

CHAPTER 4

STUDY OF EARLY WARNING SYSTEM AND

COMMUNICATION SYSTEM

4.1 Early Warning System(EWS)

4.1.1 NDMG (2008), states, Hydro-meteorological hazards occur all over the world. Some regions are more vulnerable to these hazards than others. This is more so in the case of Least Developed Countries (LDCs) or highly populated countries. Hazards become disasters when people's lives and livelihoods are destroyed. Human and material losses as a result of disasters are a major obstacle to sustainable development. By developing a system of issuing accurate forecasts and warnings in a form that is readily understood, lives and property can be protected. The World Met Organisation (WMO) coordinates the efforts of national meteorological services to mitigate human and property losses through improved early warning services, risk assessments and to raise public awareness on the risk and vulnerability for Tropical Cyclones. Early warning in being a short-term mitigation measure, it employs detection of the system, continuous monitoring, prediction, formulation of warnings, identification of threat areas and population and communication of warning with lead time and clarity so that action is taken by the concerned people to avoid negative consequences. The emphasis is on disaster risk reduction. It is said that a stitch in time saves nine, so anything spend on disaster preparedness can prevent many times worth of disaster-related economic losses which is a considerable return on investment.

4.1.2 Reliable operational techniques for forecasting the track, intensity and hazards associated with TCs such as storm surge, strong winds and heavy rainfall based on sound hydrodynamics through numerical models and storm

surge modeling is urgently required. Surge prediction requires accurate surface wind forecast for several hours prior to land fall.

4.2 **Present Status and Future Strategies**

4.2.1 Cyclones in the NIO Basin are monitored with the help of land-based, ocean-based and space-based observational systems which include conventional meteorological observations, reports from ships, observations from ocean data buoys, coastal radars (conventional and Doppler) and national and international satellites (geo-stationary and polar orbiting). Automatic instruments capable of measuring and processing to provide reliable information at the earliest along with effective communication which can withstand the cyclone is the need of the hour. The number of radars (Doppler Weather Radars) deployed need to be increased to remove gaps in the network thus covering the long coastline. Data should be received from the origin as early as possible to be of any use. Data reception facilities necessary from INSAT, MEGHATROPIQUES²² and METSAT will be operationalised so that cyclone EWS can become available.

²² **Megha-Tropiques** is a satellite mission to study the water cycle in the tropical atmosphere designed to understand tropical meteorological and climatic processes and describe the evolution of major tropical weather systems

S No	Observation type	Present Status	Prposed increase for IMD	Additional Augmentation
1	Automatic weather Stations(AWS)	125	1000	3000
2	Rain Gauges	2579	4000	Taluk level Rain Gauge Network
3	Doppler Weather Radars(S Band DWR)	5	12	
4	Radars (storm detection Radars X-Band)	21	26(C-Band Doppler Radar)	
5	Wind Profiler	1	45	84

Table 6: Augmentation of Land Based Observational Systems at IMD.

Source: NDMG (2008)

Land Based Observations

- Early operationalising of AWS and Rain Gauge network
- One surge recorder and high speed wind recorder to be operationalised
- Set up DWR along the coast at distances of 300 km.
- Enhancement of Radio Sonde (RS) / Radio Wind network.
- Integration of Wind Profilers

Box 2: Land Based Observations

Source: NDMG,2008

- Enhance shallow water and deep water buoy network over Indian seas.
- Enhance ocean observations involving ships of opportunity, Coast Guard vessels and Indian Naval Ships; off-shore oil platforms and Islands.
- Inclusion of subsurface ocean parameters from space and in situ observations.

Box 3. Ocean Based Observations

Source: NDMG,2008

- Ensure the operational service of at least two geostationary satellites over Indian seas at any given point of time (with water vapour channel and vertical sounder capability as planned in INSAT 3D), especially during cyclone months.
- Generation of high spatial resolution data sets of land-surface parameters on weekly/bi-weekly basis utilising IRS and other global satellites.
- Real time reception of global satellite products, especially from microwave sensors, over Indian seas for operational use through bilateral and multi-lateral arrangements.

Box 4: Space Based Observations

Source: NDMG,2008

4.2.2 Zschau and Kuppers (2003), states, the cyclone warning service of IMD is more than a century old. In the last few years, new developments in technology helped improve quality of information to assess the potential risk of a cyclone. Cyclone warnings are provided by IMD from Area Cyclone Warning Centers (ACWCs) at Calcutta, Chennai and Mumbai and Cyclone Warning Centers (CWCs) at Bhubhaneshwar, Vishakhapatnam and Ahmedabad. Necessary infrastructure for originating and disseminating cyclone warnings at appropriate levels. In addition a satellite based Cyclone Warning Dissemination Warning has also been operationalised. IMD runs a Limited Area Analysis and Forecast system (LAFS) to provide numerical guidance. Cyclone forecasting is done through conventional synoptic method.

4.3.3 **Cyclone Warning Services.** The extensive coastal belts are exposed to Tropical Cyclones (TCs) which are accompanied by heavy rain, gales and surges, known as tidal waves. They result in loss to human lives, property, crop and livestock. Cyclone warning is the first and most important service taken up by IMD. Dissemination is done by respective Cyclone Warning Center (CWC) and warning work is coordinated by forecasting division at Pune. A cyclone warning Division (CWD) has been set up at Delhi to coordinate cyclone warning work in India. A control room has been formed under Ministry of Home Affairs where real time information is given by the CWD. CWD advises Govt at apex level, and also serves as Regional Specialized Meteorological Center (RSMC).

(a) **Cyclone Warning Division** In addition to the above CWD has the following function at the international level as given below:-

- (i) To serve as RSMC – Tropical Cyclones New Delhi.
- (ii) To implement Regional Cyclone Operational Plan of WMO/ESCAP panel on Tropical Cyclones.
- (iii) To prepare yearly comprehensive scientific report on cyclones in North Indian Ocean.

- (iv) To issue daily Tropical Weather Outlook for NIO oceans to panel countries, Thailand, Myanmar, Bangladesh, Pakistan, Sri Lanka, Maldives and Oman.
- (v) To provide cyclone advisories four to five times a day to panel countries.

