Satellite Navigation and Communication[1, 2, 3, 7, 9, 11]

A way to improve the chances that an emergency link will remain operational during a disaster is to connect it via satellite. Satellites are the only wireless communications infrastructure that are not susceptible to damage from disasters, because the main equipment sending and receiving signals (the satellite spacecraft) is located outside the earth's atmosphere. Two kinds of satellite communications networks support disaster management and emergency response activities: geo-stationary satellite systems (GEO) and low-earth orbit satellites (LEO).

Geo-stationary satellite systems: GEO satellites are located 36,000 km above the earth in a fixed position, and provide service to a country or a region extending up to one-third of the globe. They are capable of providing a full range of communications services, including voice, video, and broadband data. These satellites operate with ground equipment, ranging from very large, fixed gateway antennas down to mobile terminals the size of a cellular phone. Currently, almost 300 commercial GEO satellites are in orbit, being operated by global, regional, and national satellite carriers.

Low-Earth Orbit satellites: LEO satellites operate in orbits between 780 km and 1500 km (depending on the system), and provide voice and low speed data communications. These satellites can operate with hand-held units about the size of a large cellular phone. As with hand-held terminals that rely upon GEO satellites, the highly portable nature of LEO-based units makes them another valuable satellite solution for first responders in the field.

Even before disaster strikes, these networks are used in many countries to provide seismic and flood-sensing data to government agencies, enabling early warning of an impending crisis. Also, they broadcast disaster-warning notices and facilitate general communication and information flow between government agencies, relief organizations, and the public.

Satellite technology can provide narrowband and broadband Internet Protocol (IP) communications (internet, data, video, and voice over IP) with speeds starting at 64 Kbps from hand-held terminals up to 4 Mbps bi-directional from portable VSAT antennas. Fixed installation can bring the bandwidth up to 40 Mbps. The operation of these satellite systems and services follows the general topology depicted in Figure 1.2.[11]

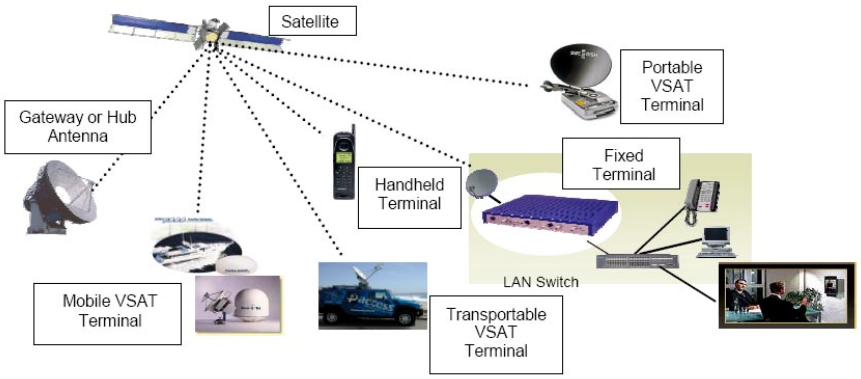

Figure 1.2 General topology of satellite systems and services

Solutions using this topology can be applied in both advance disaster mitigation services and in supporting relief and recovery efforts under three general categories: [11]

1. hand-held mobile satellite communications;
2. portable and transportable mobile satellite communications; and
3. fixed satellite communications.

Hand-held Mobile Satellite Communications

Once a disaster has occurred, local infrastructure – including microwave, cellular, and other communication facilities – is often inoperative, either because transmission towers are destroyed, or because of electrical failure. In the immediate aftermath of such a disaster, the only reliable form of communications is the hand-held satellite telephone systems provided by mobile satellite service providers. These systems provide access through very small, cell-phone-sized devices, as well as pagers and in-vehicle units.

Portable and Transportable Mobile Satellite Communications

Mobile satellite systems, or terminals used for "communications on the move", include equipment that can be transported and operated from inside a car, truck, or maritime vessel, as well as in helicopters and other aircraft, including commercial airplanes. This kind of terminal is an asset where data-intensive, high-speed connections are needed on an expedited basis for damage assessment, medical evaluation, or other applications for voice, video, and data. Depending on the satellite system and type of equipment, they can be operational anywhere from 5-30 minutes, usually without expert technical staff, and can be deployed anywhere. As with communication systems in general, higher satellite terminal prices – whether portable, mobile, or fixed – equate to more robust services, higher reliability, faster delivery, and a wide range of other features and options.

Fixed Satellite Communications

Fixed satellite communication terminals would typically be installed by a qualified technical team in cases where the equipment is required for longer than a week, in both pre-disaster applications – e.g. environmental monitoring, communications redundancy, etc – and post-disaster recovery operations. Such systems can be configured to all specifications – from low-speed data transmissions up to very broad bandwidth data and full broadcast-quality video –, replacing local and national telecommunications infrastructure. To support the installation and deployment of such systems, satellite companies have developed an industry-standard VSAT Installation & Maintenance Training Certification Program.

