Final Report

ITU-D
Study Group 2

Question 5/2

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

6th Study Period
2014-2017

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Question 5/2: Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response

Final Report

Preface

ITU Telecommunication Development Sector (ITU-D) study groups provide a neutral contribution-driven platform where experts from governments, industry and academia gather to produce practical tools, useful guidelines and resources to address development issues. Through the work of the ITU-D study groups, ITU-D members study and analyse specific task-oriented telecommunication/ICT questions with an aim to accelerate progress on national development priorities.

Study groups provide an opportunity for all ITU-D members to share experiences, present ideas, exchange views and achieve consensus on appropriate strategies to address telecommunication/ICT priorities. ITU-D study groups are responsible for developing reports, guidelines and recommendations based on inputs or contributions received from the membership. Information, which is gathered through surveys, contributions and case studies, is made available for easy access by the membership using content-management and web-publication tools. Their work is linked to the various ITU-D programmes and initiatives to create synergies that benefit the membership in terms of resources and expertise. Collaboration with other groups and organizations conducting work on related topics is essential.

The topics for study by the ITU-D study groups are decided every four years at the World Telecommunication Development Conferences (WTDCs), which establish work programmes and guidelines for defining telecommunication/ICT development questions and priorities for the next four years.

The scope of work for **ITU-D Study Group 1** is to study "**Enabling environment for the development of telecommunications/ICTs**", and of **ITU-D Study Group 2** to study **"ICT applications, cybersecurity, emergency telecommunications and climate-change adaptation"**.

During the 2014-2017 study period **ITU-D Study Group 2** was led by the Chairman, Ahmad Reza Sharafat (Islamic Republic of Iran), and Vice-Chairmen representing the six regions: Aminata Kaba-Camara (Republic of Guinea), Christopher Kemei (Republic of Kenya), Celina Delgado (Nicaragua), Nasser Al Marzouqi (United Arab Emirates), Nadir Ahmed Gaylani (Republic of the Sudan), Ke Wang (People's Republic of China), Ananda Raj Khanal (Republic of Nepal), Evgeny Bondarenko (Russian Federation), Henadz Asipovich (Republic of Belarus), and Petko Kantchev (Republic of Bulgaria).

Final report

This final report in response to **Question 5/2: "Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response"** has been developed under the leadership of its Rapporteur: Kelly O'Keefe (United States of America); and three appointed Vice-Rapporteurs: Hideo Imanaka (Japan), Richard Krock (Alcatel-Lucent USA Inc., United States of America) and Jean-Marie Maignan (Haiti). They have also been assisted by ITU-D focal points and the ITU-D Study Groups Secretariat.

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

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Executive Summary

ITU-D Study Group 2 is pleased to share the final report on Question 5/2 *"Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response"*. This report is based on contributions from Member States and sector members and interactive discussions held throughout the study period. This report consists of two parts. The first part of this report is on use of Information and Communication Technologies (ICTs) for disaster communications management, approaches and systems available to increase redundancy and resiliency of ICTs, and a review and analysis of a range of technology and policy case studies presented by administrations and organizations regarding implementation of ICTs during all disaster phases. The second part of this report provides an Emergency Communications Checklist outlining the types of activities and expected decision points that could be considered for inclusion in a National Disaster Communications Plan.

Disasters can be natural or man-made and can negatively impact societies, causing disruption of the normal functioning of social and economic life. These negative impacts require an immediate response from authorities and from citizens in order to help those impacted and to re-establish acceptable thresholds of well-being and life opportunities. The combination of hazards, vulnerability and inability to reduce the potential negative consequences of risk results in disaster. Because most disasters cannot be predicted, preparedness and disaster risk management are crucial to saving lives and protecting property. It is also important to consider risk management (i.e. damage mitigation, damage preparedness, and early warning/prediction) during non-emergency times. Effective planning and preparedness can save lives.

In this context, Information and Communications Technologies (ICTs) play a pivotal role in disaster prevention, mitigation and management. Effective disaster management relies upon the timely and effective sharing of information among diverse stakeholders, and ICTs are essential tools to support these communication requirements. ICTs can support all phases of disaters including prediction and early warning (remote sensing via satellites, radar, telemetry and meteorology; satellite M2M sensing technologies; alerts distributed via broadcasting or mobile technology); initial response (radio and television broadcasting, amateur radio, satellite, mobile telephony and Internet); and recovery (temporary base stations; portable emergency systems). ICTs play a major role in informing the public about the risks of a potential or impending disaster, disseminating information once a disaster occurs, and enabling the continuity of business and social activities once the recovery begins.

Due to the importance and demand for ICTs during all phases of disasters, continuity of operations is an important consideration for disaster communications management. Organizations use a variety of technical approaches and systems to ensure resiliency and redundancy and facilitate the rapid restoration of connectivity after a disaster takes place. Additionally, data collected following major disaster events on the use and performance of ICT networks and applications help contribute to technological developments and towards improving disaster plans and processes.

Chapter summaries

– **PART I: Report on ICT experiences and best practices in disaster mitigation and relief**

Chapter 1 provides a brief overview of the role of ICTs in the overall disaster management process and also addresses accessibility considerations.

Chapter 2 provides a comprehensive overview of the variety of existing and emerging ICT networks, services and applications available to support evolving user demands. The chapter discusses approaches to ensure resiliency and redundancy of systems to enable connectivity following a disaster event.

Chapter 3 provides a summary table of the case studies received throughout the study period discussing use of ICTs in different phases of disaster management. **Annex 1** contains summaries of the case studies referenced in the table, providing further detail on disaster communications plans and policies, different types of systems deployed and used for disaster communications, and emerging technological developments that can help improve disaster response capabilities. Also, included in **Annex 1** are hyperlinks to the complete case studies as submitted to Q5/2 in this study period.

Chapter 4 provides lessons learned and best practices identified through the wide range of inputs received during the study period. This chapter also provides a glimpse into the future of the Question identifying any new areas for study should it continue.

PART II: Emergency communications checklist

This checklist considers the types of activities and decision points that could be considered for inclusion in a National Disaster Communications Plan. It has been developed for use in helping establish or refine national or regional disaster communications management plans, rather than for use in an actual disaster.

Throughout the study cycle, ITU-D Study Group 2 has been able to examine a wide range of activities throughout both developed and developing countries related to emergency communications and disaster relief. Whereas 10 years ago, only few developing countries may have had comprehensive emergency communications plans or frameworks, input contributions have shown that such plans are more common. Further, more countries and organizations are taking steps to develop early warning systems and make telecommunications/ICT networks more resilient to disaster risks. That being said, discussions during the study cycle identified the need for additional implementation support for developing countries in the area of disaster communications management.

Since disasters cannot be eliminated all over the world, and new and emerging ICTs can be developed year by year, in the next study period, the Study Question could continue studying emergency telecommunication and disaster preparedness, mitigation, response and relief, in order to save human lives in the case of disasters. Considering the value of disaster preparedness, the output of the Question may focus on implementation and how to enable and empower developing countries to benefit from the vast amount of available information that already exists about use of ICTs for disaster communications management. More time could be devoted to exchange of experiences among developing countries to identify common challenges and successful practices and support ongoing development and implementation of disaster communications frameworks, technologies and plans.

PART 1 – Report on ICT Experiences and Best Practices in disaster mitigation and relief

1 CHAPTER 1 – General overview: Use of ICTs for disaster management

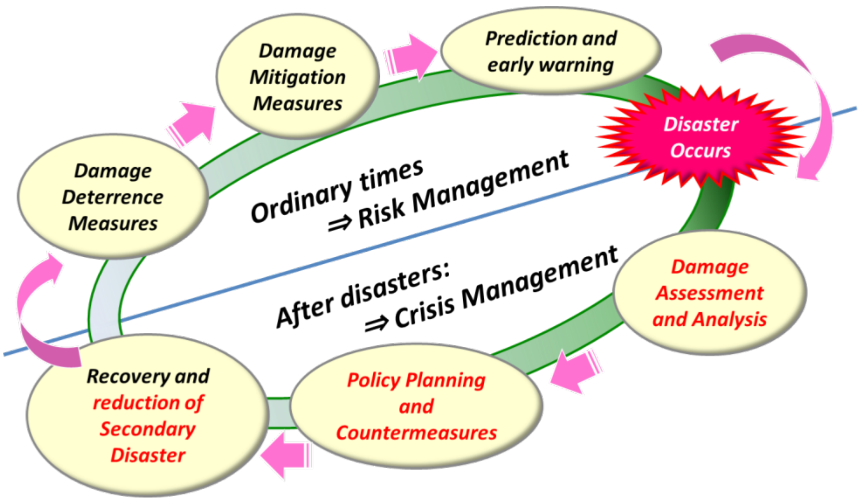
1.1 Introduction

Effective disaster management is dependent on the timely and effective delivery of information to those who need it. Types of information needed to support disaster management cover wide-ranging areas such as disaster sensing and alerts, damage assessments, shelter locations, logistical and supply chain coordination, emergency medical support, determining the safety and welfare of family and friends, and search and rescue. Communication channels involve citizens, government and public safety officials, relief workers, private sector organizations, and more. Information and Communication Technologies (ICTs) are essential tools to support the diverse communication requirements between these diverse stakeholders. This chapter presents an overview of key considerations supporting the use of ICTs for all phases of disaster management.

1.2 Use of ICTs in all phases of disasters

As shown in **Figure 1**, disaster risk management involves several steps during the risk (i.e. pre-disaster) and crisis (i.e. post-disaster) management phases. These phases are generally applicable to both natural and mand-made disasters.

Figure 1: Disaster risk management flow



Risk management – Pre-disaster

– Damage deterrence measures: increasing ICT resiliency and redundancy;

– Damage mitigation measures: organizational planning and policy development; pre-positioning supplies and equipment; training and capacity building; community and citizen outreach and preparedness;

– Prediction and early warning: sensors and early warning systems; big data analysis can also provide general estimates.

Crisis management – After-disaster

– Damage assessment and analysis: information collection on disaster impact (e.g., locations of damage, victim numbers, and/or damage/impact analysis); impact to ICT networks.

– Policy planning and countermeasures:

1) activating disaster plans,

2) enacting countermeasures to address disaster damage,

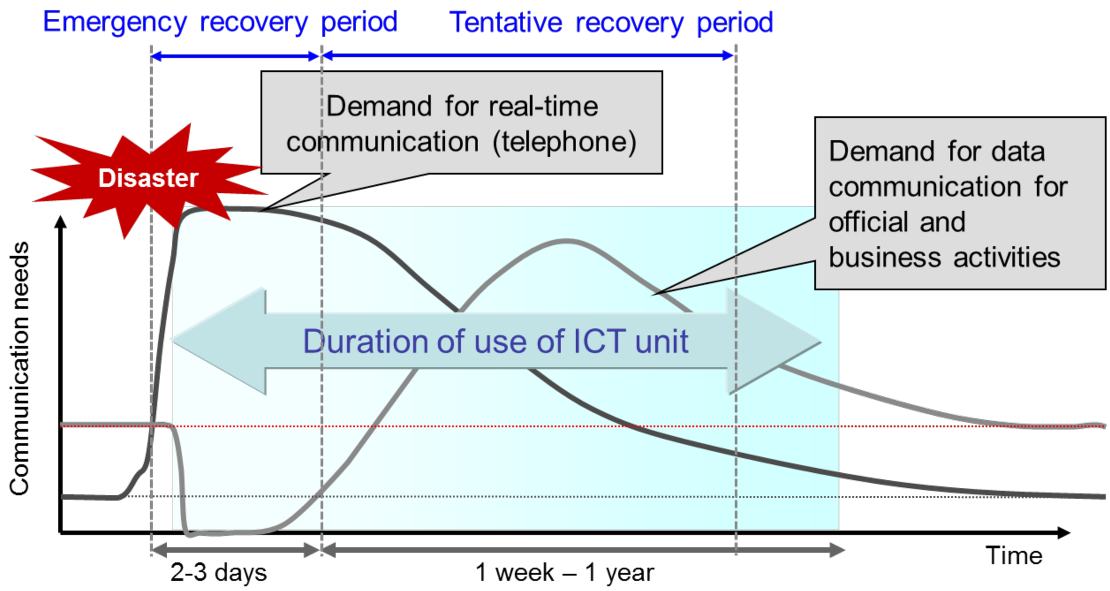
3) command and instruction to/coordination with first responders (e.g., local government staff), and

4) calls to government, police, military and relief organizations for reinforcement as required.

– Recovery and reduction of Secondary Disaster: Provision of information (e.g., evacuation centers, relief goods); network restoration and infrastructure rebuilding.

ICTs support and enable all of the above phases of disaster management, with user demand for different types of systems, services and applications shifting throughout the cycle. **Figure 2** shows a general trend of post-disaster ICT use, with horizontal and vertical axes indicating time and demand for ICT services, respectively. Generally, the initial emergency response period sees an increasing demand for real-time communications like telephone and email. Real-time communication in this time period is essential for life-saving efforts like search and rescue operations. During this period, people's primary ICT needs often are to confirm the safety and security of family, friends, personnel, and assets. After initial recovery, restoration efforts begin. However, the duration of this recovery period depends on the disaster's severity. **Chapter 2** will describe in more detail the types of existing and emerging ICT networks, services and applications available to support evolving user demands as well as approaches to ensure network resiliency.

Figure 2: ICT service demand after a disaster



Source: Satoshi Kotabe, Toshikazu Sakano, Katsuhiro Sebayashi, and Tetsuro Komukai: "Rapidly Deployable Phone Service to Counter Catastrophic Loss of Telecommunication Facilities", NTT Technical Review, Vol. 12 No. 3 Mar. 2014.

1.3 ICTs for disaster management and smart sustainable development

The United Nations International Strategy for Disaster Reduction's (UN ISDR) 2013 Global Assessment Report on Disaster Risk Reduction puts the total global annual loss from earthquakes at more than

US$100 billion, with the losses from tropical cyclones accounting for more than US$80 billion. In real terms, developed countries experience greater economic losses whereas developing countries suffer most casualties, injuries and displacements. The Sendai Framework for Disaster Risk Reduction 2015-2030 and the UN Sustainable Development Goals (SDGs) have brought renewed focus to concepts of sustainability, disaster risk reduction and resiliency. In 2013, the ITU BDT launched a Smart Sustainable Development Model (SSDM) Initiative to help create a framework for optimizing use of ICT resources for both development (ICT4D) and disaster management (ICT4DM). The intention is that a dual ICT4D and ICT4DM approach may be efficient, cost effective, and timely in utilization of scarce resources.[1] Further information about the Sendai Framework for Disaster Risk Reduction 2015-2030 may be found at: http://www.unisdr.org/we/inform/publications/43291.

1.4 Enabling policy and regulatory environment

While this report focuses on technology considerations and case studies, establishment of an enabling policy and regulatory environment is an important component of disaster communiations management. The enabling policy environment includes both general telecommunications regulatory and policy frameworks affecting overall deployment and use of ICTs, but also the establishment of frameworks and policies specific to disaster events. General policy considerations include reduction of regulatory barriers to the deployment of ICTs, promotion of robust and resilient ICT infrastructure development, streamlining of licensing procedures, and spectrum management. Disaster communications frameworks and policies help guide activities, roles and responsibilities throughout a disaster event and help ensure continuitiy of ICT operations following a disaster. Specific ICT policy and regulatory considerations for disaster response frameworks may include development of special, expedited licensing procedures for use during a disaster, addressing possible customs barriers to entry of emergency communications equipment, or considering implementation of the Tampere Convention. A number of input contributions addressed government and organizational policy and planning throughout the 2014-2017 study period. **Chapter 3** and **Annex 1** on case studies and **Chapter 4** on lessons learned provide additional information on policy and regulatory considerations, as does the Emergency Communications Checklist in **Part II**.

1.5 Human factors and stakeholder collaboration

A wide range of players and stakeholders are impacted by disasters and are brought into the disaster management process. Any given disaster event may involve several different ministries and government departments at the national, state and local levels, foreign aid and relief organizations, NGOs and civil society, private sector entities, and volunteers and citizen action groups. In some cases each agency and organization has a prescribed mandate, but often these mandates and roles overlap. It is important for all agencies and organizations involved in the response efforts to communicate, coordinate, and work with each other to ensure an effective response – before, during and after a disaster. Training on use of ICTs for a response and implementation of disaster drills and exercises should include and account for these diverse stakeholders. The Emergency Communications Checklist in **Part II** provides additional guidance on the stakeholder cooperation required in developing and implementing a disaster communications framework or plan.

Additionally, the impact of a disaster is rarely limited to just one country, and cooperation with neighbors and within a region is an important component of disaster communications planning and preparedness. Throughout the study period, ITU-D Study Group 2 received information from regional organizations including the Asia-Pacific Telecommunity (APT) and the Inter-American Telecommunication Commission (CITEL) regarding workshops and other activities in support of regional capacity building, cooperation and coordination in disaster communications.

[1] Additional information on the SSDM may be found at: http://www.itu.int/en/ITU-D/Initiatives/SSDM/Pages/default.aspx.

In addition to the involvement of numerous stakeholders in disaster preparedness, it is important to remember the impact of a disaster on individual citizens and their families when planning for response. Disaster plans should account for the liklihood that key staff or their families may have been impacted directly by a disaster and thus may not be able to support a response. For example, in the wake of a disaster, organizations should identify mechanisms to confirm their staff's safety, such as through safety confirmation and broadcast message systems that broadcast messages about staff members' safety.

Additionally, all disasters are local – when a disaster strikes neighbors are the first responders; citizens will first seek to help themselves. ICTs can offer tools to address this reality – enabling citizens to help themselves or by mutual assistance between citizens. For this purpose, citizens and local government could develop hazard maps in coordination with citizens, anticipating areas impacted by a disaster or evactuaion and shelter locations to help support disaster risk reduction and improve citizen awareness.

1.6 Accessibility considerations

Times of disaster are especially difficult for the vulnerable, such as persons with disabilities, children and the elderly, migrant workers, the unemployed, those displaced from their homes due to earlier disasters, underlining the need to ensure that disaster management is inclusive of and responsive to their needs. Comprehensive information on the role ICTs can play in assisting marginalized populations who face barriers in accessing disaster response services may be found in ITU Report *"Accessible ICTs for persons with disabilities: Addressing preparedness"*.[2] This report also includes a *"How-To Action Guide"* which offers specific recommendations for stakeholders at each phase of disaster management. Cross cutting recommendations include:

– Consult with members of vulnerable populations directly on their needs and facilitate their involvement at all stages of the disaster management process.

– Ensure that accessibility and usability of ICTs is considered in any project on ICT-based disaster management processes or ICT-based development projects.

– Use different types of strategies and mechanisms to promote accessible ICTs including legislation, policy, regulations, license requirements, codes of conduct, and monetary or other incentives.

– Build the capacity of vulnerable populations to use ICTs in disaster situations through awareness raising programmes, trainings, and skills development programmes.

– Use multiple modes of communication to provide information before, during, and after disasters including through:
  - Accessible websites and mobile apps designed as per the current WCAG guidelines;
  - Radio and television public service announcements (using measures for accessibility such as audio, text, captions, and sign language interpretation);
  - Announcements and tips sent through SMS, MMS; mass emails to citizens from government authorities, aid and relief agencies, and others;
  - Accessible electronic fact sheets, handbooks, and manuals;
  - Multimedia including presentations, webinars, webcasts, and videos including on popular sites such as YouTube;
  - Dedicated social media such as Facebook pages and Twitter accounts created by governments and disaster response organizations;

[2] ITU Report on *"Accessible ICTs for persons with disabilities: Addressing preparedness"*, 2017 can be found at: https://www.itu.int/md/D14-SG02-C-0401/.

- Citizen focused working groups and discussion forums.

– Be aware of the potential for misuse of personal data of vulnerable populations in disaster situations and develop ethical norms and standards for data sharing.

– Provide information packs, guides and manuals and conduct public awareness campaigns in multiple accessible formats in different languages and provide sensitized resource persons to impart the contents of these packs to persons with disabilities and other vulnerable groups.

– Develop, promote and distribute mainstream and assistive technologies which can be used at times of emergencies and disasters; provide necessary training to persons to use them.

– Develop frameworks to facilitate inter-agency collaboration and conduct drills and trust building initiatives.

– Specify accessible ICT infrastructure as part of procurement guidelines wherever applicable.

– Ensure that all services, facilities and infrastructure developed after a disaster are accessible and inclusive.

– Provide information in multiple formats and through multiple modes about ongoing recovery efforts and how to get help or access to resources.

– Review disaster response efforts to assess any challenges for vulnerable groups, discuss lessons learned, and undertake efforts to fix any issues in ICT-based disaster management services.

2 CHAPTER 2 – Network resiliency and ICT systems for early warning, response and recovery

Telecommunications and ICTs support all disaster phases. The following chapter provides information on a variety of existing and emerging ICT networks, services and applications available to support evolving user demands. The chapter also discusses approaches to ensure resiliency and redundancy of systems to enable connectivity following a disaster event.

2.1 Early warning and remote sensing systems

Early warning and prevention includes:

– Disaster prediction, including the acquisition and processing of data concerning the probability of future disaster occurrence, location and duration; and

– Disaster detection, including the detailed analysis of the topical likelihood and severity of a disaster event.

Meteorological aids, meteorological-satellite and Earth exploration-satellite services play a major role in activities such as:

– Identifying areas at risk;

– Forecasting weather and predicting climate change;

– Detecting and tracking earthquakes, tsunamis, hurricanes, forest fires, oil leaks, etc.;

– Providing alerting/warning information of such disasters;

– Assessing the damage caused by such disasters;

– Providing information for planning relief operations; and

– Monitoring recovery from a disaster.

These services provide useful if not essential data for maintaining and improving accuracy of weather forecasts, monitoring and predicting climate changes and for information on natural resources. The frequencies used by those services and their associated applications are summarized in Table 1 of Recommendation ITU-R RS.1859 "*Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies*".[3]

On-the-ground, at-the-spot (in situ), at-the-time measurements or observations are usually more precise and more accurate than similar observations made from space. These kinds of observations are known as "ground truth" and are used to calibrate spaceborne instrumentation. However, when in situ instrumentation or the supporting infrastructures necessary to use such instrumentation are not in place or have been disabled by the disaster, or the ground measurements are not accurate enough, spaceborne observations can provide useful information helpful in alleviating the effects of disasters. Spaceborne observations are particularly useful when the areas are vast, the population densities low, and the technical infrastructure is vulnerable or not well developed.

Descriptions of how data products from satellites may be useful in alleviating the effects of natural and man-made disasters are provided in Recommendation ITU-R RS.1859.

[3] ITU-R Recommendation RS.1859-2010, "*Use of remote sensing systems for data collections to be used in the event of natural disasters and similar emergencies*", January 2010: https://www.itu.int/rec/R-REC-RS.1859/.

2.2 Broadcast emergency warning systems

One function of broadcasters is delivering information to the public. Some municipalities in some countries may have a multicasting system to outdoor receivers with loudspeakers in their own disaster radiocommunication network. However, it may be difficult to hear the sound indoors, especially in bad weather such as storms or heavy rain. Disaster alerts and information via broadcasting is particularly useful in such situations.

A number of Emergency Warning Systems (EWS) exist which allow broadcast networks to alert people of impending disasters and enable them to prepare for emergencies. The emergency warning systems can use special warning or alert signals embedded in digital radio transmissions to automatically switch on the receiver equipment (if so equipped) and issue an emergency bulletin, alerting people to an impending disaster such as a tsunami or an earthquake.

For analogue broadcasting the EWS should use relatively simple equipment to ensure stable operations. In an emergency, the EWS control signal, which is an analogue signal, automatically activates receivers equipped with the EWS function even when they are in standby mode. Depending on its characteristics, the EWS control signal might also be used as an alarm sound to draw the attention of listeners/viewers to the emergency broadcast programme. Broadcasters operating analogue platforms can transmit the EWS control signal. The EWS control signal could include an area code as well as a time code, keeping the receiver protected from intentionally fake control signals.