4.3.4 **Radar and Satellite Facilities.**

(a) High power Cyclone Detection Radars (CDRs) Installed along the coastal belt have proved to be useful tool for cyclone warning. Radars are used in IMD for detection of various weather systems like, thunderstorms, hailstorm and tracking of cyclonic storms. They are also used in rainfall estimation and hail warning. Various meteorological, hydrological and aviation products generated from Doppler weather radar²³ data using are extremely useful to the forecasters. Radars helps to estimate the storm's intensity, location and in forecasting its future path for safe navigation of aircrafts and ships. IMD has upgraded the conventional radars in the observational network with Doppler radars using digital technology. The first such radar procured from M/S Gematronik GmbH, Germany was installed at Chennai in 2002 followed by at Kolkata. By 2006 two more such radars were installed at Visakhapatnam and Machilipatnam respectively, IMD-weather on web

(b) Indigenous efforts were also made to design and develop advanced Radar technology for cost effectiveness and self reliance. Under an MOU with ISRO, DoS, one S-Band, Doppler weather radar was designed, developed and installed at Sriharikota in 2004. By the year 2006, IMD

²³ Radar used to locate precipitation, calculate its motion, and estimate its type (rain, snow, hail etc.). Modern weather radars are mostly pulse-Doppler radars, capable of detecting the motion of rain droplets in addition to the intensity of the precipitation. Both types of data can be analyzed to determine the structure of storms and their potential to cause severe weather.

installed five operational Doppler weather radars in its network.²⁴ In 2007, under Modernization of IMDs observational network 13 old and obsolete analogue radars were replaced with Doppler Weather Radars (DWRs). Radars were installed in Delhi (2010), Hyderabad (2010), Nagpur (2011), Agartala (2011), Patna (2011), Lucknow (2011), Patiala (2011), Mohanbari (2012), Bhopal (2013). Two C-band Polarimetric DWRs were also installed at Delhi and Jaipur. These Radars provide additional information of shape, size and classification of hydrometeors. Three M/s Metstar make DWRs are being installed at Karaikal, Goa and Paradeep. Two indigenously built S- band Doppler radars developed by M/S Bharat Electronics, Bangalore, are installed at Mumbai and Bhuj. These two are now under process of commissioning.

(c) In second phase of Modernization plan of IMD, 30 DWRs are proposed to be procured and installed at various locations throughout India. There is a separate plan to install 9 DWRs at hilly region under the scheme "Integrated Himalayan Metrology Programme" for western and Central Himalayas. One X-band DWR is under installation at Srinagar to cater the needs of Amarnath Yatra. The existing Doppler weather radars have also been networked to provide data for numerical weather prediction models for now casting. Composite Radar images are being generated centrally. Data is also converted to various formats such as NetCDF, HDF5, and Opera BUFR. Thus Radar network is playing significant role in the modernization of IMD's observational and forecasting systems.

(d) **Meteorology** India Meteorological Department (IMD) is the primary user of meteorological payload on INSAT satellites. The meteorological data from the satellites is processed and disseminated by INSAT Meteorological Data Processing System (IMDPS) operational at

²⁴ Radar network-IMD-weather on web/imd.gov.in/doc/Ins-radar.htm

IMD, New Delhi. At present, KALPANA-1 and INSAT-3A satellites are supporting the meteorological imaging and data collections. Zschau and Kuppers (2003), explains, apart from receiving low resolution satellite pictures at Bhubhaneshwar, Mumbai, Kolkotta, Guwahatti, Chennai, Pune and Vishakhapatnam; Advanced Very High Resolution Radiometer (AVHRR) facilities are available at Delhi and Chennai for monitoring high resolution cloud imageries from polar orbiting satellites. These cloud pictures are useful in tracking of cyclonic storms.

(e) **Conventional Network** In addition to surface observatories which provide synoptic observations every day, IMD operates pilot balloon observatories and Radio Sonde observatories for upper Air Data. National Instt of Oceanography, Goa and Dept of Ocean development operates few drifting buoys in North Indian Ocean for making Met and oceanographic observations under National Data Buoy Programme (NDBP). Four High Wind Speed Recorders (HWSRs) were installed and commissioned at Karaikal, Paradip, Vishakhapatnam and Machilipatnam for assessment of maximum gust and wind in cyclone.

(f) **Bulletins and Warnings** IMD furnishes the following bulletins and warnings through Cyclone warning Centers:-

- (i) Sea area bulletins for ships plying in ocean.
- (ii) INMARSAT bulletins.
- (ii) Port and Fisheries warnings.
- (iii) Two stage warnings for stae Govt officials.
- (iv) All India radio and Press Bulletins.
- (v) Warnings for Aviation.

Warnings are communicated by telecom, police wireless. Two stage warning involves one warning 48 hrs in advance and second 24 hrs in advance.

(h) **Cyclone Warning Dissemination System (CWDS)**

Cyclone warnings are disseminated through a variety of communication media, such as, radio, television, print media, telephones, fax, telex, telegrams, police wireless network. A specially designed Cyclone Warning Dissemination System which works via the INSAT satellite provides area-specific service even when there is a failure of conventional communication channels. Warnings are issued for general public, fishermen, farmers and different categories of users such as central and state government officials responsible for disaster mitigation and relief, industrial and other establishments located in the coastal areas, railways, aviation, communications and power authorities, Cyclone warning-IMD, 1985. First implemented in south Andhra Pradesh, and seeing the success the same was implemented in other cyclone prone coastal areas. So far 250 CWDS have been installed.

(i) **Numerical Weather Prediction** Numerical Weather Prediction (NWP) is used to predict the future state of the atmospheric circulation and weather based on knowledge of its initial state, using known physical and hydrodynamical laws of atmospheric motions. NWP was initiated in IMD as early as in 1973 with a simple model on an IBM 360/44 computer. A new computer, Cyber 2000U, supported by many peripheral equipments, was installed and commissioned at IMD in New Delhi in 1995. RSMC activities such as plotting of data on weather charts for synoptic analysis and production of prognostic charts, have been automated on the Cyber system with its comprehensive applications and graphics software package.

(j) **Limited Area Analysis and Forecast System (LAFS)** which comprises an advanced NWP model, has been implemented for short range forecasting. The analyses and prognostic charts produced by LAFS are disseminated to centres in panel countries as a part of RSMC's responsibilities. The forecast model is also used for generating tropical cyclone track predictions. The Cyber system also processes grid point data received from World Area Forecast Centres at Washington and Bracknell for production of documentation charts for aviation purposes.

(k) **Long Range Forecasts** IMD issues every year the Long Range Forecast for the southwest monsoon rainfall. The scientific basis for long range forecasting is that there are several signals prior to the monsoon which are indicative of its likely performance. The parameters having a bearing with the monsoon rainfall should not only be statistically well-correlated but also be physically relevant. Developing better techniques and improving the accuracy of the long range forecasts are two continuous research activities of IMD.