Common Satellite Communication Systems[12]

Mobile satellite systems: Currently, the most widely used mobile satellite system is the Inmarsat system. The Inmarsat system is composed of geo-stationary satellites, which connect mobile terminals via Land Earth Stations (LES) to the Public Switched Telephone Network (PSTN) and other networks. A communication link includes at least one LES which is the actual service provider.

Standard M and mini-M terminal for Inmarsat applications: Mini-M terminals are about the size and weight of a laptop computer, and standard M terminals the size of a briefcase. They enable connections with any PSTN subscriber worldwide, including other mobile satellite terminals. They cannot be used when a vehicle is in motion unless equipped with special antennas that compensate for the vehicle's movement.

Global Mobile Personal Communications by Satellite (GMPCS): The advantage of GMPCS over other mobile satellite systems is that the terminals are very small and lightweight, about the size and weight of a cell phone. Also, the terminals being of dual mode type are able to connect to either satellite or terrestrial service. Normally, users program the terminal to connect to a cellular system when such service is available, but automatically connect to the satellite system when cellular coverage does not exist. During a disaster, the terminal gets directly connected to the satellite. Regional mobile satellite systems have the capacity to restore telecommunication services in disaster-hit areas.

Very Small Aperture Terminal (VSAT) networks; VSAT networks are designed mostly for fixed installation, but "Flyway" systems are available for disaster recovery purposes and disaster communications. For serious reliable long-range communication, VSAT is considered a superior system. The terminal equipment needs to be protected from physical damage. The dish, in particular, should be installed in a strategic position, where it is shielded from exposure to flying debris during storms, while its connectivity with the satellite remains unimpaired. After a storm or an earthquake, the antenna's position may need to be adjusted, for which special equipment in addition to the actual VSAT terminal is required. VSAT systems connect the Private Branch Exchange (PBX) directly to another location via a satellite link. This means immunity from failure of the ground services as long as the earth station remains operational and has independent power.

The possibility of the use of a VSAT-based Private Automatic Branch Exchange (PABX) in disaster management is also useful as it provides wide connectivity. Land/satellite mobile communication with voice, data, and video facility are best suited for rescue operations. Further restoration work is possible with advanced storage of the required rebuild equipment.

Amateur Radio[12, 13, 14, 15, 19]

Amateur radio has earned its reputation as an instrument best used to communicate during disasters in areas where other means of communication have failed. Amateur radio operators provide vital assistance to their communities and countries during disasters by providing reliable communication on voice mode about the status of survivors as well as information on casualties to disaster relief organizations and friends and relatives.

The amateur radio operator's licence is also called a 'Ham' licence, and the licence holders are referred to as ham operators. 'Ham' is the abbreviation of **H**ertz **A**rmstrong and **M**arconi, though it is also known as Home Amateur Mechanic. Ham operators use many modes of operation to communicate: Continuous Wave; Frequency Modulation (FM); Amplitude Modulation (AM); Single Side Band; Digital mode which includes radio telephony; Radio TeleType (RTTY), Continuous Wave – CW for Morse Code; Tele-printing Over Radio (TOR); PSK31 – a type of modulation, and packet radio transmission; Fast and Slow Scan Television; and Internet Radio Linking. In an emergency operation, these modes can be used to transmit different information depending upon the urgency of the communication.

Amateur radio is a scientific hobby which can be cultivated by individuals of all age groups and professions. In an emergency such as a natural disaster, two main activities by amateur radio operators can prevent loss of life. The first is to forewarn people about a possible emergency, enabling them to take appropriate preventive measures for saving lives. And the other is to pass messages, images, and other information to aid agencies to help the survivors and injured as soon as possible in an emergency situation. Satellite images or video pictures of the affected area can be transmitted without delay as soon as amateur radio operators reach the disaster site or by those who are already present. This information and knowledge can facilitate speedy decision-making when it comes to providing basic aid to disaster victims.

Community Radio[16, 17, 19]

Community radio stations are usually set up "by the community, for the community". They differ from national and international radio broadcasters in that they feature local news and issues and often include local people in the programmes which are broadcast in the local language. Most community radio stations broadcast on the FM (VHF) waveband, and their coverage varies, depending upon the equipment in use. Some small stations cover areas of a few square kilometres whereas others broadcast across hundreds of kilometres to a large population. The regulations concerning the licensing of radio broadcasters vary from country to country, and should be understood before undertaking radio initiatives.

Community radio has proved to be a key agent in the prevention of natural disasters and in relief operations by allowing access to information and voice at the local level.

