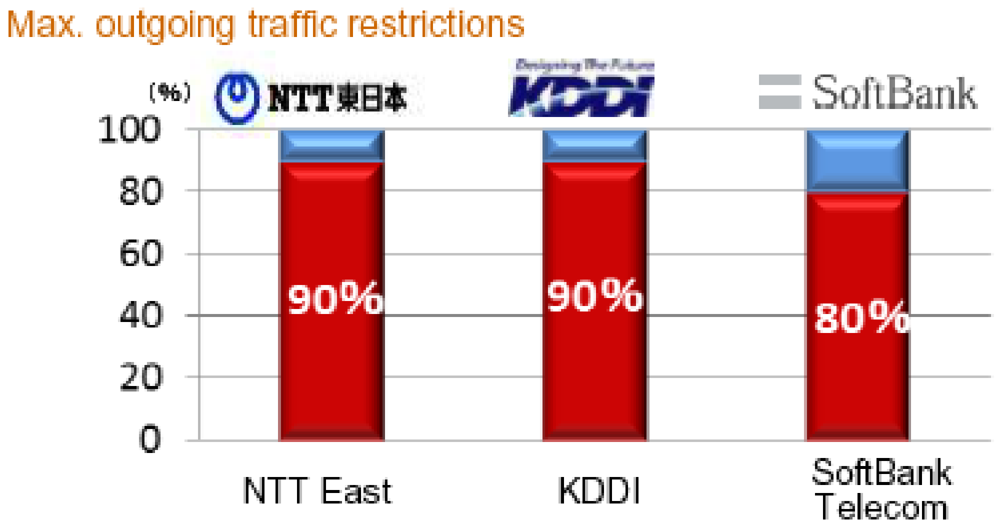


Figure 10. Fixed line congestion [13]

About 29,000 mobile base stations were shut down, amounting to about 22% of those in the affected region. KDDI reported that 1933 base stations out of 3004 in 6 prefectures in Tohoku were out of action (i.e. 64% of base stations in that area). Congestion resulted in voice traffic being restricted by 70 to 95%, although packet traffic was only restricted by 0 to 30% [13].

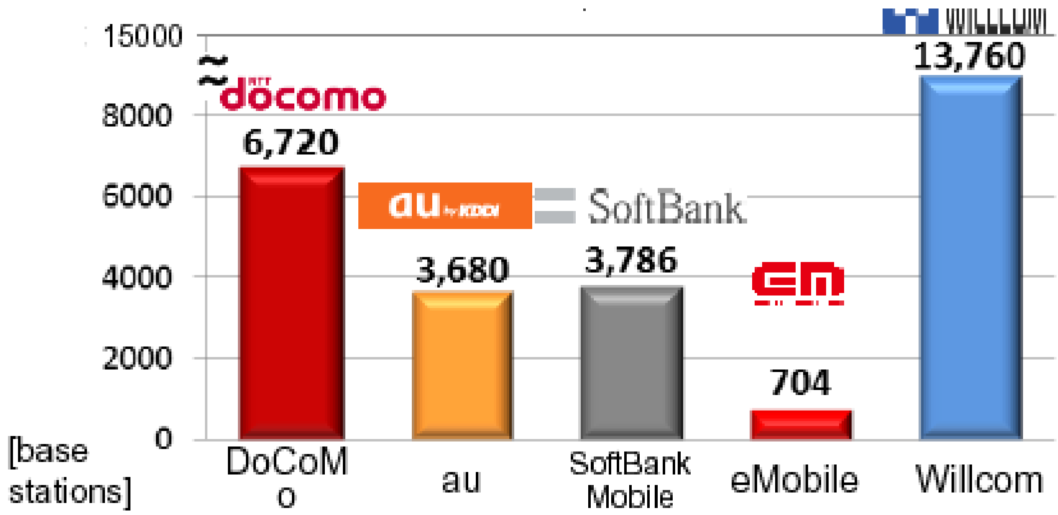


Figure 11. Maximum number of damaged mobile base stations [13]

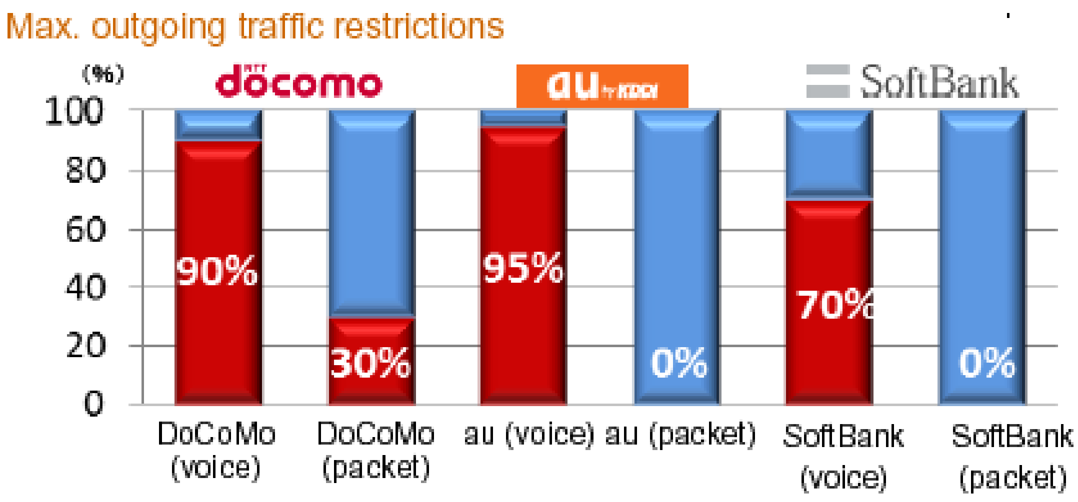


Figure 12. Mobile network congestion [13]

According to a survey by questionnaire conducted later in 2011 about 55% of respondents within the affected areas could make no telephone contact whatsoever compared with 41% in the Kanto region (Tokyo, Kanagawa, Saitama, Chiba, Ibaraki, Gunma, Tochigi). Text messages were more likely to get through as packet traffic was largely unrestricted, although they were often delayed [15]. It has also been reported that social anxiety increased when mobile contact could not be established and the inability to recharge batteries increased frustration.

It was also difficult to make contact using emergency priority calls [15] perhaps because, although priority was given to the calling party, the receiving station was damaged or the called party was occupied.

Submarine cable landing stations were damaged and fibre optic cables were cut by the tsunami. Submarine cables were also cut affecting international services (see Figure 13).

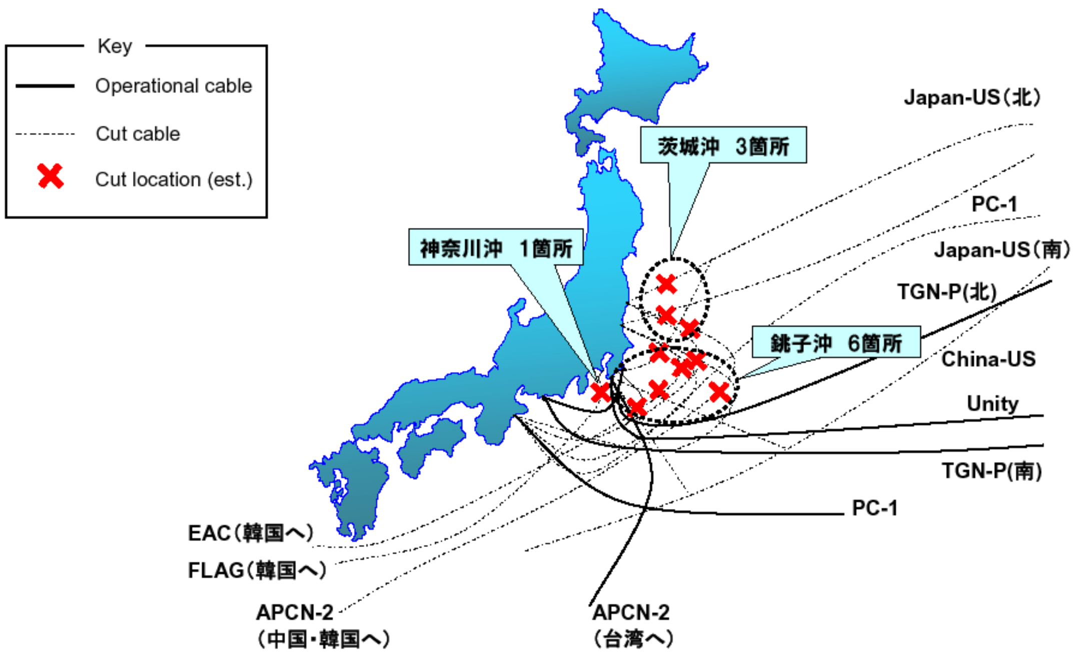


Figure 13. Damage to submarine cables. Source: KDDI corporation [16]

Om 12 March 120 TV relay stations and only 2 radio relay stations (1 in Iwate prefecture and 1 in Fukushima prefecture) were out of action [17].

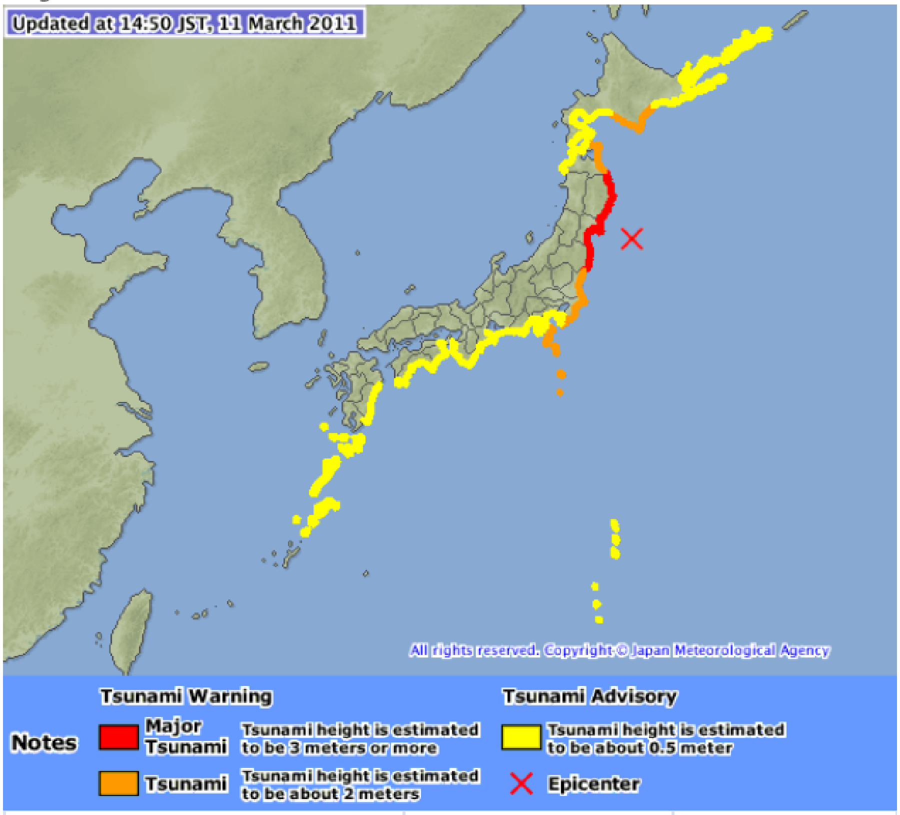
2.1.3 Information dissemination

The Japan Meteorological Agency collects data from thousands of seismometers and issues warnings on earthquakes and tsunamis. A public warning was issued 31 seconds after the earthquake was detected, followed by a tsunami warning within 3 minutes but the initial predictions of a tsunami reaching the closest land in 10 minutes underestimated the height of the tsunami (see Figure 14) and it was not until 20 minutes later that an accurate warning was given [18].

Tsunami Information (Estimated Tsunami arrival time and Height)

This Tsunami Information was issued in the past

Occurred at	14:46 JST 11 Mar 2011
Region name	Sanriku Oki
Depth	about 10 km
Magnitude	7.9



Tsunami Forecast Region	Estimated Tsunami Arrival Time	Estimated Tsunami Height
IWATE PREF.	(*1)	3 m
MIYAGI PREF.	15:00 JST 11 Mar	6 m
FUKUSHIMA PREF.	15:10 JST 11 Mar	3 m
CENTRAL PART OF PACIFIC COAST OF HOKKAIDO	15:30 JST 11 Mar	1 m
PACIFIC COAST OF AOMORI PREF.	15:30 JST 11 Mar	1 m
IBARAKI PREF.	15:30 JST 11 Mar	2 m
KUJUKURI AND SOTOBO AREA, CHIBA PREF.	15:20 JST 11 Mar	2 m
IZU ISLANDS	15:20 JST 11 Mar	1 m
EASTERN PART OF PACIFIC COAST OF HOKKAIDO	15:30 JST 11 Mar	0.5 m
WESTERN PART OF PACIFIC COAST OF HOKKAIDO	15:40 JST 11 Mar	0.5 m
JAPAN SEA COAST OF AOMORI PREF.	16:10 JST 11 Mar	0.5 m
UCHIBO AREA, CHIBA PREF.	15:20 JST 11 Mar	0.5 m
OGASAWARA ISLANDS	16:00 JST 11 Mar	0.5 m
SAGAMI BAY AND MIURA PENINSULA	15:30 JST 11 Mar	0.5 m
SHIZUOKA PREF.	15:30 JST 11 Mar	0.5 m
PACIFIC COAST OF AICHI PREF.	16:10 JST 11 Mar	0.5 m
SOUTHERN PART OF MIE PREF.	16:00 JST 11 Mar	0.5 m
WAKAYAMA PREF.	16:10 JST 11 Mar	0.5 m
TOKUSHIMA PREF.	16:40 JST 11 Mar	0.5 m
KOCHI PREF.	16:30 JST 11 Mar	0.5 m
MIYAZAKI PREF.	17:00 JST 11 Mar	0.5 m

Figure 14. Tsunami warning issued by Japan Meteorological Agency [19]

Earthquake Early Warnings (EEWs) are broadcast on TV, radio and mobile networks. Although NTT DoCoMo, au and SoftBank Mobile have supported EEW broadcasts using the Cell Broadcast Service since 2007, it was not supported on all mobile phone models.

Radio was the main source of information immediately following the tsunami. Figure 15 indicates that the majority of people in the disaster-stricken areas heard the tsunami warning on the radio or on community wireless systems and also that word-of-mouth and TV were important methods of disseminating the warning.