(l) In 1988, a new model termed as "Parametric and Power Regression Model" was developed and adopted by IMD for operational use. This model uses 16 regional and global land-ocean-atmosphere parameters which are physically related to the Indian monsoon rainfall. Each parameter is defined in terms of observations over a specific location and period, which in some cases extends up to the end of May. The long range forecast can as such be generated only by May end.

(m) **Aircraft Probing of Cyclones** Information from cyclone core can reduce error by almost 30%. To overcome the present constraint of non availability of this information India will soon acquire a Hercules WC-

130J aircraft and an unmanned aerial vehicle to ensure improved monitoring of cyclones. APC facility will be set up on high priority. IMD/NRSA will provide the technical control and operational control will be provided by the Indian Air Force (IAF). Day-to-day operational schedules and flight paths will be decided in consultation with user departments such as IMD, Central Water Commission (CWC), etc. Ministry of Earth Sciences (MoES) will initiate all necessary actions for establishing APC facilities. Considering its vast coastline, India will develop and utilize UAV capabilities for surveillance and prediction of TCs. This effort can be coordinated by the IAF and IMD/MoES.

Communication for Early Warning System

4.3.5 **Requirement of Communication system** Sakshi education, stated; in october 2013, Cyclone Phailin in Gopalpur, Odisha caused major devastation. Many district head quarters got totally cut-off from the State head quarter and neighboring districts due to submerged telephone exchanges or damaged cables and disrupted roads and railways communication. In the worst affected districts the need for relief and rescue operation could not be communicated to the State head quarters. Realizing this, State Government requested National Disaster Management Division of the Government of India to immediately send the emergency coordination kits containing satellite phones to establish communication links among the severely affected districts and state headquarters. that during any major disaster or emergency situation, the communication links are totally disrupted. Therefore, it is crucially important to have completely functional communication links among Government authorities at various levels to provide adequate assistance to the affected population. The communication facilities were found to be inadequate after Odisha Super Cyclone and was augmented with new equipment and facilities added in Odisha, a list of facilities added is attached as **Annexure 5**. This research tries to explain various basic telecommunication facilities, need for alternative communication systems during the large-scale natural disaster/emergency situations, and modes of emergency communication systems including satellite based communication systems.

4.3.6 **Present Status** The telecommunication links have become a vital part of our daily life. Most popular means of communication is the public wired telephone, which is known as Public Switched Telephone Network (PSTN) line. This is the prime network connecting all Government and Private offices, police

stations, fire stations, hospitals and majority of homes and business places by transmitting and receiving voice, fax and data. The usage of Wireless phones such as mobile (cellular) phones have also become widespread in recent times. Why does telecommunication network get disrupted or jammed in event of a major natural disaster or emergency situation? Unfortunately at the time of major natural disasters such as earthquake, cyclone, flood and landslide, the regular telecommunication infrastructure of public wired and wireless (mobile) telephones get severely damaged and become nonfunctional. This mainly happens because of the damaged cables and cellular transmission towers or disrupted power supply to operate the telephone exchanges and cellular transmission towers. The wireless radio communication network of Police and Civil authorities also gets affected due to damaged transmission towers. During this emergency situation, the communication traffic goes beyond its capacity which leads to congestion of the network or in worst case, complete failure of network. Generally, a perfectly working PSTN system is designed so that no more than 5% of the phones connected to it can be talking at the same time²⁵. During a crisis, there may be too much traffic for it to handle as 'Everyone wants to speak to everyone', and hence the network gets jammed.

4.3.7 At the time of any major disaster or emergency situation, it is extremely necessary to have the communication links operational among Government authorities at various levels and the people/volunteers working in the disaster affected areas to help the affected population. It becomes imperative to ensure that the critical needs of search and rescue operations, relief and response measures are communicated among the authorities of State Government, local administration, voluntary organizations and the affected population. This situation

²⁵ Alternative Communication Systems...during disasters [http://www. Sakshi education.com/ GroupII/Disaster_Management/ Alternative_Communication_Systems.pdf](http://www.Sakshi education.com/GroupII/Disaster_Management/Alternative_Communication_Systems.pdf)

calls for reliable alternate communication links, which ensures the rapid movement of the right resources to the right place at the right time. It may also happen that some severely affected areas get completely disconnected from other parts of the world. In such situations, the urgent needs of the disaster-affected population are not known or communicated to the responsible Government authorities, voluntary organizations and unaffected populations in the vicinity. This may lead to severe losses in terms of human lives, livestock and property.

4.3.8 Due to advancement in Information Technology (IT) in the form of the Internet, GIS, Remote Sensing, Satellite Communication, etc., it has become possible to plan and implement disaster reduction plans which, in turn, help to contain the damage on a long-term basis. Weather warnings can be communicated through a variety of formats (text, graphics, voice) and disseminated via a wide range of media (press, radio, television, e-mail, cell phone, Internet, etc.). Radio broadcast of warning bulletins has proved to be one of the most effective and cheapest modes of cyclone warnings to communities the world over. IMD's INSAT satellite based CWDS is one of the fail-proof systems (satellite-based) currently in use in India to communicate cyclone warnings from IMD to communities and important officials in affected areas directly and quickly. The cyclone warnings are uplinked to the INSAT satellite in C-band. The satellite audio broadcasts in regional languages are continuously sent at fixed time intervals to the coastal CWDS receiving stations. These warnings are selective and received only by the likely affected receiving stations in S-band. IMD has installed specially designed receivers in the vulnerable coastal areas for direct transmission of warnings to officials and people in general. CWDS is soon to be replaced by Digital CWDS.

4.3.9 **Prerequisites of Effective Communication System** The importance of telecommunication for the EWS for cyclone warning has been

widely accepted since the early days of development of radio communications. Technology can help reduce losses but many developing countries are yet to adopt this due to lack of trained manpower, organization and institutions. Utilisation of Radio, Satellite Communication and Ham Radios etc can help overcome the lack of public awareness about the system.

(a) **Terrestrial Radio Network** ISRO notes, MSAT.II.5, explains, terrestrial network can be the first tier of communication for a good EWS. The following can be envisaged for ensuring effective dissemination of warnings and in case of a disaster to ensure two communication:-

(i) Terrestrial audio and TV broadcasting (Audio in MW, SW and FM bands by public service broadcaster, private operators and community radios).

(ii) TV broadcasting in V/UHF bands.

(iii) Fixed and mobile communication (GSM and CDMA).

(iv) Wireless communication used by agencies like police, armed forces, fire service etc.