2.3 Disaster information and relief systems

The following are additional examples of disaster information, warning and relief systems which can help ensure vital information is provided to the public and/or to relief workers, taking account of disruptions caused by disaster events.

1) Mobile broadcast warning and notification systems

To alleviate network congestion, mobile systems can distribute notifications via mobile broadcast technology that operates independently of voice calls. Notifications can simultaneously reach multiple mobile terminals within disaster areas.

2) Digital signage

Digital Signage (DS) delivers information through visual displays. Digital signage provides another route for information dissemination by connecting to broadcast and telecommunication networks, acting similarly to TV and online information message board services. DS receives information from government authorities and delivers notifications from early warning systems. The following should be considered to mitigate capacity limitations:

- New technologies (e.g., Scale Vector Graphics (SVG)),
- The volume of transmitted information, and
- The use of pre-stored graphics.

3) Disaster message board aystems

IP-based mobile message services enable affected persons to inform others about their condition. by placing a text message on the system's message board which is delivered to the recipient(s).

4) Disaster voice delivery systems

Some users prefer voice-based communications. IP packet networks are generally not as congested post-disaster as circuit-switched networks because voice calls can be packetized and sent as notification messages through the IP network.

5) Disaster relief guidance systems

During and after a disaster, victims may require access to hospitals and temporary evacuation shelters whose locations are unknown or unfamiliar to them. Additionally, new and unfamiliar routes may be required due to physical damage to roads. A disaster relief guidance system can provide geographical guidance by displaying a map with key locations and available routes. Once a victim identifies a terminal location (by GPS) and selects a target location (e.g,. a home, a hospital, or a shelter), a graphical route to the selected destination is displayed.

6) Search and rescue systems

Figure 3 demonstrates a search and rescue service that relies on a dual-mode BTS to support a drone's GSM and LTE technologies. GSM is mainly used for communication between disaster headquarters (HQ) and victims whereas LTE is used for communication between disaster HQ and first responders. Search and rescue involves the following two-step search process and one-step rescue process:

- **Search and triage (Step 1 of search process)**

First, a BTS transmits a radio signal from a drone before attempting to operate in GSM mode. Then, once mobile phones detect the drone, disaster HQ collects all reachable International Mobile Subscriber Identities (IMSI) and broadcast SMS messages. By asking the local cellular service to confirm receipt of these messages, disaster HQ locates mobile phones. If detected mobile phones do not confirm SMS receipt, the disaster HQ may consider preferential identification of these phones' locations.

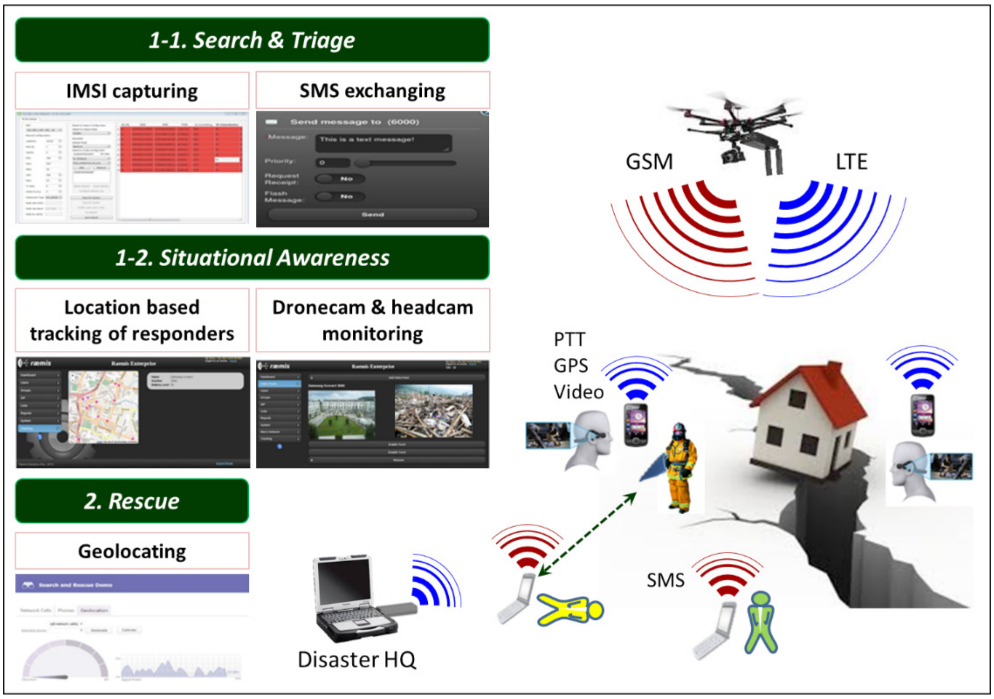
- **Situational awareness (Step 2 of search process)**

Disaster HQ processes each responder's location and checks the status of the disaster-affected area by using LTE to access image data from both the drone camera and responder's terminals.

- **Rescue**

After analyzing all the information collected, disaster HQ targets an IMSI to which relevant responders must be dispatched. The responders use the IMSI and directional antenna to identify the mobile phone's location.

Figure 3: An example of a search and rescue service



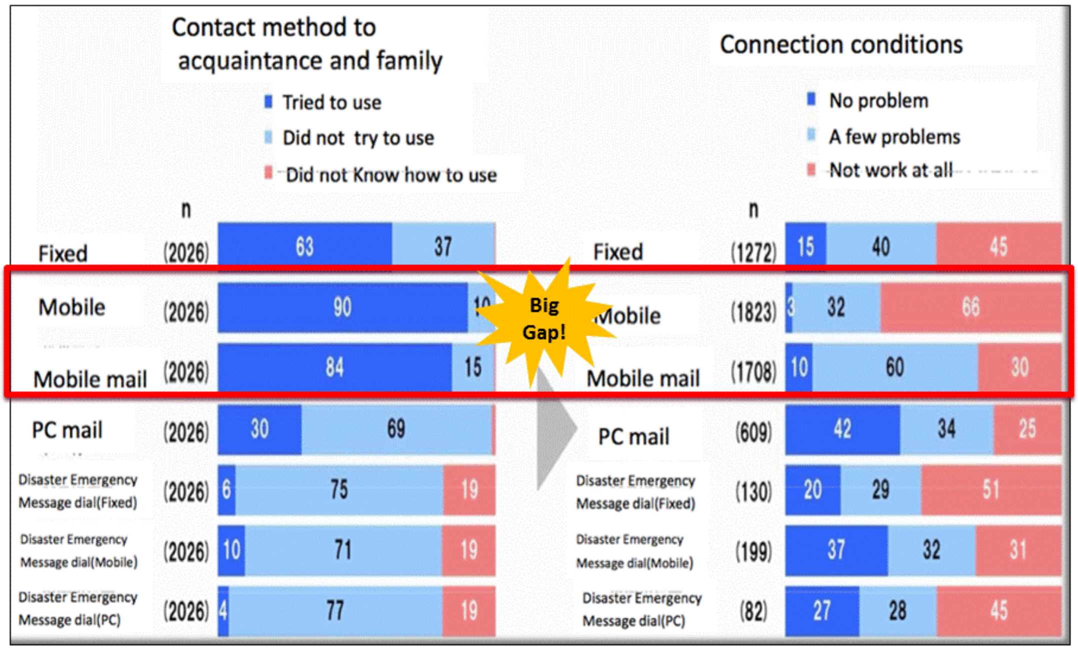
2.4 Resilient network technologies

2.4.1 Overview

Due to the importance and demand for ICTs during all phases of disasters, continuity of operations is an important consideration for disaster communications management. Organizations use a variety of technical approaches and systems to ensure resiliency and redundancy.

The availability or continuity of ICTs can be impacted by both phyiscal damage to the network caused by a disaster, but also due to network congestion in the immediate aftermath of a disaster. **Figure 4** shows the public's means of safety confirmation after the catastrophic earthquake striking Japan in March 2011. Though most disaster-affected people tried to use public mobile networks, they were unable to do so due to network congestion and a small number of available base stations.

Figure 4: Damages to communication infrastructure

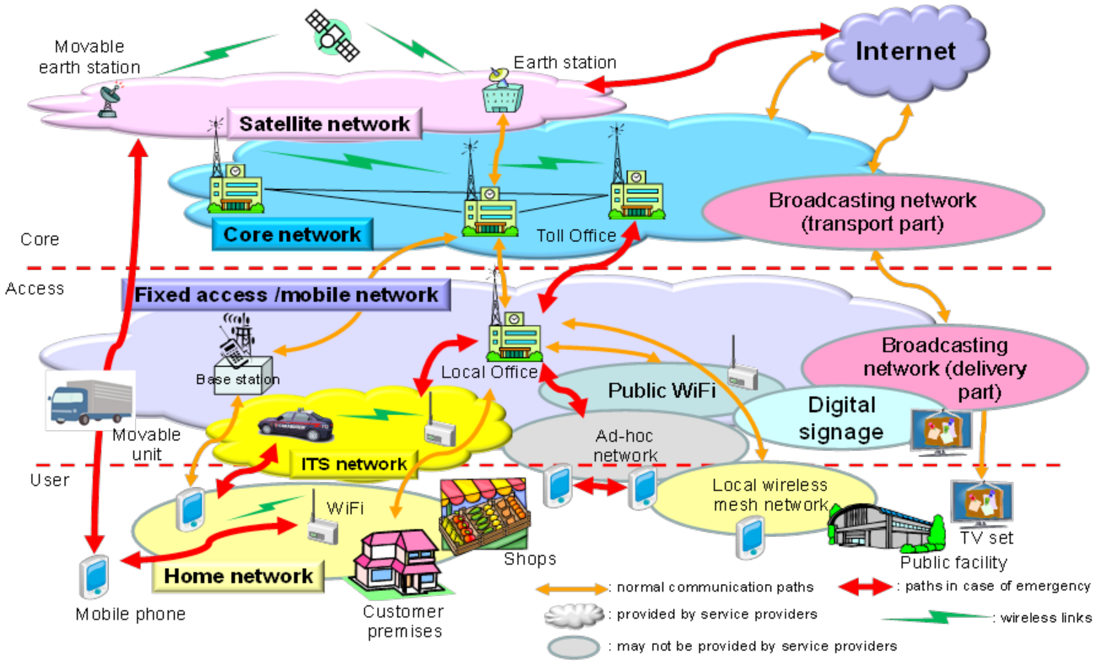


**Created from the presentation materials of the Ministry of Internal Affairs and Communications*

Diversification of network paths and system redundancy are important considerations, as are taking steps to make networks more physically resilient to the types of disasters that may be common in a certain environment. Terminals may be enhanced to allow the use of systems on different networks (e.g., fixed access networks, public WiFi, Intelligent Transport Systems (ITS) and satellite networks) so that people can communicate during disasters. Networks also can be enhanced by providing access to several communication paths that differ from the normal communication paths and combining usually independent networks and their capabilities (which are owned and/or operated by different organizations with different policies) in an integrated manner.

Figure 5 shows an integrated network infrastructure that supports disaster response services. Generally, there are two types (indicated by the different cloud shapes) of networks (i.e. service-provider owned and non-service-provider owned) comprised of the following three parts: core network, access network, and user. **Figure 5** compares emergency communication paths with non-emergency paths.

Figure 5: Integrated view of networks supporting disaster relief services



Because damage to the core network has an extensive negative effect on fixed and mobile networks, most telecommunication service providers adopt some form of core network redundancy to prevent or mitigate this damage. For example, there are many telecommunication satellites around the earth that remain operable even when terrestrial network equipment is damaged. Therefore, disaster-resistant core networks can be established using satellites and temporary earth stations.

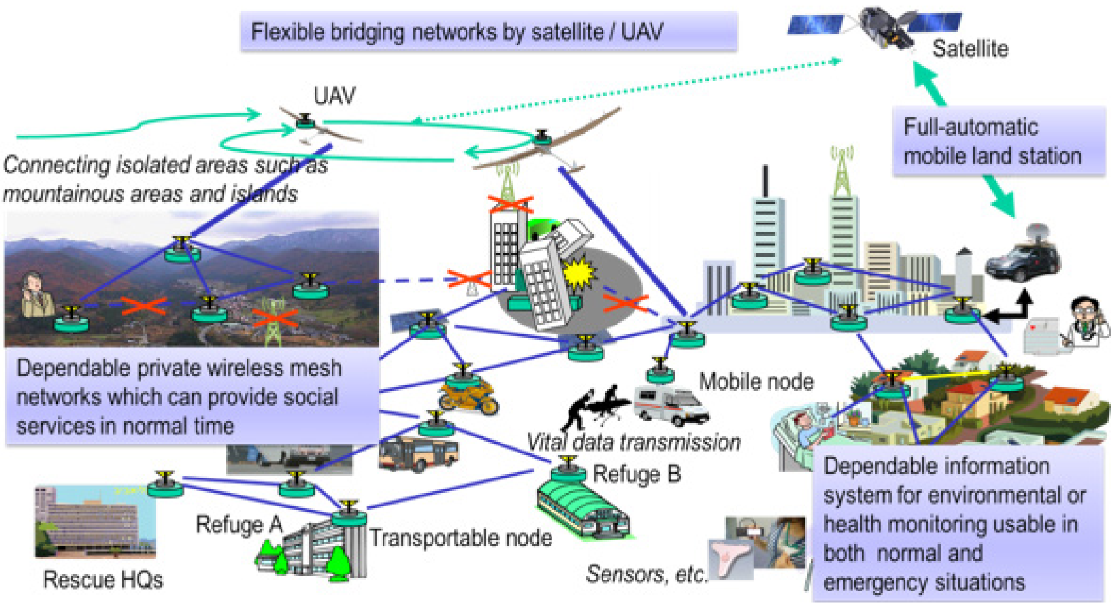
Access networks, including fixed line facilities like fibre optics, copper lines, and cable networks, connect users to core networks. However, because of high costs, access networks are less likely to have redundancy built-in, making disaster protection and restoration plans critical. The situation is similar for mobile networks; however, these can be easier to use than fixed-line access networks because users can move and connect with an alternative base station. Cars' mobility and recent telecommunication functionality also enable ITS networks (i.e. inter-car ad-hoc access networks) during disasters. Similarly, because most mobile terminals (e.g., PCs, smartphones) are equipped with WiFi functionality and many service providers offer public WiFi, such networks could be made available to distribute emergency information during disasters. Additionally, home WiFi networks could be opened to the public during disasters. Local (private) wireless mesh networks are also another option for connectivity in the face of partial network damage.

All of these ad-hoc networks can act as placeholders for damaged access and core networks and consist of several facilities including WiFi functionality. To further increase connectivity during a disaster, the networks above may interact closely with each other. For example, in a normal situation, each network operates independently, uses its own policy, and does not make network information (e.g., traffic volume, network performance, and resource availability) widely available to other networks and users. However, during a disaster, a network could relax authentication and charging policies to make functions available to non-subscribers' terminals. Networks would notify terminals of these changes (e.g., service availability) and share network information and operation changes among themselves in order to harmonize effective emergency communications, choose alternative networks, or communicate through surviving components.

2.4.2 Local wireless mesh network systems

The local (private) wireless mesh network is based on decentralized mesh architecture and avoids total network blackout that is caused by damage to part of the network. Distributed databases and application technologies can also significantly improve network resilience. Additionally, local wireless mesh networks provide wireless LAN access through inter-mesh node links and can connect to the small and on-vehicle satellite earth stations and mobile repeaters that program-controlled small unmanned aircrafts (UAV) provide. Therefore, it is likely that these stations and mobile repeaters can rapidly provide isolated areas with communication and monitoring links pending infrastructure recovery.

Figure 6: Local wireless mesh network architecture



The system's infrastructure consists of fixed and portable mesh relay nodes that are placed on top of buildings or on the ground (see **Figure 6**). Therefore, its components should have the following functionalities: connection capabilities to the nearest local exchange and/or IP network, electricity supply, necessary telecommunication functions, privacy, security, and transport network access.

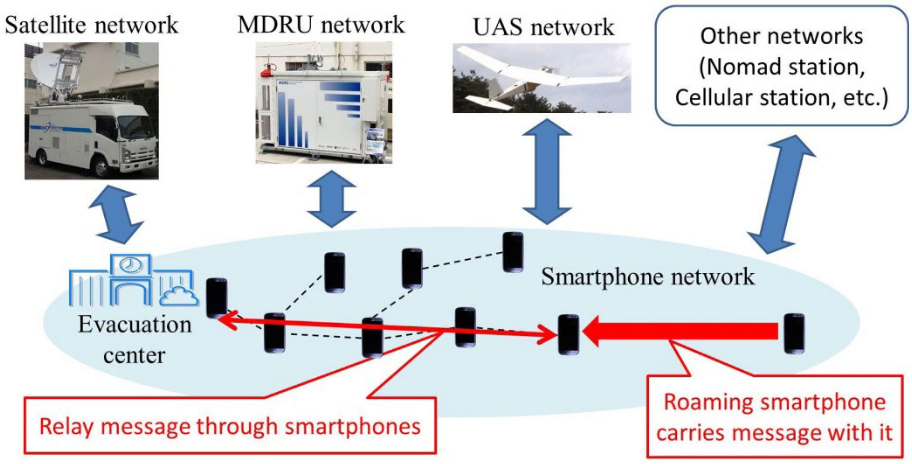
2.4.3 Delay tolerant networking

Delay Tolerant Networking (DTN) based communication systems have attracted attention due to their network disruption and disconnection resilience. DTN may be linked to mobile terminals or nomad stations and describes protocol architecture that overcomes technical issues in heterogeneous net-works that can lack continuous connectivity.

a) Mobile terminals with DTN functionalities

Most user terminals, such as smartphone or tablet devices, are now equipped with WiFi functionality that DTN enhances through the creation of a dynamic network in which terminals send each other delay tolerant messages (see **Figure 7**).

Figure 7: Mobile terminal delay tolerant networking enrichment



This enables communication between common WiFi-equipped devices within and outside disaster areas that have no physical infrastructure. Additionally, this is user-friendly because it just requires users to open a distributed application on a device and follow the instructions.

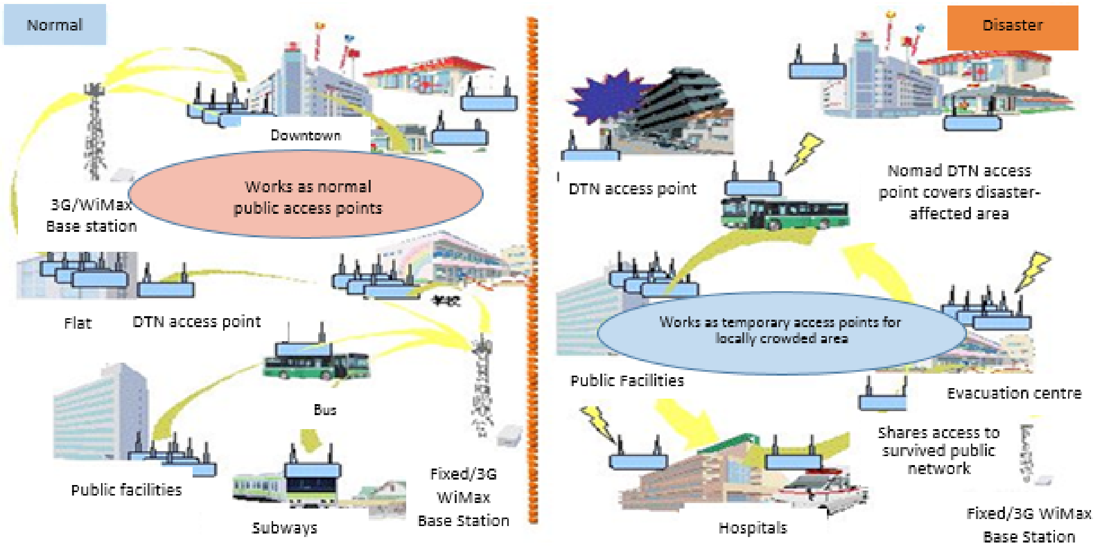
Furthermore, DTN can also adopt Mobile Ad-hoc Networks (MANET) to improve message relay performance. Even when MANET functions alone, it can increase the efficiency of multiple-terminal message relay in intermediate nodes located in areas where there is limited mobility (e.g., evacuation centers, population-dense areas). However, since MANET must maintain routing information, it can increase the network's control of overhead costs and reduce message relay efficiency among highly-mobile nodes and in low-density areas. Optimization is needed to maximize message relay performance so that each terminal or remote controller automatically selects DTN or MANET mode. Also, because mobile terminals can easily access the information (e.g., as GPS signals, a three-dimensional accelerometer reading, and remaining battery life) necessary for automatic mode selection, they are an attractive option.

It is easy to incorporate DTN into networking technologies such as cellular networks, Movable and Deployable Resource Unit (MDRU) networks, nomad stations, satellite networks, and Unmanned Aircraft Systems (UAS). Through a satellite or MDRU connection, messages can be sent to distant recipients, but, if it is impossible to deploy satellite station or resource units, an unmanned aircraft can act as a terminal to carry messages from the disaster area to other connected areas. Additionally, because the message sent via DTN can propagate over great distances, it may reach a terminal with cellular connectivity that then enables its relay over cellular networks. Or, alternatively, the message may propagate to a WiFi-connected location or a nomad station (e.g., an evacuation center) that forwards the message beyond the disaster area.

b) Nomad stations with DTN functionalities

Current WiFi technology is not well-suited to handling locally crowded terminals because throughput degrades and ultimately fails as terminals increase. Therefore, it is useful to develop WiFi-enabled nomad stations that can handle many terminals. Normally, the nomad station acts as a temporary access point. For example, downtown and schools connect to the public backbone and operate as normal WiFi access points. During disasters, the station switches to DTN mode, begins circulating information to key locations (e.g., city hall, hospitals), stores essential information, such as open evacuation centres and food distribution points, and collects server-access requests. This process continues until the public network stabilizes.

Figure 8: Nomad stations with DTN functionalities



Nevertheless, nomad stations encounter connectivity problems with the public backbone network because it is not always possible to connect the two during disasters. Because this disconnection prevents the nomad station from accessing information, satellite communication facilities are traditionally installed for continued connectivity despite their associated expense and limited bandwidth. Nomad stations with DTN functionality are a good option because DTN stores information upon source-connection and delivers information upon locating the end user (see **Figure 8**).

2.4.4 Portable emergency communication system

During a recovery and restoration period, Portable Emergency Communication Systems (PECS) may play important intermediate roles. Different PECS (e.g., standalone trailers or embedded in operational vehicles) have pros and cons. Though this report considers PECS meeting military standards, civilian versions of PECS are different and likely include the following:

a) User terminals
   - Analogue and Digital Radios: VHF, UHF, HF/SSB, DMR, P25 (APCO), TETRA
   - Mobile Phones: Cellular Interfaces such as GSM, CDMA, W-CDMA, LTE
   - IP Phones: Analogue/Digital PABX Phones, DECT/WiFi phones
   - Satellite Interfaces: Low and GEO-orbit satellite phones

b) IP-based Integration Switch: User terminals connect to the “integration switch” via interfaces, such as analogue/digital radios and mobile phones that enable users to communicate and teleconference.

c) Antennae and quasi-antenna products: The frequency band’s air interface requirements determine what type of antenna is used. For example, open field applications/operations require antennae that include one or two expandable tripods.

d) Power units: Lightweight power units (e.g., batteries, foldable solar panels, and generators) facilitate easy portability.