Did you hear tsunami warning after main quake on 3/11 ?			How did you hear the tsunami warning ?										
%	Yes	No	Radio	TV	Web site	E-mail	SNS, BBS	Twitter	Community wireless systems	Public announce -ment	Word of mouth	Other
O Residents of temporary housing												
All (500)	57.0	43.0	21.4	9.1	1.8	1.4	0.0	1.1	49.5	13.7	15.1	0.4
Sendai (125)	40.8	59.2	43.1	9.8	2.0	3.9	0.0	0.0	15.7	23.5	15.7	2.0
Natori (125)	48.0	52.0	35.0	21.7	5.0	3.3	0.0	1.7	3.3	16.7	33.3	0.0
Kesennuma (125)	71.2	28.8	9.0	6.7	1.1	0.0	0.0	2.2	80.9	4.5	4.5	0.0
Rikuzentakata (125)	68.0	32.0	11.8	2.4	0.0	0.0	0.0	0.0	69.4	15.3	12.9	0.0
O Internet users												
All (2266)	39.8	60.2	40.0	38.9	5.1	2.5	0.2	0.7	27.8	12.5	7.6	0.7
Iwate(170)	71.8	28.2	27.0	15.6	4.1	1.6	0.0	0.8	71.3	17.2	4.1	0.0
Miyagi (1628)	35.4	64.6	47.2	33.7	5.0	2.8	0.3	0.9	25.7	14.1	9.2	1.0
Fukushima (468)	43.6	56.4	27.5	67.6	5.9	2.5	0.0	0.0	7.8	5.4	5.4	0.0

Figure 15. How did people learn of the tsunami warning? [20]

Further questions to internet users about the available means of communication for information dissemination indicate that radio and TV were by far the most available (see Figure 16).

%	Radio	TV	Car navigation system	Mobile phone call	Fixed phone call	E-mail	Twitter	SNS, BBS	Web site	Video site	Community wireless systems	Public announce -ment	Family, Neighbor, Friend	Others	could't get any informa -tion
All(1677)	**47.6**	**40.4**	2.2	2.7	0.1	1.9	1.6	0.4	3.2	0.2	8.6	6.6	11.4	1.7	12.8
Iwate(143)	**45.5**	**25.9**	4.2	3.5	0.0	1.4	0.7	0.0	3.5	0.0	28.7	11.9	13.3	0.7	15.4
Miyagi(1159)	**52.1**	**34.3**	2.2	2.4	0.0	1.5	2.1	0.6	2.4	0.3	7.9	6.6	12.9	2.0	14.2
Fukushima(375)	**34.7**	**64.5**	1.6	3.5	0.3	3.5	0.5	0.0	5.6	0.0	3.2	4.5	6.1	1.1	7.2

Figure 16. How could you get information on tsunami at the time of evacuation? (Internet users only who evacuated from the tsunami on 3/11)

The available information tools were very much affected by the damage caused by the tsunami. Figure 17 shows the availability of information tools before and following the tsunami based on a survey of 3000 people in the affected districts [21].

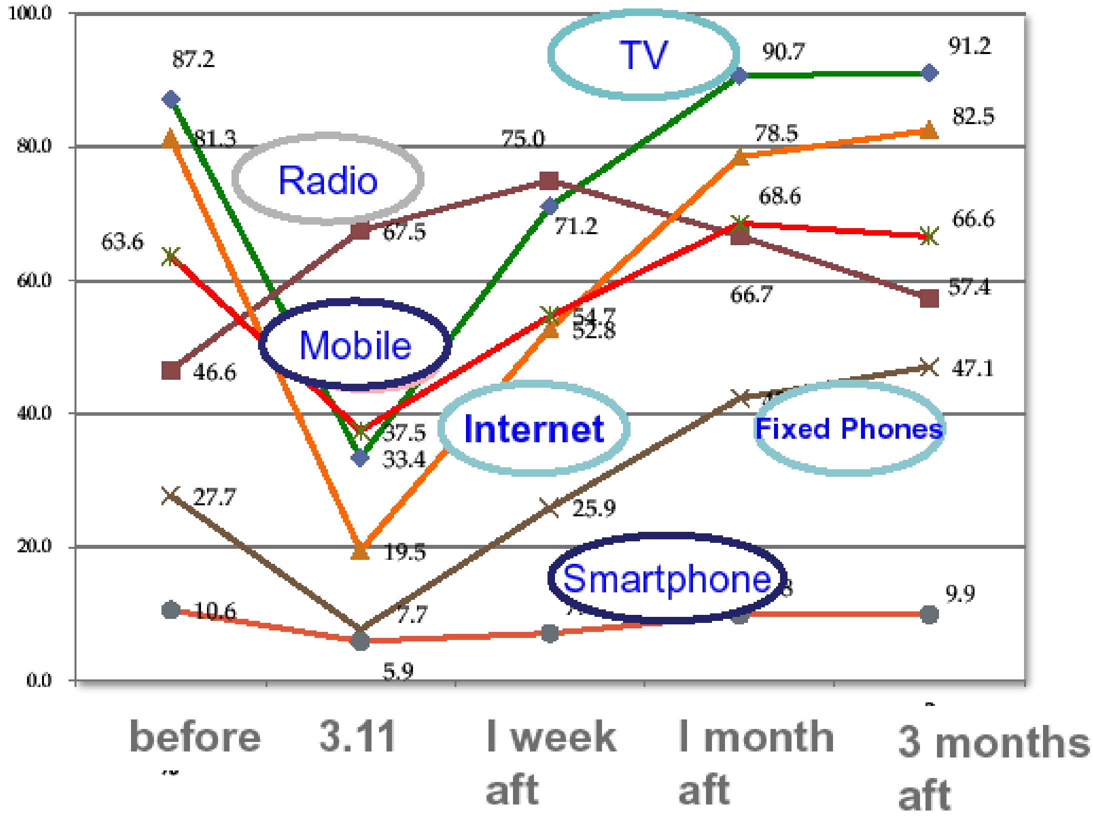


Figure 17. Available information tools [21]

Use of the internet decreased significantly directly following the earthquake due to infrastructure damage but more use was made of email (5 times normal level), social networking sites, such as Twitter and mixi, and Skype, although some of these services are not so widely used in Japan. For example, internet telephony “softphones” (such as Skype) are used by only about 2.7% of the population [22]. Some studies have also reported that, as might well be expected, “misinformation was also rampant on the internet in the midst of the confusion following the earthquake” [20].

Use was made of NTT East’s Disaster Emergency Message (Dial 171) and Disaster Emergency Broadband Message Board (web 171) services that allow people to leave messages confirming their personal safety. In addition, mobile operators (NTT DoCoMo, KDDI, Softbank Mobile, eAccess, Willcom) provide message boards. These services are activated at times of disaster and as an alternative means of conveying safety confirmation messages decrease the number of telephone network call attempts. As of 31 May 2011, Dial171 had been used approximately 3.33 million times, web171 approximately 2.3 million times, and mobile message boards had been used 5.8 million times [15]. However, a survey has indicated that 21% of all respondents were unaware of the availability of these services and that 91% did not use them.

The general conclusion reached by studies of how people received information and communicated during the crisis is that media diversity is extremely important for relaying information in disaster-stricken areas.

2.1.4 Restoration of Telecommunication Services

Although the telecommunications infrastructure was severely impacted the damages affected fewer households than the damages to other utilities such as power and water supply and the recovery time was shorter than for these services (see Table 3). It is important that the telecommunications infrastructure is more resilient than other utility infrastructures as ICT is used both to support these other services and is critical in the overall recovery process

Social Infrastructure	Damage (# of Houses)	Recovery (days)
Power Grid	8.5 Millions	99
City Gas	2.0 Millions	54
Water Supply	2.3 Millions	Not completed by the end of July, 2011
Telecommunication	1.0 Millions	56

Table 3. Damages to social infrastructure
[http://www.bousai.go.jp/jishin/chubou/higashinihon/8/4.pdf]

As can be seen in Figure 18 the majority of lines were lost due to loss of power and significant recovery was achieved within ten days. The glitch on 7 April is the result of an aftershock off the Miyagi coast. Public telephony and internet services were provided free of charge at evacuation centres and calls from public call boxes were treated as emergency priority calls. Satellite links were used to bypass damaged trunks and satellite phones were distributed by the MIC to local government authorities for use in the recovery effort, to organize evacuees and manage reconstruction.

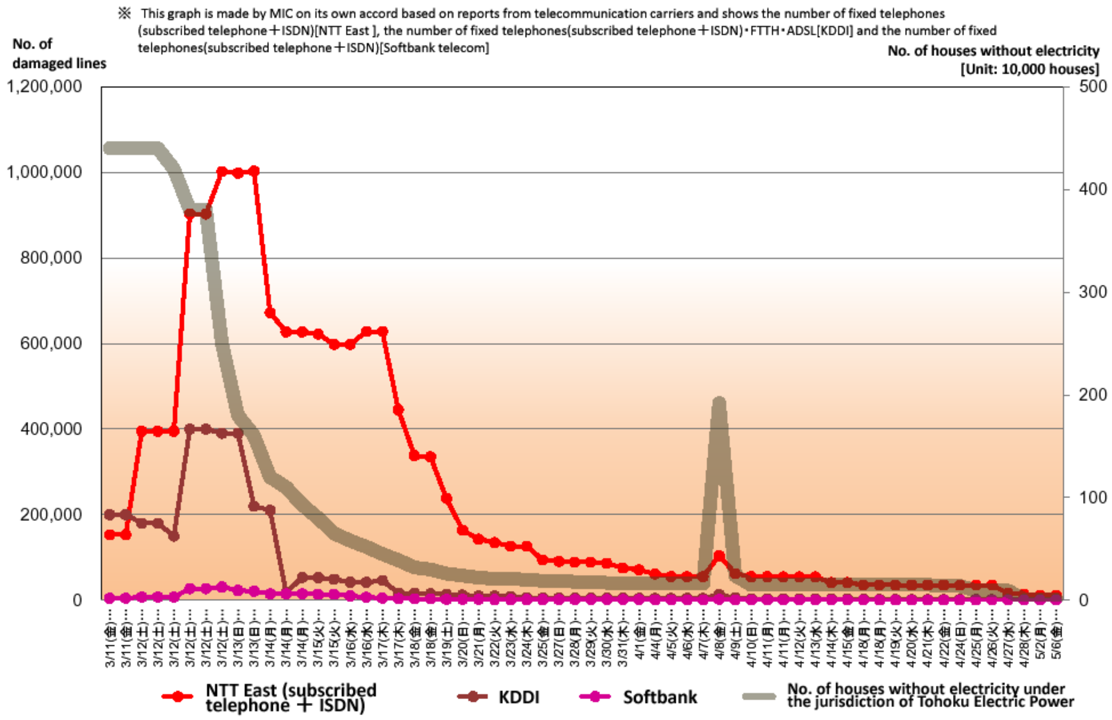


Figure 18. Changes in the number of damaged fixed lines [MIC].

NTT East had achieved 70% restoration by March 22 and full restoration of its services by the end of April, with the exception of 3 exchange offices in the nuclear accident area and two island exchange offices. Submarine cable traffic re-routed on March 15 to restore international service.

Similarly mobile base stations went out-of-service as backup power was lost. Vehicle-mounted mobile base stations were deployed within 36 hours as a temporary measure, and mobile services had fully recovered by the end of June (excepting the area around the Fukushima Nuclear plant).

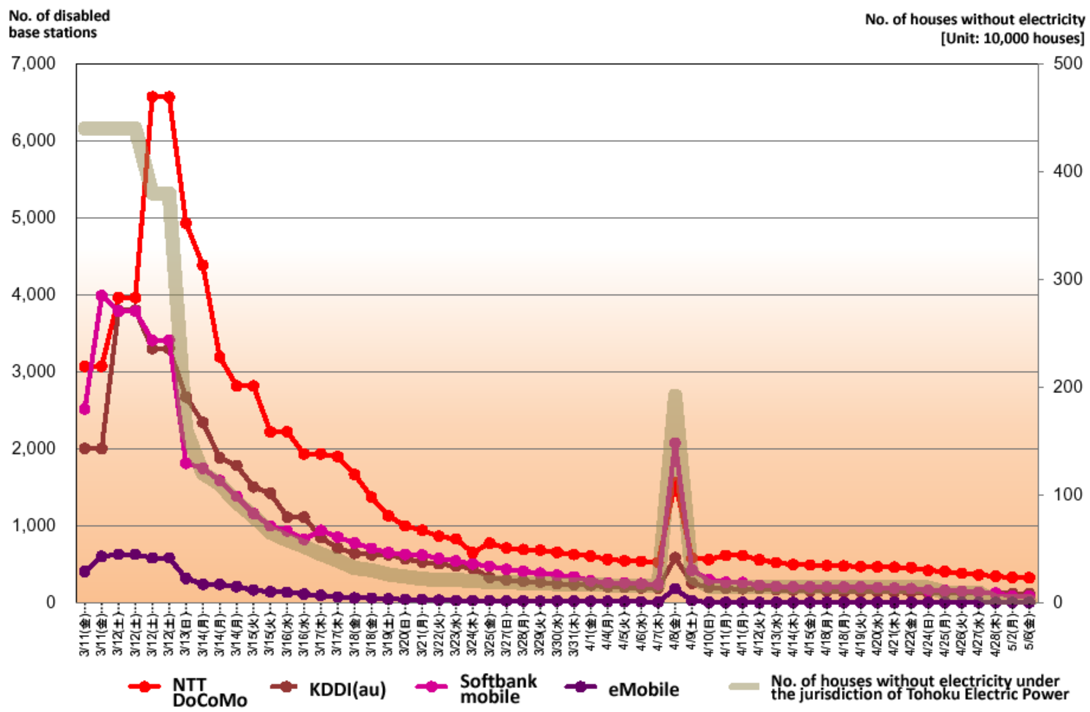


Figure 19. Number of disabled mobile base stations [MIC].

Internet usage had recovered by 66% in 1 week and almost fully in 1 month [21].

2.1.5 What can be done to be better prepared in the future?

The damage caused to the telecommunications infrastructure of eastern Japan by the tsunami on 11 March 2011 indicates the importance of ensuring autonomous power supply for at least 72 hours; installing equipment in locations that are as high and dry as possible – either on high ground or protected against flooding; routing lines inland; and avoiding the use of aerial facilities. Transmission routes can also be duplicated and diversified so as to increase resilience against transmission links being cut. And critical equipment such as authentication servers should be geographically dispersed.

Means also need to be found to handle the surge in call attempts following a disaster in a graceful manner. This could be achieved by:

- redesigning systems such that resources are diverted from less critical applications to voice services, by using distributed cloud computing platforms for example;
- reducing call hold times and perhaps imposing limits on the duration of calls;
- reducing call quality so as to handle a larger volume of calls; and
- encouraging the use of other media, such as text or emergency messaging services.

The Ministry of Internal Affairs and Communications (MIC) established a study group on maintaining communications capabilities during major natural disasters and other emergency situations in April 2011 that produced a final report in December 2011 [11]. This report considered the issues of alleviating congestion in emergency situations; minimizing disruption in the event of damage to infrastructure; and the implications for future network infrastructure and internet usage.

The upgrading of the Disaster Emergency Messaging services Dial 171, web 171 and the mobile emergency message boards to support cross-referenced searching (illustrated in Figure 20) so as to integrate the various systems is under consideration.

