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DISASTER PREDICTION, WARNING AND MITIGATION

Background paper 2

The full list of the background papers:

1. The Earth and its environment in space
2. Disaster prediction, warning and mitigation
3. Management of Earth resources
4. Satellite navigation and location systems
5. Space communications and applications
6. Basic space science and micro gravity research and their benefits
7. Commercial aspects of space exploration including spin-off benefits
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PREFACE

The General Assembly, in its resolution 52/56, agreed that the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) should be convened at the United Nations Office at Vienna from 19 to 30 July 1999 as a special session of the Committee on the Peaceful Uses of Outer Space, open to all Member States of the United Nations.

The primary objectives of UNISPACE III will be:

(a) To promote effective means of using space technology to assist in the solution of problems of regional or global significance;

(b) To strengthen the capabilities of Member States, in particular developing countries, to use the applications of space research for economic and cultural development.

Other objectives of UNISPACE III will be as follows:

(a) To provide developing countries with opportunities to define their needs for space applications for development purposes;

(b) To consider ways of expediting the use of space applications by Member States to promote sustainable development;

(c) To address the various issues related to education, training and technical assistance in space science and technology;

(d) To provide a valuable forum for a critical evaluation of space activities and to increase awareness among the general public regarding the benefits of space technology;

(e) To strengthen international cooperation in the development and use of space technology and applications.

As one of the preparatory activities for UNISPACE III, the Office for Outer Space Affairs of the Secretariat has prepared a number of background papers to provide Member States participating in the Conference, as well as in the regional preparatory meetings, with information on the latest status and trends in the use of space-related technologies. The papers have been prepared on the basis of input provided by international organizations, space agencies and experts from all over the world. A set of 12 complementary background papers have been published and should be read collectively.

Member States, international organizations and space industry planning to attend UNISPACE III should consider the contents of the present paper, particularly in deciding on the composition of their delegation and in formulating contributions to the work of the Conference.

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SUMMARY

The present paper presents an overview of the various types of hazards, their impact on development and how space technologies can be used to enhance the effectiveness of all phases of disaster management.

The social and economic costs of natural disasters are rising. There has been a five-fold increase in economic costs in the past 30 years. On average, over 110,000 persons lose their lives each year on account of natural disasters. The rising trend is attributed to increasing vulnerability of the world's population. Vulnerability is linked to several factors, including population pressure, declining resource base, degradation of the environment, illiteracy and poverty. National programmes for disaster management should therefore aim at reducing the various elements of vulnerability as part of an integrated sustainable development strategy through the cost-effective use of space technologies.

Specific stages of disaster management programmes are pre-disaster planning and preparedness, forecast and warning, emergency response and rehabilitation. The main needs of these activities are information and data exchange, education and training, technology transfer and emergency communications. Space technologies, in particular satellite telecommunications, remote sensing (including optical and radar systems), satellite meteorology and geo-positioning systems, respond to these needs. These technologies offer a source of information that complements that available from other sources, particularly ground-based sources.

Notable examples of space technology applications include the use of (a) high spatial resolution remote sensing imagery for mapping hazardous zones during land-use planning, (b) information from Global Positioning System (GPS) satellites for emergency location and navigation purposes, especially within the context of search and rescue operations, (c) satellite telecommunications systems for the issue of warnings of impending disasters or for sending distress signals, especially from ships and aircraft, (d) satellite-based mobile telephone systems in emergency instances where the terrestrial networks have been damaged or destroyed, (e) television broadcasts, videoconferencing, data transfer, and Internet services to support a variety of educational activities as well as emergency services, (f) satellites to detect and monitor meteorological hazards, such as hurricanes (typhoons/cyclones) and to facilitate the issue of public warnings, (g) radar and GPS satellites to monitor a variety of geological hazards, including earthquakes and volcanoes, and (h) sea surface temperature and topography measurements to forecast El Niño events.

Some relevant areas of concern in the use of space technology are the need for (a) adequate information exchange infrastructure at the national level to support disaster management, (b) Governments to give high priority to disaster management activities, (c) better international cooperation to facilitate the use of telecommunications equipment, (d) access to relevant space technologies and techniques by developing countries, (e) access to satellites during emergencies, and (f) the enhancement of education and training in matters related to the application of space technology to disaster management.