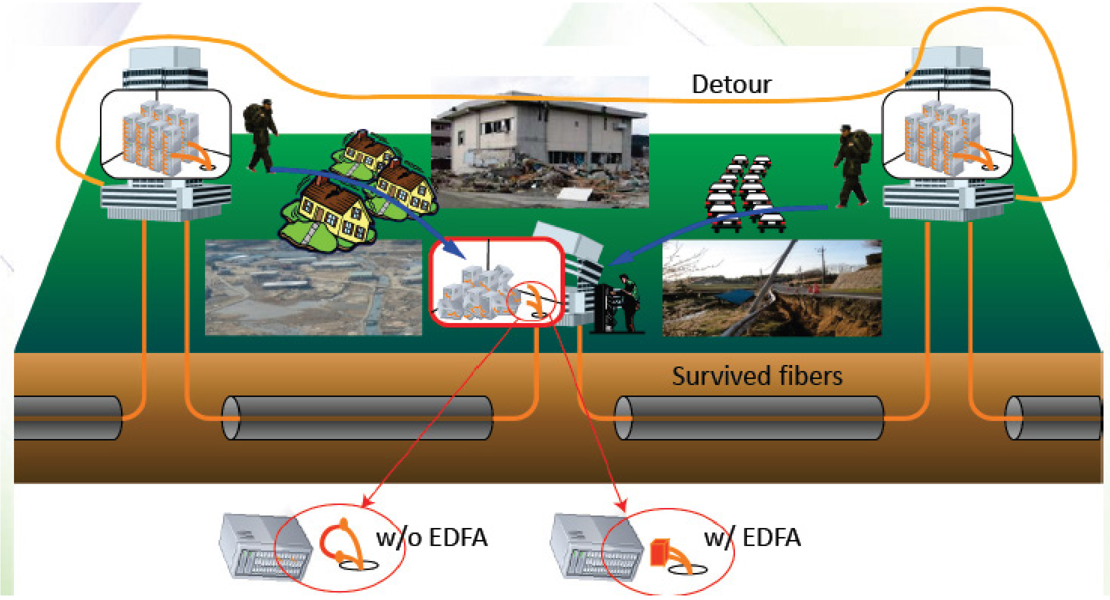
e) Accessories: Examples include cables, electrical/mechanical user adapters, and power converters.

f) Measurement and Peripheral Devices: PECS Maintenance requires measurement devices such as power meters, SWR meters, and voltmeters. Peripheral devices include rugged notebooks, smartphones, and tablet PCs that can easily be transported in rugged military standard cases.

2.5 Restoration of optical fibre links

As the Great East Japan Earthquake and Tsunami demonstrated, optical networks' buried fibre can survive to support vital emergency services when above-ground infrastructure (e.g., repeater stations, switches, or exchanges) is damaged. A portable Erbium-Doped Fibre Amplifier (EDFA) can actually enable the swift reconnection of surviving fibre links to optical fibre networks or provide a means of bypassing any damaged network infrastructure (see **Figure 9**).

Figure 9: Reconnection of optical fibre links



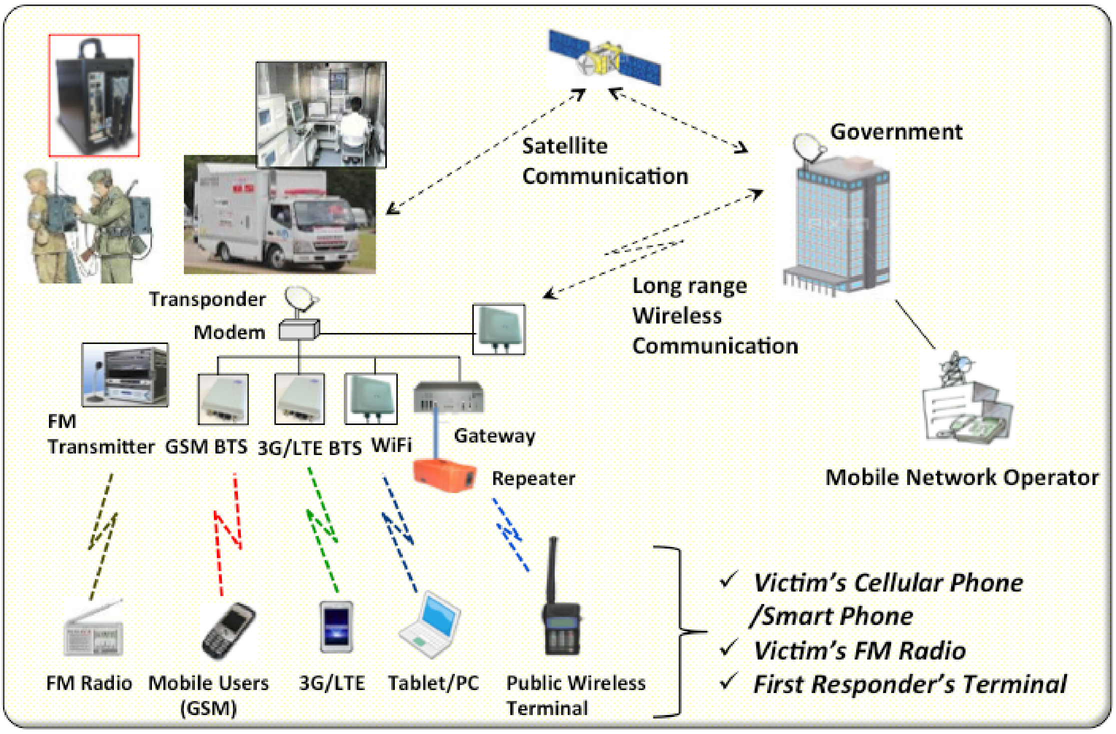
Because portable EDFAs are battery-powered, they do not need electricity for optical amplification in remote areas and their waterproof and shock-proof construction facilitates use in harsh environments. Additionally, EDFAs' full-duplex modules are burst-mode compatible and can thus amplify bursts without distortion or optical power surges.

2.6 Terrestrial systems – Fixed and mobile

a) Emergency Mobile Networks (EMN)

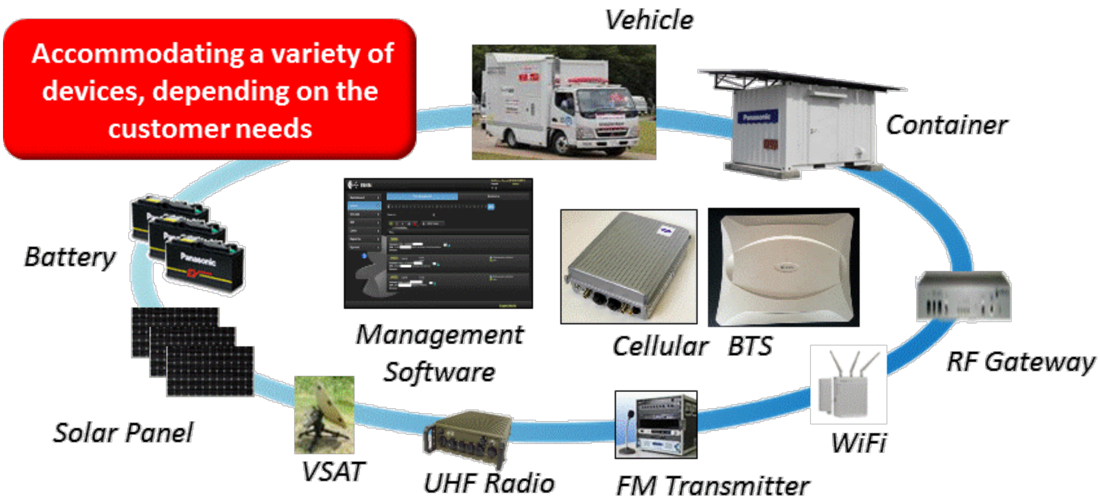
Countries with high risk for natural disaster should consider Emergency Mobile Networks (EMN) (see **Figure 10**) that consist of several types of communication equipment and self-generated power. EMNs offer voice and data connectivity on a Bring Your Own Device (BYOD) basis to first responders, public safety (e.g., army and police) officers, humanitarian organizations, and the general public. This is important because it is difficult for municipalities to secure funds and training for new devices whereas BYOD allows users to use their own devices during disasters.

Figure 10: Network diagram of an emergency mobile network



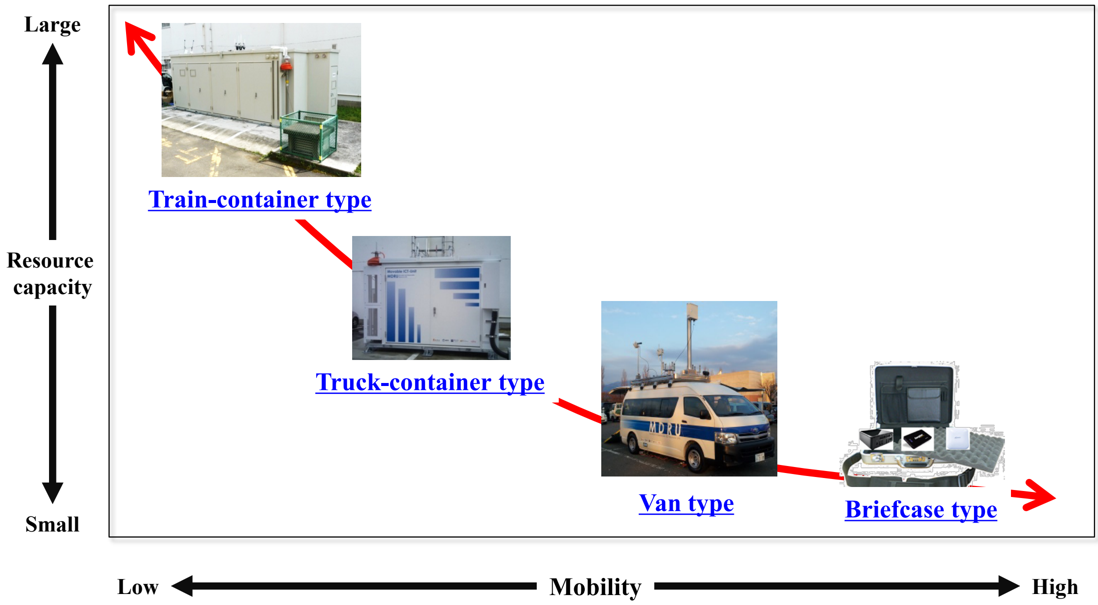
Emergency responders also enjoy enhanced situational awareness with wideband technology and smart devices (e.g., smartphones) that support cellular (GSM, 3G and LTE) and WiFi connectivity. Similarly, ICT resource units must support data and voice transmission as well as national roaming that 1) accommodates all mobile users regardless of their subscribed Mobile Network Operator (MNO) and 2) enables communication between the disaster area and distant locations. PECS can be used to implement an ICT Resource Unit that accommodates a variety of communication devices (see **Figure 11**).

Figure 11: ICT Resource Unit for emergency response



Weight and size dictate ICT resource units' portability and effectiveness so available transportation modes should be considered when selecting unit size. Though components of ICT resource units are often modules that enable customization, larger units have their merits (see **Figure 12**) including bigger batteries, greater capacity, and enhanced functionality (e.g., satellite access, FM radio broadcasting, and PC servers).

Figure 12: Scale of ICT resource unit implementations



Larger-capacity ICT resource units are also best for semi-permanent use due to their increased capacity and functionality. For example, large ICT units enable different applications and services in the absence of broadband paths. However, smaller units (e.g., van and briefcase types) offer increased mobility.

b) ICT service functions for disaster areas

Internet-based systems can transmit valuable information, including images, text, and video, for those affected by disasters. However, fixed and mobile internet may not be accessible due to destruction of telecommunication facilities (e.g., exchanges and routers).

Regardless of the existing network's condition, ICT resource units can enable the delivery of internet traffic, for example an evacuee management system, via a WiFi-based LAN. Additionally, once equipped with PC servers, these units offer local area data communication services such as e-mail and web access. However, if connected network facilities are unavailable, ICT resource units can provide temporary communication channels (e.g., via satellite). If these channels are limited or otherwise unavailable, the units can operate as independent local data centres and provide Internet-type services to local users.

c) Use case of local cellular service

Figure 13: Use cases of local cellular services

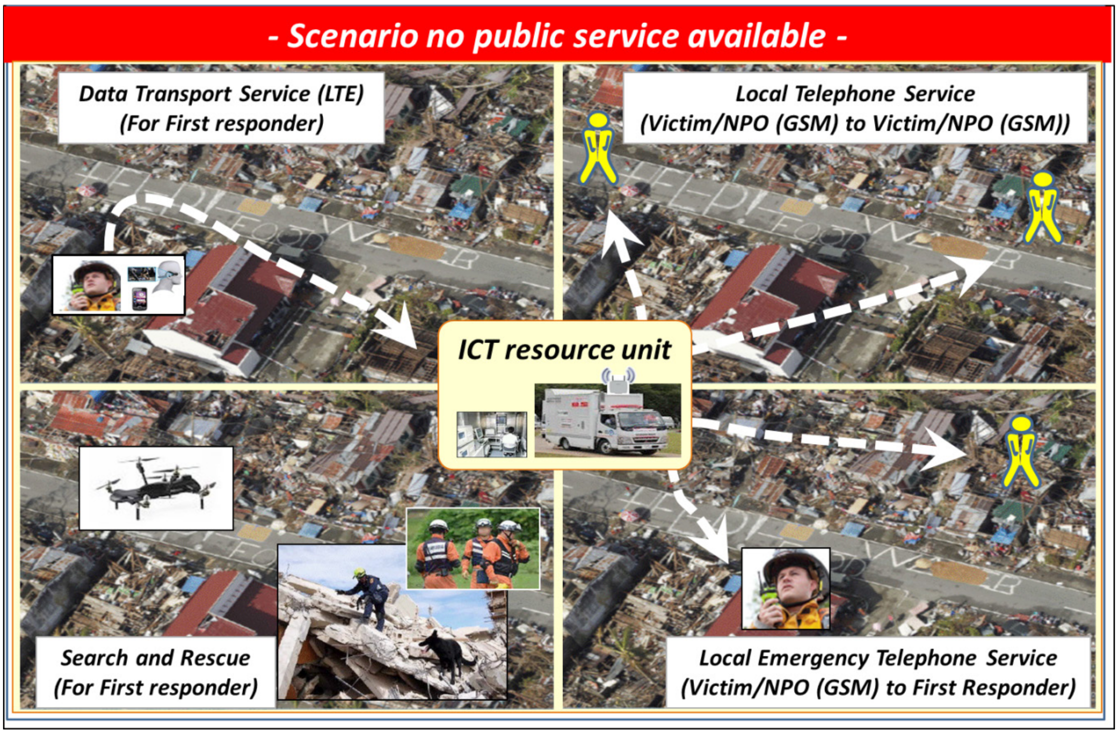


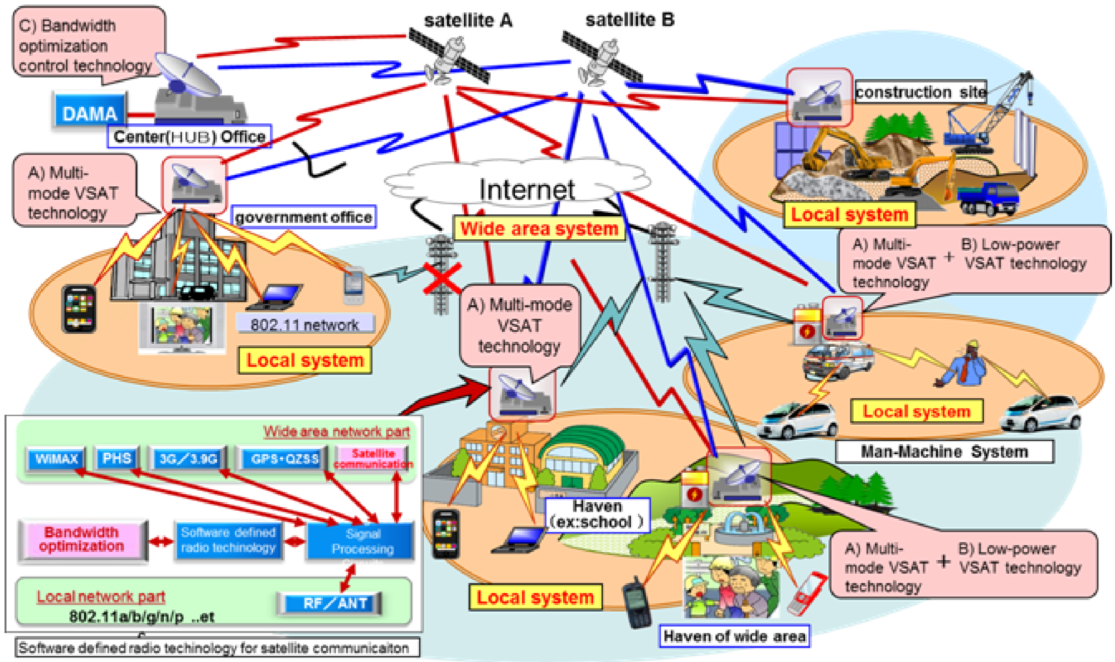
Figure 13 shows several use cases of local cellular services. In the upper right, cell phones' GSM mode accommodates the ICT units that enable local calls between victims. The lower right shows a local emergency call that victims make to first responders using their own cellular phones. The upper left demonstrates LTE's facilitation of the transmission of several types of images for enhanced situational awareness. The lower left shows search and rescue efforts that aim to detect victims' locations from the sky.

2.7 Satellite communications

2.7.1 Very Small Aperture Terminals (VSAT)

Research is currently being done to enable the compatibility of Very Small Aperture Terminals (VSAT) with multiple communication methods in order to ensure rapid resolution of technical problems during disasters. Because the goal is to secure satellite communication lines to meet the needs of areas where disasters have destroyed communication infrastructure, this work focuses on resolving satellite communications issues (see **Figure 14**) including:

Figure 14: VSAT enrichment for disaster preparedness



– Inter-satellite communication.

Solution: Use of a single VSAT to communicate between different satellite communication systems via 1) a software definition radio system, 2) small antenna, and 3) algorithm. For example, as **Figure 15** demonstrates, VSAT accesses satellite communication system B when satellite communication system A is unavailable post-disaster network congestion.

– Shortage of VSATs for disaster area.

Solution: Multi-mode VSAT technology that enables systems to withstand increased traffic during disasters.

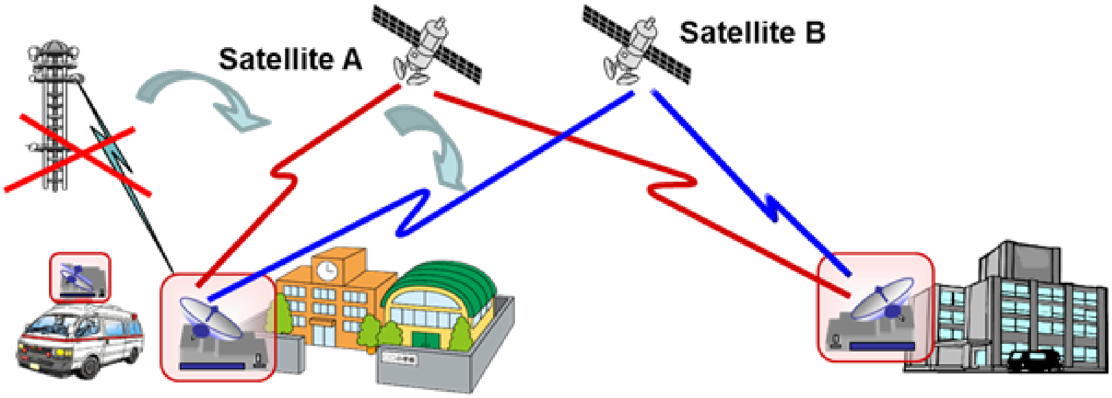
– VSAT deactivation due to prolonged electricity failure.

Solultion: Low-power VSAT technology are essential communication tools during disasters because they optimise power consumption and integrate Out-Door Unit (ODU)/in-door units for easy maintenance.

– Satellite network traffic congestion.

Solution: Bandwidth optimisation control technology that uses a Demand-Assigned Multiple Access (DAMA) controller to allocate optimum bandwidth on a session-by session basis.

Figure 15: Communication between different satellite systems



– VSAT Recovery.

  Solution: Novices' easy establishment of satellite links vis-à-vis small transportable VSATs.

Generally, VSATs include HUB stations that monitor, control, and auto-adjust for antenna azimuth, elevation, and polarization angles with a number of additional features.

2.7.2 Push-To-Talk (PTT) communications and mobile satellite PTT

To use PTT, one party must push a button and speak into the device. Once she releases the button, her communication is instantly transmitted to the receiving party who then responds by pushing a button. Unlike standard mobile phone calls which are full-duplex and allow two parties to be heard simultaneously, PTT calls are half-duplex and only allow one party to be heard at a given time. However, PTT services are advantageous in a number of ways including:

– **Efficiency:** PTT services eliminates traditional wireless services' delays. For example, when using a cell phone, a user must dial a number and wait for the called party to answer whereas PTT services simply require a user to push a button and speak into the device for nearly instantaneous message transmission.

– **Clarity:** Low quality transmissions and/or parties' ability to speak simultaneously increase the risk of miscommunication, therefore, clarity is paramount for crisis communication. Because PTT services only allow one party to speak at a given time, the called party must focus on the single incoming transmission, eliminating risk of jumbled communications.

– **Durability:** PTT devices are typically robust and designed to withstand extreme physical conditions.

– **Connectivity:** PTT services facilitates coordination by allowing person-to-person and person-to-group communications. Rather than communicating with individuals via separate calls, PTT allows individual users to communicate instantly with multiple individuals located in several geographic locations.

Mobile satellite PTT services present additional benefits in emergencies including:

– **Reliability:** Whereas terrestrial (e.g., cell towers) telecommunications infrastructure can be vulnerable to changing environmental conditions, satellite networks operate beyond the reach of natural disasters and allow users to maintain connectivity when it is needed most.

– **Expanded coverage:** Because many emergencies occur in remote locations with limited infrastructure, or where terrestrial infrastructure may have been damaged, satellites are the only option for guaranteed reliable PTT coverage.

– **Interoperability:** Satellite PTT services can be integrated into non-satellite PTT, terrestrial cellular, WiFi, and other communications networks to support agencies' use of different communications services for emergency management coordination.

2.8 Broadcasting

For many decades, radio and television broadcasters have been a primary source of critical information to the public before and after disaster events. On these occasions, radio and television broadcasting provides reliable point-to-everywhere delivery of essential information and safety advice to the public, to first responders and others via widely available consumer receivers, both mobile and fixed. In many cases major broadcasting facilities have their own independent power supply facilities to maintain communications even if utility supplies are lost.

ITU-R Report [BT.2299-1] on "*Broadcasting for Public Warning, Disaster Mitigation and Relief*"[4] provides technical and operational information on how the broadcasting service is used to support emergency communications, as well as providing case studies and describing new broadcasting techniques and systems for distributing emergency information.

2.8.1 Overview

Following a disaster, many people will immediately tune to radio and/or television broadcast stations which can provide a mix of national network information and local information. While non-broadcast communications links often suffer infrastructure failure within a disaster area, broadcasting's architecture is simple and powerful. If the main transmitter and the radio or television studios that feed it remain on the air, reception is available wherever there are working receivers. Moreover, there has been rapid growth and availability of small handheld and car equipped television receivers, plus large screen devices operating in most emergency shelters such as police stations, hospitals, sports arenas, public buildings, etc. The overall robustness of broadcast services is enhanced by the geographical diversity of multiple radio and television services within a given country. If one or a few radio and television broadcasters are not able to remain in service, or suffer an outage, other broadcast signals are usually available.