*How to Use Community Radio**:*** Setting up and running a community radio station is a significant undertaking which requires careful planning:

- Secure a licence before broadcasting starts.
- Assess the funds required for equipment, premises, and all running costs.

- Ensure that the necessary technical and broadcasting know-how will be available.
- Decide on the number of broadcasting hours per day and ensure that interesting programme content is collected to fill time 'on air'. Consider making your own local programmes or sourcing material from other stations. Build up a library of recordings and music, and share this information with others.
- Consider live programming, including interviews, group discussions, and phone-ins.
- Encourage feedback and involvement from the listening audience.

Advantages of Community Radio

- Community radio is often greatly appreciated by its audience because of the localized nature of the programming.
- The community feels involved and can contribute directly to the programme content through letters, phone-ins, or by visiting the station.
- Listeners do not require literacy.
- A large audience can be reached.
- For isolated communities without electricity and telephone, it may be the only communication medium.

Constraints of Community Radio

- Some countries restrict the issuing of licences or have time-consuming, complicated application processes.

- The necessary technical and broadcasting skills may not be available.
- The radio station owners/managers are in control of a powerful communications medium, and must use it responsibly.

WLL[12]

The Wireless Local Loop (WLL) equipment with V5.2 interface, which is connected to the Base Station (BS), is an exchange of approximately 1000 lines. It could be transported in an air-conditioned van which should have built-in power supply, battery, generator, and the WLL antenna installed on the rooftop. The subscribers are given hand-held terminals, and Mobile PCOs could also be set up. The exchange's junction E1 lines are connected to a nearby working exchange either by a radio system (within 30 km) or by optical fibre cable. If difficulties arise in the installation of a rooftop antenna on a microwave tower, a collapsible/ready-to-assemble on-site microwave tower could be taken to the disaster area to solve this problem.

GSM/Cellular Mobile Telephone System[12]

The Global System for Mobile Communications (GSM)/Cellular Mobile Telephone system can be installed on the van with emergency equipment which could be taken as near as possible to the disaster site. If a cellular mobile telephone network is working near the disaster-hit area, the air-conditioned van containing Base Transceiver Station (BTS) equipment, three panel antennas, and a 15 GHz radio system/Optical Line Transmission Multiplexer (OLTE) for an E1 line connection to BSC could be taken to the disaster area. The subscribers are given hand-held terminals. Mobile PCOs could also be set up.

The BTS is connected to a nearby working Base Station Controller (BSC) either by radio system (within 30 km) or pre-terminated optical fibre cable. The air-conditioned van should be equipped for built-in power supply, battery, generator, etc. If installing a rooftop antenna or microwave tower is difficult, a collapsible/ready-to-assemble on-site microwave tower could be taken to the disaster site.

For the provision of 2 Mbps connectivity to WLL-based equipment or a Cellular Mobile Telephone, satellite Intermediate Data Rate (IDR) equipment with a 2.4 m antenna in Ku band, or a 3.8 m antenna in C band, can be used instead of a Microwave Radio or optical fibre. This mobile station should have the capability to uplink audio, data, and video broadcasting information.

Internet[12]

In the present era of electronic communication, the internet provides a useful platform for disaster mitigation communication. The internet becomes a valuable asset, provided the rate of illiteracy in the disaster area is insignificant, the residents understand the language in use and are familiar with the computers and the software, and have physical access to both the net and computers, with both clients and servers up and not overloaded. Well-defined websites have been a cost-effective means of rapid, automatic, and global dissemination of disaster-related information. A number of individuals and groups, including several national meteorological services, are experimenting with the internet for real-time dissemination of weather observation, forecasts, satellite, and other data.

The internet provides support for major operations and functions of organizations, irrespective of distances between headquarters and field offices. For disaster relief managers and workers, access to the internet permits continuous updates of disaster information, accounts of human and material resources available for response, and state-of-the-art technical advice.

TV and Radio Broadcasting [9, 17, 18, 19]

Television and radio broadcasting are among the most important traditional electronic media used for disaster warning. The effectiveness of these two media is high because, even in developing countries and rural environments where the tele-density is relatively low, they can be used to quickly send out a warning to

a sizeable population. The only possible drawback of these two media is that their effectiveness is significantly reduced at night, when they are normally switched off.

Allocated Frequency Bands[18]
The frequency choice is critical for transmitting the alert. Theoretically, all bands from AM to FM, LM and Band IV and V up to L-Band for satellite can be used. Band IV and V is nowadays used mostly for TV; and the L-Band is used mainly by satellite radio systems such as XM, Sirius, and WorldSpace. The advantages of this technology are the miniscule antennas, the absence of terrestrial transmitters needing power, and a proven technology. Some countries use the L-Band also for terrestrial transmission, but the main problem today is the economics and the scale of a whole network.