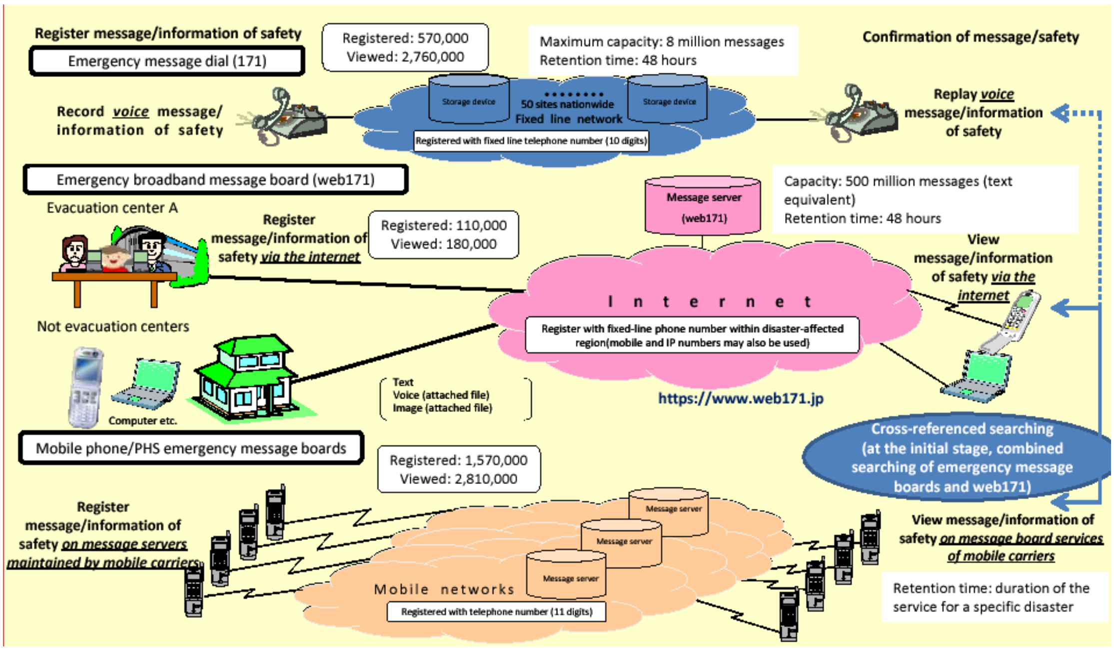


Figure 20. Upgrading of Emergency Message Services [MIC].

This report also makes various recommendations including:

- that the number of permanent public telephones should not be reduced from the current number of 109,000;
- that emergency email notifications be used to send both earthquake and tsunami warnings to mobile phones;
- that information provided in disaster situations use lightweight file formats (for example, html rather than pdf); and
- that consideration be given to the issue of disclosing personal data without the consent of the person as is normally required for personal data protection.

In addition, during an emergency situation information needs to be provided to those affected using ICT systems on such things as the routes and distances to evacuation shelters and indications of hazardous areas, without causing confusion. Information also needs to be effectively shared between different organizations.

2.2 USA - Hurricane Katrina 29 August 2005

Hurricane Katrina was one of the most devastating natural disasters in the history of the United States with some 1833 fatalities and material damage estimated at $108 billion [23]. The majority of fatalities occurred as a result of the storm surge, which broke through the levees protecting New

Orleans, and the flooding of large areas. Elderly people were most severely affected. Of the deceased victims in the New Orleans metropolitan area, 60% were over 65 years old and this is not due to an overrepresentation of elderly people in those areas as only 12% of residents were over 65 years of age [24]. This indicates the difficulty of evacuating elderly people and also perhaps the unwillingness on the part of some to take the effort to evacuate at times of emergency. Estimates of the number of displaced people vary between 1 and 1.5 million [4].

Infrastructural damage was immense. The FCC Report to Congress on “Vulnerability Assessment and Feasibility of Creating a Back-Up Emergency Communications System” noted that Hurricane Katrina was the prime example of a worst-case disaster scenario in which there is wide-area power disruption coupled with significant terrestrial damage [25]. Power outages affected 2.5 million customers in Louisiana, Mississippi and Alabama [26], back-up power sources failed and difficulty was experienced refueling generators. More than 3 million subscriber lines, 1,477 mobile towers, 38 “911” emergency call centers and about 100 broadcast stations were out-of-service. Not unexpectedly there was enormous congestion and “even generally resilient public safety networks experienced massive outages” [25].

Paul McHale, the Assistant Secretary of Defense for Homeland Defense, commented that “the magnitude of the storm was such that the local communications system wasn’t simply degraded; it was, at least for a period of time, destroyed” [26]. Disinformation was rife.

2.3 The Indian Ocean (Sumatra) tsunami of 26 December2004

On 26 December 2004 an earthquake of magnitude 9.3 occurred off the coast of Sumatra creating a tsunami that struck the coasts around the Indian Ocean from Indonesia to South Africa, causing immense human suffering with around 280,000 fatalities [27] and 1.5 million people losing their homes. Total losses have been estimated by the World Bank to be more than US$7 billion. The Indonesian province of Aceh was severely affected with 157,464 fatalities and 27,303 people missing. Indonesia is particularly prone to tsunamis – 23 occurring between 1960 and 2010 [28].

No early warning system was then in place for the Indian Ocean. The Pacific Tsunami Warning Center in Hawaii sent alerts to 26 countries within 15 minutes of the earthquake but it took another 45 minutes for warnings to be broadcast by TV and radio stations in Thailand [29]. This disaster stimulated the creation of a tsunami early warning system for the Indian Ocean which became active in the spring of 2006.

2.4 “9/11” New York City 11 September 2001

At 8:46 on the morning of 11 September 2001 a hijacked commercial aircraft crashed into the north tower of the World Trade Center (WTC) in New York City. This was followed by another hijacked aircraft being crashed into the south tower of the WTC at 9:03 and into the Pentagon in Washington DC at 9:37. Both towers of the World Trade Center collapsed later than morning causing many casualties and severe material damage.

The WTC was a significant wireless repeater site and Sprint PCS, Verizon and AT&T Wireless services were disrupted. Also, the Internet service provider points-of-presence (POPs) of Worldcom, AT&T Local Service and Verizon/Genuity that were in the complex were destroyed.

Telephone traffic increased and there was severe congestion in both the fixed and mobile networks. Mobile networks in New York City experienced a blocking ration of 92% as call volumes increased ten-fold [30].

At around 5:30 pm WTC building 7 collapsed, destroying a Consolidated Edison electrical substation and damaging the Verizon central office building at 140 West Street. The basement power supplies in this building were flooded and

1.5 million lines serving the financial district were then out-of-service [31].

The 9/11 attacks occurred in the same month that the Government Emergency Telecommunications Service (GETS) became fully operational with priority treatment for GETS calls being provided to National Security / Emergency Preparedness (NS/EP) users from more than 85% of access lines in the United States. Over 10,000 GETS calls were made over the wireline networks in New York City and Washington DC following the attacks with a successful completion rate of over 95% [32].

Although the FCC issued an order [33] in 2000 permitting commercial mobile network operators to offer Priority Access Services to NS/EP personnel, such services were not available in 2001.

Since then the Wireless Priority Service (WPS) has been implemented to provide a similar service to GETS in mobile networks. WPS is available from Alltel, AT&T (formerly Cingular Wireless), Cellular South, Edge Wireless, SouthernLINC, Sprint Nextel, Sprint PCS, T-Mobile, and Verizon Wireless. [34].

The operation of the Internet was not severely impacted by the 9/11 attacks even though New York is an important Internet hub. News sites, such as CNN, were stressed as people sought information but the Internet did not suffer congestion. In fact, it seems that Internet traffic decreased.

A committee established to assess the performance of the Internet under the 9/11 crisis [35] observed that:

“People used the Internet very differently in the aftermath of the September 11 attacks. For example, they sent less e-mail overall (although some substituted e-mail for phoning where the telephone networks were congested), and they used news sites more heavily. They made greater use of instant messaging. The overall picture that emerges is that individuals used the Internet to supplement the information received from television (which was the preferred source of news). Those unable to view television often substituted Internet news. The telephone, meanwhile, remained the preferred means of communicating with friends and loved ones, but chat rooms and e-mail were also used, especially where the telephone infrastructure was damaged or overloaded.

The levels of other activities on the Internet, such as e-commerce, declined. One consequence of this decrease was that in spite of larger numbers of person-to-person communications, total load on the Internet decreased rather than increased, so that the network was not at risk of congestion."

Hosts became unreachable immediately following the attacks but the network recovered in about 1 hour (see Figure 21) [36].

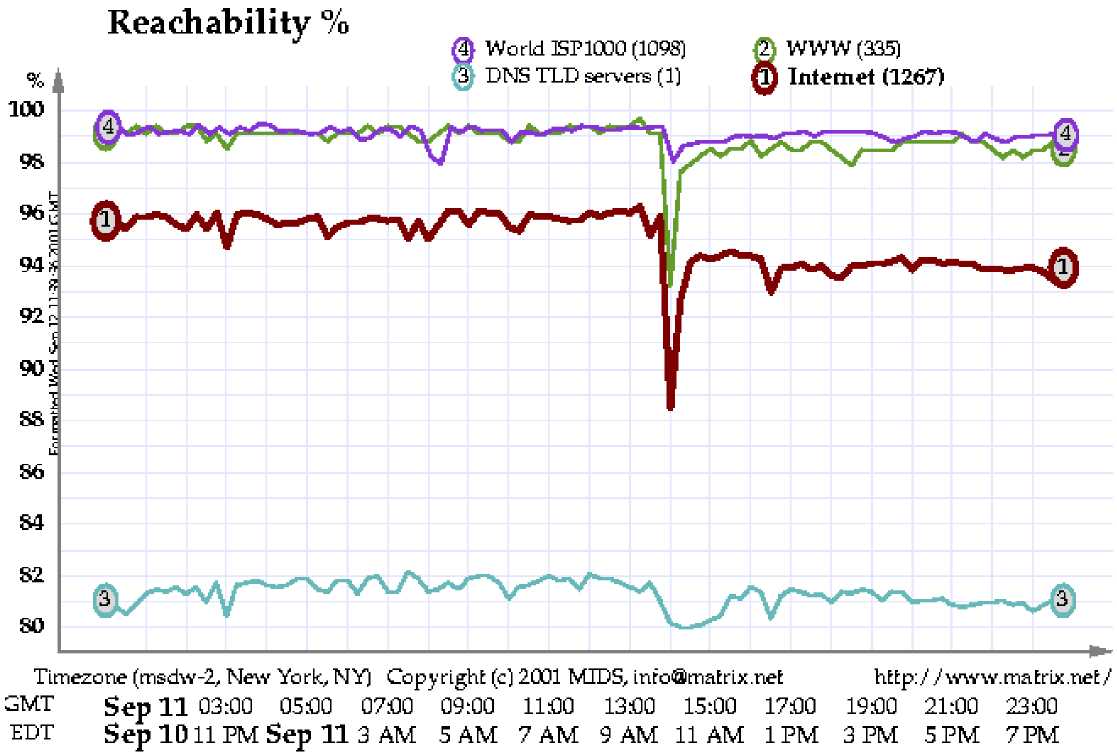


Figure 21. Internet reachability on 9/11.

As was the case following the March 2011 earthquake in Japan communications were further disrupted due to power failures. Power was lost in much of Lower Manhattan for nearly a week and on 13 September backup power failed at the New York International Internet eXchange (NYIIX) located at 25 Broadway. The effect of this on Internet reachability can be seen in Figure 22.

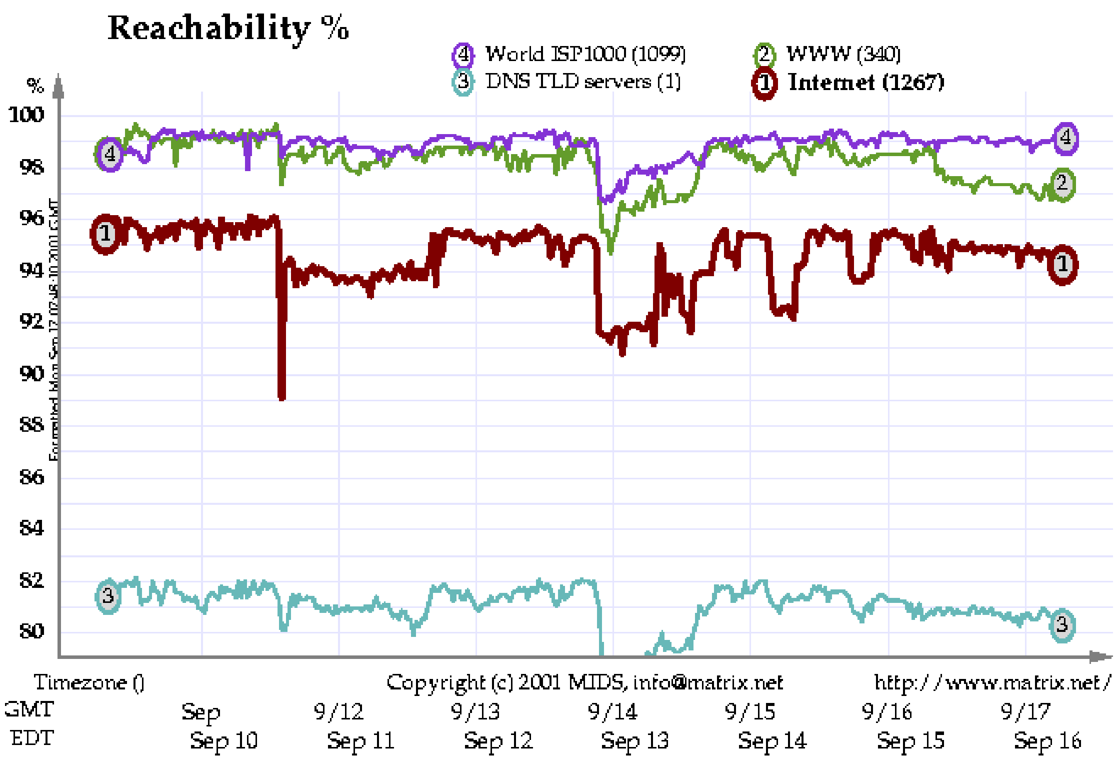


Figure 22. Internet reachability in the week following 9/11.

2.5 Earthquakes in Turkey[2]

2.5.1 The Kocaeli-Golcuk Earthquake of August 17, 1999

2.5.1.1 Preparation before the incident

Scientists had been repeating making statements in the media about the imminent danger of a devastating earthquake in the Marmara Region since mid-1998. The Turkish Amateur Radio Society (TRAC) took these statements seriously and visited the National Earthquake Monitoring and Research Centre (Bogazici University Kandilli Observatory) in Istanbul to get more detailed information from the head of the “Earthquake Engineering Department”, Prof. Mustafa Erdik, PhD (now general director of the centre). This contact was facilitated by TRAC’s existing contacts with this institute since 1992 at the time of the Erzincan Earthquake.