Radio receivers can be AC-powered, battery, or hand crank-operated, and are present in virtually all motor vehicles. These are nearly always reliable, regardless of almost any disruption taking place in the affected disaster area. Portable television receivers are much less common, but this is expected to change as mobile DTV reception capability is beginning to be rolled out to portable devices such as cellular phones.

2.8.2 Operational methods used to assure continued broadcast service

The broadcast imperative is to be on the air and available at all times, especially during emergency situations. Most facilities possess redundant capabilities and signal paths in order to maintain their over-the-air and cable feeds. In larger markets, more robust measures are employed. These are usually "case-hardened" facilities that include multiple power feeds from diverse power generation stations, full backup power generators at the studio and transmitter sites, multiple signal paths from studio to transmitter sites, redundant transmitters/antennas and direct feeds to cable and satellite operators. All of these minimize the number of single points of failure that could keep vital information from being broadcast.

Some humanitarian agencies have "radio in a suitcase" kits on standby, which are used to re-establish FM radio services when these are destroyed or damaged. Used in conjunction with a small petrol-driven generator, the equipment can enable an FM radio station to be on-air within hours of

[4] ITU-R Report BT.2299-1, "*Broadcasting for public warning, disaster mitigation and relief*", July 2015: http://www.itu.int/pub/R-REP-BT.2299-1-2015.

a disaster occurring. The idea is usually not to set up a completely new radio station, but to operate a special radio service on the FM frequency and broadcasting licence of a local partner station that is no longer able to broadcast from its own studios and transmitters.

2.8.3 Use of existing terrestrial broadcasting infrastructure to support emergency communications

Television broadcasting has created established in-house procedures to deal with the dissemination of all types of news which are easily and quickly adaptable to provide life and safety information to the public. Stations are linked via Emergency Alert Systems to state and national emergency information channels and can repeat messages from civil and governmental authorities very quickly. Electronic News Gathering and satellite outside broadcast vehicles are quickly deployed to be on-the-scene with live pictures and sound. Closed Captioning systems along with full screen graphical displays, news "tickers" and lower-third screen text information make sure that those who are hearing impaired are also provided with emergency information. Even the simplest form of communication, for example, telephone calls can serve as a source to the broadcast signal and can be placed on-air from public officials or civilians in the disaster area and their messages relayed to viewers and listeners.

As society becomes more mobile, there is increased appreciation by broadcasters for including broadcast reception capability in mobile devices. In some parts of the world, such as Europe, FM radio reception capability in mobile phones is commonplace, while in the United States of America and some other countries, this feature is less prevalent. Active programs are underway in the United States of America to encourage mobile network providers and phone manufacturers to include broadcast signal reception in more products.

Terrestrial broadcasters have adapted many different technologies to aid in news gathering and the dissemination of emergency information:

- Live and recorded mobile phone videos can be placed on the air, making it possible to use non-traditional broadcasting equipment to share important information;
- Broadcasters are adapting small aperture satellite dish technology that allows for a more easily deployed satellite news gathering tool in a local market;
- Diversity microwave receive sites that make it possible to use small vehicles equipped with microwave transmitters to drive and report on road and other conditions;
- Helicopters to give overall views of an area-wide emergency;
- Computer mapping software to quickly document and display details of an emergency to the public.

2.8.4 Collaboration between broadcasting organizations

Broadcasters in most cities have developed coordination networks that allow stations to share limited microwave channels for news gathering. These same networks are used during emergencies to pool feed coverage to all stations and obtain the most efficiency from the microwave band for news gathering. Additionally, stations in overlapping markets routinely share video coverage and many TV stations partner with radio stations and allow them to rebroadcast their TV audio over radio, in order to reach citizens who are listening on battery-powered radios. These are usually people who have lost power and must rely on car or portable radios for news and information.

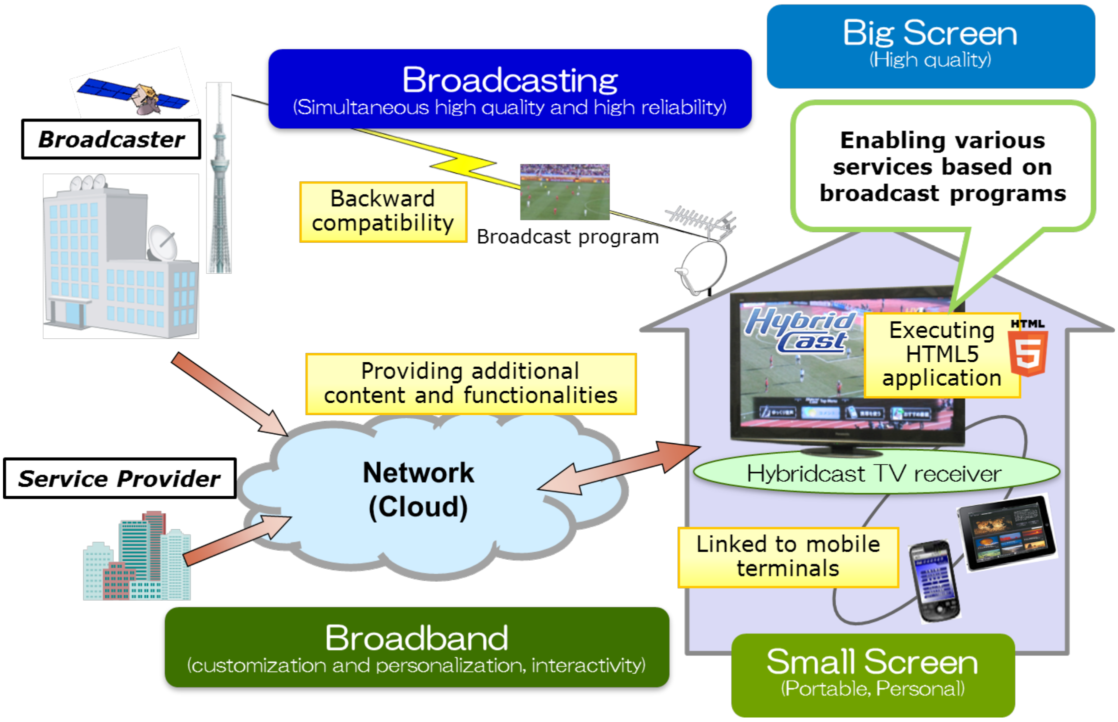
2.8.5 Shortwave radio

The most effective dissemination of information to the disaster stricken population is multi-platform, but radio is the most dominant technology, especially in early post-disaster situations. The specific technology of international broadcasting on shortwave is disaster-resilient, because the transmission facilities are well removed from the affected region. Due to the unique long-distance propagation property of shortwave radio, by means of multiple reflections from layers in the upper earth's atmosphere, a transmitter can reach easily relatively near or more distant world regions. This is important where other platforms such as satellite, FM or Internet are unavailable because of high cost, geographical location, and lack of infrastructure or due to restrictions or disasters. Receivers are inexpensive and there are no access fees.

2.8.6 Hybrid broadcast-broadband television systems

Hybridcast is an integrated system that has been standardized by the IPTV Forum Japan and enhances broadcasting services with broadband. Broadcasting provides high-quality content and broadband offers flexible responses to users' personal requests. These functionalities enable Hybridcast to provide advanced broadcasting services that can be enabled during disasters. **Figure 16** shows an overview of the Hybridcast system.

Figure 16: Hybrid cast system overview



Hybridcast allows users to obtain information that can change rapidly during disasters.

a) Example: Earthquake

When an "Earthquake Early Warning" signal is broadcast, it is sent to a Hybridcast TV receiver that automatically launches an application to display detailed local disaster information (see **Figure 17**).

Figure 17: Display detailed disaster information

2.9 Amateur radio

2.9.1 Nature of the amateur services

Most developed countries have robust and active amateur radio and amateur-satellite services. Many administrations recognize the amateur radio services as resources that are available in the context of disaster preparedness, response and mitigation.

2.9.2 Role of the amateur service in emergency telecommunications

Its wide scope of activities and the skills of amateur radio operators make the amateur service a valuable asset in emergency telecommunications. It has a large number of operational amateur stations in almost all countries of the world, providing a robust network independent from any other. In many cases, it has provided the first, and sometimes the only, link outside the area immediately affected by a disaster. The amateur radio emergency telecommunication services are available when infrastructure-dependent radio services are not available. Amateur radio stations operating during emergency telecommunication disasters do not depend of the infrastructure since many of the stations can operate on battery power, solar power and other non-infrastructure-dependent means of operation.

Typical situations for which the amateur service can supplement emergency telecommunications include:

– *Initial emergency alerts* may originate from individual amateur stations to bring an incident to the attention of competent institutional emergency services.

– *Damage assessment* and assessments regarding the scope of the disaster.

– In *search and rescue operations*, amateur stations can reinforce the professional teams by increasing their communication capabilities and reporting observations.

– *Hospitals* and similar establishments might in the aftermath of a disaster be without communications. Local amateur radio emergency groups prepare in advance for such assistance.

– *Hazardous materials (HAZMAT)* and other incidents may require the evacuation of residents, and coordination between the disaster site and the evacuation sites or shelters. Amateur emergency stations may be asked to establish communications with such institutions.

Administrations that make use of amateur radio as a resource during communications emergencies include amateur radio in training exercises and simulated emergency drills and incorporate the resource in disaster planning and preparedness.

2.9.3 Amateur networks available for emergency telecommunications

Amateur short-range networks provide operational or tactical communications at the site of a disaster and with the surrounding areas. They can include fixed, mobile and nomadic equipment typically using frequencies in the bands 50-54 MHz, 144-148 MHz and 420-450 MHz, noting that there are regional and national differences in these frequency ranges.

Repeater stations are used to extend the communication range of VHF and UHF stations. Positioned in elevated locations, they allow communication between fixed or mobile amateur stations separated by obstructions such as mountains or tall buildings when operating in an urban environment. A repeater station receives on one channel and transmits on a different frequency, usually within the same frequency band.

Amateur medium-range networks typically provide communication from the disaster site to organizational and administrative centres outside an affected area, or to headquarters of response providers in neighbouring countries. They also ensure communication with vehicles, vessels and aircraft operating outside the coverage of available VHF or UHF networks. Communication at medium distances of up to 500 km may be accomplished by Near-Vertical-Incidence Sky-wave (NVIS) propagation at lower MF/HF in bands 1 800-2 000 kHz, 3 500-4 000 kHz and 7 000-7 300 kHz, noting that there are regional and national differences in these bands. In addition, several national administrations have designated specific frequencies (channels) for amateur radio emergency traffic and related training.

Amateur long-range networks provide communication with headquarters of international emergency and disaster response providers. They serve as backup connections between offices of such institutions in different countries or on different continents. Amateur stations routinely communicate over long distances typically beyond 500 km, using oblique-incidence sky-wave propagation in bands from 3 500 kHz through 29.7 MHz.

2.9.4 Characteristics of amateur systems

Characteristics of typical amateur systems are documented in Recommendation ITU-R M.1732 "*Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies*".[5]

2.9.5 Training

The amateur services include self-training as an important objective. This includes training of young people in radiocommunications. Radio amateurs have the opportunity to plan, design, build, operate and maintain a complete radio station, which contributes to the telecommunication human resources development and capacity building within a country.

Many national amateur radio societies also have one or more training courses and publications designed for individuals preparing to take amateur licence examinations. Many national societies have continuing education courses in a variety of subjects including courses on disaster preparedness,

[5] Recommendation ITU-R M.1732 "*Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies*": https://www.itu.int/rec/R-REC-M.1732/.

response and mitigation including damage assessment. An example of the training materials available can be found on the International Amateur Radio Union (IARU) web site at: http://www.iaru.org/emergency-telecommunications-guide.html.

2.9.6 Amateur radio service is available at no cost to administrations

The amateur radio service is available for emergency telecommunications at no cost to local or administration government entities. The amateur radio operators supply their own equipment and their services in times of emergency telecommunication events is on a voluntary basis.

3 CHAPTER 3 – Case studies

3.1 Summaries of case studies received during study period

This section summarizes case studies received during this 2014-2017 study period of ITU-D Study Group 2 Question 5/2. This section divides the case studies into four groups, coinciding with how ICTs are used in the different phases of disaster management:

1) Before a disaster;
2) Initial emergency response period;
3) Tentative recovery period; and
4) Reconstruction period.

The case studies are further grouped by objectives or themes such as as policy, disaster relief and network resiliency. A mapping of the case studies is shown in **Table 1**. The information in this chapter is intended only as a guide to the topics considered in the study period. The case studies summaries are shown in **Annex 1**, with links provided to the complete case study text as submitted.

Table 1: Categorization of case studies

Category	Before disaster	After Disaster		
		Initial response period	Tentative recovery period	Reconstruction period
Policy	Network Disaster Recovery plan (See **A1.1**) (GSMA)	Hurricane Sandy and the Federal Communications Commission (See **A1.4**) (United States)		
	Upgrading technology support and R&D capability (See **A1.3** part 5) (People's Republic of China)			
	Disaster communications management in Madagascar (See **A1.7**) (Madagascar)			
	Single number based Integrated Emergency Communication & Response System (IECRS) (See **A1.11**) (India)			
	Mobile telephony providers' contingency plan for disaster preparedness, mitigation and response (See **A1.9**) (Argentina)			
	Emergency telecommunications: National legal framework (See **A1.18**) (Central African Republic)			

Category	Before disaster	After Disaster		
		Initial response period	Tentative recovery period	Reconstruction period
Emergency telecom		Enhancing Command and dispatch in emergency telecommunications (See **A1.3** part 1) (People's Republic of China)		
		Allocating 1.4GHz frequency band (See **A1.3** part 6) (People's Republic of China)		
	Developing emergency communications Standards system (See **A1.3** part 7) (People's Republic of China)			
	Emergency communication management system (See **A1.3** part 9) (People's Republic of China)	Emergency communication management system (See **A1.3** part 9) (People's Republic of China)		
	Enhancing national emergency early warning ability (See **A1.3** part 10) (People's Republic of China)			
		Multiply technical means for emergency telecommunications (See **A1.3** part 4) (People's Republic of China)	Multiply technical means for emergency telecommunications (See **A1.3** part 4) (People's Republic of China)	Multiply technical means for emergency telecommunications (See **A1.3** part 4) (People's Republic of China)
		Emergency communication equipment (See **A1.3** part 11) (People's Republic of China)	Emergency communication equipment (See **A1.3** part 11) (People's Republic of China)	
		First Responder Network Authority (FirstNet) - a nationwide public safety broadband network (See **A1.5**) (United States)		

Category	Before disaster	After Disaster		
		Initial response period	Tentative recovery period	Reconstruction period
		Strengthening resilience of public networks/ Super base station (See **A1.3** part 2) (People's Republic of China)	Strengthening resilience of public networks/ Super base station (See **A1.3** part 2) (People's Republic of China)	Strengthening resilience of public networks/ Super base station (Sec **A1.3** part 2) (People's Republic of China)
Network resilience		Increasing Emergency material reserves (See **A1.3** part 3) (People's Republic of China)		
		Disaster management with MDRU – Feasibility study (See **A1.8**) (Philippines)	Disaster management with MDRU – Feasibility study (See **A1.8**) (Philippines)	
		Local cellular (Sec **A1.14**) (Japan)	Local cellular (See **A1.14**) (Japan)	
		Rapid ICT-relief system used at Kumamoto earthquakes (See **A1.17**) (Japan)	Rapid ICT-relief system used at Kumamoto earthquakes (See **A1.17**) (Japan)	

Category	Before disaster	After Disaster		
		Initial response period	Tentative recovery period	Reconstruction period
Early warning	Pacific Coast Tsunami WS (See **A1.2** part 1) (Pacific coast)			
	Glacial Lake Outburst Flood monitoring and WS in Bhutan (See **A1.2** part 2) (Bhutan)			
	Using Big Data analysis to improve emergency management capabilities (See **A1.3** part 8) (People's Republic of China)			Using Big Data analysis to improve emergency management capabilities (See **A1.3** part 8) (People's Republic of China)
	Enhancing national emergency early warning ability (See **A1.3** part 10) (People's Republic of China)			
	Cyclone warning in India (See **A1.11** part b) (India)			
	Community-Based Flood Early warning System (See **A1.11** part c) (India)			
	Early Warning System (See **A1.12**) (Uganda)			
	Early Warning System in Zambia (See **A1.13**) (Zambia)			
Disaster relief	Combat Epidemic diseases (such as Ebola) (See **A1.6**) (Guinea)	Combat Epidemic diseases (such as Ebola) (See **A1.6**) (Guinea)	Combat Epidemic diseases (such as Ebola) (See **A1.6**) (Guinea)	
		Use case of emergency warning system over broadcasting (See **A1.10**) (Kazakhstan)		
	Hazard map project in Kumamoto-city, Japan (See **A1.16**) (Japan)	Hazard map project in Kumamoto-city, Japan (See **A1.16**) (Japan)		

Category	Before disaster	After Disaster		
		Initial response period	Tentative recovery period	Reconstruction period
Risk control	Data center related infrastructure development for disaster prevention (See **A1.15**) (Latin America and Caribbean)			
Capacity building	Strengthening the construction of emergency communication team (See **A1.3** part 12) (People's Republic of China)			
	Disaster management with MDRU – Feasibility study (See **A1.8**) (Philippines)			
	Hazard map project in Kumamoto-city, Japan (See **A1.16**) (Japan)			

4 CHAPTER 4 – Best Practice Guidelines and Conclusions

4.1 Analysis and identification of Best Practice Guidelines and lessons learned

Across the study cycle, there were many common themes and best practices that emerged as Members shared experiences and lessons learned.

- **Preparedness never stops:** National Emergency Communications planning must be a sustained, ongoing effort. Plans must be continuously updated, and incorporate lessons learned from drills and response efforts, and must address multiple, potential hazards.
- **Practice, Practice, Practice!:** Disaster management plans require practice. Regular exercises and drills are needed to test plans and allow for continuous refinement and improvement based on lessons learned. Drills should incorporate personnel from the wide range skill sets, and a wide range of stakeholders, such as government, industry, humanitarian organizations, hospitals and local communities, who will be involved in a response to allow for development of relationships and testing of procedures. Drills for citizens are also needed to improve disaster prevention mindsets, which empower citizens to help prevent damage themselves, and support citizens in helping each other. Improving disaster prevention mindsets of citizens is expected to decrease victims.
- **Pre-positioning:** Investing in pre-positioning of equipment and mobile resource units or temporary base stations across hazard prone areas also support resiliency and disaster risk reduction. Additionally, restrictive import and export rules, license constraints, and other issues can delay the mobilization of equipment to the disaster area, hindering the ability of non-governmental relief organizations, government agencies, and private entities to respond. Pre-positioning, however, can help to mitigate these issues and ensure equipment and other supplies are mobilized as soon as possible.
- **Enabling environment:** Regulatory and policy frameworks can facilitate or serve as barriers to the deployment of ICTs during a disaster. Governments should review rules – including licensing procedures, import/export requirements, and credentialing – and assess whether modifications or temporary procedures are needed to facilitate rapid disaster response. This is especially true in light of rapidly evolving technologies and applications which may benefit from a review to identify any barriers. For example, satellite Machine-to-Machine (M2M) services used for tracking emergency equipment or sending emergency messages are particularly affected by complex licensing procedures.
- **Emergency licensing procedures:** To ensure needed ICT equipment is available when it is needed most, simplified approval processes and licensing regimes are critical. For example, an approval process might waive customs duties or visa requirements in emergency response scenarios, or waive restrictions on foreign operators or service providers. In terms of licensing, ICT equipment and satellite telecommunications services might be exempt from licensing requirements during emergencies or enjoy expedited licensing procedures. Alternatively, certain license classes might exist for temporary or emergency use.
- **Accessibility:** Times of disaster are especially difficult for the vulnerable, such as persons with disabilities, children and the elderly, underlining the need to ensure that disaster management is inclusive of and responsive to their needs.
- **Situational awareness:** Exchanging information across relevant stakeholders drives increased situational awareness for reduced duplication and more targeted response efforts. When a disaster strikes, ICT responders urgently need information on the condition of ICT networks and potential ICT response needs to support continued communications or to help restore communications. Common approaches or terminology for outage reporting could help facilitate international response.

– **Developing relationships:** Developing relationships and building trust with internal and external stakeholders involved in a response will greatly facilitate implementation efforts and exchange of information when a disaster strikes.

– **Empowering citizens:** ICTs are no longer a luxury for citizens during a disaster – they are an essential tool not only for receiving and sharing life-saving information, but also in restoring economic activities. Restoration of public telecom networks should be prioritized, with consideration of temporary solutions to allow for mobile connectivity. Charging stations are also an important consideration.

– **Capacity building:** Training of personnel is critical to support implementation of disaster response plans, and should cover all aspects including use of equipment. ITU capacity building assistance, including emergency communications planning, early warning systems deployment and country/regional seminars have helped member states to plan and prioritize, and socialize communications preparedness as a part of national emergency response efforts. Training efforts should also include citizens to ensure they are prepared and aware of how to respond when a disaster occurs, or when an alert or warning is received.

– **New technologies and innovations:** Members should continue to incorporate new and emerging technologies and applications into emergency preparedness and response planning, including social media, big data, the Internet of Things, GIS mapping, remote sensing, and drones equipped with wireless communications solutions.

– **Partnerships and collaboration:** Significant coordination is taking place in support of communications for humanitarian response, including the development of the GSMA "Humanitarian Connectivity Charter" (mobile connectivity or humanitarian response), and the "Crisis Connectivity Charter" coordinated by the European Satellite Operators Association (ESOA) and Global VSAT Forum GVF Crisis connectivity charter, which are coordinated with the Emergency Telecommunications Cluster (ETC), run by the UN World Food Program (WFP). The ITU Framework for Cooperation in Emergencies (IFCE) is another example. Advance relationship building with technology responders, and the sharing of information are key.

– **After action reports:** Develop a culture of learning and continuous improvement – track and incorporate lessons learned.

4.2 ICTs for disaster relief, response and recovery

As discussed in **Chapter 2**, there are many disaster relief systems that rely upon ICTs. ICTs have been evolving, as have disaster relief systems, so there is a need to re-examine systems and emerging tools and applications on a periodic basis. In order to mitigate risks of communication outages in the event of disaster, the following should be considered:

Network resilience: In order to prevent or reduce risks of telecommunication outages in the event of disaster, telecommunication equipment should be resilient and redundant, by means of preparing alternative communication paths. In addition, it is important to understand network availability to mitigate impact of a disaster. Supporting research and investment in more resilient networks, can further help ensure operational continuity in disasters. Diverse means of connectivity are important in case networks are damaged, including satellite, broadcasting and amateur radio services.

Diverse emergency telecommunication equipment: Disaster risk management includes ensuring the proper equipment is on hand for a disaster. For example, emergency telecommunication equipment such as satellite mobile phones, movable ICT units, WiFi adhoc networks, delay torrent networks, local wireless mesh networks and emergency optical fibre cables may be deployed, particularly within hospitals, local governments, polis and military services, to support emergency connectivity if fixed telecommunication networks are damaged. Furthermore, securing important telecommunication for rescue official and communication channels for victims and their families are also important. Since the scale of a disaster varies, it is better to prepare several sizes or types of emergency telecommunication equipment.

1) Early warning

While many disasters cannot be predicted in advance, early detection and warning can help mitigate damage. For natural disasters such as tsunami, flood, landslides and earthquakes, ICT based early warning systems are recommended. Rough prediction may also be possible through big data analysis of historical disaster records.

2) Warning notification and evacuation guidance

Just after a disaster detection, it is recommended to warn citizens by multiple means such as mobile phones, TV and radio broadcasting and digital signage, so that citizens evacuate as soon as possible.