(v) Public Address system.

(b) **VSAT based satcom network** The Mobile Satellite System-MSS Type 'C' Communication Terminals enables transmission of messages at a low data rate to a central hub from a handheld terminal using satellite. It is a one-way satellite based messaging service available through INSAT. This system is a transmit-only service that provides a reporting channel via satellite to a group of people, and due to all India coverage of INSAT, this service provides one-way message reporting

[transmit-only] facility from anywhere in India. The Mobile Satellite System - MSS Type 'C' Communication Terminals is suitable for sending short message, position or data from remote locations to a predefined location for a group of closed users. A closed user group may be served by a single Hub station. The system is battery operated, so the system will work uninterrupted with low power consumption, moreover internal battery charger is provided so no more maintenance of battery. MSS provides high security by means of Encryption which is programmable. PC interface is also provided which makes MSS user-friendly. INSAT 3C has the MSS payload for Mmobile service. Satphones are another useful means to communicate from remote inaccessible areas.

(c) **Amateur Radio (HAM)** HAM Radio India- VU2.in, states, in the event of major disasters/emergencies, it has been experienced that Amateur Radios have worked successfully when no other communications worked. is the use of designated radio frequency spectra for purposes of private recreation, non-commercial exchange of messages, wireless experimentation, self-training, and emergency communication. The term "amateur" is used to specify persons interested in radio technique solely with a personal aim and without direct monetary or other similar reward, and to differentiate it from commercial broadcasting, public safety (such as police and fire), or professional two-way radio services (such as maritime, aviation, taxis, etc.). Radios of police may not be necessarily on same frequency as that of fire fighters. The military has its own set of frequencies and even other departments that use radio for communication can communicate, however the communication is limited within their own group. The truth is they cannot communicate with each other - and that is the biggest challenge. How to convey message between diverse group of disaster or relief agencies when they all have sets, but cannot talk to each other. The response phase after any disaster includes the mobilization of

the necessary emergency services and first responders in the disaster area. This is likely to include a first wave of core emergency services, such as fire fighters, police and ambulance crews. This is where HAM (Amateur) Radio **Fig 11**, comes in picture. Using HF radio sets, messages can be conveyed or relayed to long distance and accurate picture of situation on the ground, requirements and key information could be sent to disaster response team. The HAM operators have been effective in India in the following disasters:-

- (i) Orissa Super Cyclone.
- (ii) Latur Earth Quake.
- (iii) Tsunami.
- (iv) Cyclone Aila.

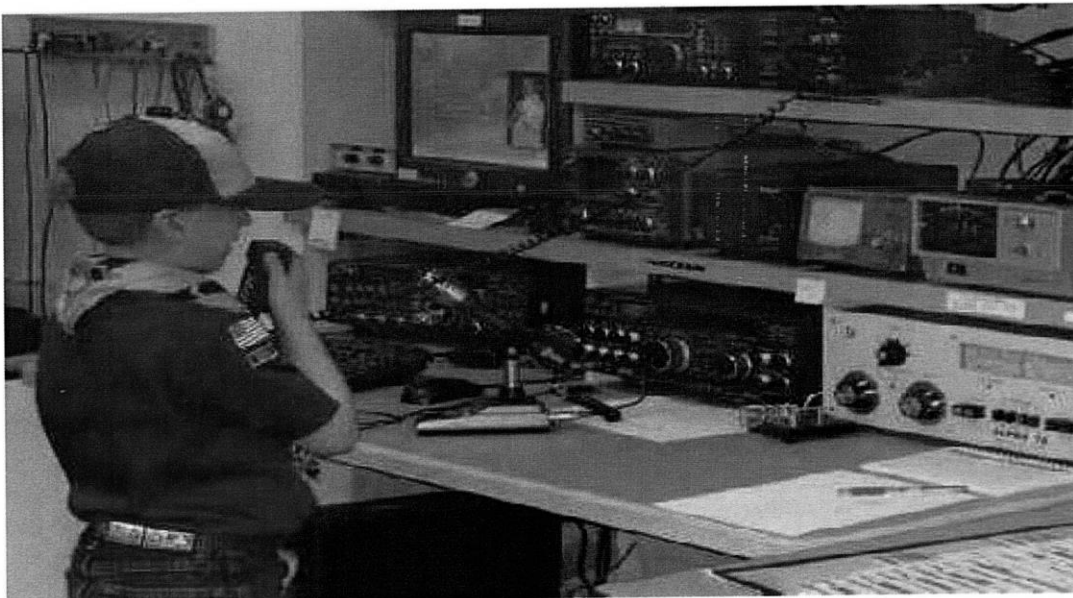


Figure 11: Amateur Radio (HAM).

Source: <http://www.vu2.in/disaster-management-emergency-communications/112-why-ham-radio-for-disaster-management.html>

4.3.9 Initiatives at National Level

- (a) **VSAT Network of the National Informatics Centre (NICNET)** NDMG (2008), the mode of NICNET communication is leased lines, VSATs, RF and ISDN/PSDN dial-up lines. The service provided over the network is primarily data. Voice and video is also provided in a limited scale. Video conferencing facilities are available in more than 450 locations.
- (b) **Satellite-based real time voice data messaging for Cyclone Warning System.** It is not enough that timely information or bulletins are furnished by IMD. The same has to reach the targeted people be it the authorities or the affected people. Emergency managers thus need to send common alerts through Internet, news media, television, radio, wired telephones, mobile phones etc.
- (c) **Satellite-based multi-lingual disaster warning software for DCWDS.** Network Management Software (NMS) for Digital Cyclone Warning Dissemination Systems (DCWDS) is responsible for and monitoring of cyclone warning messages and creation as well as transmission to unmanned satellite receivers installed all along the Indian coastal line. Audio messages, captured by a microphone, are digitised using MPEG-II format to create message packets in a customized protocol, with unique headers for selected stations. Header and message packets jointly form a data packet. This ensures that only required receivers are given the message while others are not energised. Acknowledgement messages sent by the remote station's receivers

are captured, analysed and checked periodically. All the transmitted messages and acknowledgement messages are logged systematically. IMD and concerned state governments are the users of this system.

(d) **Digital Video Broadcast with Return Carrier through satellite (DVB-RC)**

The DVB-RCS system supports communication in the channel in two directions:-

- (i) Forward channel from the hub-station to multiple terminals.
- (ii) Return channel from the terminals to the hubstation.