Prof. Erdik explained the situation to TRAC, presenting 2 possible scenarios that included details such as the risks concerning roads and harbours. One scenario assumed the epicentre to be in the east and the other assumed it would be in the western part of the Marmara-Graben. TRAC prepared a simple checklist for determining what could happen if this threat occurred and all public communication facilities would break down, making information gathering via the usual public channels impossible. This checklist was based on the expected damages in the various areas. TRAC’s plan would be to ask the police about information related to incoming damage reports in

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[2] The material for this section was kindly provided by Aziz Sasa, President of TRAC, the Turkish Amateur Radio Society (member of IARU), and, in particular, represents TRAC’s perspective.

order to make the determination of the epicentre possible. The police radio communication system was regarded as the only reliable source of information.

The other initiative, among several others made by TRAC, was to bring the “Communication Service Group” mechanism onto the agenda. This Service Group is one of nine different service groups, which are intended to handle various planning aspects of emergency management prior to emergencies together with the operational aspects during and after emergencies. It is lead by Turk Telekom and all GSM-providers, satellite service providers, the maritime communication service provider, law enforcement agencies, Turkish Radio TV (TRT), and other agencies with a strong radio communication structure are members. TRAC is the only voluntary organisation that is member of this group. The main idea of this structure is to enhance co-operation among all communication providers, aiming at mutual aid in order to provide emergency communication and quick network recovery in the aftermath of emergencies. The “Communication Service Group” has to be established in every province in accordance with Decree 88/12777, based on the Law No: 7269 (“Law of Disaster Management in Provinces”).

Due to the insistence of TRAC this mechanism became operational (most probably for the first time since its creation in 1988) in Istanbul with a meeting being held in April 1999. The head of this service group, the regional director of Turk Telekom in Istanbul, advised all participants to liaise with TRAC, stating that the Amateur Service, coordinated by TRAC, will be most likely the only remaining means of communication if the earthquake occurs.

TRAC applied to TRT (Turkish Radio Television) to get free access to their mountaintop locations in order to install our repeaters but this application was denied. Requests to install a facility in a university campus in an area of Istanbul where a military heliport and the biggest hospitals are located and to convert a military museum ship to a EOC for Izmit almost 6 months before the incident were also denied.

Further steps in terms of preparation were efforts to liaise with the authorities. Attempts to liaise with the Office of the Prime Minister were not successful but liaison was established with the Governor of Istanbul and the Istanbul Fire Brigade and TRAC conducted an exercise with these agencies one month before the earthquake occurred. Liaison with the Civil Defence and the Istanbul Ambulance Unit already existed.

2.5.1.2 Operations

The earthquake (Mw=7.6) happened on August 17, 1999, at 00:02 UTC. It was widely felt. Electrical power was cut off in large areas of the country seconds later. Telephones (GSM and wired) remained operational for about one minute before they were affected although some GSM networks continued to operate for about an hour in the severely affected areas before they become congested or power was lost.

It took about an hour to overcome the shock, arranging care for elderly family members and getting ready for action. Before getting ready for action it was necessary to determine the epicentre of the earthquake. The police station in the near vicinity was visited, where first reports of damage were arriving through the police radio network. Damage in only one part of Istanbul was reported – in a section of Istanbul already identified as the most risky area in the city by scientists. No damage was reported from other parts of the city. This was clearly fitting into the scenario that had been evaluated with the Kandilli Observatory in the stage of preparations. It meant that the epicentre was in the east, most likely around Izmit (Kocaeli). If the epicentre had been in the west, almost all coastal areas of Istanbul would have experienced severe damage.

At this stage, media sources were unusable for gathering reliable information, as they were passing only rumours and unconfirmed statements. It would take almost one day more to get substantial observations and news from them.

The next step was to start to communicate. As all equipment was installed in a car, there was no problem with electrical power. When the predetermined net frequency on HF (40 Meters Amateur Radio Band) was accessed it was clear that stations from all over the country were already on the air. One of them was in the HQ of Civil Defence in Ankara (HQ), operated by TRAC members in liaison with the Ministry of Interior. All stations were supplied by emergency power - either generators or car batteries. HQ was informed about the situation and the next step of the operation was that the TRAC team would move towards Izmit, avoiding the motorway where the risk of bridges collapsing was imminent and reporting observations from cities along the route.

A second TRAC team was also formed which was deployed to the Government of Istanbul in order to serve there as communicators and install a station. Liaison with this team was obtained by either simplex radio communication or via our only remaining repeater with emergency power.

First observations were relayed from Gebze (Province of Kocaeli, half way to Izmit) where the TRAC team met the Chief of the local Civil Defence and passed his report to Ankara. He urged us to move towards Izmit where he expected the most severe damage. Approaching Izmit the dimension of damage grew constantly. Roughly 2 hours after the incident the team observed that the state of shock had changed to one of panic. The traffic on the road became extremely dense, because thousands of people were trying to get through to their relatives living around Izmit.

A police patrol escorted the TRAC team to the Government Building in Izmit. The team arrived at the Governor’s office at 03:30 UTC (06:30 Local Time) and met the Vice Governor in charge, an official with whom TRAC had cooperated on several occasions in the past and who knew about their capabilities, and the Governor. The TRAC team conveyed the Governor’s messages to Ankara via HF Radio, assisted by other stations within the network, which relayed the messages if propagation conditions changed. There was no problem of passing the messages back and forth.

Shortly afterwards, a team from TRAC in Sakarya (Adapazari) started to relay the messages of the Governor of Sakarya (the other city severely damaged) via VHF to the team in Izmit. One member, residing in a village on a high location, relayed the incoming messages from Adapazari to the TRAC team on VHF simplex with his handheld radio. This traffic was then relayed to Ankara via HF. He reported that one bridge on the Istanbul-Ankara Motorway had collapsed, making the road unusable and burying one bus and several cars under it. This information, confirming the scenario of the Observatory, was instantly passed to HQ in order to warn their SAR-deployment that was supposed to start for Izmit from Ankara. All TRAC stations along the route of this Civil Defence Team were urged to call them on the VHF Civil Defence channel, warning and guiding them to alternative routes. This information was also passed to other provinces from where aid was expected to come. TRAC were later praised by Civil Defence for this action, as otherwise their deployment would have experienced severe difficulties.

In a few hours an HF Radio was deployed in Adapazari which then allowed the traffic to be passed to Ankara directly. At around 03:30 UTC, the TRAC station in the Istanbul Emergency Operation Center (EOC) became operational and it then passed messages from there to Ankara on HF. Part of the Istanbul team was deployed to the severely damaged township of Avcilar (in the western part of Istanbul) in order to set up tactical communication between the agencies in the field and/or with the EOC.

Aid from other provinces was being sent to the disaster area and most of these deployments were accompanied by TRAC members who acted as communicators of the convoys. Communication with the Ankara-Civil Defence SAR-Deployment in Izmit was accomplished by simplex VHF. 24 hours after the incident, TRAC had installed a repeater in a TRT mountaintop location in the vicinity of Izmit that enabled the entire disaster area to be covered with simple VHF radios, thus enhancing communication capabilities significantly.

A TRAC team member was deployed to a water-bottling facility near Adapazari to organize the drinking water supply by radio communication with the Emergency Operation Centres where TRAC members were stationed. After the arrival of more members to take over the duties in the Emergency Operation Centres, the TRAC mobile station was released for other tasks. It was moved to a problematic area according to orders from HQ and used to convey messages to or from these problematic zones where no other means of communication was available.

Co-ordination between the large number of incoming foreign SAR-Units and the local Emergency Operation Centres (EOC) appeared to be one major problem because no communication structure for this purpose was available. As a result, an unnecessary accumulation of SAR-Units on one site did occur, while on others where survivors were reported to be buried, no SAR-Unit was present. The TRAC team therefore focussed on the task of establishing communication between the SAR-Units and the EOC. As the affected area was large and no official knew the distribution or location of the operational SAR-units, it was impossible to track all units and get an overview of the situation. This was accomplished in only one area (Yalova) at least partly, because the local authorities had concentrated the camps of the SAR-Units in one particular place, and it was therefore possible to contact the logistics personnel of the units to obtain information about their communication facilities. It turned out that the larger SAR-Units had amateur radio operators in their ranks. This made co-ordination with them very easy as frequency compatibility was no problem.

The entire communication of the Interior Ministry and the Ministry of Housing and Infrastructure with the disaster area was accomplished using the TRAC-Network. The operation lasted for 10 days and 170 TRAC members were engaged in the disaster area.

2.5.1.3 Impact on public networks

As mentioned before, GSM and fixed lines communications were not operational. There was no connection between Istanbul and Ankara as the fibre-optic cable had multiple ruptures near

Adapazari. Additionally, a major switch in the Adapazari Region was destroyed completely. A bypass between Istanbul and Ankara was established by utilizing military satellite infrastructure approximately 24 hours after the incident. With this, the east-west connection was restored, but Adapazari and Izmit (the most problematic areas) could not be connected. The east-west fibre-optic connection was restored (by an operation lasting 36 hours) approximately 48 hours after the earthquake. However, due to the destruction of the switch near Adapazari, phone lines (fixed and mobile) in a large portion of the disaster area could not be completely restored within 10 days. In the areas where the lines were restored, the assignment of subscribers took additional time.

The deployment of mobile GSM utilities in the immediate aftermath of the disaster became a problem due to congestion on the motorways. Transport was directed through alternative routes but stopped at police roadblocks and not allowed to pass through. And as the transport crews had no communication with the EOC, they could not contact any official to obtain permission to pass through. Their arrival at the incident area was thereby delayed for almost 24 hours.

2.5.1.4 Learning from the disaster

After the earthquake TRAC was invited by the Secretary of State at the Prime Ministry to sign a MoU with the Prime Ministry. Free access to TRT locations was obtained and MoU's were also signed with the International Federation of Red Cross and Red Crescent Societies and the Turkish Red Crescent.

The TRAC stations in the Istanbul EOC and the EOC's of Izmit and Adapazari became operational permanently. The repeater installed near Izmit was equipped with better antennas which increased its performance. This repeater, working in the amateur radio band, became the main source of tactical communication for the field hospitals for a 3 month period. This rather unusual situation was made possible by a temporary frequency assignment by the Turkish Regulatory Body.

2.5.1.5 Summary

This was a typical "if everything else fails - amateur radio will work" case. It also demonstrated the complexity and difficulty of recovering public network services. TRAC's success in ensuring service in the most critical hours was based on efforts in the pre-disaster preparation period and also demonstrated the necessity of a multidisciplinary approach (obtaining risk analyses) and tight co-operation among stakeholders (an example being the military-civil cooperation to bridge the damaged east-west fibre-optic cable in this particular case).

It thereby indicates the importance of the "Communication Service Group" mechanism.

2.5.2 The Duzce-Kaynasli Earthquake of 12 November, 1999

2.5.2.1 Preparation before the incident

In this case the post-disaster period of the 17 August 1999 disaster can be regarded as the preparation for the disaster of November 12 that devastated the eastern neighbours of Sakarya and Kocaeli.

The biggest improvements in comparison with the previous disaster were the installation of permanent EOC's in Kocaeli and Sakarya with the participation of TRAC and the raising of awareness of the role of TRAC among the administration.

To sum up: many lessons having been learned from the 17 August disaster made a better preparation possible.

2.5.2.2 Operations

The earthquake happened at 16:57 UTC (18:57 LT) and had a magnitude Mw=7.2. When it happened, all TRAC stations in the EOC's were manned and active. GSM and phone lines became almost instantly nonoperational in the affected area and also in areas where the earthquake was strongly felt.

Communication between the affected area and the neighbouring areas could easily and instantly be accomplished via VHF repeater near Izmit. HF was the second communication resource.

One member of the TRAC Sakarya-branch, living near Duzce, drove to Duzce and met the Governor there 15 minutes after the incident. He reported via the TRAC network that the most urgent need was support to fight fires. This information was instantly delivered to the Sakarya and Istanbul EOC's. Starting with Sakarya, the very next city to the affected area, fire brigades were deployed to Duzce, followed by fire brigades from Izmit and Istanbul.

A TRAC member from Bolu, the neighbouring district of the affected area to the east, reported damage from Bolu. He also reported that the main road to Duzce (the Ankara-Istanbul Highway) was disrupted due a landslide and advised all aid convoys heading to Duzce from Ankara to contact him by radio to be guided to alternative roads. He also organized military-civil communication (by operating side by side with an officer who took over communication with the military).

30 minutes after the incident the Minister for Interior Affairs arrived at the Istanbul EOC and received his first briefing from the TRAC team on duty there.

Members of the TRAC branches in Izmit (Kocaeli) and Sakarya were deployed to Duzce and Kaynasli (a severely damaged township of Duzce), to take communication duty in the provisional EOC's that had been installed. They were assisted by a TRAC member in a village near Duzce who acted as a control station of the TRAC HF Radio Network.

As it appeared that no further immediate deployment from Istanbul was needed at this stage, the team in Istanbul decided to take care of the foreign SAR and aid groups being deployed from various countries to Istanbul and expected to be assigned to different sites in the disaster area. As a first step liaison was established with the delegations of the Ministry of Foreign Affairs and OCHA already present at the airport.

A proposal by TRAC that all incoming foreign groups complete a questionnaire before being deployed to the disaster area was accepted. This questionnaire required essential information about their communication equipment (type, amount and frequency) together with information about the qualification of the communicators (amateur radio operator, possibility of programming the radios to other frequencies). An information leaflet for the groups stating the frequencies predefined for in-field communication with the local EOC's was also prepared. No group was deployed to the disaster area without having filled in the questionnaire and received the frequency information leaflet. As it was possible that some of the groups would have no information about the frequencies of their radios, appropriate measurement equipment (frequency counter) was deployed to Istanbul Airport as a precaution.

38 different groups with a total of 384 personnel were registered. The most experienced groups in large-scale international operations (among them THW from Germany and the Swiss Rescue Dog Team) had amateur radio operators in their ranks.

The information collected from the questionnaires was relayed to the EOC's in the affected area by the TRAC radio network. With this information being available, the TRAC operators in the EOC's could move to the frequency of any foreign group, guiding them by radio communication in the disaster area.

Our communicators in these EOC's were assisted by voluntary translators in order to overcome possible language problems.

As a result of this operation, no problems in the coordination of the foreign groups were encountered this time unlike following the earthquake of August 17, 1999. This operation was much praised by foreign groups. For example, the British Civil Defence (BCD) stated that "this perfect communication structure was the very first of its kind ever experienced in 30 years of international disaster operations" in its debriefing report. BCD also recommended it to become an international standard.

After the arrival of all the foreign teams, the Istanbul TRAC team left the airport and went to the disaster area to take over duties from the first shift.

The governor of a city in southeast Turkey deployed a UHF portable repeater and some handheld radios in the area. TRAC assisted with the installation of the repeater. The radios were distributed to the government agencies in order to provide them with a common command channel.

2.5.2.3 Impact on public networks

GSM and fixed line services were knocked out instantly. Their recovery in those areas not directly affected, such as Istanbul, was accomplished within a few hours whereas recovery in the disaster area took 72 hours. The deployment of mobile GSM units was not a problem this time as the roads from the western direction were clear.

2.5.2.4 Summary

As this disaster happened relative shortly after the August 17 earthquake and in its adjacent vicinity, with experienced and skilled personnel still present in Adapazari and Izmit, initiating the first response was greatly facilitated.