3) Safety confirmation and countermeasures for disaster damages

Traffic congestion on telecommunication networks may occur in the event of huge disasters, preventing citizens from being able to confirm the safety of friends and family. ICT systems for safety confirmation can avoid traffic congestion of telecommunication networks, and also allow for a means for local officials to assess well-being of citizens or prioritize search and rescue.

4) Rescue

ICTs can facilitate search and rescue and new systems have been improving means for finding survivors. In addition, accessibility for persons with disabilities must be considered when deploying search and rescue systems.

4.3 Conclusions

Throughout the study cycle, ITU-D Study Group 2 has been able to examine a wide range of activities throughout both developed and developing countries related to emergency communications and disaster relief. Whereas 10 years ago, only few developing countries may have had comprehensive emergency communications plans or frameworks, input contributions have shown that such plans are more common. Further, more countries and organizations are taking steps to develop early warning systems and make telecommunications/ICT networks more resilient to disaster risks. That being said, discussions during the study cycle identified the need for additional implementation support for developing countries in the area of disaster communications.

Since disasters cannot be eliminated all over the world, and new and emerging ICTs can be developed year by year, in the next study period, the Study Question could continue studying emergency telecommunication and disaster preparedness, mitigation, response and relief, in order to save human lives in the case of disasters. Considering the value of disaster preparedness, the output of the Question may focus on implementation and how to enable and empower developing countries to benefit from the vast amount of available information that already exists about use of ICTs for disaster communications management. More time could be devoted to exchange of experiences among developing countries to identify common challenges and successful practices and support ongoing development and implementation of disaster communications frameworks, technologies and plans.

PART 2 – Emergency Communications Checklist

The Emergency Communications Checklist outlines the types of activities and expected decision points that could be considered for inclusion in a National Disaster Communications Plan.

I. Preparedness

a) Administration and responsibility setting

Establishment and clarification of roles and responsibilities within a government and with stakeholders is one of the most basic – but critical – parts of developing a disaster communications management plan. Points of contact should be identified within the various agencies, and decision making authority and responsibilities in key areas should be clarified. In cases where there may be overlapping expertise or responsibility within an agency, or across multiple agencies, governments should work in advance to clearly determine leads and lines of responsibility to save time and improve the overall response when disaster strikes.

Government roles and responsibilities

- ☐ What government agency / ministry is responsible for disaster management and response overall in the country?
- ☐ What other ministries are involved/should be involved in disaster preparedness and response? What are their respective roles or mandates? What is the role of the communications regulator and ministry? Is the Communications Ministry or Regulator a participant in the activities of the National Disaster Management Authority?
  - o What authorities (legislation or mandates) enable each ministry/agency to respond to certain aspects of disaster response that will help guide identification of leads and roles and responsibilities?
- ☐ Who leads on particular aspects of response in each of those agencies in the event of a disaster? Does that lead vary depending on the type of disaster? How is disaster response coordinated within a ministry and organization? Who are the back-up points of contact in case the disaster impacts the lead person? What authority/decision-making ability does each point of contact have and in what area/subject matter?
- ☐ How does the lead disaster management ministry coordinate with other relevant ministries across government? How frequent does the core contact group coordinate, meet or conduct drills/exercises between disasters? Who maintains the point of contact list, and how often is it updated? Does it contain all possible contacts both for home and work?
- ☐ How is telecommunications/ICT prioritized or addressed within the country's disaster management framework?
- ☐ How is disaster response management responsibility or authority managed between central government and local or provincial / state governments?

b) External coordination

Disaster response involves many actors/stakeholders such as the central government, local communities, state/provincial authorities, public safety officials, the private sector, relief and technology organizations, hospitals, citizen groups and civil society organizations, UN, and foreign governments. In order to support an effective and coordinated response, a disaster communications plan should incorporate these external actors (stakeholders), and they should be actively involved in preparedness activities.

I.	Preparedness
□	Ensure coordination processes, define partnerships, and establish points of contact with external organizations. These may include: • Private telecommunication entities (carriers and equipment) • Other ministries • Local and state/provincial government agencies • NGO relief and response organizations; hospitals • United Nations / ITU • Foreign governments / military • Volunteer technical communities • Amateur radio • Citizen and community groups; civil society organizations
□	Who are the actors in your country that have been involved in or could improve/enable disaster response? Which foreign/international actors could support the response? How are citizens and local communities involved in disaster response planning; how are citizens informed about disaster response plans?
□	Who are the points of contact in each organization and how will the government engage/exchange information with those organizations before, during and after a disaster? What types of information or situational awareness can be shared by these stakeholders? What types of information or situational awareness can be provided to these stakeholders to facilitate a response?
□	How will you coordinate with these actors/stakeholders when developing a disaster response plan? How will you coordinate with these actors in any preparedness activities? How frequent will those communications or interactions be? What is your stakeholder engagement strategy or plan? Does your government have any requirements or legislation governing stakeholder engagement, public outreach or advisory committees?
□	Do external international actors require credentialing to enter the affected areas or visas to enter into the country when a disaster occurs? Have expedited processes been established in advance for both the entry of experts and communications equipment in times of disaster?
□	How are persons with disabilities and specific needs included in preparedness activities; how are these specific needs taken into account in planning?
c)	**Training and exercises**
	Once roles and responsibilities are defined, exercises are the best way to prepare teams to respond effectively to an emergency. Exercises should be designed to engage team members and get them working together to manage the response to a hypothetical incident. Exercises enhance knowledge of plans, allow members to improve their own performance and identify opportunities to improve capabilities to respond to real events with further training and education.

I. Preparedness
Exercises are a great method to: • Evaluate a preparedness program; • Identify planning and procedural deficiencies; • Test or validate recently changed procedures or plans; • Clarify roles and responsibilities; • Obtain participant feedback and recommendations for program improvement; • Measure improvement compared to performance objectives; • Improve coordination between internal and external teams, organizations and entities; • Validate training and education; • Increase awareness and understanding of hazards and the potential impacts of hazards; • Assess the capabilities of existing resources and identify needed resources.*
Some considerations are below: □ Is training or certification mandatory for officials designated to support a response effort? Consideration should be given to what type of training or certification may be needed for each type of personnel, and how regularly it should take place. □ Do exercises include both internal stakeholders and external, non-government partners? Consideration should be given to how regularly exercises take place among various stakeholders. Are drills conducted to ensure that the public is aware of disaster response plans and can recognize and react to a warning (for example, how to respond if an early warning alarm is triggered?). □ Are telecommunications/ICT exercises conducted separately and/or as part of more comprehensive national disaster exercises; how do national disaster exercises incorporate the role and priority of addressing telecommunications/ICTs? □ Which communications exercises are held? (e.g., early warning system testing, or regional/ national outage responses and restoration). □ Are exercises tailored to the types of disasters known to your country? (i.e. extreme weather, flood, earthquake, wildfires, humanitarian responses or cyber-attack?). □ Which agencies or ministries oversee and participate in communications-related exercises or drills? What are their roles? What is the role of local communities or governments? □ How are stakeholders, such as communications operators and suppliers, and technology focused organizations/associations engaged in disaster response or disaster communications exercises? Are they part of the exercise planning process? □ Are outage reporting requirements of carriers exercised? Do carriers follow a uniform reporting process, and know which contacts to report outages to and how? □ Is online training available for stakeholders prior to exercises? □ How is feedback collected after an exercise to help improve procedures or performance? Which stakeholders would you request feedback from? Is an “after action” report done, and is it circulated to participants?

I. Preparedness

d) Infrastructure and technology

Telecommunications/ICTs are a critical tool facilitating disaster early warning, relief and response. One objective of a disaster communications plan is to help ensure the continuity or restoration of communications in the event of a disaster. Below are some considerations related to infrastructure and technology when developing and implementing a disaster communications management plan during the preparedness phase.

- ◻ Technology Inventory or Assessment. A wide range of technologies and services can and should be used to support disaster communications response. When developing a plan, it is helpful to take stock of the technologies used by stakeholders (government, responders, citizens) to communicate on a daily basis, and which are often used in times of emergency. Such technologies could include emergency dispatch services, amateur radio, first responder systems including radio and public safety broadband, television and radio broadcasting, terrestrial mobile networks, wireline voice networks, broadband networks, satellite networks, and social media.
- ◻ Redundancy and resiliency planning; ensuring operational continuity and preparing for continuity and restoration of primary communications channels to minimize outages
- ◻ Power. Available and pre-positioned power sources (for infrastructure and individuals); what back-up power resources are available (for operators? For government? Responders? Citizens?) and how are these resources prioritized for restorations? Are processes in place to expedite or facilitate fuel delivery for communications network generators? Are there guidelines in place for critical facilities to have back-up power supplies?
- ◻ Identification and Training of key public and private personnel; regular training should take place for those personnel who will need to use and maintain/test emergency communications equipment. Local communities and local staff should also be considered for training in the use and maintenance of such equipment.
- ◻ Identifying critical sites/priority sites for restoration; what mechanisms are in place to prioritize critical sites for restoration efforts? How are these priority sites communicated to, and discussed with operators?
- ◻ Establish situational awareness and reporting mechanisms (public/private sector cooperation), such as a communications-focused advisory committee. How is information about business continuity plans exchanged with government officials?
- ◻ Spectrum and frequency planning; licensing/authorizations, including expedited frequency and type approvals, emergency spectrum management and authorization, expedited licensing approvals and possible temporary/emergency authorities. Has there been an assessment of any regulatory or policy barriers to entry or operation of needed equipment for disaster relief or restoration of networks?
- ◻ Priority and expedited customs procedures for approved/authorized incoming communications equipment.
- ◻ Consideration of emergency and network resilience/redundancy needs/requirements in national telecommunications development plans (e.g., broadband or infrastructure development plans).

I.	Preparedness
□	Human Factors; preparedness plans should take account that many personnel or their families may be directly impacted by a disaster and will be operating under stressful circumstances.
□	"Harmonized" outage reporting: to increase situational awareness and more rapidly identify needed resources for telecom/ICT restorations or to provide appropriate information to the public, authorities can identify terminology and a common format for reporting of outages to ensure a common understanding of status and requirements.
□	Use of 'Big Data' analytics to support disaster prediction and forecasting or projecting possible impact or risk; and to support decision–making and allocation of resources; What data sets are available for government or public use to aid in disaster response and risk reduction planning? What policies are in place to ensure that data can be shared by operators with responders in a way that protects individual privacy, while enabling response? What collaboration or public private partnerships could support improved use of data in support of disaster preparedness?
□	Establishing Emergency Alerting Systems 1) Mechanisms and technologies (broadcast, mobile, M2M/sensor networks; remote sensing technologies; big data; integration of delivery mechanisms, social media) What technologies and applications are best suited for the environment, geography, type of disasters and method of communication needed by citizens. Are multiple platforms used to ensure information gets to those affected? How should existing alert systems adapt to new technologies while also ensuring the broadest delivery of alerts. How to incorporate social media platforms? 2) Alert content (language, CAP, accessibility considerations) What officials are empowered to authorize the sending of an alert? What consideration is given to ensuring citizens are informed, while avoiding 'alert fatigue'. What information is placed in an alert and what standard is used to avoid confusion? 3) Enabling policies – expectations of carriers or broadcasters, policies and procedures for preparing, approving, and disseminating messaging. 4) Regular/ongoing national and regional alerting exercises and system testing. Who are involved in testing? How often will tests take place? 5) Public education; working with local communities and civil society to recognize early warnings and act on them. 6) How do alerts and early warning systems take account of those most vulnerable to disasters such as persons with disabilities including radio and television announcements or alerts and information distributed through SMS, emails, etc.

I.	Preparedness

□ Accessibility Considerations

1) How are members of vulnerable populations consulted regarding their needs? How are capacities of vulnerable populations developed for example through awareness raising programs or trainings? Are information materials including websites or apps accessible?
2) Are accessibility and usability of ICTs considered in projects? What strategies and mechanisms are used to promote accessible ICTs including legislation, policy, regulations, license requirements, codes of conduct, and monetary or other incentives?
3) Are information materials provided targeting vulnerable populations? Are public awareness campaigns conducted in multiple accessible formats in different languages along with sensitized resource persons to impart the contents of these packs to persons with disabilities and other vulnerable groups?
4) Following a disaster, are disaster response efforts reviewed to assess challenges for vulnerable groups, discuss lessons learned, and undertake efforts to fix any issues in ICT-based disaster management services?

* United States Department of Homeland Security (https://www.ready.gov/business/testing/exercises).

II.	Response, Relief and Restoration

a) Communications Channels and Information Sharing

Telecommunications/ICTs are tools to support exchange of critical information between those affected by a disaster, including citizens and those participating in response, relief and restoration activities. While operational continuity or ongoing availability of the underlying technologies is important, when developing a response plan it is also important to understand the channels of communication and types of information that need to be shared. Flexibility is important as needs quickly evolve during a disaster.

II.	Response, Relief and Restoration

- ◻ What Information is being communicated? What types of information are needed (and could be provided) by certain parties? (e.g., network outage status, safety and location of family members or key personnel, meteorological and seismic information, the location of shelters, damage and infrastructure assessments (including status of roads or transportation systems to allow for movement of supplies or personnel); rules and regulations associated with emergency equipment approvals and operation; response coordination, including what supplies or personnel are needed to support relief and restoration efforts and who are able to provide support?)
- ◻ Who is communicating? What are the channels of communication? Who has priority to communicate?
  - Intra-governmental communications;
  - Government to UN or non-governmental organizations (NGOs) that provide relief and response;
  - Interactions between Government and UN/NGO responders and private sector (telecom/ICT providers);
  - Government to public; UN/NGO's to public;
  - Public to government/UN/NGO community;
  - Private sector to public;
  - Private Sector to Private sector;
  - Citizen to citizen.
- ◻ Are back up or diverse/redundant means of communication in place in case of outages? Has consideration been given to whether a disaster may render a planned communication tool unusable and what redundant means of communication might be used? (e.g., if the expectation is to communicate via conference call how will accommodation be made if phone networks are down?) Are portable communication units available to establish temporary connectivity?
- ◻ Ensuring accuracy of data / verifying information. Consideration should be given to how to verify and report/disseminate information before acting upon it to ensure the most efficient use of resources and improve coordination and decision making.
- ◻ Understanding cultural norms and behaviors. Different cultural groups may communicate in different ways, or trust information from different types of sources. Consideration should be given to linguistic and cultural behaviors and how they affect communication.
- ◻ Social Media: How can social media be used as a tool for collecting data and sharing information for two way communications? How do relief and response authorities respond to requests for help received via social media? What partnerships can be established to best use social media tools? How do citizens use social media for information gathering and exchange during a disaster as compared to other tools?
- ◻ Establishing mechanisms for communicating across and with (CwC) diverse groups; sharing information/situational awareness/reporting

II. Response, Relief and Restoration

b) Infrastructure and Technology

In evaluation of damage and reestablishment of networks, communication must happen rapidly between those assessing the damage, determining priority of restoration efforts and directing assistance, and those providing emergency communications services. Determinations should be made in advance, whenever possible, about points of contact for functions such as technical coordination and sharing of network outage information. In addition, there should be backup (redundant) networks in place for government and first responder use in order to facilitate restoration efforts, such as dedicated government communications networks.

Evaluation of damage / ICT assessment

- □ What is the role of the communications ministry/regulator regarding reporting damage or outages to public or commercial telecommunications networks and enabling continuity and restoration and how is that role defined (through a license, etc.)?
- □ Who will be the designated ministry/regulator or point of contact to collect, analyze, and react to/report/release information regarding damage to networks? What information and analysis from operators should be obtained and utilized? How will these information needs be communicated in advance to operators?
- □ For those networks that are commercial or public, are there reporting requirements already in place that would establish a process, format, and timeline for submitting evaluations? If not, can government set up a coordinating mechanism by which to establish expectations and receive information?
- □ Will initial damage assessments be connected to award of disaster recovery funding?
- □ For government networks, what interagency coordination and information sharing processes will need to be established? Will public or private networks be more suitable/reliable for this purpose?
- □ Are there policies in place that consider communications network status, needs, conditions and requests, and that enable the maintenance and restoration of the following communications capabilities? What process is followed to determine the priority of each restoration?
  - Local agency Land Mobile Radio systems;
  - Emergency dispatch services;
  - Status of terrestrial systems/ public mobile systems;
  - Broadcast radio/TV stations;
  - Amateur radio services;
  - In-country VSAT provider availability;
  - Pre-positioned emergency MSS equipment;
  - Internet services.

II. Response, Relief and Restoration

Establishment of emergency connectivity

□ Which emergency telecommunication partners will be contacted in the event of a disaster? What information will be provided to them, and how will they be contacted?

□ How will offers of assistance from foreign governments, humanitarian organizations, or private sector be received and processed?

□ Who are points of contact for authorization of incoming equipment or to allocate requested frequencies? Is there a mechanism to ensure timely coordination with local operators to avoid interference?

□ Which emergency ICT resources will be prepositioned and at which priority locations, and by whom? Who has authorization to activate or distribute? How will these pre-positioned resources be maintained and tested? What consideration is given to fuel supplies for power generators and restoration of telecommunication networks?

□ Ensure coordination between telecommunications teams and the central disaster management institutions to meet needs. Consider which networks and communications technologies are most used by first responders (e.g., land mobile radio vs. mobile data services), or by the public to reach emergency services, and could therefore prioritized for immediate restoration or additional maintenance support. How can government agencies facilitate private sector restoration of networks?

□ Where will emergency connectivity be first established? Consider whether there are previously determined disaster recovery sites that will require immediate connectivity, or whether connectivity will be required for mobile disaster recovery centers.

II.	Response, Relief and Restoration
Maintenance and reestablishment of networks	
□	Is there a source of expert advice and assistance for government agencies with respect to restoring government networks and telecommunication infrastructures? In cases where government uses private networks, will restoration be carried out by government or private sector technicians? Consider whether there are commercial networks in place to use as backup for closed government networks in the event of disruption. Does government have mechanisms or emergency procedures in place to facilitate customs clearance or import of equipment needed for restoration of critical networks or to facilitate entry of any external expert personnel needed to restore and rebuild networks?
□	Is there a process in place to routinely test networks designed for emergency communication?
□	Are commercial or public network operators encouraged to have a business continuity plan in place? How frequently are restoration plans exercised and updated?
□	Is there a plan for reporting on progress of network restoration? How frequently are these plans exercised?
□	Is information related to network outages and restoration activity safeguarded and classified appropriately to mitigate security concerns?
□	What is the single government point of contact for sharing communications outage and restoration information with other stakeholders? Having one point of contact can prevent duplication of effort on the operators' part.
□	Has a forum for operators to share information and coordinate possible assistance been established? Consider the group's mandate, operational procedures or guidelines, and ways in which to utilize this forum.
□	Consider whether a procedure could be put in place to allow the government to share sensitive threat information with network operators.
□	What procedure is in place to assist operators with critical items such as physical access and expedited fuel deliveries?

Abbreviations and acronyms

Various abbreviations and acronyms are used through the document, they are provided here.

Abbreviation/acronym	Description
AC	Alternating current
AFTIC	Autoridad Federal de Tecnologías de la Información y la Comunicación (Argentine Republic)
AP	Access Point
APCO	Association of Public-Safety Communications Officials
APT	Asia-Pacific Telecommunity
AWS	Automatic Weather Stations
BDT	Telecommunication Development Bureau
BNGRC	National Bureau for Risk and Disaster Management (Bureau National de Gestion des Risques et Catastrophes) (Madagascar)
BTS	Base Transceiver Station
BYOD	Bring Your Own Device
CAR	Central African Republic
CCSA	China Communications Standards
CDMA	Code Division Multiple Access
CIP	Critical Infrastructure Protection
CITEL	Inter-American Telecommunication Commission
CO2	Carbon Dioxide
DAMA	Demand-Assigned Multiple Access
DART	Deep-Ocean Assessment and Reporting of Tsunami
DCDI	Data Center Development Index
DCnum	Number of Data Centers
DECT	Digital Enhanced Cordless Telecommunication
DHS	Department of Homeland Security (United States of America)
DIRS	Disaster Information Reporting System
DMR	Delay Measurement Reply
DOST	Department of Science and Technology (Philippines)
DS	Digital Signage
DTN	Delay Tolerant Networking
DTV	Digital Television

Abbreviation/acronym	Description
EDFA	Erbium-Doped Fibre Amplifier
EMN	Emergency Mobile Networks
ESOA	European Satellite Operators Association
ETC	Emergency Telecommunications Cluster
EWS	Emergency Warning Systems
FCC	Federal Communications Commission (United States of America)
FDI	Foreign Direct Investment
FEMA	Federal Emergency Management Agency
FM	Frequency Modulation
FWA	Fixed Wireless Access
GDP	Gross Domestic Product
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
GPS	Global Positioning System
GRI	Geographic Redundancy Index
GSM	Global System for Mobile Communications
GVF	Global VSAT Forum
HAZMAT	Hazardous materials
HF	High Frequency
HF/SSB	High-Frequency Single Sideband
HQ	Headquarters
IARU	International Amateur Radio Union
ICIMOD	International Centre for Integrated Mountain Development
ICT4D	ICTs for Development
ICT4DM	ICTs for Disaster Management
ICTs	Information and Communication Technologies
IDB	Inter-American Development Bank
IECRS	Integrated Emergency Communication & Response System
IFCE	ITU Framework for Cooperation in Emergencies
IMD	India Meteorological Department
IMS	IP Multimedia Subsystem

Abbreviation/acronym	Description
IMSI	International Mobile Subscriber Identities
IP	Internet Protocol
IPTV	Internet Protocol Television
IT	Information Technology
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
ITU-D	ITU Telecommunication Development Sector
IXP	Internet eXchange Point
IXPnum	Number of Internet eXchange Points
kHz	Kilohertz
LAC	Latin America and Caribbean
LAN	Local-Area Network
LEO	Low-Earth Orbit
LMR	Land Mobile Radio
LTE	Long-Term Evolution
M2M	Machine to Machine
MANET	Mobile Ad-hoc Networks
MDRU	Movable and Deployable Resource Unit
MF	Medium Frequency
MHz	Megahertz
MIC	Ministry of Internal Affairs and Communications (Japan)
MIIT	Ministry of Industry and Information Technology (People's Republic of China)
MMS	Multimedia Messaging Service
MNO	Mobile Network Operator
MWE	Ministry of Water and Environment (Uganda)
NDR	Network Disaster Recovery
NDRI	Natural Disaster Risk Index
NGO	Non-Governmental Organisation
NOAA	National Oceanic and Atmospheric Administration MetSat operator for the United States
NPSBN	National Public Safety Broadband Network

Abbreviation/acronym	Description
NTT	Nippon Telegraph and Telephone Corporation (Japan)
NVIS	Near-Vertical-Incidence Sky-wave
NWP	Numerical Weather Prediction
ODU	Out-Door Unit
OPM	Office of the Prime Minister
PABX	Private Automatic Branch Exchange
PC	Personal Computer
PECS	Portable Emergency Communication Systems
PSAP	Public Safety Answering Point
PTT	Push-To-Talk
R&D	Research and Development
ROI	Return On Investment
SATCOM	Satellite Communication
SDGs	Sustainable Development Goals
SMS	Short Message Service
SSDM	Smart Sustainable Development Model
ST3	Special Task Group
STA	Special Temporary Authority
SVG	Scale Vector Graphics
SWR	Standing Wave Ratio
TC	Tropical Cyclone
TETRA	Terrestrial Trunked Radio System
TRAI	Telecom Regulatory Authority of India
UAS	Unmamed Aircraft System
UAV	Unmanned Aircraft Vehicle
UCC	Uganda Communications Commission
UHF	Ultra-High Frequency
UN ISDR	United Nations International Strategy for Disaster Reduction
UNCTAD	United Nations Conference on Trade and Development
UPS	Uninterruptible Power Supply
VHF	Very High Frequency

Abbreviation/acronym	Description
VSAT	Very Small Aperture Terminals
W-CDMA	Wideband Code Division Multiple Access
WAN	Wide Area Network
WCAG	Web Content Accessibility Guidelines
WFP	World Food Program
WINDS	Wideband Internetworking engineering test and Demonstration Satellite
ZICTA	Zambia's Telecommunication Regulatory Authority

Annexes

Annex 1: Case study summaries

A1.1 Network disaster recovery plans (GSM Association)

To remain competitive and ensure sustainability, firms are focusing more heavily on disaster risk management. Additionally, as company disaster recovery plans become more detailed, they force similar effects through their suppliers via audits and management practices. While at a high level this appears to be a business continuity and revenue protection issue, it also has much broader implications for sustainable development globally. Countries that are attempting to climb out of poverty are often held back by frequent natural disasters. This case study from the GSMA Disaster Response program details AT&T's Network Disaster Recovery Plan, focusing on its extensive reach and rigorous procedures.[6]

The AT&T Network Disaster Recovery (NDR) team has 29 full-time staff members but a total of 100 people in the expanded emergency management team dealing with business continuity and emergency management. As with any disaster response or business continuity team, the team is made up of people with different skills, drawn from different business units across the company. The part-time team is deliberately populated by staff from a wide variety of disciplines to ensure that the NDR team is expert on everything from core network to radio frequencies to location and geography of each central office and network location.