The forward channel provides 'point to multipoint' or multicast service because it is sent by a station at a single point to stations at many different points. The terminals share the return channel capacity of one or more satellite transponders by transmitting in burst, using multi-frequency-Time Division Multiple Access. This is a two-way communication system and suitable for Disaster Management (DM).

(e) **EDUSAT** EDUSAT is the first Indian satellite designed and developed exclusively for serving the educational sector. DM programmes can be developed and telecast on the EDUSAT network.

4.4 **Communication Network** Surveys have been carried out in all states of India to establish a VSAT network to link the state headquarters with divisional and district headquarters. VHF radio network link is planned for the district headquarters to connect with the sub-divisional and taluka headquarters which will have control at the national level. The basic communication and IT support for DM is therefore required for the following agencies:-

- (a) IMD, CWC, NRSA and DoS and so on- DM Monitoring and forecasting agencies.
- (b) Governmental machinery – Responsible for early warning of impending disasters/disaster like situations.
- (c) NDMA/OC - All stakeholders linked in a bilateral mode at the national, states/UTs and district levels.
- (d) Communication and IT support is also required for various other ministries, departments and organizations involved in DM along with NDMA. This is mainly for coordination and execution.
- (e) Response forces such as NDRF, SDRF, Para Military Force (PMF), Police, Defence forces, Corporate, NGOs and any other organization, national or international.

4.5 **Existing Backbone Communication Infrastructure** As already stated, the communication infrastructure is a pre-requisite for proper functioning of the cyclone warning and DM system. The existing communication infrastructure has evolved over a period of time using various communication technologies available from time to time. The systems that are functioning are:-

- (a) DTH service is available all over the country. Advantage of DTH broadcast is its digital quality, fail-proof communication. Since the DTH services of Prasar Bharati, Dish TV and Tata Sky are providing reception in remote and rural areas, their services will be utilised for dissemination of cyclone warnings and for weather

information on radio/TV channels to the places not covered by terrestrial and cable operators.

(b) **World Space Satellite based Digital Broadcast Service**

IMD had started a new meteorological data and processed products broadcasting service from 1 July 2003 using the World Space 'Asia Star' satellite. This was a replacement of the HF broadcast system which has become outdated. System and can be used to visualise data, satellite images, weather charts, automatic plotting of data, analysis and manipulation of data for the benefit of weather forecasters and other users. This could be considered as an alternative option. Fishermen out at sea could benefit the most from this system.

(c) **Community Radio** Community radio is owned by the community and airs programmes designed and produced by it specifically for its own developmental needs. The communities that produce these radio programmes buy time from the AIR local radio stations. In order to give wide publicity of natural disasters among the communities, community radio will be established in cyclone-prone areas with the help of IGNOU and other open universities, NGOs and Community Based Organisations (CBOs); the cost if any, will also be met by them. Co-locating DCWDS receiver with the community radio, will add value and considerably increase the outreach of warnings.

(d) **Battery-less Hand Radio** Corrosion of batteries in transistors carried by some fishermen out at sea is one of the major reasons for the non receipt of warning broadcasts by AIR, besides attenuation of signals in adverse weather. Some battery-less, low-cost hand radios are now available in the market which will be

useful for receiving warnings by fishermen at sea where battery operated radios generally do not work.

(e) **Satellite Phone Services (Sat phones)** At the time of emergencies, a communication system with clear voice and data communication facility having mobility and reliability, are important factors. Satellite phone services provide these assurances almost anywhere in the world, even in areas of total devastation and in areas where even electricity is not available. Satellite portable phones work like cellular phones where cellular coverage is available, and as sat phones where it is absent. The communications are completely independent of any local telephony infrastructure. One need not worry about service disruptions because of power failures or other events common in disaster areas. Therefore, satellite phone services can be extremely useful in saving lives and coordinating efforts during rescue operations, such as the setting up of telemedicine links up to the taluka/mandal level. These phone services can be used by the Red Cross, doctors, police, fire departments, ambulance services, search and rescue, NDRF, district collectors and other government emergency response organisations.

(f) **Mobile Phone** Mobile phone with Global System for Mobile communications (GSM) and Code Division Multiple Access (CDMA) technologies are available. BSNL, MTNL and private telecom companies like Bharti, Reliance, Tata, Idea, Vodafone offer both GSM and CDMA mobile phone services in India. Some GSM operators offer GPRS services also, where a download speed of up to 30 kbps is available. The battery-based mobile base stations can be quite helpful during natural disasters when electricity supply links become inoperative. Besides voice communications,

nowadays mobile phones also provide pay services like Short Message Service (SMS), news updates, railway and airline information, etc., that can be used by subscribers. BSNL/MTNL and all private telecom companies will provide capability to access the designated four digit toll free number for information related to cyclone alerts and warnings from landlines and mobile phones.

- (g) **Cell Broadcast** A GSM mobile network can provide the facility to broadcast short messages to mobile phone users within the network of an operator on a real time basis (in seconds). This is the cell broadcast facility. Radio and TV stations can have access to the cell broadcast facility via an entry provided by the GSM mobile network operator. Various areas can be identified using GIS. For every area, an emergency message can be specified such as for cyclone alert, cyclone warning, etc. This message can be broadcast on a regular basis (for example, every 5 minutes).
- (h) **Internet** In the present era of electronic communication, the Internet provides a useful platform for DM communications. Launching of a well-defined web site is a very cost-effective means of making an intra-national and international impact. It provides a new and potentially revolutionary option for the rapid, automatic and global dissemination of disaster information. A number of individuals, organisations and groups, including IMD, are using the Internet for real time dissemination of weather observations, forecasts, satellite and other data. In the most critical phase of natural disasters, electronic communication has provided the most effective, and in some instances perhaps the only means of communication with the outside world.

(i) **Emergency Warning System for Analog Broadcasting**

This system uses relatively simple equipment and ensures stable operations. In an emergency, the emergency warning system control signal replaces the radio and TV programme signals and automatically activates the emergency warning system ready receivers even when they are in sleep mode. It is anticipated that in future the digital emergency warning system function will most likely be incorporated in mobile hand-held devices.

(j) **Radio Receivers for Emergency Warning System.**

AIR has a large network of AM/FM transmitters which can be effectively used to convey emergency messages to the public on natural disasters. A transmission format which has fixed code will be more suitable for India as it does not contain the area code. The CD containing EWS control signals can be played back on AM/FM transmitters located in the region affected by natural disasters as an alarm for users of analog radio receivers even in sleep mode.