I. NATURAL DISASTERS

A. Description

1. Natural hazards are natural or human-induced processes or events with the potential to create loss to humans and to their welfare. Many so-called “natural” hazards have both natural and human components. Natural hazards have thus been defined as extreme geophysical events, biological processes and major technological accidents, characterized by concentrated releases of energy or materials that pose a largely unexpected threat to humans. Natural hazards therefore include events such as the following:

Floods
Typhoons
Hurricanes and cyclones
Earthquakes
Tornadoes
Whirlwinds and thunderstorms
Snowstorms
Heatwaves
Cold spells
Volcanic eruptions
Landslides
Avalanches
Tidal waves
Drought
Sandstorms or dust storms
Windstorms
Wildfires
Locust or other insect infestations

2. When the interaction between the human population and a hazard results in the loss, at a sufficiently large scale, of lives, of material possessions or of what is valued by humans, the event is termed a disaster. Many disasters, such as earthquakes, are usually limited in time as well as in space and are disruptive to the social structure and functioning of communities. Others, such as droughts, are more gradual in their onset, but their impact may be no less severe.

3. The most notable natural disasters are due to a few events of a very high magnitude that occur relatively infrequently. Many of these disasters occur repeatedly in certain regions that, owing to natural geophysical characteristics, are susceptible to a variety of hazards (e.g. volcanic eruptions and earthquakes in tectonically active zones or extensive flooding in lowland coastal areas due to tropical cyclones).

B. Economic and social impact

4. More than 3 million people were killed in natural disasters worldwide during the 20-year period 1974-1994. Those disasters brought injury, homelessness and misery to 1 billion others and caused many billions of dollars of property damage. In 1991 and 1992 alone, property damage amounted to 100 billion United States dollars. A single event, Hurricane Andrew, caused US$ 25 billion of damage in the southern part of the United States of America in 1992. On average each year, natural disasters around the world leave 4 million people homeless, injure another 900,000 people and kill 128,000 people.

5. There were 180 reported natural disaster events worldwide in 1996, of which 50 were major, requiring international assistance. It has been estimated that in 1992 the world economy lost more money (US$ 62 billion)

from natural disasters in the less developed countries than it spent on development aid (US$ 60 billion). In Bangladesh, for example, more than 5 per cent of gross domestic product (GDP) is lost annually to recurrent natural disasters. In 1970 and 1991, 300,000 and 138,000 lives, respectively, were lost in Bangladesh due to cyclones. In industrialized countries, even major disasters rarely cost more than 0.1 per cent of gross national product; however, it can be 20-30 times more in less developed countries. The relatively small size and specialized nature of the economies of many developing nations make them more vulnerable to the effects of natural hazards than the larger economies of industrialized countries. Also, in many developing countries, disasters recur regularly, principally because of a lack of funds to introduce sustainable disaster-management solutions.

6. The more notable social and economic consequences of natural disasters include the following:

(a) Loss of human lives;

(b) Panic; social disruption (e.g. no sense of community, security or control);

(c) Increase in the likelihood of social unrest or violent conflict;

(d) Damage to the natural resource base and to the environment;

(e) Loss of housing; temporary and/or permanent migration;

(f) Loss of industrial and/or agricultural production (hence employment, income and tax revenue);

(g) Damage to infrastructure (including transportation and communication systems);

(h) Disordered markets and distribution; loss of commerce;

(i) Immediate downgrading of living conditions owing to the deferral or cancellation of other development plans that deal with real social needs;

(j) Short-term reduction in GDP and per capita income;

(k) Imbalances in the fiscal budget as a result of emergency reallocations of expenditure;

(l) Immediate and medium-term inflationary pressure due to market disorders and externally financed reconstruction expenditure.

Approximately 25 per cent of the world's population lives in regions that are at risk of natural disaster. However, the impact of disasters and their secondary effects (e.g. loss of life, property damage and social and economic disruption) are invariably the greatest where poverty-stricken people are concentrated. Asia has been the continent most affected by major disasters, accounting for over 60 per cent of the 45 million disaster-related deaths, and 85 per cent of the 3.7 billion victims of natural disasters, since 1900. Of all those disasters, drought and floods have been responsible for the largest number of deaths (over 53 per cent). About 60 per cent of all deaths due to storm surges have occurred in the low-lying coastal areas of countries bordering the Bay of Bengal and the adjoining Andaman Sea.

7. Two thirds of the world's population live in developing countries. Yet approximately 90 per cent of all natural disasters and 95 per cent of disaster-related deaths occur in developing countries. In the period 1947-1981, for example, there were 3,958 and 3,174 disaster-related deaths per 1 million of population in Bangladesh and Guatemala, respectively. In contrast, in Japan and the United Kingdom of Great Britain and Northern Ireland, the corresponding figures were 276 and 89. However, while deaths due to natural disasters in industrialized nations are

decreasing as a consequence of effective public policies and technological developments, the level of economic losses is rising (a fivefold increase in economic costs compared with the 1960s). In the period 1986-1996, the economic losses from 64 very large disasters amounted to some US$ 400 billion. It is estimated that economic losses due to disasters in the United States amount to approximately 1 billion dollars per week and that much of those losses are incurred through a few very costly disasters such as hurricanes and earthquakes.*

C. Increasing vulnerability

8. The social and economic costs of natural disasters are increasing worldwide. This tendency is attributed in part to increasing vulnerability in less developed countries, where people are often left more vulnerable to subsequent hazards after experiencing one disaster.