Therefore TRAC was able to focus on the serious problem of coordinating the numerous incoming foreign groups. The statement of BCD showed that in-site coordination was a general problem, also being encountered during other large-scale disasters in other parts of the world. TRAC demonstrated that this kind of problem, common to all disasters, can easily be solved by the engagement of amateur radio.

2.5.3 The Van Earthquake on 23 October, 2011-10:41 UTC, Mw=7.2

2.5.3.1 Preparation before the incident

Being informed of the seismic risks in the area, TRAC had already formed a branch in Van, headed by a communication technician of the Ministry of Health. HF Radio and a VHF repeater were available.

2.5.3.2 Operations

Having been alerted by media, TRAC checked its Automatic Position Reporting System (APRS) network to obtain observation data. Then as many stations as possible from various parts of the country were made operational on a predetermined emergency alerting frequency in the 40-Meters HF Amateur Radio band. Additionally, the chief communicator of the voluntary SAR-Group AKUT in Istanbul, an amateur radio operator and member of TRAC, was contacted. They were getting ready for deployment to the disaster area and a “modus operandi” was determined with him.

The TRAC representative in Van appeared on the predetermined HF-channel about 2 hours later, reporting on the situation in the region (the GSM-Network remained operational, for example) and coordinating communication with the Ministry of Health (MoH) command centre. The TRAC HF-network stood by on the channel of MoH, relaying messages when direct communication between Van and Ankara was not possible.

A member of the TRAC Trabzon branch, employed as a chief technician of the major GSM service provider, reported periodically about the condition of the network, in order to be ready for possible outages in the GSM network, and the deployment of mobile GSM-Stations to the area. As on-site radio communication for coordination between the agencies became a major problem it was decided to deploy a well-equipped and experienced member from the nearest possible location (Gaziantep in this case). He went to the area with a Turkish Red Crescent (TRC) convoy and organized the on-site coordination between all agencies, setting up a station in the local TRC Command Centre.

2.5.3.3 Observations

As the local switch of Turk Telekom remained intact and all GSM providers had their local infrastructure in the same location, the GSM network remained operational. Another ameliorating factor was the low number of inhabitants in the affected area. The network reached its limits only when an extensive number of media and VIP visitors arrived in the area, significantly raising the traffic volume. Relatively quick and numerous deployment of mobile GSM infrastructure solved that problem “just in time”.

It was reported by the official of a GSM provider in a Communication Service Group meeting at a later date that a lack of coordination among the agencies again caused the delayed arrival of mobile GSM units (as was also experienced during the 17 August 1999 incident). One convoy was misguided and forced to stop for almost 24 hours on the way to the incident area at a control post. Determining and reaching the key person responsible for solving this problem by GSM became a major and time-consuming matter. With the availability of a well-organized interagency radio communication network, this problem could have been solved in a matter of minutes.

Because the operational GSM infrastructure remained operational the local authorities believed that all communication problems were solved. They were not aware that the interagency communication was not existent at all. This indicates a severe and apparently typical deficit in terms of situation assessment. This was a key factor causing TRAC’s delayed intervention regarding the interagency radio communication network in this particular case.

2.5.3.4 Conclusion

This incident showed that the availability of public networks does not mean that all communication duties can be fulfilled properly. It showed also, that the availability of public networks can cause a deficit in terms of situation assessment which results in chaotic conditions in the field where extremely critical duties such as search and rescue have to be supported by a well-working interagency radio communication. TRAC decided to organize immediate deployments to remote incident areas, regardless of inquiries from government agencies, with the primary task of organising the interagency radio communication structure.

3. Some conclusions from the case studies

In all of these case studies loss of power and insufficient fuel for back-up generators was a major factor in putting telecommunications equipment out-of-service. Flooding also, even in the one case study that was not a natural disaster caused by a tsunami or a storm (that of 9/11), caused significant damage. It is clear that locating equipment where it is least exposed to risk can reduce damage to infrastructure and make telecommunications installations less susceptible to natural disasters. Autonomous power supply is critical and there should be sufficient fuel for back-up generators as power outages can be prolonged. Equipment should be installed in buildings in higher locations where the risk of flooding is reduced and basements should be avoided as sites for equipment and reserve generators. The use of aerial facilities should be avoided and critical equipment such as authentication servers should be geographically dispersed.

Cities may well require different measures than rural areas. For example, metropolitan areas hit by an earthquake or flood are likely to be so chaotic that transport into and movement within the affected area may be extremely difficult making it infeasible to ship in mobile communications facilities. To face this particular risk Turkcell for instance is planning to build very strong telecommunications towers that can withstand major earthquakes in key locations in cities such as Istanbul. In rural areas and smaller cities transportable facilities can be deployed where infrastructure has been destroyed.

The response of people affected by a disaster is to attempt to call to report that they are safe or to call to check whether others are safe, causing telecommunication network congestion. It is therefore necessary to implement measures to alleviate congestion. Congestion can be avoided by:

- encouraging alternative means of communication;
- reducing call hold times;
- reducing call quality;
- reassigning network resources to telephony;
- developing new network architectures that can handle spikes in telephone traffic; or
- when Internet Protocol networks are employed, implementing congestion control algorithms for media streams so as to reduce load during periods of congestion.

Priority can also be given to users with special privileges to make calls during disaster situations.

The elderly and disabled are particularly vulnerable in case of disaster, both in terms of understanding what action to take and also in requiring assistance. As seen in the case of Hurricane Katrina the majority of fatalities were elderly people. Accessibility is therefore a key criteria in designing disaster response systems. The "Phuket Declaration on Tsunami Preparedness for Persons with

Disabilities" (Phuket, 2007) emphasized the need for inclusive emergency warning and disaster management systems using technology based on open, non-proprietary, global standards. It must be possible to inform the deaf, blind and illiterate and it should be possible to obtain information in one's own language. For example, text-to-speech, text-to-sign language and talking books may be used. Disaster information services should be suitable for all, including the very young, aged and people with disabilities, visitors, foreigners and roamers. Services ideally should not be specific to a certain network operator.

It would also be useful to be able to download evacuation plans (for town, building or ship, for example) automatically to mobiles and also to automatically switching on any services that are required to receive warning messages. For example, to switch on a mobile data service that may have been switched off by the subscriber to avoid high roaming charges.

Early warning and public information in the aftermath of a disaster can be disseminated by the media (TV, radio, newspapers), public mobile networks (using services based on the Cell Broadcast Service (CBS) as is the “Area Mail” service that has been deployed in Japan, for example), the Internet (email, social networking sites and other web services) or using sirens or loudspeakers. Media usage following the 2011 tsunami in Japan indicates that media diversity is important. Large video advertising screens in public spaces (“Digital Signage”) can be used to give warnings and also provide information such as evacuation routes and traffic conditions applicable in the area in which the screen is located.

The UN-ISDR defines an Early Warning System as “the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and act appropriately and in sufficient time to reduce the possibility of harm or loss.”

An early warning system requires monitoring apparatus to provide the data on which predictions can be made of events with specified margins of error on the location and intensity; a communications system for the effective dissemination of warnings in a timely fashion; and an informed public able to act in a an appropriate manner to the warnings. People need to be well informed beforehand about hazards and other eventualities such as evacuation procedures and routes. Evacuations may be ordered and vulnerable systems may be controlled automatically. For example, industrial plants and nuclear power stations (as is the case at the Ignalina power station in Lithuania) may be shutdown and railway systems, traffic lights and elevators may be controlled in an appropriate manner. Early warnings may have local, regional or global significance. All of this requires a network of institutions to implement and coordinate early warning system operations.

The lead times between detection of an event indicative of a disaster and the disaster itself are those in which early warnings can be provided. Lead times vary enormously depending upon the type of threat - tens of seconds for earthquakes, minutes for tornadoes, minutes to hours for tsunamis, hours to days for volcanic eruptions, hours to weeks for hurricanes, weeks to months for droughts and years for long term climatic events such as El Nino and climate change. Earthquakes, according to the statistician Nate Silver, are “not really predictable at all” but forecasting of other hazards has improved immensely. For example, the accuracy of predicting the course of hurricanes has improved 12-fold over the last 25 years [37].

Three phases can be considered for disaster relief:

1. Preparedness – identify vulnerabilities and assess regional needs; build resilient, less vulnerable infrastructure; establish Early Warning Systems and standard emergency operational procedures.
2. Response - implement operational procedures such as message boards, evacuation instructions, install temporary radio links.
3. Rehabilitation and Recovery.

The disaster management cycle id shown in Figure 23.

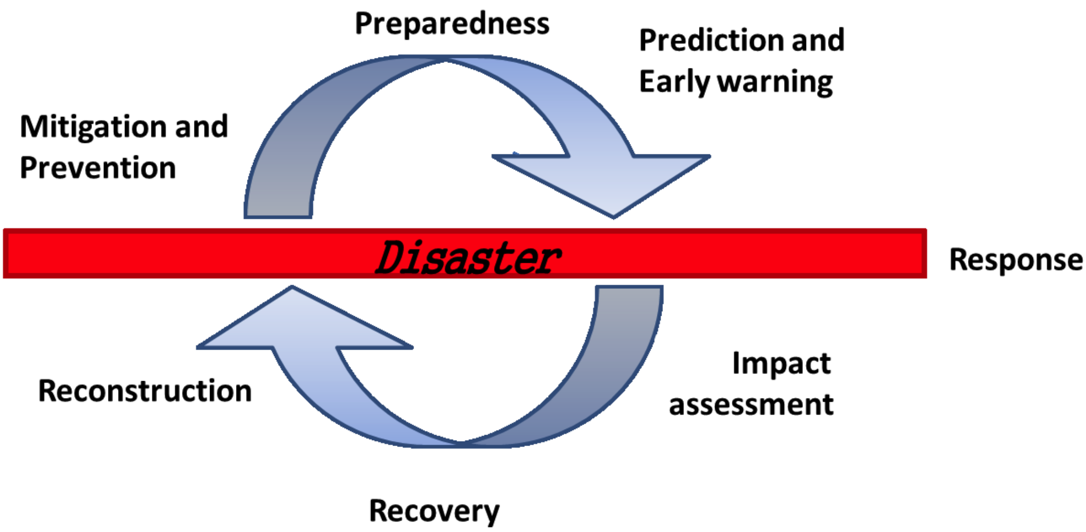

Figure 23. The disaster management cycle.

4. United Nations disaster relief initiatives

4.1 United Nations Office for the Coordination of Humanitarian Affairs (OCHA)

The United Nations Office for the Coordination of Humanitarian Affairs [38] performs its coordination function through the Inter-Agency Standing Committee (IASC) and convenes a Working Group on Emergency Telecommunications (WGET) [39].

OCHA provides news and analysis through the Integrated Regional Information Networks (IRIN) and operates ReliefWeb [40], a global information system for the dissemination of reliable and timely information on emergencies and natural disasters. OCHA also provides the RedHum (Red de Informacion Humanitaria para America Latina y el Caribe) and OCHA 3W Who does What Where – Contact Management Directory services.

OCHA manages the following emergency response activities:

- UN Disaster Assessment and Coordination (UNDAC)
- International Search and Rescue Advisory Group (INSARAG)
- Global Disaster Alert and Coordination System (GDACS)
- Virtual OSOCC (On-Site Operations Coordination Centre)
- Global mapping of emergency stockpiles

In addition, OCHA manages the Consolidated Appeal Process (CAP), Central Emergency Response Fund (CERF), Financial Tracking Service (FTS) and the United Nations Trust Fund for Human Security (UNTFHS).

4.2 United Nations International Strategy for Disaster Reduction (UNISDR)

The UNISDR [41] was established in 1999 to ensure the implementation of the International Strategy for Disaster Reduction and in 2001 was mandated to be the focal point in the UN system coordination of disaster risk reduction activities. In particular, the UNISDR supports implementation of the "Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters" [42]. The UNISDR has created PreventionWeb and publishes many reports including a Global Assessment Report every other year. A number of reports on early warning systems were published in 2006 including a report to the United Nations Secretary General on "A Global Survey of Early Warning Systems".

4.3 World Meteorological Organization (WMO)

As has already been noted the weather is the main cause of natural disaster. The WMO operates a Disaster Risk Reduction (DRR) programme [43] to provide the meteorological, hydrological and climate information required for disaster risk management in an effective and timely manner. WMO DRR projects cover hazard risk assessment, multi-hazard early warning systems, disaster risk financing and humanitarian planning and response.

4.4 World Health Organization (WHO)

The World Health Organization undertakes emergency response operations and assists member states in the development of strategies for emergency preparedness and response [44]. The WHO has produced a number of reports and manuals including:

- "Risk reduction and emergency preparedness – WHO six-year strategy for the health sector and community capacity development" (2007) [45]
- "Global Assessment of National Health Sector Emergency Preparedness and Response" (2008) [46]
- "Manual for the public health management of chemical incidents" (2009)[47]
- "Community emergency preparedness: a manual for managers and policy makers" (1999) [48]

The WHO has also published a set of factsheets on many aspects of disaster risk management. An overview is given in "Disaster Risk Management for Health Overview" (2011) [49] and there are factsheets on chemical safety; child health; climate risk management; communicable diseases; people with disabilities and older people; mass casualty management; mass fatalities/dead bodies; mental health and psychosocial support; useful definitions and early warning information for natural hazards; non-communicable diseases; nutrition; radiation emergencies; safe hospitals: prepared for emergencies and disasters; sexual and reproductive health; and water, sanitation and hygiene.

4.5 United Nations Office for Outer Space Affairs (UNOOSA)

UOOOSA operates the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER). UN-SPIDER is a programme "to provide universal access to all countries and all relevant international and regional organizations to all types of space-based information and services relevant to disaster management to support the full disaster management cycle" [50]. Space technologies can be used for communication (SATCOM), navigation (SATNAV) and earth observation and remote sensing (EO/RS).

4.6 The World Bank

The World Bank Independent Evaluation Group (IEG) provides some information on natural disasters [51] and has produced the reports "Hazards of Nature, Risks to Development – An IEG Evaluation of World Bank Assistance for Natural Disasters" and "Development Actions and the Rising Incidence of Disasters".

The World Bank also manages the Global Facility for Disaster Reduction and Recovery (GFDRR) [52].

4.7 Internal Displacement Monitoring Centre (IDMC)

The Internal Displacement Monitoring Centre was established in 1998 by the Norwegian Refugee Council to monitor internal displacement worldwide. As well as conflict-induced displacement the IDMC provides information on population displacement due to natural disasters and climate change [53].

5 Regional initiatives

5.1 Asian Disaster Preparedness Center

The Asian Disaster Preparedness Center [54] was created in 1986 with the aim of "promoting disaster awareness and the development of local capabilities to foster institutionalized disaster management and mitigation policies" [55].

5.2 Association of South East Asian Nations (ASEAN) Regional Cooperation on Disaster Management

The ASEAN countries (Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam) are particularly vulnerable to natural hazards, as illustrated by the December 2004 Indian Ocean tsunami and Cyclone Nargis in 2008. They have all therefore ratified the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) that provides a common platform for responding to disasters and also established the ASEAN Coordinating Centre for Humanitarian Assistance (AHA Centre). The AHA Centre was officially launched in November 2011.