(k) Village Information Centres (VICs) of the Department of Science and Technology (DST). The setting up of VICs is supported by DST as part of its major initiative to provide information and empower the rural population with the fruits of Information and Communication Technology (ICT). DST provides all the infrastructure support for operating an information kiosk in any village under the supervision of the state government, technical institutions such as state S&T councils, technical universities, remote sensing application centers, IT departments, etc. Details of the establishment plans of VICs in other states include:-

(i) Karnataka: All 28 districts with spatial data information scaled up to seven village level.

(ii) Tamil Nadu: Seven districts.

(iii) Kerala: Four districts.

Such VICs will be utilised in addition to CWDS for communicating cyclone warnings and emergency messages directly to the community.

4.6 VSAT Based Satcom Network

4.6.1 ISRO, M Sat. II. 5, A²⁶, defines, very small aperture terminal (VSAT) is a two-way satellite ground station or a stabilized maritime VSAT antenna with a dish antenna that is smaller than 3 meters. The majority of VSAT antennas range from 75 cm to 1.2 m. Data rates range from 4 kbit/s up to 4 Mbit/s; some upgraded modules can even reach a max downlink of up to 16 Mbit/s. VSATs access satellites in geosynchronous orbit to relay data from small remote earth stations (terminals) to other terminals (in mesh topology) or master earth station "hubs" (in star topology). VSATs are used to transmit narrowband data (e.g., point-of-sale transactions using credit cards, polling or RFID data, or SCADA), or broadband data (for the provision of satellite Internet access to remote locations, VoIP or video). VSATs are also used for transportable, on-the-move (utilising phased array antennas) or mobile maritime communications. Mobile satellite service plays an important role during disaster when all other communications fail. All terrestrial communication is affected during major disaster, whereas SATCOM link is not affected. Laying of cable in ocean is impractical. VSAT per se consists of ground segment and space segment. Ground segment consists of VSATs and hub Earth Station. **Advantages** of communications satellites are the inherent broadcast capability, high bandwidth, reliability and flexibility in network expansion. Small transportable terminals can be made operational very quickly.

²⁶ ISRO training notes on Application and Trends in Satellite Communications, M Sat II.5

Recent developments in communications and computer technology allow to provide low-cost equipment, which is affordable even in developing countries. Communications satellites can also play an important role in case of emergencies or natural disasters. The combination of satellite communications and navigation can support new services for emergency teams.

4.6.2 Before planning a VSAT the satellite/transponder to be used is to be decided and footprint of satellite is important. In addition to this; Satcom is also used for integrating Geo Information Technology. Geo Informatics Technology consists of GIS, Spatial Decision Support system (SDSS), Global Positioning system and Remote Sensing (RS). Space technology i.e. Remote sensing and GPS has the advantage of comparing geo-information and man-made features on various time –scales and when combined with GIS helps in understanding changing hazard scenario, vulnerability and rapid assessment of disaster related damages and losses. Advanced high- resolution and multi-spectral sensors has provide immense scope for scientists for mapping and analysis, which help in near accurate identification of various objects. GIS and GPS gives us relevant, authentic and interpretable information in time and in a cost effective manner.

4.6.3 **Data Collection System** Even though this research is on cyclones, I am including the Early Warning System for Tsunami and Storm surges. This is all the more important as data on Tsunami and Storm surges is related to any ocean based disaster. **Data from Acoustic Tide Gauge (ATG) and Deep Ocean assessment and Reporting of Tsunami (DART)**. ATG works on echo ranging whereas DART works on two premises, i.e Bottom Pressure recorder and Surface Buoy. The two data can be transmitted to the satellite for further transfer DMH. From DMH info is then relayed to higher authorities as well as to TV/Radio for dissemination to large number of people likely to be affected. A total of four ATG and DART on each coast employed along the coastal line is sufficient to provide early warning and thus provide precious time to DMP planners. A Data collection Network which is a combination of :-

- (a) Sensor Network-Acquires disaster info with own sensors, like Buoys. Consists of sensor, Relay and Sink Nodes.
- (b) Access network combining cellular and DAB technology.
- (c) Access net are configured to cellular network and other Ad Hoc networks

4.7 **Abis interface for Restoration of Cellular Communication**

4.7.1 The first victim after any disaster is terrestrial communication and the first resource required immediately after the disaster is communication. Quick restoration is the best option compared to providing a new alternate communication system. Global system mobile (GSM) achieved wide popularity with wide network availability, affordable handsets and variety of applications. The interface between Base Trans Receivers (BTs) and Base Station controller (BSC) of a GSM network is the first victim in any disaster. The existing handset cannot extend communication in spite of the handset being operational. Under these circumstances the best option is to **restore a BTS with an ABIS interface, see Fig 12, over the same handsets rather than extending communication using a terminal and SATPHONES.** Satellites can play a major role in establishing a new communication network which is quick, cost effective and reliable. The Abis-satellite link can be restored with any independent BSC in the network. The Abis-satellite link provides maximum interoperability and flexibility between terrestrial and satellite scenario for the handset. The handset configuration remains same Abis interface was initially designed for more wire line communication links, hence to establish Abis interface over satellite, the signalling architecture of the interface and its protocol stack should be evaluated considering the parameters like satellite delay and high loss. An Abis interface emulator is required to be developed and tested over a satellite link to study the protocol modification without losing the interoperability between adjacent

interfaces. Impairment of satellite communication such as high delay (240 -300 ms)²⁷ will affect protocol, which work in acknowledge mode need to be evaluated.

4.7.2 Two areas where satellite based communication links can be used is as below:-

- (a) Abis Interface- Interconnecting the BSC with multiple pico BTSs.
- (b) A Interface - Interconnecting MSC with multiple BSCs.

Abis interface is used in the access portion of network and is a key air interface. A interface is the primary interface within core portion of network. These two interfaces have different characteristics and requirements which necessitate different solutions to optimise their performance over satellite. The capacity of ABIS is limited, but sufficient in case of emergency. The satellite network suggested for Disaster management Programme is using Very Small Aperture Terminal (VSAT). Number of terminal can be planned as per area covered. One of the VSAT terminal can work as a Hub. Each District headquarter can be planned with a VSAT terminal along with a terminal at Bhubhaneshwar. Figure 10 shows the block diagram of integration of ABIS Interface and A Interface. The interface can be used which can be utilised to restore the network by itegrating the damaged network through satellite.

²⁷ 2nd India Disaster Management Congress, Abstracts, NIDM (2009).