Receiving Equipment[18]
For awareness and prevention of disasters, the standard radio and TV receivers are sufficient. The only critical element of these sets is the need for batteries which can be overcome by resorting to a combination of A.C. power and batteries. Radio and TV provide a major broadcast channel for populations at risk. The advent and proliferation of high-bandwidth cable modems, value-added services such as WebTV, and low-cost network computers suggest that this could be a primary information dissemination system of warnings and public information for the foreseeable future.

Satellite Radio [9, 17]
Satellite radio or subscription radio is a digital radio that receives signals broadcast by communications satellite, which covers a much wider geographical range than terrestrial radio signals. Satellite radio functions anywhere, given a line of vision between the antenna and the satellite, and no major obstructions such as towers or buildings. Satellite radio audiences can follow a single channel, regardless of location within a given range.

Satellite radio can play a key role during both disaster warning and disaster recovery phases. Its major advantage is the ability to work even outside of areas not covered by normal radio channels. Satellite radios can also be of help when the transmission towers of the normal radio station are damaged in a disaster.

The International Telecommunication Union (ITU) has identified various radio communication media for disaster-related situations (Table 1.2).[17]

Table 1.2 Radio communication media in disaster warning and management

Disaster phases	Major radio communication services	Major tasks of radio communication services
Prediction and Detection	• Meteorological services (meteorological aids and meteorological-satellite service) • Earth exploration-satellite service	Weather and climate prediction Detection and tracking of earthquakes, tsunamis, hurricanes, typhoons, forest fires, oil leaks, etc Providing warning information
Alerting	• Amateur services	Receiving and distributing alert messages
	• Broadcasting services: terrestrial and satellite (radio, television, etc)	Disseminating alert messages and advice to large sections of the public
	• Fixed services: terrestrial and satellite	Delivering alert messages and instructions to telecommunication centres for further dissemination to the public
	• Mobile services (land, satellite, maritime services, etc)	Distributing alert messages and advice to individuals
Relief	• Amateur services	Assisting in organizing relief operations in areas (especially when other services are not operational)
	• Broadcasting services: terrestrial and satellite (radio, television, etc)	Coordination of relief activities by disseminating information from relief planning teams to population
	• Earth exploration-satellite service	Assessment of damage and providing information for planning relief activities
	• Fixed services:	Exchange of information between

terrestrial and satellite	different teams/groups for planning and coordination of relief activities
• Mobile services (land, satellite, maritime services, etc)	Exchange of information between individuals and/or groups of people involved in relief activities

Telephone (fixed and mobile) [9]

Telephones play an important role in warning communities about an impending disaster. For example, simple phone warnings saved many lives in South Asian countries during the 2004 tsunami. In some countries, mechanisms called 'telephone trees' are used to warn communities of impending danger: an individual represents a 'node' in a telephone tree; when that individual receives a warning message (either by phone or other means), s/he is supposed to make a pre-determined number of phone calls (usually four or five) to others in a pre-prepared list. This arrangement not only ensures the timely delivery of the warning message, but also ensures a minimum duplication of efforts. However, the use of telephones for disaster warning has two drawbacks: telephone penetration in many areas is still unsatisfactory – particularly in rural and coastal areas most at risk; notwithstanding the exponential increase in the number of phones that has occurred in recent years, a telephone is still considered a luxury in many regions in the Asia-Pacific region. The other drawback is the congestion of phone lines that usually occurs immediately before and during a disaster, hindering the users from contacting the disaster management authorities during the emergency situation.

Short Message Service[9]

Short Message Service (SMS) is available on most digital mobile phones that permit the sending of short messages (also known as 'text messages', 'SMSes', 'texts', or 'txts') between mobile phones, other hand-held devices, and even landline telephones. SMS works on a different band and can be sent or received even when phone lines are congested. SMS also has another advantage over voice calls in that one message can be sent to a group simultaneously.

Cell Broadcasting[9]

Most of today's wireless systems support a feature called *cell broadcasting*. A public warning message in text can be sent to the screens of all mobile devices with such capability in any group of cells of any size, ranging from a single cell (about 8 km across) to the whole country, if necessary. CDMA, D-AMPS, GSM, and UMTS4 phones have this capability.

Some of the many advantages of using cell broadcasting for emergency purposes are:

- No additional cost is incurred when implementing cell broadcasting as this function is already built into most network infrastructure as also the phones. So there is no need to build any towers, nor lay any cables, nor write any software, nor replace handsets.
- It is not affected by traffic load; therefore it is of use during a disaster, when load spikes tend to crash networks. Also, cell broadcasting does not cause any significant load of its own, so it does not add to congestion.
- It is geo-scalable, allowing a message to reach innumerable people across continents within a minute. It is also geo-specific, enabling government disaster managers to avoid panic and road jamming by sending specific alerts to each neighbourhood on whether they should opt to evacuate or stay put.