6. ITU activities concerning telecommunications for disaster mitigation

6.1 Introduction

The value of telecommunications for helping people in need is recognized in the constitution of the International Telecommunications Union (ITU) and each of its three sectors – the radiocommunication, standardization and development bureaus - have activities related to early warning and disaster relief.

Information and communication technology plays a critical role in environmental monitoring to predict and detect natural disasters and provide warnings of their occurrence and also in the aftermath of a disaster by ensuring the timely flow of information needed by citizens, government agencies and those aid organizations involved in rescue and recovery operations and providing medical assistance to the injured.

Developing countries, in particular, need support to deploy early-warning systems and emergency communications and often also assistance in reconstructing the infrastructure that is destroyed by a disaster. The impacts of climate change also fall most heavily on developing countries and challenge the achievement of economic and social objectives to support sustainable development. One of the objectives of the ITU Development Bureau is to "provide concentrated and special assistance to least developed countries (LDCs) and countries in special need, and to assist ITU Member States in responding to climate change and integrating telecommunications/ICTs in disaster management." [56]. The ITU-D has produced a number of handbooks on emergency telecommunications (see section 6.8).

The ITU-R develops emergency radiocommunication specifications applicable to all phases of a disaster (prediction and detection, alerting and relief operations) [57] and also maintains databases of the frequencies available for terrestrial and space radiocommunication services for use in emergency situations [58].

ITU-T Study Groups 2, 11, 13, 15, 16 and 17 work on various aspects of emergency communications; primarily on specification of the Emergency Telecommunication Service (ETS), the International Emergency Preference Scheme (IEPS) and a Common Alerting Protocol. In addition, the ITU-D

has produced guidelines on the use of the Common Alerting Protocol [59] and the Q.22-1/2 Rapporteurs Group is studying the utilization of telecommunications / ICTs for disaster preparedness, mitigation and response [60].

A framework for emergency communications is given in Figure 24.

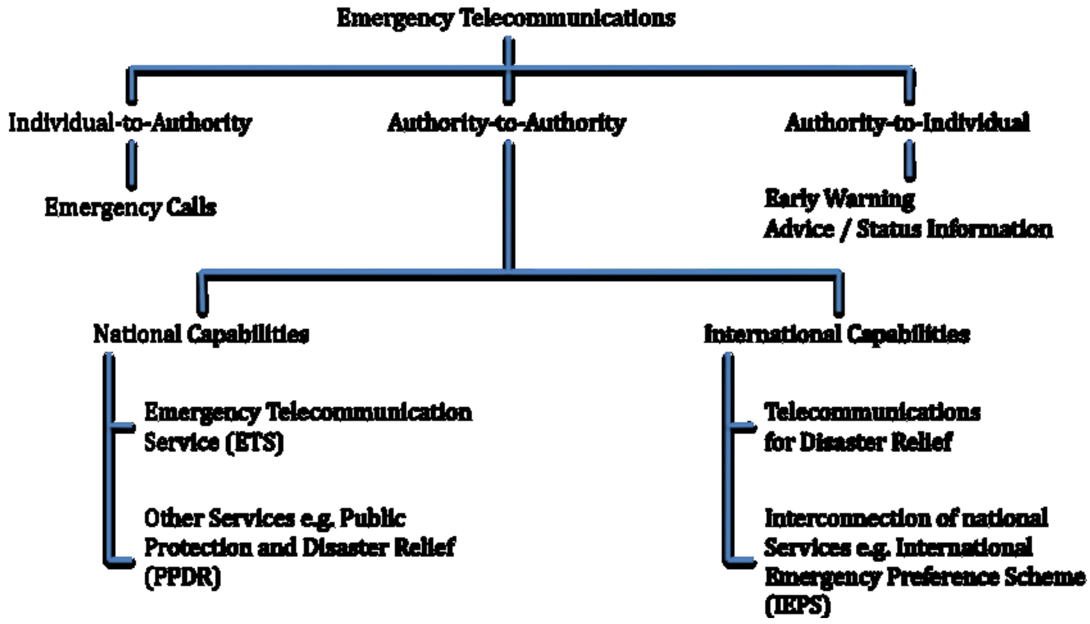

Figure 24. Framework for emergency telecommunications

6.2 The Constitution of the International Telecommunication and International Telecommunication Regulations

The Constitution of the International Telecommunication Union [61] states that the ITU shall "promote the adoption of measures for ensuring the safety of life through the cooperation of telecommunication services". Additionally, article 40 states that "international telecommunication services must give absolute priority to all telecommunications concerning safety of life at sea, on land, in the air or in outer space, as well as to epidemiological telecommunications of exceptional urgency of the World Health Organization".

The International Telecommunication Regulations [62] supplement the constitution with the aim of "promoting the development of telecommunication services and their most efficient operation while harmonizing the development of facilities for world-wide telecommunications." Article 5 of the International Telecommunication Regulations reinforces the constitution by stating that: "Safety of life telecommunications, such as distress telecommunications, shall be entitled to transmission as of right and shall, where technically practicable, have absolute priority over all other telecommunications…"

The 2012 – 2015 strategic plan for the ITU given in Resoloution 71 of the 2010 ITU Plenipotentiary Conference [63] stresses the roles of the Radiocommunication and Development Bureaus in disaster mitigation and relief operations.

Regarding the ITU-R, Resolution 71 states:

- "4.1.5 The domain of radiocommunications also includes aeronautical telemetry and telecommand systems, satellite services, mobile communications, maritime distress and safety signals, digital broadcasting, satellites for meteorology, and the prediction and detection of natural disasters."

- "4.1.7 The need for continuing development of radiocommunication systems used in disaster mitigation and relief operations has increased and will be a key challenge for the future. Telecommunications are critical at all phases of disaster management. Aspects of emergency radiocommunication services associated with disasters include, inter alia, disaster prediction, detection, alerting and relief."
- "4.1.8 In the area of climate change, the work of ITU-R focuses on the use of ICT (different radio and telecommunication technologies and equipment) for weather and climate-change monitoring and for prediction, detection and mitigation of hurricanes, typhoons, thunderstorms, earthquakes, tsunamis, man-made disasters, etc."

Resolution 71 notes that:

- "Emergency telecommunications play a critical role in both warning of disasters and their immediate aftermath, by ensuring timely flow of information needed by government agencies, humanitarian-oriented organizations and industry involved in rescue and recovery operations and providing medical assistance to the injured. There will be continuing need to support developing countries with early-warning systems, emergency communications and assistance in reconstructing infrastructure destroyed by disasters."[clause 6.1.10]
- "Climate change challenges our ability to achieve economic and social objectives to support sustainable development. The adverse effects of climate change are likely to fall disproportionately on developing countries given their limited resources. Telecommunications/ICTs make a valuable contribution to monitoring, mitigating and adapting to climate change. There will continue to be a need to help countries, in particular developing ones, respond to climate change."[clause 6.1.12]

It is an objective of the ITU-D "to provide concentrated and special assistance to least developed countries (LDCs) and countries in special need, and to assist ITU Member States in responding to climate change and integrating telecommunications/ICTs in disaster management."

In addition, the plenipotentiary conference of the ITU in Guadalajara, 2010, agreed Resolution 136 on "The use of telecommunications/information and communication technologies for monitoring and management in emergency and disaster situations for early warning, prevention, mitigation and relief" that:

"resolves to instruct the Directors of the Bureaux

1. to continue their technical studies and to develop recommendations, through the ITU study groups, concerning technical and operational implementation, as necessary, of advanced solutions to meet the needs of public-protection and disaster-relief telecommunications/ICTs, taking into account the capabilities, evolution and any resulting transition requirements of existing systems, particularly those of many developing countries, for national and international operations;
2. to support the development of robust, comprehensive, all-hazards emergency and disaster early-warning, mitigation and relief systems, at national, regional and international levels, including monitoring and management systems involving the use of telecommunications/ICTs (e.g. remote sensing), in collaboration with other

international agencies, in order to support coordination at the global and regional level;

3. to promote implementation by appropriate alerting authorities of the international content standard for all-media public warning, in concert with ongoing development of guidelines by all ITU Sectors for application to all disaster and emergency situations;
4. to continue to collaborate with organizations that are working in the area of standards for emergency telecommunications/ICTs and for communication of alert and warning information, in order to study the appropriate inclusion of such standards in ITU's work and their dissemination, in particular in developing countries."

6.3 World Summit on the Information Society (WSIS)

The Geneva Plan of Action adopted by WSIS in 2003 called for the strengthening and expansion of "ICT-based initiatives for providing medical and humanitarian assistance in disasters and emergencies" and the establishment of "monitoring systems, using ICTs, to forecast and monitor the impact of natural and man-made disasters, particularly in developing countries, least developed countries and small economies".

This commitment was reiterated in the WSIS Tunis Agenda for the Information Society in 2005:

"**We recognize** the intrinsic relationship between disaster reduction, sustainable development and the eradication of poverty and that disasters seriously undermine investment in a very short time and remain a major impediment to sustainable development and poverty eradication. **We are clear** as to the important enabling role of ICTs at the national, regional and international levels including:

- Promoting technical cooperation and enhancing the capacity of countries, particularly developing countries, in utilizing ICT tools for disaster early-warning, management and emergency communications, including dissemination of understandable warnings to those at risk.
- Promoting regional and international cooperation for easy access to and sharing of information for disaster management, and exploring modalities for the easier participation of developing countries.
- Working expeditiously towards the establishment of standards-based monitoring and worldwide early-warning systems linked to national and regional networks and facilitating emergency disaster response all over the world, particularly in high-risk regions."

6.4 The Tampere Convention on disaster relief

The First Intergovernmental Conference on Emergency Telecommunications took place in 1998 (ICET-98) and resulted in the Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations [64]. This is an international treaty that came into force on 8 January 2005 and has now been ratified by 45 countries. This treaty simplifies the provision of telecommunications equipment by other states for use in relief operations by waiving the regulatory requirements of the assisted state such as the need to obtain a license for radio frequency use and any restrictions that may apply to the importation of equipment.

The 2nd Tampere Conference on Disaster Communications in 2001 suggested that the ITU should study the use of public mobile networks for the dissemination of early warning and emergency information, as well as the operational aspects of emergency communications such as the prioritization of calls and the 3rd Tampere Conference in 2006 encouraged wider understanding and cooperation between governments on implementation of the Tampere Convention.

6.5 ITU Framework for Cooperation in Emergencies (IFCE)

The IFCE is a framework for the provision of telecommunications equipment in a timely manner wherever a disaster occurs. This is a multi-stakeholder framework as shown in Figure 25.

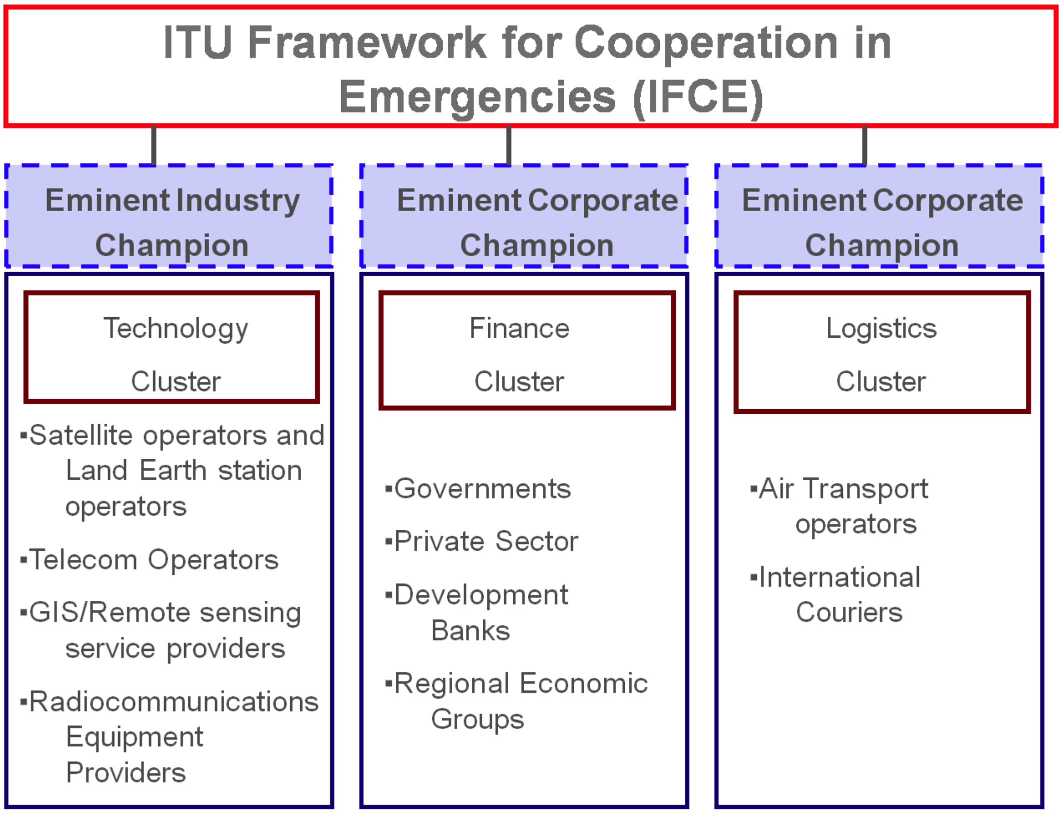

Figure 25. Stakeholders in the ITU Framework for Cooperation in Emergencies (IFCE).

6.6 ITU-T Recommendations

6.6.1 Emergency calls

Recommendation ITU-T E.161.1 [65] recommends the use of either 112 or 911 as the primary or alternative number for calling emergency services. Although, GSM networks support 112 and 911 as emergency numbers there are many countries that do not use a common emergency services number (rather than separate numbers for the police, medical and fire services) in their fixed telecommunication networks, and when a single number is used it is not always 112 or 911. For example, 111 is used in New Zealand and 999 is used in a number of countries.

Amendment 1 of Recommendation ITU-T E123 [66] specifies an Emergency contact number notation.

6.6.2 The Emergency Telecommunication Service (ETS) and International Emergency Preference Scheme (IEPS)

6.6.2.1 Introduction

During crisis situations there is usually a dramatic increase in the number of telephone call attempts as people try to find out if others are safe or to report that they are safe themselves. At the same time the telecommunications system infrastructure may well be damaged and relief operations requiring telecommunications services have to be performed urgently. For this reason priority needs to be given to certain telecommunications users who are authorized to perform relief operations. The ITU-T has specified the Emergency Telecommunications Service (ETS) for use within a nation and the International Emergency Preference Scheme (IEPS) to give authorities preferential access to the international telephone network.