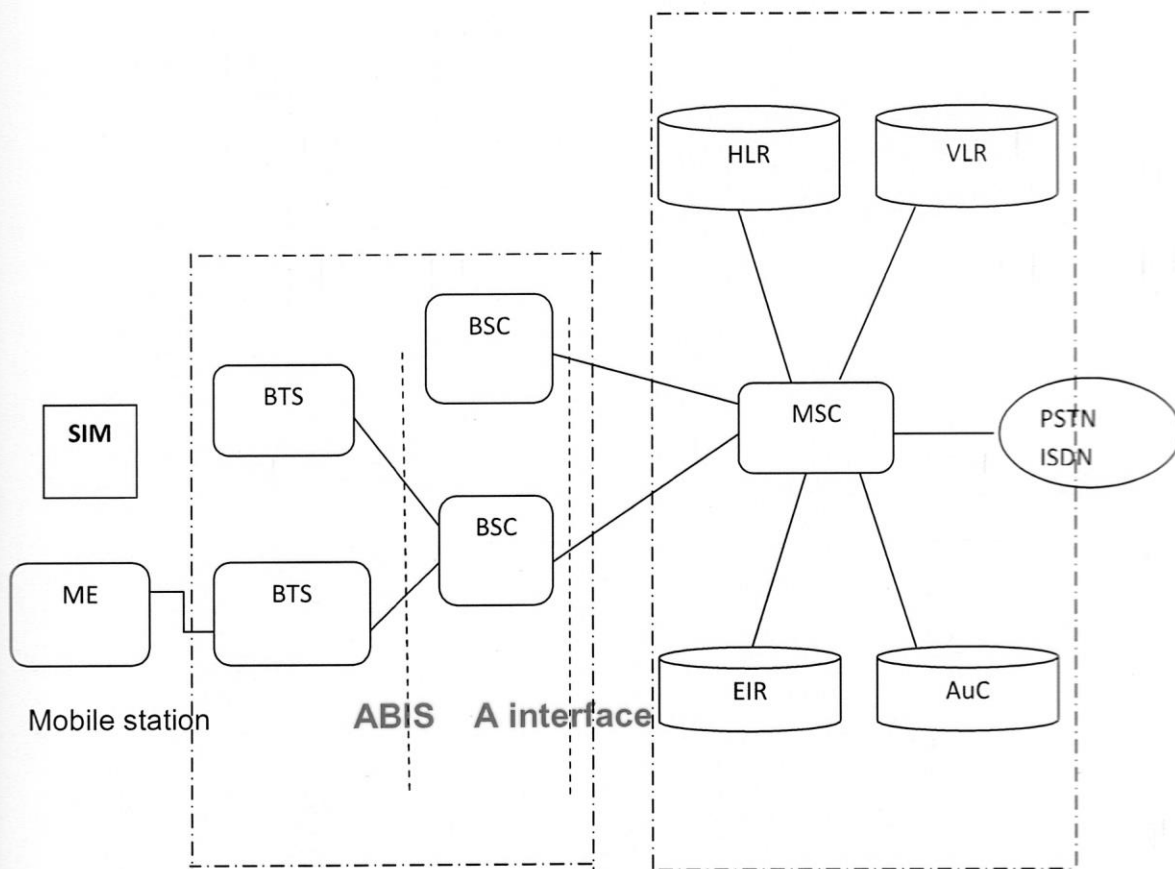


Figure 12: Block Diagram of GSM network with ABIS interface

Source: ISRO course notes, 2nd India Disaster Management Congress, 2009

Base station

Network Subsystem

SIM-Subscriber Identity Module

BSC –Base Station Controller

ME- Mobile eqpt

MSC-Mobile Services Switching Center

HLR- Home Location Register

EIR-Eqpt Identity Register

BTS- Base Transeiver

VLR- Visitor Location Register

AuC –Authentication Center

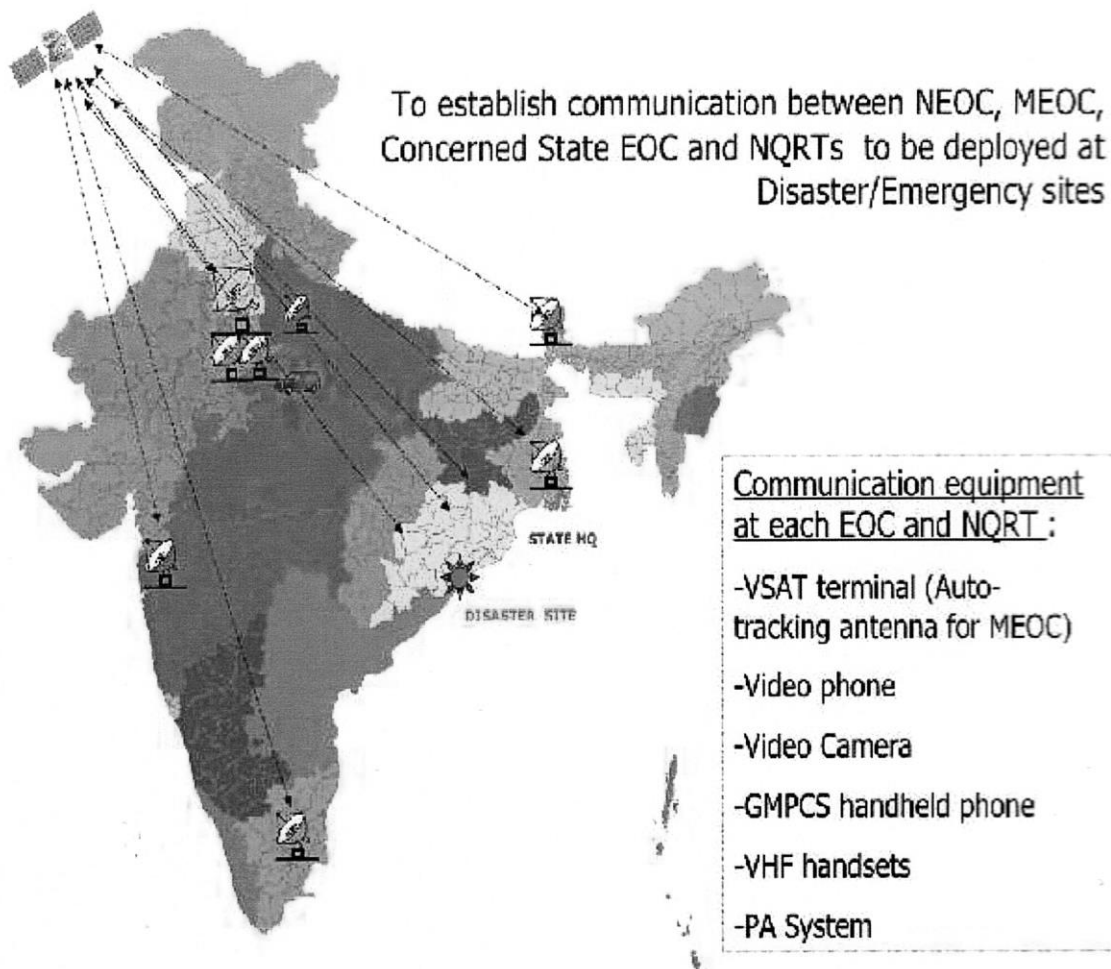


Figure 13: Communication between National, Mobile, State Emergency operation Centers and National Quick Response Team

Source: <http://www.slideshare.net/sujit29/ict-in-disaster-risk-reduction-india-case>.