9. Many factors contribute to increasing vulnerability. These include (a) increasing population, with resultant increased densities of people and investments on marginal lands (e.g. increasing use of unsuitable and unsafe lands), (b) unsustainable development practices, especially in marginally productive lands, (c) the inability of Governments faced with a rising population to provide adequate social services, including services related to disaster reduction, (d) degradation of natural resources (e.g. overgrazing of rangelands and overexploitation of forests), (e) increasing insecurity of food and water supplies, (f) rural-urban migration and urbanization pressures that concentrate people in unsafe cities, (g) increasing poverty and illiteracy and increasing numbers of poor people being exposed to hazards, (h) weak institutional capacity for confronting disasters, (i) inadequacy of disaster management measures and forecasting techniques, (j) inadequate participation of local community in disaster management, (k) inadequate training, (l) inadequate communications and transport infrastructure, (m) lack of strict environmental control measures, (n) inadequate market mechanisms to help buffer against disasters and spread risks, (o) increasing global interdependence of economies, leading to more extensive impacts from a single disaster, and (p) global climate changes increasing the vulnerability of certain geographic regions to hazards.

10. While some societal factors tend to increase vulnerability to disasters, there are several technological trends that serve to decrease it. Examples of such positive trends are (a) increased understanding of hazardous processes and phenomena, (b) improved analytical methods, which permit the development and use of complex models, (c) enhanced communications, which permit applications resulting from this new understanding to be communicated in a timely manner, and (d) advanced engineering practices, which have given an improved understanding of the susceptibility of materials and structures together with the development of new approaches to engineering and design. These positive trends, however, must be partially balanced against the negative aspect of an increased reliance on technology, which is often somewhat fragile and sensitive to the impact of hazards.

11. Over the past several years, there has been an increased awareness that the frequency of many hazards—particularly those involving atmospheric or meteorological phenomena—may be not constant but subject to environmental trends. The most pronounced example is that due to short-term climate changes such as the El Niño phenomenon: this is the seasonal-to-interannual fluctuation of ocean and atmospheric currents in the eastern equatorial Pacific, which can alter rainfall and wind patterns and, thus, the occurrence of droughts and floods. Beyond this, on the decadal timescale and beyond, lies the possibility that long-term climate change, induced by anthropogenic increases in carbon dioxide and an enhanced greenhouse effect, will similarly alter the frequency of storms and droughts.

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*Estimation of economic losses due to disasters is complicated by several factorssuch as the large (and potentially under-reported) number of smaller disasters, the difficulty inherent in assessing damage in larger disasters, and the effects of secondary losses (e.g. to businesses and employment), as well as possible benefits (e.g. to construction industries).A comprehensive methodology for assessing disaster losses is currently being developed by the United States National Academy of Sciences Board on Natural Disasters.

12. The increasing trend in the frequency and impact of natural disasters led the General Assembly, in its resolution 44/236 of 22 December 1989, to proclaim the International Decade for Natural Disaster Reduction, beginning on 1 January 1990. The objective of the Decade is to reduce through concerted international action the impact of natural disasters, especially in developing countries. Governments have been called upon to enact a number of measures, including: formulating national disaster mitigation plans; establishing multisectoral national committees to stimulate and coordinate activities aimed at fulfilling the goals of the Decade; mobilizing support from the public and private sectors; increasing public awareness of risk reduction, relief and short-term recovery activities and enhancing preparedness; paying closer attention to the impact of natural disasters on health care; and improving the early availability of emergency supplies.

13. A target of the Decade is that, by the year 2000, all countries should, as part of their plans to achieve sustainable development, have in place (a) comprehensive national assessments of risks from natural hazards, (b) mitigation plans (and the necessary legal framework) at the national or local level or both, involving long-term prevention, preparedness and community awareness, and (c) ready access to global, regional, national and local warning systems and broad dissemination of warnings.

II. DISASTER MANAGEMENT

A. Information needs

14. Given their significant social and economic costs, it is evident that sustainable development could be considerably enhanced by reducing the impacts of natural disasters. The reduction of vulnerability should, as part of an overall disaster management strategy, be a routine objective of development activities and be integrated in investment decisions.