Regular disaster exercises gives NDR staff experience of reacting to disasters, working in often harrowing conditions and training in what the requirements are. Furthermore, the exercises strengthen partnerships across the departments within the mobile operator and those partnerships with external agencies such as the fire department and police service. These exercises also give the NDR team management observations and data which they can feed back into their existing plans to fine tune them for efficiency.

The extensive investment poured into the hardware, equipment and assets used by the NDR team is unparalleled. AT&T have preparations made for the recovery of large switching centres and IP hubs through the development of other extensive recovery equipment. Given the requests from emergency responders, the humanitarian community and the clients of telecommunications firms to play an increasing role in disaster response, it has never been more pressing for the mobile operators to help change the face of disaster response.

A1.2 Satellite based machine-to-machine technologies in early warning systems

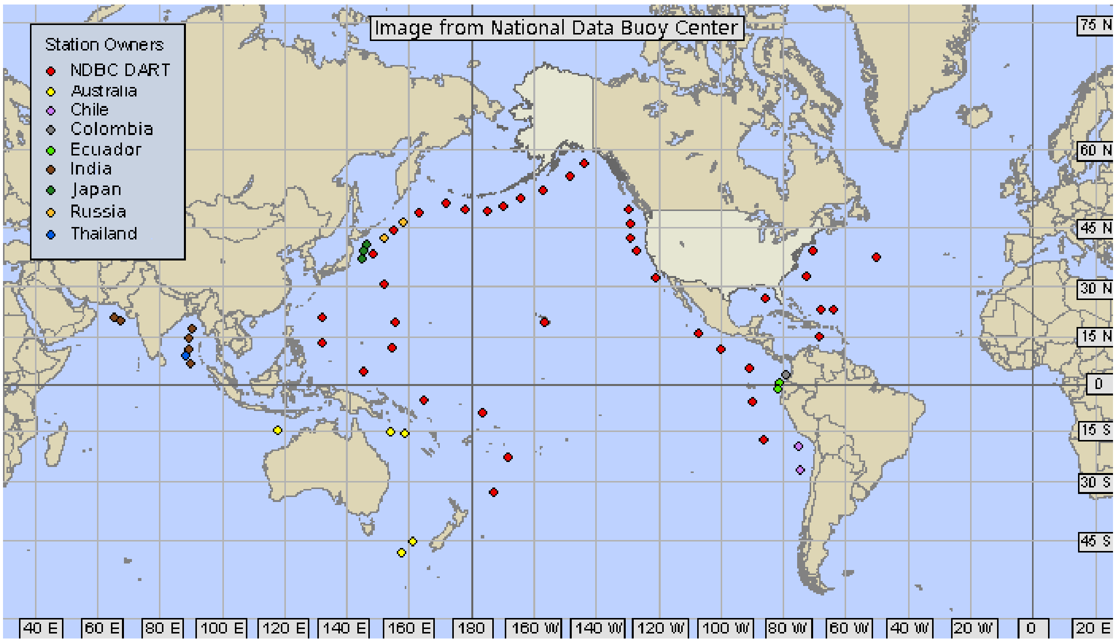
1) Case study: Pacific coast tsunami warning system

For the last decade, buoys known as Deep-Ocean Assessment and Reporting of Tsunami (DART) have measured tsunami waves. Following tsunamis in 2004 and 2011, scientists have increased global cooperation by refining ways to measure waves and to convert these measurements into meaningful forecasts for shore. This model is used in the Atlantic Ocean, Pacific Ocean, and Indian Ocean, but is also being considered for use in the Mediterranean Sea.[7]The DART system consists of pressure-sensitive tsunameters on the ocean floor and buoys on the surface. The buoys are equipped with an acoustic modem that receives data from the tsunameter sensors and a small data modem that transmits pressure measurements.

6 Document 2/239, "GSMA Case Study of AT&T's Network Disaster Recovery Plan", GSMA, AT&T (United States of America).

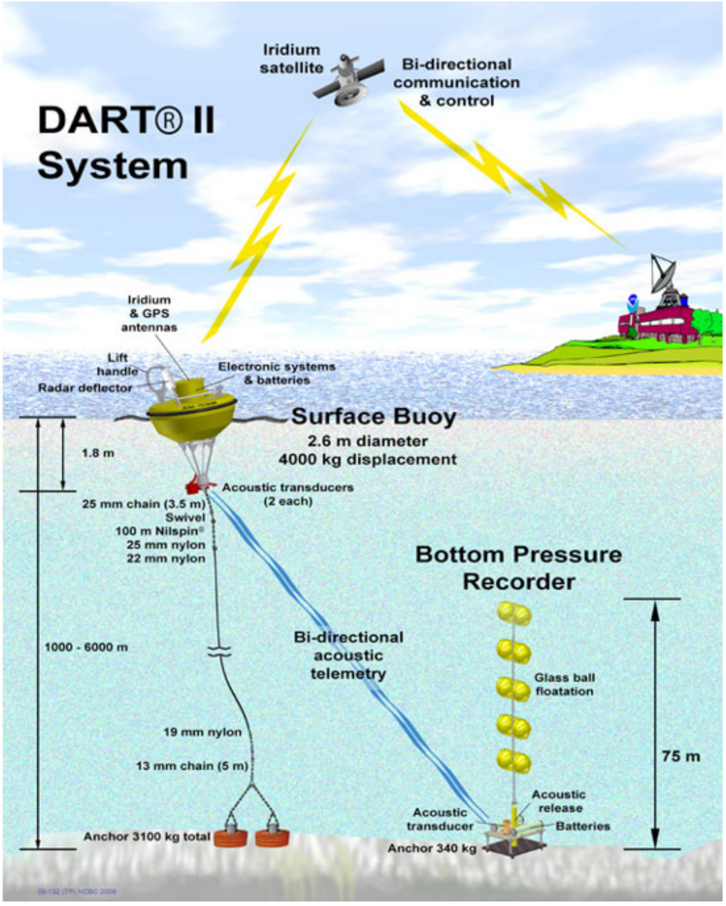
7 Document 2/243, "Applications of satellite based machine-to-machine technologies in early warning systems", Iridium Communications Inc. (United States of America).

Figure 1A: Locations of DART®II Tsunami Warning Buoys



Using this data, scientists issue appropriate warnings to areas that may be affected. Since DART leverages global mobile satellite coverage, the warning system itself is global. Since the system offers two-way communication, NOAA officials can upgrade buoy software, perform tests, or reboot stations when equipment is not working properly. The data transmitted to the tsunami warning centers can be used to issue warning guidance, provide hazard assessment, and coordinate emergency response.

Figure 2A: Diagram of tsunameter mechanism



System Components

- Anchored seafloor BPR – Bottom Pressure Recorder
- Acoustic link transmits data from BPR to buoy
- Moored surface buoy
- Real time communications
- 2-way data transmission
- Data directly routed to NOAA
- Dedicated path mitigates latency
- Global coverage (pole-to-pole

This technology has produced meaning results for Pacific communities. Following the magnitude-9 earthquake off Japan in 2011, the NOAA issued a tsunami alert to Japan minutes after the earthquake struck, which gave residents an early warning to evacuate to safer ground. The NOAA was also able to accurately model the wave coming from Japan and provide targeted warning to certain areas of the US West Coast before it made landfall.

2) Case study: Glacial lake outburst flood monitoring and warning system in Bhutan

When lake water dammed by a glacier or glacial debris suddenly breaks through, glacial lake outburst flood (GLOF) occurs.[8] GLOFs in Bhutan cause massive loss to property, livestock, and life. After the 1994 GLOF claimed 22 lives, the government of Bhutan sought to establish an early warning system to give downstream inhabitants time to evacuate.

In 2004, the government implemented a basic warning system but it relied on manual readings of gauges installed at remote glacial lakes and was susceptible to radio communication failure. The majority of the sensors were only accessible via a nine-day trip on a pack animal.

8 Document 2/243, "Applications of satellite based machine-to-machine technologies in early warning systems", Iridium Communications Inc. (United States of America).

Figure 3A: GLOF Early Warning Station

In light of these challenges, in 2010 the government sought to establish a system with two-way communications, remote diagnostics, back-up sensors, and dataloggers into the system, allowing for remote updates to software. Likewise, two-way communication with the control center enabled remote diagnostic and battery monitoring for the sirens. The use of a LEO global mobile satellite system further meant that data delays between the remote hydro-met station and the control station in Wangdu are virtually unnoticeable. The GLOF early warning system consists of 6 sensors and 17 siren stations connected to one central control station. The sensors collect and transmit water level and outflow data to the control center through Iridium telemetry. The siren stations, positioned near the population centers, are powered by 80W solar panels with 75Ah 12V batteries to ensure continuous operation. With the GLOF fully operational in 2011, this is the first system of many for Bhutan.

A1.3 Case studies from the People's Republic of China (People's Republic of China)

China promotes the development of emergency telecoms industry actively

1) Government support and guidance

The State Council issued a policy to accelerate the development of emergency industry, focusing on: "develop the products of rapid acquisition of emergency information, emergency telecoms, emergency command" and so on, the scale of the emergency telecoms industry will significantly expand by 2020, the basic emergency telecoms industry system will be formed.[9] Government departments are focusing on the following areas to increase support and promote:

a) Increase the support and investment guidance in the construction of public emergency telecoms, and support the construction of satellite mobile communications systems, broadband satellite communications systems, broadband trunked communications network, emergency telecoms vehicles, emergency telecoms equipment, to promote industrial development vitality.

b) Increase support for emergency telecom research through the national science and technology projects. Guide the advanced units including production enterprises, universities, R&D units, to actively participate in emergency telecoms technology research and development, to promote related key technology research and innovation for the development of the industry.

[9] Document 2/456, "China actively promotes the development of emergency telecommunications industry", People's Republic of China.

c) Develop emergency telecoms product guide catalogue, and attract social resources to invest in emergency telecoms industry. Try to set up emergency industry demonstration base, to enlarge the scale of emergency telecoms and other related industries.

2) Industry organizations play a key role

- In 2015 under the guidance of the Ministry of Industry and Information Technology, the emergency telecoms industry alliance was established, which is a non-profit organization with hundreds of enterprises and institutions as members, to promote the development of emergency telecoms industry. The alliance builds a communication platform between government, business and users, to strengthen the guidance of industry chain.
- The alliance is currently carrying out related research and activities in some important fields, such as standardization, high altitude platform communications system, equipment miniaturization, broadband trunked communications and so on.
- Once a year the alliance carries out emergency telecoms industry development summit forum with significant influence, around the industrial policy, information technology, cross technology integration and other aspects.
- In order to strengthen the standardization work in the field of emergency telecoms, China Communications Standards Association (CCSA) set up a Special Task Group (ST3) to strengthen the work of emergency telecoms standards. The ST3 focus on comprehensive, managerial, and framework study of standards about emergency telecoms, including policy support standards, network support standards and technology support standards.
- At present, the ST3 has finished several standards, such as Technical requirements of short message service for public early warning, Basic service requirements of public emergency telecoms in different emergency circumstances, Technical Requirements of Emergency Sessions Services based on the Unified IMS, Technical Requirements of Common Alerting Protocol, Ad hoc networks for Emergency telecoms, Technical requirements for priority calls in public telecommunication network, etc.

3) Related enterprises actively participate

Under the joint efforts of the government and industry organizations, related enterprises show high enthusiasm, and actively participate in development process of emergency telecoms industry.

a) Telecom operators actively deploy the applications of new emergency telecoms technology, such as satellite mobile communication network, Ka broadband satellite communication network, super base stations, and emergency telecom vehicles.

b) Manufacturing enterprises accelerate to carry out transformation researches about equipment's miniaturization, centralization and integration, in order to adapt to the needs of special emergency environments. There have been some achievements in the small base station, portable satellite antenna, self-organizing network equipment, satellite handheld terminal, and air base station currently.

c) Social capital continues to focus on the field of public emergency telecoms, actively invest in public broadband network and other aspects construction. Through Public-Private Partnership mode, the emergency telecoms industry gain more capital support.

In summary, under the initiative of the government, the related industry organizations, operating enterprises, manufacturing enterprises, social capital enterprises play their own advantages, to form a better emergency telecoms industrial ecosystem, and to steadily promote China's emergency telecoms industry more and much stronger, so as to provide better support for emergency telecoms guarantee work.

Enhancing command and dispatch in emergency telecommunications

In China, when a disaster strikes, relevant departments will immediately start to implement predefined plans, create steering groups, initiate consultations and allocate tasks. The Ministry of Industry and Information Technology (MIIT) uses video conference lines set up for continuous communications to command vehicles set up at the disaster site by the local telecommunication administrations and operators through the "National command and dispatch system for emergency telecommunications"[10]. These video conference lines facilitate all disaster reaction planning after they are setup.

1) Strengthening resilience of public networks

One approach to resiliency is increasing the capacity of key base-stations. These "super base-stations" are designed with higher construction standards, stronger power supply, and increased configuration capacity. When coupled with satellites, super base-stations are resistant against many disasters. Another approach is to ensure that wired connections are properly mixed with wireless connections to ensure constant connection through a variety of disruptions.

China has deployed more than 1500 super base-stations with various resiliencies ranging from anti-seismic, anti-flood, anti-typhoon, anti-ice and snow, and comprehensive super base-stations in disaster prone areas. All types of super-base stations are enhanced by: strengthening the anti-disaster ability of optical transmission system and through empowering and protecting the emergency power supply. Specific improvements for different disasters are below.

- Anti-seismic super base-station: improving the satellite transmission and backup system, better site selection strengthening materials, and improving seismic capacity.
- Anti-flood super base-station: improving the satellite transmission and backup system and better site selection.
- Anti- typhoon super base station: strengthen the feeder and enhance wind resistance.
- Anti-ice and snow base station: strengthen the feeder.
- Comprehensive disaster super base station: built to be resilient to combined disasters.

2) Increasing emergency material reserves

Additionally, having satellite phones in disaster prone locations is helpful for reporting first-hand information to the steering center and increases survival chances.

3) Multiplying technical means for emergency telecommunications

Different stages and types of emergency require different enhancements to telecommunications. At the reporting stage, easy-to-use and satellite telephones using the Beidou Satellite will work. However, at the relief stage, vehicle-mounted and portable devices will be required to ensure voice, data, and video communications for the steering centres of different levels. This supports the larger amount of coordination efforts in the area at the time. At the final support stage, devices on vehicles play a role to connect affected areas. If terrestrial communications are severely damaged, a mobile communication platform should be provided for temporary use.

The Internet and mobile communications play an ever-increasing role in disaster response. After an earthquake, information regarding the disaster situation, relief situation, and lifesaving actions are sent quickly through the instant message service WeChat. Mass media will use Weibo, the Twitter-like mini blog service, to publish authenticated information.

4) Upgrading technology support and R&D capability

People's Republic of China's emergency telecommunications plan, standards, and R&D system have taken shape over many years. The Telecommunication Standardization Association of China

[10] Document 2/181, "Summary of experience of emergency telecommunications in China", People's Republic of China.

has implemented standards that take into account how public telecommunications networks support emergency communications. Additionally, the Association set up an Ad Hoc Emergency Telecommunications Group that focuses on the further study and development of relevant standards of emergency telecommunications.

5) Allocating 1.4GHz frequency band

In traditional narrowband communications systems in China, wireless private network communications spectrum is allocated separately by industry. For example, government, public safety, power, and other key industries have their own wireless private networks, spectrum resources, and independent industry professional networks. The 4G mobile broadband trunked communications system provides a basis for mobile communications, through the 1.4GHz band[11]. Since 2012, there have been 1.4GHz TD-LTE private network tests in Beijing, Tianjin, Nanjing, Shanghai and Guangdong in succession. Additionally, TD-LTE broadband trunked communications played a major role in the 2014 Nanjing Youth Olympics and in the Yunnan Ludian earthquake.

According to “People’s Republic of China Radio Frequency Allocation Provisions” and the actual spectrum usage in China plans to allocate the 1447-1467 MHz band to digital broadband private trunked communications systems. Considering the nature of these systems and the requirements for coexistence and compatibility with other radio uses, they are recommended for shared networks in big-medium cities. The provincial radio regulatory agency should make suggestions for spectrum based on the actual needs and the application characteristics of their local areas.

6) Developing emergency communications standards system

Emergency communications technology research, development, and support integration capabilities have been improved through work by research institutes, universities, and enterprises[12]. Ad hoc networks, the regional space communications systems, digital broadband trunked systems and other 20 industry standard systems have been developed in recent years.

7) Using big data analysis to improve emergency management capabilities

Big data has brought new opportunities to emergency management innovation and enhancement. Big data assists prediction in the early stages of a disaster to improve emergency response capabilities and can sift through risk points. Statistical and correlational analysis on data identified key crisis elements which allow response teams to control them. It also accelerates emergency decision procedures.

Big data analysis aids the allocating of funds in the post-event stage for rescue and rebuilding operations. In city traffic accidents, outbreaks of mass epidemics, city floods caused by snow, and rain and other natural conditions, big data analysis helps rescue route design, staff arrangement, and material disposition through an emergency management platform. It also provides personalized data, tracks personalized needs for stakeholders, and targets assistance and services.

8) Emergency communication management system

People’s Republic of China has established an emergency management system with unified leadership, comprehensive coordination, and classification management[13]. People’s Republic of China also established a set of emergency communications working systems suitable for People’s Republic of China’s national conditions, in order to effectively prevent and properly handle all kinds of public emergencies. Depending on the situation, MIIT introduces emergency communications management, emergency supplies reserves, emergency communications professional team management, and other departmental rules and regulations.

11 Document SG2RGQ/136, “Initiative technologies and application in emergency communications”, People’s Republic of China.
12 Document SG2RGQ/136, “Initiative technologies and application in emergency communications”, People’s Republic of China.
13 Document 2/347, “Experience of emergency telecommunications in China”, People’s Republic of China.

The National Communications Security Emergency Plan System is based on the National communication emergency plan and includes the national plan, department plans, local plans and, business plans.

9) Enhancing national emergency early warning ability

The National emergency warning information release system has four levels: the national, provincial, municipal, and county level. The system releases unified meteorological, marine, geological disasters, forest and grassland fire, heavy pollution weather warning information, etc. The information can be transmitted by TV, radio, mobile, internet network, etc.

Figure 4A: National emergency warning information release system

10) Emergency communication equipment

The emergency communications equipment series covers vehicle, portable, handheld, and other devices. It includes optical transmission, microwave, satellite, mobile, data, and other technologies -mixing fixed and mobile communications. It can transmit voice, data, video, and other services with different capacity/capability levels.

Figure 5A: Emergency communication equipment

11) Strengthening the construction of emergency communication team

There are 29 professional emergency communications teams in China operated by China Telecom, China Unicom, China Mobile and China SATCOM.[14] The telecom operators also have business needs-based emergency teams setup around the country. China's emergency communications security teams contain full-time and part-time staff. Training ensures the staff are familiar with the theory and operation of emergency communications. Multiple cross regional large-scale emergency communication exercises are used to improve the team's emergency response capacity.

A1.4 Hurricane Sandy and the Federal Communications Commission (United States)

Hurricane Sandy was a Category 3 Atlantic hurricane that caused billions of dollars of damage in the US and Canada in October 2012.[15] It was the second-costliest hurricane in US history. The storm created major communications system outages in the United States.

Around the time that Sandy was named a Tropical Storm, the FCC began mapping critical US communications assets along the East Coast from Florida to Massachusetts. The FCC Operations Center also reached out to 911 coordinators and state Emergency Operations Centers to advise them directly of how to contact the FCC in case there were any issues with communications after landfall. FCC also issued a public notice informing licensees and the public safety community how to contact the FCC Operations Center 24x7 for any assistance.

The morning of expected landfall, the Disaster Information Reporting System (DIRS) was activated and outage reporting was requested from industry so that an outage snapshot could be provided hours after landfall. Once the storm hit, the FCC began assessing the status of commercial communications infrastructure to identify needs. Reports came in through DIRS, and the Commission reached out directly to dozens of entities, including 911 call centers, satellite providers, broadcast associations, carriers, telecommunications relay service administrators (services for deaf/hard of hearing) and undersea cable landing operators.

Over the next several days, the FCC worked a large number of issues, in coordination with FEMA, DHS and the affected states. Issues included contacting state/local officials about debris removal to support communications restoration, working fuel issues for generators, making referrals to incident response leadership on the ground, and issuing Special Temporary Authority (STA) to licensees to support disaster recovery. For example, during Sandy, STA was issued to energy companies that have repair crews coming from out of state and for broadcasters to exceed normal power limits to extend their broadcasts at nighttime to relay emergency information. Early outages were mostly due to lost transport, but as time went on, power outages became the primary cause of communications degradation (with prolonged electric grid outage and limited liquid fuel supply, generators at telecommunication sites began to run out of fuel or in some cases break).

A1.5 First Responder Network Authority (FirstNet) and stakeholder consultation (United States)

In 2004, the "9/11 Commission Report" found that first responder coordination during and after the terrorist attacks against the United States on September 11, 2001 was hindered due to communications system failures.[16] The Report recommended that Congress enact legislation to assign spectrum specifically for public safety purposes and develop a single interoperable broadband network for first responders. The Middle Class Tax Relief and Job Creation Act of 2012 (the "Act") created FirstNet with the mission to ensure the building, deployment, and operation of a nationwide, interoperable wireless broadband network dedicated to public safety.

[14] Document 2/347, "Experience of emergency telecommunications in China", People's Republic of China.
[15] Document 2/42, "The Federal Communications Commission's role in incident response", United States of America.
[16] Document 2/197, "First Responder Network Authority (FirstNet)- Considerations for building a nationwide public safety broadband network", United States of America.

The Act provides the framework for the organization and structure of FirstNet and made FirstNet the exclusive license holder of the 700 MHz D Block (20 MHz) spectrum. The National Public Safety Broadband Network (NPSBN) is a network that public safety can switch to with urban and rural coverage in all states and territories; priority and pre-emption services to public safety users; hardened, secure, resilient, and reliable network infrastructure; and commercial standards-based technologies to drive innovation throughout the network and related equipment, devices, applications and other services. The NPSBN will start as a mission-critical data network with non-mission critical voice capabilities, complimentary to current Land Mobile Radio (LMR) systems.

To determine potential user needs and system requirements and specifications for the NPSBN, the United States has been engaging in extensive open and transparent consultative processes with a variety of stakeholders, including federal, state, local, and tribal public safety entities; local, state, territory, and federal government agencies; federally recognized tribes, and commercial technology providers. As part of FirstNet's "State Consultation" process, each state and territory received a package of materials, including a questionnaire to gauge the state or territory's current capabilities and readiness for FirstNet. This process involved in-person meetings, webinars, conference calls, and other direct communications to address the design of the NPSBN.