NEOC: National Emergency Operation Center.

SEOC: State Emergency Operation Center.

MEOC: MOBILE Emergency Operation Center.

NQRT: National Quick Response Team

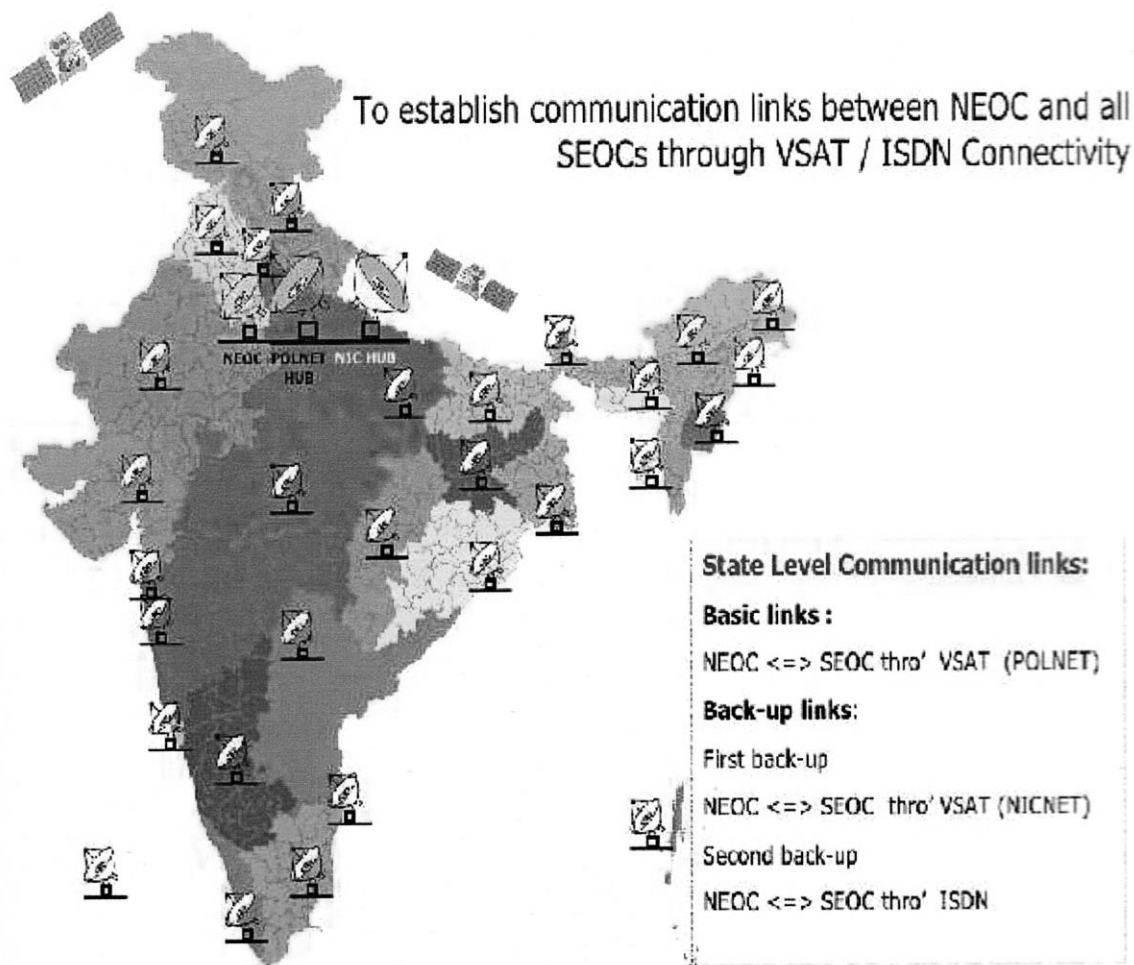


Figure14: Satellite Communication NEOC and SEOCs.

Source: <http://www.slideshare.net/sujit29/ict-in-disaster-risk-reduction-india-case>.

4.8 The network is propose to provide 100% reliable communication links for voice communication, data communication, Video Conference between NEOC, MEOC, SEOC, DEOC and NQRT as well as Emergency Operation center operating at the disaster site, see **Fig 13 and 14**. The network is designed to Operate with ISDN as main media and satellite communication as standby media

of communication. The POLNET²⁸ and NICNET bandwidth will be utilised for the network. The space net of ISRO is being expanded for same.

4.9 Summary. Zschau and Koppers (2003), states, Satellite imagery has become powerful tool for cyclone analysis and forecasting. No tropical disturbance has been missed after the launch of INSAT programme. A fairly reliable estimate of the intensity of tropical cyclones has been yielded by DVORAK scheme. Satellites like INSAT 2E has water vapour channel data would be further exploited for forecast of cyclones. It is also proposed to augment the CWDS network. The Limited Area Model with its poor resolution is not able to capture the cyclone development properly. The same has been upgraded now to a high resolution version. The importance of effective communication after a disaster has struck has been proved again and again in the past. In the chaos that follows a disaster, rumors and confusion may run rampant. Disaster victims need clear, timely, consistent and accurate information to find help and resources, avoid hazards and to minimize additional injuries or damage. As the National Incident Management System says, "Effective and accurate communication can save lives and property, as well as help ensure public trust and credibility." During an emergency or disaster, there are several alternative communication methods that individuals, employees and businesses can implement. Particularly during a disaster, it is important to have alternative strategies available. Providing communication as part of a disaster plan, as well as utilizing ham radio, social networking sites and emergency alert systems, are alternative ways to communicate during a disaster.

²⁸ Combination of Satellite and UHF Communication. Single Satellite in Geo-stationary orbit covers the entire country. Used for VOICE Communication from Police Station to Police Station and District Station. Range-35 km.