The Emergency Telecommunication Service (ETS) specified in Recommendation ITU-T E.107 [67] is a national service providing priority use of telecommunications network resources, allowing a higher probability of end-to-end communication and use of telecommunication applications, to ETS authorized users in times of disaster and emergencies. Priority treatment mechanisms may include priority call/session establishment using priority queuing schemes for network resources; access to additional resources, by using alternative routes, for example; and exemption from any restrictions that would cause the call attempt to fail, such as user-invoked services such as “do not disturb” or “call screening”. In addition, pre-emption, the release of active calls to free resources to serve a new ETS call/session request, may be supported. ETS users may be allocated different levels of priority.

Recommendation ITU-T E.107 also presents guidelines for the interconnection of national ETS systems so that an ETS call originated in one country is also given priority treatment in the destination country. One mechanism for such interconnection is the International Emergency Preference Scheme (IEPS) defined in Recommendation ITU-T E.106 [68]. As there may be situations in which the international scheme may need to be enabled without the enablement of the national ETS scheme, due to a crisis in a distant country for instance, the IEPS needs to be independent of the national scheme. E.106 describes the functional requirements, features, access and operational management of the IEPS. IEPS is applicable to voice and data services in Public Switched Telephone Networks (PSTN), Integrated Services Digital Networks (ISDN) and Public Land Mobile Networks (PLMN) irrespective of the bearer technology. The essential network features of IEPS are priority dial tone, priority call set up, including priority queuing schemes, and exemption from restrictive network management controls, such as call gapping.

6.6.2.2 IEPS signaling

An IEPS call indicator is required in signaling, switching and in bearer channels.

Supplement 53 to the ITU-T Q-Series of Recommendations specifies the signalling requirements to support the International Emergency Preferential Scheme (IEPS) [69] and the various signaling protocols have been enhanced to support IEPS, as follows:

- ISDN User Part (ISUP)
    - Q.761 Amendment 3 [70]

    - Q.762 Amendment 3 [71]
    - Q.763 Amendment 4 [72]
    - Q.764 Amendment 4 [73]
    - Q.767 Amendment 1 [74]
- Bearer Independent Call Control (BICC)
    - Q.1902.1 Amendment 2 [75]
    - Q1902.2 Amendment 3 [76]
    - Q.1902.3 Amendment 3 [77]
    - Q.1902.4 Amendment 3 [78]
- Call Bearer Control (CBC)
    - Q.1950 Amendment 1 Annex G [79]
- ATM Adaptation Layer type 2 (AAL2) signaling protocol
    - Q.2630.3 Amendment 1 [80]
- Broadband-ISUP (B-ISUP)
    - Q.2762 Amendment 1 [81]
    - Q.2763 Amendment 1 [82]
    - Q.2764 Amendment 1 [83]
- Digital Signalling System no.2 (DSS2)
    - Q.2931 Amendment 5 [84]

An IEPS priority indicator is included in the first signaling message of the call establishment procedure. In the ISDN User Part (ISUP) and Bearer Independent Call Control (BICC) protocols the Calling party's category ("IEPS call marking for preferential call set up") and IEPS call information ("country/international network of call origination" and "priority level") parameters trigger IEPS treatment. The Digital Signalling System no.2, Call Bearer Control (CBC) and ATM Adaptation Layer type 2 (AAL2) signaling protocols use a single IEPS indicator parameter.

When a node receives an IEPS call, it establishes the call with priority. The IEPS priority indicator is conveyed across the international signalling network and invokes preferential call handling in international transit exchanges, using special routing capabilities, for example, with exemption from restrictive network management controls. The network should employ procedures to reduce call set-up failures due to timer expirations caused by, for instance, queuing delays for trunk allocation on congested routes. The IEPS priority indication does not invoke pre-emption in the international network.

6.6.2.3 ETS in H.323 systems

ETS is also supported in H.323 systems. Recommendation ITU-T H.460.4 [85] specifies call priority and country/international network of call origination parameters that are transported in the H.225.0 RAS, H.225.0 Call Signalling (Q.931), Annex G/H.225.0, and H.501messages. The priority values available are: 0–emergencyAuthorised, 1–emergencyPublic, 2-High and 3-Normal.

The mapping of the Call Priority Designation and Country/International Network of Call Origination Identification between a packet network and a switched circuit network via a Gateway is described in Recommendation ITU-T H.246 Amendment 1 [86].

Multi-level precedence and preemption is supported in H.323 systems (described in Recommendation ITU-T H.460.14 [87]) as is message broadcast based on the use of internet multicast procedures (specified in Recommendation ITU-T H.460.21 [88]).

Recommendation ITU-T H.361 Amendment 1 Annex C [89] describes media stream priority mechanisms that can be used independently of call priority signaling.

6.6.2.4 ETS in H.248

ETS is also supported by the H.248 protocol that is used to communicate between a gateway controller and a gateway. Version 3 of the Gateway Control Protocol specified Recommendation ITU-T H.248.1 [90] includes the following parameters:

- Emergency call indicator
    - Individual-to-authority communication
- IEPS call indicator
- Priority indicator

The Emergency call indicator is used for the identification of emergency calls (individual-to-authority communication) and the IEPS call indicator for identification of an ETS/IEPS call. For an ETS/IEPS call, the H.248.1 IEPS call indicator carries the priority indication and the H.248.1 Priority indicator carries the priority level.

Supplement 9 to ITU-T H-Series Recommendations [91] describes how the parameters used to indicate ETS and IEPS calls in various signaling protocols are mapped into the gateway control protocol defined in H.248.1. Mappings are defined between H.248.1 and H.225 (i.e. in H.323 systems), the Session Initiation Protocol (SIP) and ISDN User Part (ISUP) to support ETS and IEPS.

Guidelines on the use of the IEPS call indicator and priority indicator in H.248 profiles for H.323 and NGN systems in support of priority services (e.g. ETS) are provided in H.248.81 [92].

The Multi-Level Precedence and Preemption service is also supported by H.248

[93].

6.6.2.5 ETS in IPCablecom

The requirements for preferential telecommunications over IPCablecom networks, covering prioritization and authentication aspects, are defined in Recommendation ITU-T [94] and a framework for implementing preferential telecommunications is given in Recommendation ITU-T J.261 [95].

Recommendation ITU-T J.262 [96] specifies authentication procedures for preferential communications over IPCablecom2 networks based on the use of PIN codes +and Session Initiation Protocol (SIP) authentication procedures.

Recommendation ITU-T J.263 is a specification for priority in preferential telecommunications over IPCablecom2 networks. The Resource-Priority and Accept-Resource-Priority headers (IETF RFC 4412) are used to signal the priority in SIP request and response messages and COPS interfaces are used to perform resource management and admission control. A GateSpec object specifies a session class ID with subfields to set priority and enable preemption.

6.6.2.6 ETS in Next Generation Networks

Recommendation ITU-T Y.1271 [98] presents an overview of the basic requirements, features and concepts for emergency telecommunications provided by both circuit and packet-switched networks.

Recommendation ITU-T Y.2205 [99] describes how emergency telecommunication and early warning services may be supported in Next Generation Networks, by indicating the interfaces within the NGN architecture for which priority indications can be given to support ETS, for example.

Three levels of admission control priority (from 1 indicating that highest priority should be given to this traffic to 3 indicating lowest priority) are defined in Recommendation ITU-T Y.2171 [100] and Recommendation ITU-T Y.2172 [101] specifies service restoration priority levels.

Appendix II of Recommendation ITU-T Y.2702 [102] describes the procedures for authentication and authorization to ETS in Next Generation Networks.

The signaling requirements to support ETS are described in Supplement 57 to ITU-T Q-Series Recommendations [103]. The Session Initiation Protocol (SIP), Gateway Control (H.248) and Diameter interfaces within the NGN architecture to which requirements are applicable are identified.

Supplement 61 to ITU-T Q-Series Recommendations [104] describes how the 3 priority levels defined in Y.2171 [100] can be supported in SIP, H.248.1 and Diameter (see Table 4).

[ITU-T Y.2171] priority level/category	SIP header values	[ITU-T H.248.1] values	Diameter AVP values
Level 1	RPH = 0, 1, 2, 3, 4	Indicator levels 15-11	Reservation-Priority AVP levels 15-11 Priority-Level AVP levels 1-7 Session-Priority AVP levels 0-4
Level 2	No RPH present	Indicator levels 10-1	Reservation-Priority AVP levels 10-1 Priority-Level AVP levels 8-13 No Session-Priority AVP present
Level 3	No RPH present	Indicator level 0	Reservation-Priority AVP level 0 Priority-Level AVP level 14 No Session-Priority AVP present

Table 4. Example mappings of signalling protocol extension values into ITU-T Y.2171 priority levels.

As NGN is built upon the Internet Protocol suite reference is made to a number of IETF specifications. RFCs 3689 [105] and 3690 [106] consider the requirements for an Internet Emergency Telecommunication Service and RFC 4542 [107] describes how the ETS is implemented in the Internet Protocol suite for real-time services. An IEPS (in this case an *Internet* Emergency Preparedness Service) requiring a Call Admission Control (CAC) procedure to be used in association with H.323 or SIP, for example, and a Per Hop Behaviour (PHB) for the associated data, such as that associated with the VOICE-ADMIT Differentiated Services Code Point defined in RFC 5865 [108] is described.

A mechanism for indication resource priority in SIP is defined in RFC 4412 [109]. This RFC defines two header fields for this purpose: the “Resource-Priority” and “Accept-Resource-Priority” header fields.

The Diameter Base Protocol (specified in RFC 6733[110]) has been enhanced by the addition of the following attribute value pairs (AVPs) to support of priority services (such as ETS):

- Reservation-Priority in ETSI TS 183 017 [111];
- Priority-Level (as part of the allocation retention priority (ARP) AVP) in ETSI TS 129 212 [112];
- Session-Priority in ETSI TS 129 229 [113]; and
- Multimedia Priority Service MPS-Identifier in ETSI TS 129 214 [114].

Further Diameter AVPs for the indication of priority are defined in RFC 6735 [115].

6.6.2.7 ETS in the Cloud

Support of ETS by Cloud Computing Services is under development in ITU-T Study Group 13.

6.6.2.8 ETS management

The Emergency Telecommunication Service (ETS) Management Service (ETSMS) is specified in Recommendation ITU-T M.3350 [116]. This Recommendation provides the basic functional requirements, framework, and use-cases for interchange of service management information across the TMN X-interface between authorized service customers and service providers associated with provision of Emergency Telecommunication Service (ETS).

6.6.2.9 ETS specifications defined by other SDOs

Supplement 62 to ITU-T Q-Series Recommendations [117] provides an overview of the work of standards development organizations and other telecommunications industry forums on emergency telecommunication services. It lists the specifications concerning ETS produced by the following organizations:

- ITU-T
- 3GPP
- 3GPP2
- ATIS
- Broadband Forum
- ETSI
- IEEE
- IETF
- TIA
- TM Forum
- WiMAX Forum

6.6.3 Emergency services for IMT-2000 networks

Supplement 47 to ITU-T Q-Series Recommendations [118] recommends both the support of emergency calls (with capabilities for the identification of emergency calls, emergency call handling and emergency caller location) and IEPS in IMT-2000 systems.

6.6.4 Early warning

6.6.4.1 Common Alerting Protocol

The Common Alerting Protocol (CAP) is defined in Recommendation ITU-T X.1303 [119]. CAP provides a general format using XML and compact binary encodings for exchanging all-hazard emergency alerts and public warnings over all kinds of networks.

The capabilities of CAP are as follows:

- flexible geographic targeting using latitude/longitude shapes and other geospatial representations in three dimensions;
- multilingual and multi-audience messaging;
- phased and delayed effective times and expirations;
- enhanced message update and cancellation features;
- template support for framing complete and effective warning messages;
- compatible with digital encryption and signature capability; and

- facility for digital images and audio.

CAP is used by, for example, the World Meteorological Organization, the United States Geological Survey, Department of Homeland Security and National Oceanic and Atmospheric Administration.

The ITU-D has produced guidelines for the use of CAP [120].

6.6.4.2 Alerting object identifier

Recommendation ITU-T X.674 [121] enables the identification of different kinds of alert and alerting agencies; specifies the information and justification to be provided when requesting an OID for alerting purposes; and the procedures for the operation of the Registration Authority. The World Meteorological Organization, for example, has registered {joint-iso-itu-t(2) alerting(49) wmo(0)} for weather alerts and weather alerting agencies and use it in conjunction with the Common Alerting Protocol.

6.6.4.3 Alerting in H.323 systems

Annex M5 of Recommendation ITU-T H.323 [122] specifies a mechanism for the tunnelling of common alerting protocol (CAP) messages in H.323 and Recommendation ITU-T H.460.25 [123] describes how geographic information can be transported in H.323 systems.

6.6.5 Outside plant

The measures that can be taken to minimize the risk to outside plant are described in Recommendation ITU-T L.92 [124]. A summary of the various measures appropriate to combat typical environmental hazards is provided in Table 5.

Natural disaster	Countermeasure
Earthquake	Observe earthquake-resistance design standards and building codes; Restrict installation in active earthquake faults; Strengthen materials used in outside plant facilities; Rubber joints for cable tunnels; Liquefaction countermeasures on manholes; Extendable joints for ducts and seismic simulations; Install vibration controlling or mitigating systems; Install structural health monitoring systems.
Tsunami	Locate central offices and cable routes on high ground; Strengthen trunk line backup systems by subdividing physical network loops; Lay cables with ducts under riverbed rather than installing cables along bridges near the mouths of rivers; Ensure an emergency electrical power supply is available.
Flood	Restrict installation in potential flood zones;

	Install concrete structures at sites in which ground settlement may be expected due to heavy rains; Install retaining structures or guardrails between outside plant facilities and steep slopes; Install waterproof doors; Water-proof cable channels and manholes; Seal the ends of the plastic tubes (at the manholes/pits of underground infrastructure) with foam filler; Install drainage pumps and install flood walls in cable tunnels; Submersion detection modules and cable tunnel management systems.
Strong wind	Observe design criteria for protection against strong winds; Install supports (i.e. struts, guy lines or stay wires); Brace poles alternatively with steel wires when the expected wind speed exceeds 40 m/s; Use bracing between poles in windy locations; Use vibration dampers to protect cables.
Landslides	Avoid landslide-prone areas; Increase the stability of slopes.
Forest fire	Create fire breaks (isolating clean land strips) especially in the rural areas; Protect outside plant facilities with non-flammable or fire-retarding materials; Use non-flammable materials in cable structures.
Severe cold, snow, ice or heat	Cover manholes in snow covered areas and install tubes for antifreeze in ducts.

Table 5. Outside plant countermeasures for natural disasters (derived from Recommendation ITU-T L.92 [124])

The protection of telecommunications lines using metallic components (symmetric pair, coaxial or optical fibre cables) against direct lightning flashes to the line itself or to structures that the line enters is described in Recommendation ITU-T K.47 [125].

6.6.6 Service restoration priority

It is important that critical services, such as control plane traffic and emergency communications, be given priority when services are restored following network failure. Three levels of restoration priority are recommended for use in Next Generation Networks in Recommendation ITU-T Y.2172 [101].