A1.6 Combating epidemic diseases with ICTs (such as Ebola) (Guinea)

Throughout the Ebola epidemic in Guinea, information and communication technologies (ICTs) circulated real-time information for patient care and treatment decision-making. ITU provided support in setting up an IT application (Ebola-Info-Sharing), a contribution reinforced by applications already used by the ICT ministry.[17]

1) Health information system

Most of the country's hospitals operate on the basis of non-automated processes which are hard to access. Automation is necessary for the operation and expansion of cyber health and e-health initiatives, with pilots underway at the University of Dhonka. In order to improve the health systems and overcome the deficiencies in the sector, ICT can be used at different stages, including:

- Decision-making at all levels of public health to improve management of health system programs and projects among institutions;
- Raising awareness in the private sector in order to promote improvements in quality of care and follow-up;
- Encouraging widespread use of cyber health and ICTs, while ensuring access to health care and capacity building in health care and academic institutions.

2) General information on the existing system in Guinea

Most of Guinea's hospital infrastructure does not met international standards, due to shortages of equipment and the geographical distribution of staff. There is currently no connectivity and very little information sharing between the various health sector structures, resulting in deficiencies in health services in remote or isolated areas.

How can outbreaks of disease be prevented?

Timely health information helps anticipate and prevent potential epidemics. Systems that operate on data indicators of pathologies and syndromes likely to lead to epidemics are necessary.

Available systems include the following IT applications:

- The health surveillance system;

[17] Document 2/170, "ICTs, e-health and cyber health to combat epidemic diseases (such as Ebola)", Republic of Guinea.

- Sharing and dissemination of health information by SMS, audio or audio/visual means;
- The mobile application "Ebola-Info-Sharing''.

3) ITU and big data use for mitigating Epidemics

In implementing the ITU Plenipotentiary Conference Resolution 202, (Busan, 2014) a successful Ministerial meeting was held in Sierra Leone resulting in a declaration calling for continued efforts to use big data for combating the scourge of Ebola and other epidemics. Fifteen Ministers from both the ICT and Health sectors and more than 430 delegates participated. The ITU launched a big data project based on the analysis of Sierra-Leone's Call Data Records. The project evolved to include two other countries; Sierra Leone, Guinea, and Liberia. Two missions to these countries to train staff from both regulatory authorities and mobile network operators to anonymize, analyse, visualize data, and interpret the results were carried out. The project involves all mobile network operators and helps track the movement of subscribers in order to contain infectious diseases spread by humans. An added feature is that of tracking cross-border movement of persons. The success of this project could be replicated in other countries for other use such as road planning, public transportation investment, hospital establishment, etc.

Data anonymization at the source ensures a balance between public benefit and safety/privacy.

A1.7 Disaster communications management in Madagascar (Madagascar)

Madagascar falls victim to natural disasters including floods and cyclones every year, making it necessary for the country's authorities to introduce a rational system for natural disaster prevention, management and response.[18]

A National Bureau for Risk and Disaster Management (BNGRC) has been set up as part of the Ministry of the Interior and Decentralisation. It is responsible for:

- Coordinating programmes and activities relating to emergency response and relief;
- Preparation and prevention for disaster mitigation;
- Gathering post-hazard data, by telephone, SSB radio and written reports;
- Evaluating different aspects relating to food, sanitation, equipment available in places of shelter, and medical assistance.

Nevertheless, the means available to the Bureau for dispatching emergency communications are restricted, as it uses only simple technologies such as telephony offering a single function and low efficiency. It therefore seeks strong collaboration with the country's telecommunication operators in order to obtain the necessary communication facilities. In addition, in order to educate the public on the origins and key aspects of disasters, the Bureau is launching a campaign through the country's TV and radio stations.

The country's Sectoral Group on emergency telecommunications and new technology has a vital role as the body responsible for ensuring continuity of telecommunications by facilitating efforts to provide mobile communications capacity that can temporarily take over from any network (mobile, Internet, etc.) as a result of disaster damage or because a region has been cut off.

The group sees its role in terms of contributing at a number of stages in disaster response:

- Understanding risks;
- Improving resilience;
- Early warning systems;

[18] Document 2/406, "Organizing the use of ICTs to save lives", Republic of Madagascar.

– Mechanisms for repair and recovery.

Using the databases available to it and meteorological data, the Sectoral Group ensures that any given telecommunication/ICT system is operating and that the aforementioned four phases are better organized.

The sectoral group uses all the available services of the four telephone operators and two data operators to relay information to all sectors of the disaster risk management system:

– Telephony (with a free emergency number available to all operators);
– SMS (periodic messages regarding the current situation, and so on;
– Data transmission (images from satellites or agents on the ground, specific difficulties likely to affect rescue measures, and so on).

Local FM broadcasts are used to relay information directly to homes.

A1.8 Disaster management with MDRU – Feasibility study (Philippines)

Because of its location, typhoon-fed storms and high water are the biggest problems for the Philippines' government and residents. In November 2013, the Visayas region of the Philippines felt the full force of Super Typhoon Haiyan. Typhoon-fed storm surges grew to several meters high along the coast and caused widespread devastation that resembled tsunami damage. Additionally, the subsequent communication blackout impeded evacuation efforts resulting in 6,300 deaths, 28,689 injuries, and 1,061 missing persons.

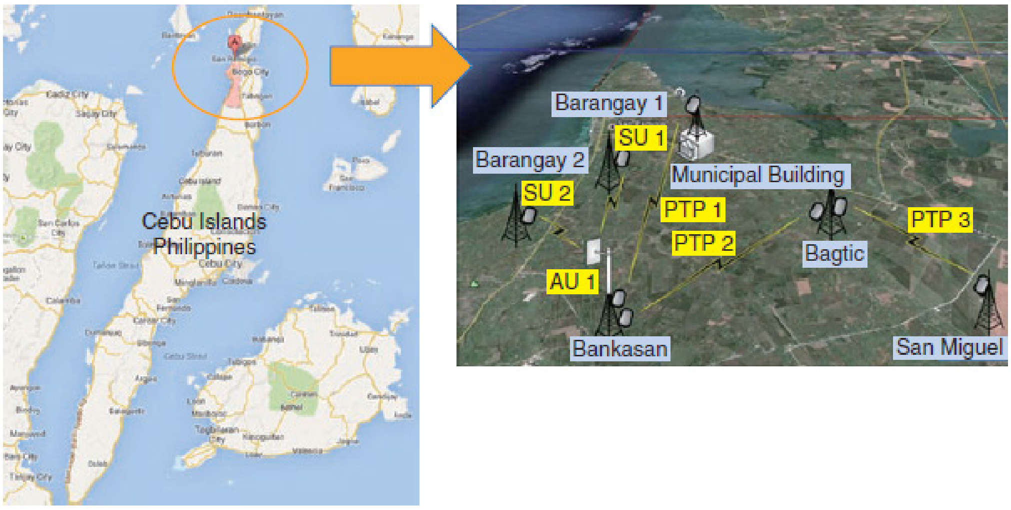
Japan and the ITU are collaborating to assist in telecommunication restoration on one of the islands that Haiyan hit hardest. On May 13, 2014, Japan's Ministry of Internal Affairs and Communications (MIC), the Philippines' Department of Science and Technology (DOST), and the ITU launched this project after finalizing a cooperation agreement for a feasibility study on MDRU use to restore connectivity.[19]

1) Summary of the project

In May 2014, the ITU began the *Feasibility Study of Restoring Connectivity through the Use of the Movable and Deployable ICT Resource Unit* in order to study the effectiveness and viability of the MDRU as a communication solution for damaged communications infrastructure and IT (Information Technology) facilities in areas like Cebu, Philippines where Haiyan had caused the most damage. The MDRU feasibility study took place in Cebu Island's San Remigio municipality which has about 64,000 residents and 27 barangays (i.e. districts). Because Haiyan had destroyed all of Cebu's communication networks (see **Figure 6A**), onsite disaster reports were compiled manually. Post-typhoon, the Mayor's satellite phone was the only means of communications with the government.

[19] Document SG2RGQ/138 (Rev.1), "Proposal for adding the results of MDRU experiences into document for ICT experiences in disaster relief", Japan.

Figure 6A: Location of San Remigio municipality in the Philippines and depiction of wireless network in San Remigio before the typhoon. (The network was destroyed by the typhoon.)



The scope of the feasibility study includes technical testing, sustainable operation and management, local staff training, and local communities' improved disaster management planning.

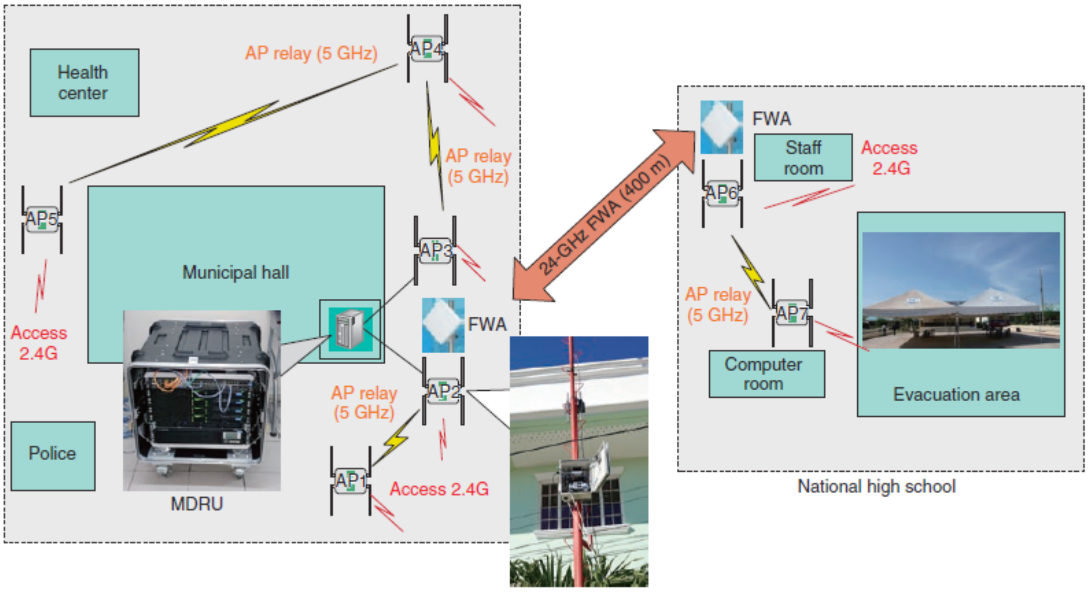
Table 1A: Summary of project

Project scope	Test the feasibility of installing the newly developed MDRU in disaster-affected areas. Adequately train local key personnel for sustainable MDRU network operation and management. Improve local communities' disaster management planning structure to facilitate increased disaster preparedness. Seek feedback from government organizations and local communities on MDRU-powered services. Monitor and evaluate the installed MDRU in order to provide government organizations with project feedback.
Project management	Because the ITU is the project lead, the ITU Project Manager collaborates with MIC and DOST to provide overall management and project administration. A steering committee was also established immediately after the signing of the cooperation agreement.
Monitoring	The ITU will use key performance indicators and project expectations to monitor and evaluate the project.
Term	May 2014 – March 2016

2) System configuration

Figure 7A shows the MDRU server unit and wireless system that are being used in the project. The unit and system were installed in December 2014 in San Remigio Municipal Hall and an evacuation centre, respectively. The two locations were connected by a communication link vis-a-vis point-to-point wireless equipment. The MDRU team also used Access Point (AP) to access point connections to establish a 1) wide area Wi-Fi network and a 2) 24-GHz FWA (Fixed Wireless Access) connection between the evacuation centre and municipal hall. Despite differences between Japan and the Philippines, the feasibility study showed that the MDRU operated effectively in the latter.

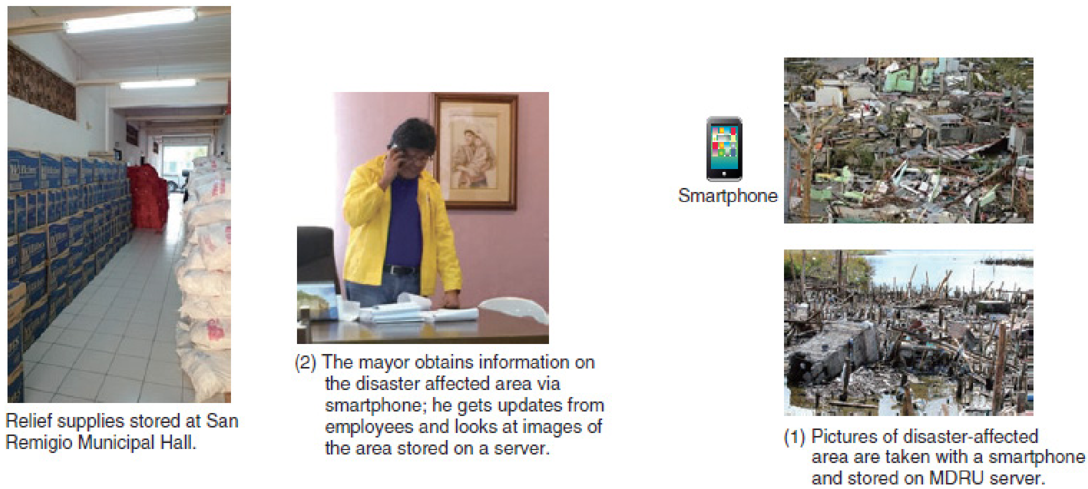
Figure 7A: MDRU and wireless equipment installed at San Remigio Municipal Hall and at a high school



3) Results of the feasibility study

Figure 8A shows an example of a use case during a disaster. Here, the mayor first placed phone calls to municipal employees to get information about the disaster. Next, municipal employees used smartphones to photograph the disaster area and then saved these to the MDRU's server. This enabled the mayor to look at the stored pictures to gain a visual understanding of the disaster. Ultimately, the mayor instructed municipal hall employees to provide relief goods to the affected area before he reported the situation to the central government.

Figure 8A: Use case of MDRU: Investigating the extent of damage from the typhoon



The plan is to conduct a feasibility study of each use case in order to 1) meet municipal employees' and local residents' need and 2) continue to improve MDRU operation rules, connectivity, and specifications.

4) Training on installing and running MDRU applications

Although there is a plan to confirm MDRU feasibility and review the units' rules of operation with residents, a training session (see **Figure 9A**) was held for San Remigio residents on installing and running MDRU applications on smartphones. More than 90 per cent of the 30 attendees said that the

MDRU phone was "easy" or "very easy" to use just as the MDRU feasibility study has demonstrated. At an the earlier briefing session in San Remigio, project participants discussed the technologies used in the MDRU project as well as the feasibility study's importance of the MDRU feasibility study with the engineers. Additionally, to facilitate operation of MDRU applications, the unit will need to be equipped with a power although some MDRUs have already been equipped with Uninterruptible Power Supplies (UPS).

Figure 9A: Training session for residents of San Remigio

A1.9 Mobile telephony providers' contingency plan for disaster preparedness, mitigation and response (Argentina)

After a series of floods affected more than 500,000 people in La Plata, the capital of the Province of Buenos Aires, Argentina, Argentina's Communications Secretariat (Telecommunication/ICT enforcement/regulation agency) approved Resolution 1/2013 in April 2013 to facilitate the city's use of mobile communications for disaster preparedness.[20]

1) Content of the standard on ICTs for emergency and disaster situations

Among its main provisions, this standard addresses operations of mobile communications providers following a disaster including requirements for back-up energy supplies, priority for emergency services, and mobile contingency units to enable continued service at sites that cannot be restored.

Providers had 45-days from publication of the rules and regulations to submit contingency plans to Argentina's communication control entity, *Autoridad Federal de Tecnologías de la Información y las Comunicaciones* (the Federal Authority for Information and Communication Technologies and formerly *Comisión Nacional de Comunicaciones).*

2) Implementation of the infrastructure required by the standard

[20] Document SG2RGQ/84, "Argentina and the implementation of the mobile telephony providers' contingency plan for disaster preparedness, mitigation and response", Argentine Republic.

In Resolution 34 of WTDC 2014, the ITU invites "Sector Members to make the necessary efforts to enable the operation of telecommunication services in emergency or disaster situations, giving priority, in all cases, to telecommunications concerning safety of life in the affected areas, and providing for such purpose contingency plans". To this end, Argentina completed internal work at its supervisory telecom organization *Autoridad Federal de Tecnologías de la Información y la Comunicación* (AFTIC) and held a national forum on these topics.

Argentina has now begun to implement a series of measures for due compliance with the rules and regulations. For example, AFTIC now requires the distribution of sample technical reports and acts among all inspectors as well as an explanation of the different procedures. Additionally, every inspection must check that the radio base station's battery bank is in perfect condition so that it provides a permanent direct current supply for the stations' operation. Since approving the Contingency Plan and issuing criteria definitions, Argentina completed 419 nationwide inspections in 2014 alone.

3) Response in recent emergency and disaster situations

At the beginning of August 2015, floods caused serious damage to cities in the province of Buenos Aires including Luján, San Antonio de Areco, and Salto. The floods required the evacuation of approximately 10,000 people. Immediately after the disaster, AFTIC control teams visited the affected areas to check the status of mobile telephone networks, but found no evidence of massive service interruption.

A1.10 Use case of emergency warning system over broadcasting (Kazakhstan)

The use of telecommunications/ICTs for natural disaster preparedness, mitigation and relief

Kazteleradio is using broadcasting resources (e.g., analogue and digital TV, FM broadcasting systems) in its development of a nationwide emergency warning system for Kazakhstan.[21] Kazteleradio will receive alerts from the authorities responsible for directing residents during emergencies and then use satellites to broadcast this information locally via regional and national radio/TV stations that have active transmission systems. The appropriate departments and offices within the Ministry of Emergency Situations will determine each alert's level.

The entire alert system will operate over national territory with due regard to the geographical disposition of radio/TV stations for which the transmissions are intended. However, radio and TV stations in regions that the emergency has not affected will continue normal broadcasting. The system should be ready for full-scale testing by the end of 2016.

It should also be noted that Communications Law No. 567 of 5 July 2004 requires owners of communication networks and assets to give absolute priority to: 1) any announcements concerning the safety of human life at sea, on land, in the air and in space, 2) urgent measures in the sphere of defence, 3) national security and law enforcement, and 4) emergency alerts. By the same token, communication operators are required to provide the "112" traffic control service at no cost to assist in caller location and short text message circulation during any state-of-emergency declaration that is of a social, natural and/or technological nature.

A1.11 ICT applications for disaster prediction case studies in India (India)

a) Single number based Integrated Emergency Communication & Response System (IECRS)

In India, there are multiple helpline numbers for emergencies. For example, "100" is for police assistance, "101" for fire brigade service, "102" for ambulance, etc.[22] Because it is difficult to remember multiple numbers during emergencies, TRAI intends to facilitate the establishment of a "Single Number

[21] Document SG2RGQ/107, "Contribution from Kazakhstan", Republic of Kazakhstan.

[22] Document SG2RGQ/122, "The role of Information and Communication Technology (ICT) in disaster mitigation, prediction and response", Republic of India.

based Integrated Emergency Communication & Response System" (IECRS) in India. Accordingly, TRAI has identified '112' as the single emergency number through which all emergency calls will be routed. The system will prioritize calls made to the single emergency number. These calls from fixed or mobile phone/devices will be routed to a Public Safety Answering Point (PSAP) which will obtain subscriber-related details (e.g., location) so that help can be sent as to the location as quickly as possible. This system is still being implemented.

b) Cyclone warning in India

Over the years, the India Meteorological Department (IMD) has constructed a dependable Cyclone Warning System that uses advanced technologies like Automatic Weather Stations (AWS), Satellites, Radars, Numerical Weather Prediction (NWP) models, and telecommunication systems. In the event of an approaching Tropical Cyclone (TC), IMD informs and warns relevant government sectors, local residents, and media through various communication channels.[23]

Components of TC early warning systems include:

- Monitoring and prediction;
- Identification of a warning organization;
- Generation, presentation, and dissemination of the warning;
- Coordination with disaster management agencies;
- Public education and outreach;
- Post-disaster reflection.

All these components are standardized in IMD to improve the system's efficiency.

c) Community-based flood early-warning system

To improve the resilience of the 45 communities located in the Indian Himalayan region[24],[25] vulnerable to glacier lake flood surges, a team of experts from International Centre for Integrated Mountain Development (ICIMOD) and Aaranyak, a leading NGO for preservation and restoration of environment and related issues, have installed the Community-Based Flood Early-Warning System. This solution consists of two units – a transmitter and a receiver. The transmitter is installed along the riverbank and the receiver is installed at a house near the river. The transmitter's attached flood sensor detects rising water levels and communicates with the receiver when the water reaches a critical level (i.e. levels that local communities helped to identify). The flood warning is then disseminated via mobile phone to relevant agencies and vulnerable communities downstream.

A1.12 Early warning system in Uganda (Uganda)

Uganda Communications Commission (UCC) and ITU in collaboration with Office of the Prime Minister (OPM), the Ministry of Water and Environment (MWE) and District Local Government of Butaleja jointly implemented a pilot project on setting up two flood early warning systems along R. Manafwa in Butaleja district in the Eastern region of Uganda. This case study described the project, including the technical aspects, and provided lessons learned.[26]

Factors that led to the successful implementation of the project:

1) Availability of the funds to implement the project.

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23 http://www.rsmcnewdelhi.imd.gov.in/images/pdf/sop.pdf.
24 http://unfccc.int/secretariat/momentum_for_change/items/8688.php.
25 http://www.icimod.org/?q=10925.
26 Document SG2RGQ/28, "Installation of Flood Early Warning Systems in the Eastern Region of Uganda", Republic of Uganda.

2) Selection of the right entities to participate in the implementation of the project.

3) Putting in place a Memorandum of Understanding that articulated the roles of each of the entities involved in the project.

4) Implementation of community awareness activities to raise awareness among stakeholders and address community concerns.

5) In order to eliminate misunderstandings between Butaleja Local Government and the owners of the land at which the siren components were installed, land use agreements were put in place.

Challenges faced during the project:

– Despite the fact that the flood early warning systems were to be used for humanitarian purposes, the Uganda Revenue Authority levied taxes on them, an additional unplanned cost to project.

– Installations were carried out during the rainy season. This therefore brought about interruptions in the installation that therefore led to delays in carrying out civil works and reduction of time for other activities such as testing of the equipment and training of stakeholders.

– A few of the items were stolen by the residents that were living within the vicinity of the siren site. Fortunately, the items were recovered quickly by the leadership of the Community.

In the month of September 2014, the flood early warning installed at Namulo Primary School was activated to warn the community about possible flooding event of the downstream area of R.Manafwa. A number of people in the community were able to run to higher grounds for safety. The installation of the flood early warning systems has brought hope to the people of Butaleja because they are now able to save their lives and properties in time before the floods occur.