15. Disaster management involves a series of information-intensive phases: pre-disaster planning, disaster preparedness and forecasting, emergency (disaster) response, recovery and reconstruction. Space technology can play a role in furnishing the information required in each of these phases.

16. *Pre-disaster planning phase*. This phase includes activities aimed at the avoidance or reduction of risks. Risks are assessed through an objective, information-intensive process requiring the evaluation of the characteristics of hazards, such as their probability of occurrence, severity and location, as well as the vulnerability of life and property to such hazards. Typical information-related needs for this phase include the following:

(a) Information access and exchange

(i) How to formulate national disaster mitigation programmes and related policies;

(ii) How to incorporate disaster reduction and risk management in development planning;

(iii) Knowledge of appropriate risk assessment/risk monitoring methodologies, including those incorporating the use of space technologies (e.g. use of automatic transmissions of information via satellite from *in situ* monitoring stations to a central decision-making facility);

(iv) Technical knowledge required to facilitate local implementation of defensive measures (e.g. restrictions regarding the location of residences and facilities in areas where they may be affected by a hazard, such as an earthquake or volcanic eruption);

(v) How to mobilize funds for implementation of disaster-reduction activities;

(vi) Public access to information on hazards;

(vii) Information on appropriate land-use legislation;

(viii) How to revise regulatory policies to allow effective deployment, including trans-border use, of telecommunications equipment during disasters;

(ix) Appropriate implementation of building codes and zoning laws;

(b) Communications and training:

(i) Building up public awareness of and commitment to disaster management and evacuation planning;

(ii) Training of public administrators of disaster management;

(iii) Dissemination of information on hazards;

(iv) Establishment of local pools of expertise and equipment needed to deal with various aspects of disaster management;

(v) Creation of disaster-related database networks;

(c) Regional/international cooperation:

(i) How to pursue regional cooperation in matters related to disaster management;

(ii) How to inform the international community of national disaster management programmes.

17. *Disaster preparedness and forecasting phase*. This phase includes activities that reflect the readiness or degree of alertness of the public to cope with a specific hazard. It also involves action taken in response to an ongoing or impending hazard; action such as hazard forecasting, warning and prediction. (These three terms are used here in terms of increasing probability, and decreasing time; that is, a forecast will be issued sooner than a prediction, but will have a lower level of confidence.) Preparedness also includes action such as stockpiling and training. Typical information-related needs during this phase are:

(a) Hazard forecasting;

(b) Arrangements for the issue of warnings and evacuations;

(c) Information related to stockpiling operations;

(d) Training for emergency workers;

(e) Information related to locations at risk where emergency equipment (e.g. telecommunications equipment) can be pre-positioned.

18. *Emergency (disaster) response phase*. This phase includes activities taken immediately before and after the onset of a hazard to reduce the effects of a disaster after it occurs. The first stage of disaster relief usually involves assessment of the extent and severity of the damage. Subsequently, relief measures such as delivering food, health care and other sustenance are undertaken. Along with this will be the implementation of the first remedial measures

(e.g. removing dams caused by lava flows or draining flood water back to rivers). The range of typical information needs includes the following:

(a) The issue of warnings following the identification of an impending hazard and the population at risk;

(b) Plans for implementing evacuations;

(c) Plans for administering emergency relief;

(d) Initial evaluation of the impact of a disaster.

19. *Recovery phase*. Disaster recovery includes those actions required to re-establish the community and its infrastructure. Properly carried out, it also includes remedial mitigation measures to prevent the disaster from happening again. Typical actions undertaken during this phase include: the initiation of efforts to restore the most pressing services and the most essential social infrastructure; the repairing of the transportation infrastructure and public utilities and services; and the building of temporary shelters. This phase is also characterized by the return to normal work and the initiation of projects to deal with the immediate consequences of the disaster. The information needs of this phase include:

(a) Localization of the population affected and their needs;

(b) Localization of damaged/destroyed infrastructure or services;

(c) Determination of the most affected sectors and areas;

(d) Identification of post-emergency projects that require financial and technical assistance;

(e) An assessment of the country's ability to contribute its share to efforts to respond to the needs following a disaster;

(f) Communication with the international donor community (Governments, non-governmental organizations and private sector groups that contribute to international disaster relief).

20. *Reconstruction phase*. This is the period during which the physical infrastructure and services damaged or destroyed by the disaster are restored. Information needs during this phase relate typically to hazard reduction measures, such as the design of hazard-resistant engineering structures.