6.7 ITU-R

6.7.1 ITU-R Resolutions

Radiocommunication services are particularly important for disaster prediction, detection, alerting and relief as in some circumstances the "wired" telecommunication infrastructure is significantly or completely destroyed by a disaster and only radiocommunication services can be employed for disaster relief operation. Radio systems are critical for first response operations and terrestrial, and especially radio, broadcasting plays an important role in distributing emergency information.

The following World Radiocommunication Conference resolutions address emergency and disaster radiocommications:

- Resolution 644 (WRC-07) Radiocommunication resources for early warning, disaster mitigation and relief operations
- Resolution 646 (WRC-03) Public protection and disaster relief
- Resolution 647 (WRC-07) Spectrum management guidelines for emergency and disaster relief radiocommunication
- Resolution 673 (WRC-07) Radiocommunications use for Earth observation applications

6.7.2 Special Supplement on Emergency and Disaster Relief

The ITU-R published a Special Supplement in 2006 that describes the activities of ITU-R Study Groups and includes copies of ITU-R texts available at that time concerning emergency and disaster relief including Radio Regulation texts, ITU-R Recommendations and ITU-R Reports. This material was also included in the "Compendium of ITU's work on Emergency Telecommunications" published in 2007.

6.7.3 ITU-R Recommendations

The following ITU-R Recommendations are applicable to various aspects of radiocommunication for emergency and disaster relief:

- ITU-R Recommendation BO/BT.1774 "Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief"
- ITU-R Recommendation F.1105 "Fixed wireless systems for disaster mitigation and relief operations"
- ITU-R Recommendation M.632 "Transmission characteristics of a satellite position-indicating radio beacon (satellite EPIRB) system operating through geostationary satellites in the 1.6 GHz band"
- ITU-R Recommendation M.633 "Transmission characteristics of a satellite emergency position-indicating radio beacon (satellite EPIRB) system operating through a satellite system in the 406 MHz band"
- ITU-R Recommendation M.690 "Technical characteristics of emergency position-indicating radio beacons (EPIRBs) operating on the carrier frequencies of 121.5 MHz and 243 MHz"
- ITU-R Recommendation M.693 "Technical characteristics of VHF emergency position-indicating radio beacons using digital selective calling (DSC VHF EPIRB)
- ITU-R Recommendation M.1042 "Disaster communications in the amateur and amateur-satellite services"

- ITU-R Recommendation M.1637 “Global cross-border circulation of radiocommunication equipment in emergency and disaster relief situations”
- ITU-R Recommendation M.1826 “Harmonized frequency channel plan for broadband public protection and disaster relief operations at 4 940-4 990 MHz in Regions 2 and 3”
- ITU-R Recommendation M.1854 “Use of mobile-satellite service in disaster response and relief”
- ITU-R Recommendation 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 (WRC-03)”
- ITU-R Recommendation 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 Recommendation RS.1859 “Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies”
- ITU-R Recommendation S.1001 “Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations”
- ITU-R Recommendation SA.1863 “Radiocommunications used for emergency in manned space flight”

6.7.3 ITU-R Reports

The following ITU-R Reports consider various aspects of radiocommunication for emergency and disaster relief:

- M.2033 “Radiocommunication objectives and requirements for public protection and disaster relief”
- M.2085 “Role of the amateur and amateur-satellite services in support of disaster mitigation and relief”
- M.2149 “Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies”
- S.2151 “Use and examples of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations”

6.8 ITU-D Handbooks

The ITU-D has produced the following handbooks:

- Handbook on Disaster Communications (2001)
- Handbook on Emergency Telecommunications (2005) [126] - under revision
- Compendium of ITU’s work on Emergency Telecommunications (2007)
- Best Practices on Emergency Telecommunications
- Guidelines on the use of the Common Alerting Protocol (Report of 2006 – 2010 study period Q.22/2 - Utilization of ICT for disaster management, resources, and active and passive space-based sensing systems as they apply to disaster and emergency relief situations) [120]

Work is currently in progress on a handbook on “Telecommunications outside plant in areas frequently exposed to natural disasters”.

7 The International Amateur Radio Union (IARU)

The International Amateur Radio Union consisting of over 160 national amateur radio societies represents the interests of the global amateur radio community of more than 2 million licensed radio "hams". The IARU is a member and participates in the work of the ITU-R and ITU-D. In particular, the IARU is active in discussions of emergency communications and disaster planning and response in the ITU-D.

The "Amateur Service" is defined in article 25 of the Radio Regulations that states:

- "Amateur stations may be used for transmitting international communications on behalf of third parties only in case of emergencies or disaster relief. An administration may determine the applicability of this provision to amateur stations under its jurisdiction."

- "Administrations are encouraged to take the necessary steps to allow amateur stations to prepare for and meet communication needs in support of disaster relief."

The constitution of the IARU promotes the use of amateur radio "as a means of providing relief in the event of natural disasters" and provides information on emergency communications [27]. Amateur radio is a valuable asset during an emergency as the global, regional, national and local links for voice and data communication are independent of vulnerable infrastructure and immune to overload. Radio hams are also very skilled and many have undertaken special training in emergency communications.

Amateur radio operators have provided valuable communication channels from areas affected by a disaster to the outside world, for example, for remote locations affected by the 2004 Indian Ocean tsunami, Hurricane Katrina, the Sichuan earthquake in 2008 and, as we have seen, in the earthquakes in Turkey. The Amateur Service is integrated into the emergency preparedness systems in a number of countries such as the USA, Germany, Finland, Indonesia and Cuba. In some countries, such as Turkey, amateur radio is integrated into the communications systems of rescue teams in national and international operations.

8 Other standardization activities

8.1 3GPP

3GPP have developed a Multimedia Priority Service (MPS) to provide an IP Multimedia Subsystem (IMS) ETS service and a Cell Broadcast Service (CBS) that can be used to broadcast information such as early warnings to mobile subscribers within a specific geographical area consisting of one or more cells.

The following specifications describe MPS:

- 3GPP TS 22.153 Multimedia priority service
- 3GPP TR 22.950 Priority service feasibility study
- 3GPP TR.22.952 Priority service guide
- 3GPP TR 23.854 Enhancements for MPS

A CBS "page" consists of 82 octets and up to 15 pages can be concatenated to form a CBS message. The Cell Broadcast Service is specified in:

- 3GPP TS 23.041 Technical realization of Cell Broadcast Service (CBS)
- 3GPP TS 44.012 Short Message Service Cell Broadcast (SMSCB) support on the mobile radio interface
- 3GPP TS 45.002 Multiplexing and multiple access on the radio path
- 3GPP TS 48.049 Base Station Controller - Cell Broadcast Centre (BSC-CBC) interface specification; Cell Broadcast Service Protocol (CBSP)

8.2 ATIS

ATIS has specified the Commercial Mobile Alert System (CMAS) over LTE (ATIS-0700010), based on the Cell Broadcast Service, that allows LTE-enabled devices to receive CMAS alerts during emergencies or natural disasters.

ATIS also has produced a number of specifications concerning ETS.

8.3 ETSI

The ETSI Emergency Communications committee (EMTEL) is working on communications:

- from citizens to authorities/organizations (emergency calls);
- between authorities/organizations (public safety communications);
- from authorities/organizations to citizens (warning systems); and
- amongst citizens during emergencies [128].

The following specifications have been produced:

- ETSI SR 002 777 Test/verification procedure for emergency calls
- ETSI TR 102 180 Basis of requirements for communication of individuals with authorities/organizations in case of distress (Emergency call handling)

- ETSI TS 102 181 Requirements for communication between authorities/organizations during emergencies
- ETSI TS 102 182 Requirements for communications from authorities/organisations to the citizens during emergencies
- ETSI TR 102 410 Basis of requirements for communications between individuals and between individuals and authorities whilst emergencies are in progress
- ETSI TR 102 299 Collection of European Regulatory Texts and orientations
- ETSI TR 102 444 Analysis of the Short Message Service (SMS) and Cell Broadcast Service (CBS) for Emergency Messaging applications; Emergency Messaging; SMS and CBS
- ETSI TR 102 445 Overview of Emergency Communications Network Resilience and Preparedness
- ETSI TR 102 476 Emergency calls and VoIP: possible short and long term solutions and standardization activities
- ETSI TR 102 850 Analysis of Mobile Device Functionality for PWS
- ETSI TS 102 900 European Public Warning System (EU-ALERT) using the Cell Broadcast Service
- ETSI TR 103 170 Total Conversation Access to Emergency Services

EMTEL is working on a Technical Specification on "Total Conversation" for the handling of emergency calls placed by people with disabilities who, for example, need video for sign language or real-time text for a text-based conversation or as a complement to a voice conversation. Draft ETSI TS 101 470 "Total Conversation Access to Emergency Services" is expected to be approved in June 2013.

8.4 Internet Engineering Task Force (IETF)

The IETF Internet Emergency Preparedness (IEPREP) working group produced the following specifications:

- RFC 3487 "Requirements for Resource Priority Mechanisms for the Session Initiation Protocol (SIP)" describes the requirements for prioritizing access to circuit-switched network, end system and proxy resources for emergency preparedness communications using the Session Initiation Protocol (SIP).
- RFC 3523 "Internet Emergency Preparedness Telephony Topology Terminology" defines the topology naming conventions that are to be used in reference to Internet Emergency Preparedness (IEPREP) phone calls. It describes 4 basic topologies: "IP Bridging", "IP at the Start", "IP at the End" and "End-to-End IP".
- RFC 3689 "General Requirements for Emergency Telecommunication Service (ETS)" describes the requirements for signalling (optional), the application of labels, the use of policy, network functionality and the security related requirements of authorization, integrity and authentication, and confidentiality.
- RFC 3690 "IP Telephony Requirements for Emergency Telecommunication Service (ETS)" is an extension to the general requirements presented in RFC 3689 that describes the requirements related to telephony signaling for Internet-based telephony services. These include the capability of the signalling protocol to carry labels mapped to the various emergency related labels/markings used in other telephony networks, such as the Public Switched Telephone Network (PSTN).
- RFC 4190 "Framework for Supporting Emergency Telecommunication Service (ETS) in IP Telephony" presents a framework for supporting authorized, emergency-related

communication within the context of IP telephony. The signaling, policy, traffic engineering, security and routing mechanisms to support traffic from ETS users are described.

- RFC 4375 “Emergency Telecommunication Service Requirements for a Single Administrative Domain”.
- RFC 4958 “A Framework for Supporting Emergency Telecommunication Service Within a Single Administrative Domain” presents a framework discussing the role of various protocols and mechanisms that could be considered candidates for supporting Emergency Telecommunication Services (ETS) within a single administrative domain.

In addition, the following specifications are relevant to communications in emergencies and disasters:

- RFC 4412 “Communications Resource Priority for the Session Initiation Protocol (SIP)” defines the SIP header fields for communicating resource priority ("Resource-Priority" and "Accept-Resource-Priority") which can be used to influence the behaviour of SIP user agents (such as telephone gateways and IP telephones) and SIP proxies.
- RFC 5115 “Telephone Routing over IP (TRIP) Attribute for Resource Priority” defines an attribute for the TRIP protocol, based on the NameSpace.Value tuple defined for the SIP Resource-Priority header field, to locate PSTN ETS services reachable through a TRIP gateway.
- RFC 5865 “A Differentiated Services Code Point (DSCP) for Capacity-Admitted Traffic” requests a Differentiated Services Code Point (DSCP) from the Internet Assigned Numbers Authority (IANA) for a class of real-time traffic which conforms to Expedited Forwarding Per-Hop Behavior.
- RFC 6401 “RSVP Extensions for Admission Priority” specifies extensions to the Resource reSerVation Protocol (RSVP) that can be used to support an admission priority capability at the network layer in times of network congestion.
- RFC 6679 “Explicit Congestion Notification (ECN) for RTP over UDP” specifies how ECN can be used with the Real-time Transport Protocol (RTP) running over User Datagram Protocol (UDP) using the RTP Control Protocol (RTCP) as a feedback mechanism.
- RFC 6735 “Diameter Priority Attribute-Value Pairs” defines Attribute-Value Pair (AVP) containers for various priority parameters for use with Diameter and the Authentication, Authorization, and Accounting (AAA) framework.
- RFC 6710 “Simple Mail Transfer Protocol Extension for Message Transfer Priorities” defines an extension to the SMTP (Simple Mail Transfer Protocol) service whereby messages are given a label to indicate preferential handling, and therefore, to enable mail handling nodes to take this information into account for onward processing.
- RFC 6758 “Tunneling of SMTP Message Transfer Priorities” defines a mechanism for tunneling of SMTP Message Transfer Priority values through MTAs (Message Transfer Agents) that don't support the MT-PRIORITY SMTP extension.

8.5 OASIS emergency management committee

The OASIS Emergency Management technical committee develops information exchange standards for emergency preparedness and response. The Emergency Data Exchange Language (EDXL) is a framework for a wide range of emergency data exchange standards to support operations, logistics, planning and finance [129]:

EDXL Common Alerting Protocol (EDXL-CAP)
EDXL Distribution Element (EDXL-DE)
EDXL Hospital AVailability Exchange (EDXL-HAVE)
EDXL Resource Message (EDXL-RM)
EDXL Reference Information Model (EDXL-RIM)
EDXL Situation Reporting (EDXL-SitRep)

EDXL Tracking Emergency Patients (EDXL-TEP)”

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[104] Supplement 61 to ITU-T Q-Series Recommendations “Evaluation of signaling protocols to support ITU-T Y.2171 admission control priority levels”

[105] IETF RFC 3689 “General Requirements for Emergency Telecommunication Service (ETS)”

[106] IETF RFC 3690 “IP Telephony Requirements for Emergency Telecommunication Service (ETS”

[107] IETF RFC 4542 “Implementing an Emergency Telecommunications Service (ETS) for Real-Time Services in the Internet Protocol Suite”

[108] IETF RFC 5865 “A Differentiated Services Code Point (DSCP) for Capacity-Admitted Traffic”

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[110] IETF RFC 6733 “Diameter Base Protocol”

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[112] ETSI TS 129 212 “Universal Mobile Telecommunications System (UMTS);

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[113] ETSI TS 129 229 "Digital cellular telecommunications system (Phase 2+);

Universal Mobile Telecommunications System (UMTS); LTE; Cx and Dx interfaces based on the Diameter protocol; Protocol details (3GPP TS 29.229 version 9.3.0 Release 9)"

[114] ETSI TS 129 214 "Universal Mobile Telecommunications System (UMTS);

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[115] IETF RFC 6735 "Diameter Priority Attribute-Value Pairs"

[116] Recommendation ITU-T M.3350 "TMN service management requirements for information interchange across the TMN X-interface to support provisioning of Emergency Telecommunication Service (ETS)"

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[122] Recommendation ITU-T H.323 "Packet-based multimedia communications systems" - Annex M5 "Tunnelling of common alerting protocol (CAP) messages in H.323"

[123] Recommendation ITU-T H.460.25 "Transport of geographic information in ITU-T H.323 systems"

[124] Recommendation ITU-T L.92 "Disaster management for outside plant facilities"

[125] Recommendation ITU-T K.47 "Protection of telecommunications lines against direct lightening flashes"

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