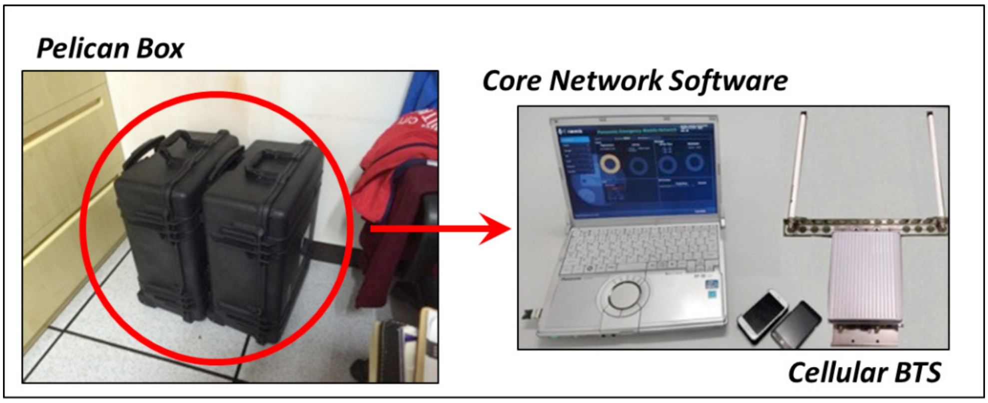
A1.13 Early warning system in Zambia (Zambia)

Co-financed by Zambia's Telecommunication Regulatory Authority (ZICTA) and ITU/BDT, two flood early warning sites were established in Zambia for dissemination of flood and mudslide alerts.[27]

A1.14 Local cellular services (Japan)

A single base station and core network function can provide local cellular services that are not being used for search and rescue efforts. This system provides excellent portability because it can be installed anywhere.[28]

Figure 10A: Local Cellular System (GSM)



[27] Document SG2RGQ/231, ITU/BDT.

[28] Document 2/323, "Introduction of a local cellular service for Emergency Response", Panasonic Corporation (Japan).

Figure 10A shows equipment for the GSM service's local cellular system which can always be stored in a pelican box. This box can be taken to disaster sites to provide local cellular services. LTE service can also be provided if the BTS mode is changed accordingly.

Figure 11A: Local Cellular System (LTE and GSM)

Figure 11A shows an example of a local cellular system for GSM and LTE services. This system provides GSM and LTE services via one PC-installed core network function.

Figure 12A: Multi mode BTS

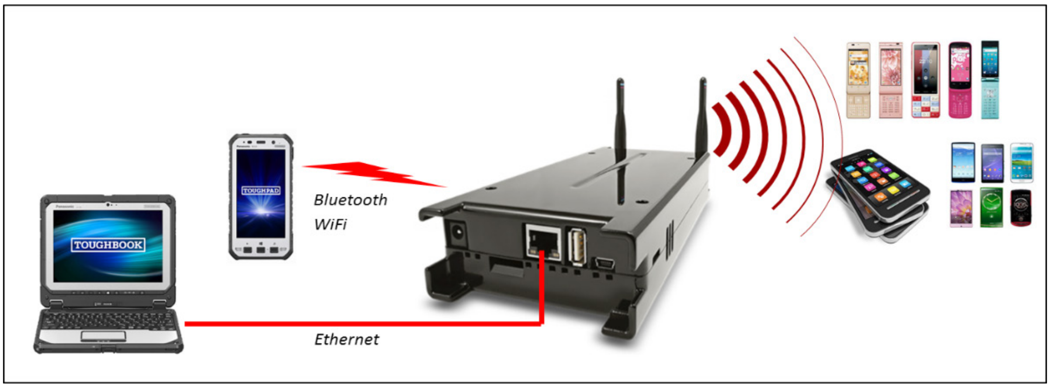


Figure 12A shows multi-mode BTS being used for IMSI capturing to support search and rescue efforts. The BTS can be small and lightweight for installation into emergency vehicles, ambulances, and drones. Additionally, it may have Bluetooth/WiFi/Ethernet interfaces that can be used for installation and monitoring purposes.

A1.15 Data center related infrastructure development for disaster prevention (Latin America and Caribbean)

1) Background

The Inter-American Development Bank (IDB) and NEC Corporation had jointly studied about data center and related infrastructures in the Latin America and Caribbean (LAC) region. Many LAC countries have high levels of natural disaster risk and disaster prevention is one of their big issues. By analysis in the study, it was recognized that for ramping up efforts to reduce vulnerability and disasters risk for "sustainable growth", IDB member countries should develop data centers and related infrastructures e.g., Internet Exchange Points and broadband.

2) Analysis method of data centers/related infrastructure

Today's global industry chains demand Productivity, Business Continuity, Environmental-friendliness and Agility. Business continuity includes disaster preparedness, mitigation and response to the countries. Critical Infrastructure Protection (CIP) is a concept that relates to the preparedness and response to serious incidents that involve the Critical Infrastructure and it is one of the highest priorities for governments. Data centers and broadband are a part of fundamental infrastructures for "sustainable development and growth" to protect Critical Infrastructure and information for society and industry.

IDB and NEC jointly designed the "Data Center Development Index" (DCDI), which is shown in Annex 2, and analyzed the current status of IDB LAC member countries from an infrastructure perspective. The aim of DCDI is not for ranking countries, but for maximizing development effectiveness, minimizing risks to "sustainable development and growth" in international regions, it is to understand and analyze indicators relevant to data centers. All indicators are taken from publically available, open data that is basically available for all 26 countries in the study. The data is absolute value except the Natural Disaster Risk Index of the UN University.

DCDI consists of main five pillars, which are used to compute DCDI value, and one auxiliary pillar. Five main pillars describe various aspects of a country development related to data centers including industry electricity prices, CO_2 emissions, network connectivity indicators, data centers and IXPs and natural disaster risk and prevention by networks of data centers.[29]

A1.16 Hazard map project in Kumamoto-city in Japan (Japan)

1) Introduction and background

From the lessons learned from flood damages in July 2012, the local government of Kumamoto-city promoted a project to develop a hazard map system for disaster risk reduction by utilizing ICTs, which aimed to educate citizens about disaster risk reduction.

2) Overview and system configuration of Kumamoto project

This hazard map system consisted of Geographic Information Systems (GIS), located on the data center, and hazard map systems, located on community sites, shown in **Figure 13A**. Citizens investigate their own town by foot and point out critical locations for the case of disaster. Based on their investigations, citizens entered critical locations and evacuation routes with some other information such as photos and historical information into hazard map system through an electronical white board system. This information is sent to the local government, and then the local government staff updates its official hazard maps. Public GIS updates hazard map information reference to government GIS to be accessed the latest hazard map by citizens from PC or smart phones via the Internet.

[29] Document 2/366, "Analysis Method of Data Center Related Infrastructure Development for Disaster Prevention and Growth of Economy in the Country and International Sub Region", NEC Corporation (Japan).

Figure 13A: System configuration of the hazard map system for disaster risk reduction

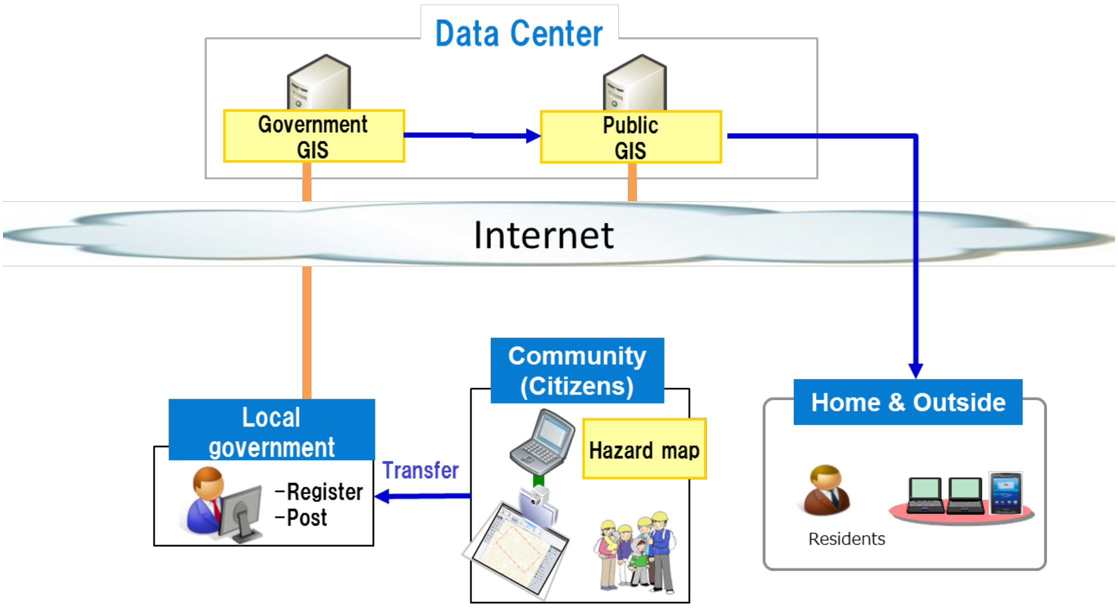


Figure 14A shows the hazard map creation process with citizens' participation, which consists of planning session, study session and town walk, preparing hazard map and completion map. In the planning session, local government explains citizens lived in the local town the goals of this project. At the study session and town walk process, citizens investigated several critical locations, evacuation routes and historical hazard information, which could only be known by citizens. There are around 900 local towns in Kumamoto-city, so the local government aims to expand this hazard map activities for all towns.

Figure 14A: Map creation process with citizens' participation

3) Expected benefits for developing countries

In order to reduce the number of victims in the event of a disaster, even in developing countries, it should be required to educate citizens for disaster risk reduction, to perceive critical locations and width of hazard in advance, and to examine or drill for evacuation periodically.

A1.17 Rapid ICT-relief system used at Kumamoto earthquakes (Japan)

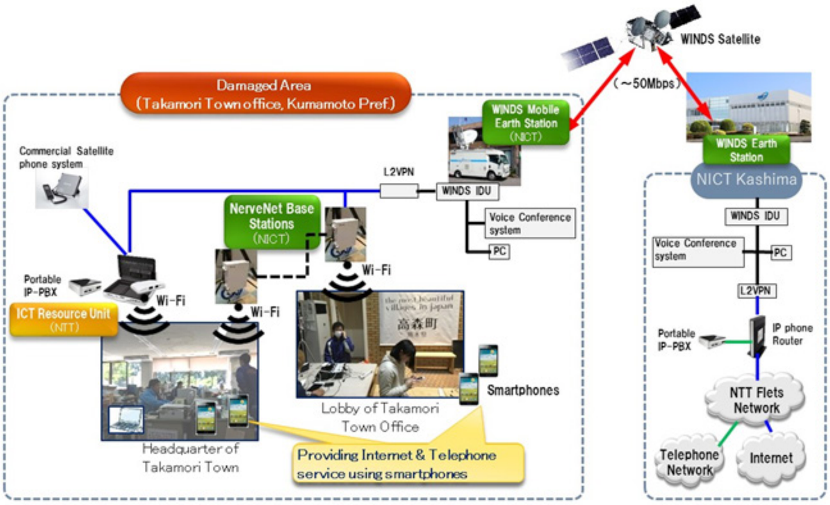
A series of intense earthquakes began on April 14, 2016 and continued subsequently at the areas centered near Kumamoto City in Kyushu Island, Japan. Serious damage including a death toll of 50 and complete destruction of over 8,000 houses was reported.[30]

The rapid ICT-relief system consisting of the wireless mesh network nodes and portable ICT resource unit (both technologies are described in 2.1 and 2.3, respectively) was transported with an on-vehicle satellite earth station for Kizuna (WINDS: Wideband Internetworking engineering test and Demonstration Satellite). When the rapid ICT-relief system arrived at Takamori Town on April 18, cellphone and Internet access were not completely restored. The ICT-relief system was set up at Takamori Town Office with the network configuration shown in **Figure 15A**. Through the satellite link of Kizuna, telephone and internet access services were provided at the Town Office. The companion earth station of the satellite link is Kashima Space Technology Center of NICT, far outside the affected area and connected to Internet and telephone lines there.

A portable ICT resource unit was also used outside the town office building with connection to the mobile satellite terminal. A merit of using a portable ICT resource unit with connection to a mobile satellite terminal was that user-owned smartphones could be used in the area covered by Wi-Fi (no need to use it near the mobile satellite terminal).

The ICT-relief activity at Takamori Town had been carried out for two days, during which period the ordinary ICT infrastructure was almost restored by ICT operators even in non-normal configuration (using means such as cellphone base stations using satellite backhaul). In ICT-relief activity, the quicker the deployment the more helpful and valuable it is to affected areas' staff and residents.

Figure 15A: Rapid ICT-relief system deployed in an area affected by the Kumamoto Earthquake



A1.18 Emergency telecommunications: National legal framework (Central African Republic)

The use of telecommunications/ICTs in disaster preparedness, mitigation and response is becoming an imperative. This was the thinking behind Central African Republic's Presidential Decree No. 16.380 of 5 November 2016 regarding the organization and functioning of the Department of Posts and Telecommunications, which established the Emergency Telecommunications Service in response to

[30] Document 2/454, "Practical application of a rapid ICT-relief system providing telephone and internet access",National Institute of Information and Communications Technology (Japan).

that need.[31] This department cooperates closely with the competent services and the authorities responsible for disaster management, prevention and mitigation, namely:

- The General Directorate for Civil Defence established under Decree No. 01.041 of 9 February 2001 within the Ministry of the Interior, Public Security and Territorial Administration. Its main remit is to devise and implement appropriate measures in the event of accidents, disasters and other such destructive events (PLAN ORSEC).
- The Ministry of Defence.
- The Ministry of Communication and Information.
- The Ministry of Social Affairs and National Reconciliation.
- The Police.
- The Gendarmerie.
- The Fire Service.
- The National Red Cross.
- International organizations.
- Non-governmental organizations.

For two decades the Central African Republic has experienced military and political crises. During the events of 2013, we saw the destruction of operators' telecommunication/ICT infrastructure. Such acts of vandalism disrupted the national communications system and drastically affected coordination of the urgent humanitarian assistance for the population badly affected in the country's interior.

Aware of the crucial role of telecommunication/ICT assets in facilitating operations on the ground, CAR in 2014 asked ITU for help with its emergency telecommunications. As a result, fixed and mobile satellite phones were provided to help the country surmount the difficulties of communication in affected areas. These tools were also used to cover the organization of the double elections (for the legislature and President) of 2016.

Given the many consequences of this problem, the Department of Posts and Telecommunications is planning the following major projects:

a) Ratification of the Tampere Convention;

b) A draft National Plan for Emergency Telecommunications;

c) A project to develop a Geographical Information System (GIS) of at-risk areas.

[31] Document 2/431, "Utilization of telecommunications/ICTs for disaster preparedness, mitigation and response: The case of the Central African Republic", Central African Republic.

Annex 2: Data Center Development Index, Geographic Redundancy Index and specific information

A2.1 Definition of Data Center Development Index

The Inter-American Development Bank and NEC jointly designed the "Data Center Development Index" (DCDI) and analyzed the current status of IDB LAC member countries from an infrastructure perspective. The aim of DCDI is not for ranking countries, but for maximizing development effectiveness, minimizing risks to "sustainable development and growth" in international regions, it is to understand and analyze indicators relevant to data centers. All indicators are taken from publically available, open data that is basically available for all 26 countries in the study. The data is absolute value except the Natural Disaster Risk Index of the UN University.

Many factors should be taken into account when constructing a data center. These factors are crucial for maximizing the Return On Investment (ROI) and meeting customer's requirements for computation power and quality services. According to an IDB partner, the three main factors to optimize construction and sustaining costs of a data center while meeting internal customers' computing and services requirements are:

1) Environment conditions: the region's climate and history of natural disasters;

2) Wide Area Network (WAN): the availability and cost of fiber and communication infrastructure;

3) Power: availability and cost of electric power infrastructure.

The "Power" and "WAN" factors directly correspond to "Energy infrastructure" and "ICT infrastructure", respectively. The "Power" / "Energy Infrastructure" factor is addressed in this study by analyzing the electricity prices in each country. The "WAN" / "ICT infrastructure" factor is considered through analysis of upload speed, network latency, fixed and mobile broadband penetration rates, and international Internet bandwidth. The "environment condition" factor in this study is considered from the point of view of natural disaster risk and geographic redundancy. Therefore, when talking about "Environment condition", it was considered how likely it is that a natural disaster will occur in a certain country, and how much redundancy there is within the national data center infrastructure to withstand the disaster strike.

The Data Center Development Index consists of main five pillars, which are used to computed DCDI value, and one auxiliary pillar. Five main pillars describe various aspects of a country development related to data centers. The auxiliary pillar contains indicators to transform original indicators into "per capita" and "per unit of area" formats. (All pillars and corresponding indicators are presented in Table of DCDI Pillars and Indicators). During the data cleansing phase, correlation between listed indicators was checked.

The value of indicators are computed with the following rule; the value of "1" means good and "0" means poor among the countries. To understand the level of data center development, all 26 countries have been segregated into four groups. These are low (values 0.00-0.25), moderate (0.26-0.36), high (0.37-0.42) and very high (>0.42) development level. These intervals are selected in accordance with variability of pillar values.

Computation of DCDI, Geographic Redundancy Index (GRI) and specific information can be found in the following sections.

It is necessary to build a network of data centers to have data duplicated at different locations. Network of data centers provides the Geographic Redundancy and reduces the risk of data loss. To evaluate and compare levels of geographic redundancy, the Geographic Redundancy Index is employed. The idea behind the GRI is to provide multiple locations of data centers and evenly distributed the data centers across those locations. The GRI value ranges from 0 (low or no redundancy) to 1 (high redundancy). To compute GRI, the number of data centers and number of areas where data centers are deployed, are used. GRI is computed as ratio between actual and maximum entropy. Adjusted GRI is adjusted for country area and population size.

One way to measure how likely natural disasters, such as earthquakes, tsunamis, typhoons, etc., are in a region is to use the Natural Disaster Risk Index (NDRI) which is published annually by the United Nations University for Environment and Human Security.

Industry Electricity prices are one of the most impact factors for the Opex of data centers. Thus Industry Electricity price is on Pillar 2. A data center exhausts large volume of CO_2 but it reduces total volume of CO_2 emission if individual offices move ICT in the office to a data center. CO_2 emission is on Pillar1.

Network connectivity indicators are on Pillar3. Pillar4 is related to data centers and IXPs and Pillar 5 is related to natural disaster risk and prevention by network of data centers.

Table 2A: DCDI Pillars and Indicators

Table: DCDI Pillars and Indicators	
Indicator	**Source**
Pillar 1: Economic Development	
GDP per capita	World Bank,2014
Foreign Direct Investment (US$ in mil.)	UNCTAD, 2014
CO_2 emission (t per capita)	World Bank,2011
Pillar 2: Fundamental Infrastructure	
Industry Electricity prices	IDB and other sources, 2011
Telco Opex/revenue	GSMA Intelligence, 2Q 2015
3G network coverage, population	GSMA Intelligence, 2Q 2015
4G network coverage, population	
Pillar 3: Connectivity	
Median fixed upload speed	2014, Cisco Global Cloud Index2015
Median fixed latency	
Median mobile upload speed	
Median mobile latency	
Fixed broadband penetration	2014, ITU Measuring the Information Society Report2015
Mobile broadband penetration	
International Internet bandwidth	
Pillar 4: Data Center Infrastructure	
Number of Secure Servers per mil.	World Bank, 2015
Number of Data Centers	DataCentermap.com accessed on May/2016

Table: DCDI Pillars and Indicators	
Indicator	**Source**
Number of Internet eXchange Points (IXPs)	Packet Clearing House accessed on May/2016
Pillar 5: Critical Infrastructure Protection	
Number of Data Center Locations	DataCentermap.com accessed on May/2016
Adjusted **Geographic Redundancy Index**	Using DataCentermap.com accessed on May/2016, Designed by NEC
Natural Disaster Risk Index	2013,United Nations University for Environment and Human Security2014
Auxiliary Pillar	
Land area	World Bank,2015
Population size	World Bank,2014
Percentage of Individuals using the Internet	2014, ITU Measuring the Information Society Report2015
	designed by Inter-American Development Bank and NEC

A2.2 Computation of Data Center Development Index

To compute DCDI value it is necessary to make two following steps. Step 1 is to compute intermediate values for each pillar. Step 2 is to compute weighted average of pillar values; this value is for IDB's request.

Step 1) Values of all indicators within each pillar are normalized using normalization formulas. Mainly formula (1.1) is used:

$$X_{normalized} = \frac{x_{country} - x_{min}}{x_{max} - x_{min}} \quad (1.1)$$

Where xcountry is original value of an indicator for a given country, xmin and xmax are min and max values of the indicator across the selected countries, and xnormalized is normalized value of an indicator for a given country. This normalization implies that the high the value of original indicator the better. For example, the higher the network coverage or broadband penetration rates the better.

On the other hand, for indicators such as Electricity Prices, Natural Disaster Risk, CO2 emission per capita and Telco Opex per Revenue, the lower the value the better it is. Therefore for these four indicators, normalization is done in accordance with formula (1.2).

$$X_{normalized} = 1 - \frac{x_{country} - x_{min}}{x_{max} - x_{min}} \quad (1.2)$$

Normalization should be applied to each indicator in a pillar. Since values of GRI and NDR originally belong to interval [0, 1], values of these indicators are not normalized. After all indicators are normalized, pillar value for each county is computed as average of normalized values. For example, according to Table of DCDI, Pillar 1 contains three indicators: GDP per capita (GDP), FDI and CO_2 emission per capita (CO_2).Pillar value for a given country is computed as:

$$Pillar1\_Value(country) = [GDP_{normalized}(country) + FDI_{normalized}(country) + CO2_{normalized}(country)]/3$$

Step 2) After all pillar values are computed for each country, final DCDI value for a given country is computed as weighted average of pillar values (formula (1.3)):

$$DCDI(country) = 0.1*Pillar1\_Value(country) + 0.1*Pillar2\_Value(country) + 0.2*Pillar3\_Value(country) + 0.3*Pillar4\_Value(country) + 0.3*Pillar5\_Value(country) \quad (1.3)$$

A2.3 Computation of Specific Indicators for number of data centers, IXPs and Geographic Redundancy Index

Original values of Number of Data Centers (DCnum) and Number of IXPs (IXPnum) are referenced to the land area (area), population and Percentage of Individuals using the Internet (Internet).Geographic Redundancy Index (GRI) is referenced only to the land area (area) and population. Before normalization, original values of these indicators are transformed as follows.

$$DCnum_{referenced} = DCnum*Internet_{normalized} / (area_{normalized}*population_{normalized})$$

$$IXPnum_{referenced} = IXPnum*Internet_{normalized} / (area_{normalized}*population_{normalized})$$

$$GRI_{Adjusted} = DCnum_{referenced} * GRI$$

A2.4 Computation of Geographic Redundancy Index

Geographic Redundancy Index (GRI) is designed to illustrate how actual distribution of data centers at various locations across the country is different from the uniform distribution of data centers among given locations. Number of locations is described by indicator Number of Areas. GRI is computed is a ratio between entropy of actual distribution (Entactual) of data centers across the existing location vs. entropy (Entmax) uniform distribution given number of locations (formula (2.1)). Entropy of actual distribution is computed in accordance of formula (2.2) .Portion of data centers at a given location p_i is computed using formula (2.3). Entropy of actual distribution is computed in accordance of formula (2.4).

$$GRI = \frac{Ent_{actual}}{Ent_{max}} \quad (2.1)$$

$$Ent_{actual} = -\sum_{i=1}^{Locations\_num} p_i \log_2(p_i) \quad (2.2)$$

$$p_i = \frac{DCnum\ at\ location\ i}{DCnum} \quad (2.3)$$

$$Ent_{max} = \log_2(Locations\ num) \quad (2.4)$$

A2.5 Computation of Adjusted Geographic Redundancy Index

Geographic Redundancy Index (GRI) allow to understand how different actual distribution of data centers from the uniform distribution within a single country. Across the countries number of locations, total number of data centers and number of data centers at each location. GRI itself may be not suitable measurement to compare situation in different countries. Therefore, Adjusted GRI has been designed. Adjusted GRI is computed as multiplication of GRI value for a given country and referenced value of DCnum (formula (2.5)):

$$GRI_{Adjusted} = DCnum_{referenced} * GRI \qquad (2.5)$$

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