B. Contributions of space technology to information needs

21. Natural hazards cannot be prevented; however, their social and economic impacts can be reduced through the cost-effective use of appropriate technologies. A number of space-based technologies (e.g. telecommunications, Earth observation, geo-positioning and meteorology)* can contribute to the information requirements of the different phases of a disaster management programme and therefore offer significant potential for minimizing the impact of natural hazards.

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*Details on specific space technologies are given in other background papers prepared for the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III). See, in particular, the background papers on the management of Earth resources (A/CONF.184/BP/3), satellite navigation and location systems (A/CONF.184/BP/4), space communications and applications (A/CONF.184/BP/5) and small satellite missions (A/CONF.184/BP/9).

1. Satellite meteorology

22. *Satellite meteorology*. Meteorological satellites now monitor the Earth's atmosphere, oceans and land surface in almost real time. In general, the satellites perform the following three major functions: (a) make remote sensing observations that can be converted into meteorological parameters such as cloud cover, cloud motion vectors, surface temperature, vertical profiles of atmospheric temperature and humidity, snow and ice cover, ozone, solar radiation and infrared radiation, (b) collect data from sensors placed on remote fixed or mobile platforms, located either on the Earth's surface or in the atmosphere, and (c) make direct broadcasts to provide cloud-cover images and other meteorological information to users through a direct read-out station.

23. The satellites provide data that are essential for the day-to-day-prediction of local and global weather and for supporting disaster management activities, such as the early warning of meteorological and hydrological hazards and the preparation of disaster situation reports. The meteorological data are also used for monitoring climatic changes.

24. Both geostationary and near-polar orbiting satellites are routinely used for meteorological applications. At present there are three polar orbiting and six geostationary orbiting meteorological satellites. The satellites are provided by China, India, Japan, Russian Federation and United States and by the European Organisation for the Exploration of Meteorological Satellites (EUMETSAT). The abilities of geostationary satellites to provide a continuous view of weather systems make them invaluable in following the motion, development and decay of such phenomena. Even such short-term events as severe thunderstorms, with a life time of only a few hours, can be successfully recognized in their early stages, and appropriate warnings of the time and area of their likely maximum impact can be expeditiously provided to the general public.

25. Polar-orbiting satellite systems provide data needed to compensate for many of the deficiencies in conventional surface-based observing networks, especially over marine regions and sparsely inhabited land areas. In their near-polar orbit, such satellites acquire data from all parts of the globe in successive revolutions, each of which takes just over an hour and a half. From a relatively low altitude (approximately 800 km), the satellite's sensors can acquire data at high resolution, both spatially and spectrally.

26. Additional meteorological satellites continue to be launched both to replace and to expand existing capabilities. If all currently planned commercial and governmental meteorological satellites are launched, by the year 2010, some 15 geostationary satellites and up to 18 polar-orbiting satellites could potentially be available for use for disaster management

2. Mobile satellite services

27. Mobile satellite services (offering voice, facsimile and data transmission, and paging)* are one of the most effective means of communications in the event of disasters owing to several important advantages that they have over other means of communications: (a) they do not depend on the presence of an existing infrastructure, which may in any event be destroyed or damaged, (b) they are unaffected by ionospheric noise, (c) they are highly portable and can be set up and used anywhere easily and quickly, and (d) they are cost-effective. Several firms offer mobile satellite services.

28. The International Mobile Satellite Organization (Inmarsat) caters to over 80,000 terminals worldwide. Some 5,000 of these are used in disaster management by international organizations, including the Office of the United Nations High Commissioner for Refugees, the International Atomic Energy Agency, the International Committee of the Red Cross, the International Federation of Red Cross and Red Crescent Societies and Médecins sans frontières, various civil protection agencies, and wildfire and rescue services around the world. Among the services offered are voice, facsimile, Internet and data transmission services via laptop-sized satellite stations. The terminals have been used, for example, for monitoring water levels in rivers in Argentina, China, France and India and for ocean monitoring as part of the World Weather Watch of the World Meteorological Organization (WMO). Newly available services that are useful for issuing warnings and community alerts are satellite paging and two-way short messaging.

29. TMI Canada operates the mobile-satellite communications (MSAT) system for mobile voice, facsimile and 2.4 kbps data services; the Australian regional system, Mobilesat, is similar. TMI Canada, together with the American Mobile Satellite Corporation (AMSC) in the United States, forms a regional mobile satellite system with coverage of Canada and the United States. Disaster management agencies, such as the Federal Emergency Management Agency (FEMA) in the United States and Emergency Canada, use these regional systems extensively, not only for coordinating relief, but also for informing people, keeping them in touch with relatives, and helping them to stay calm. MSAT terminals are also used in fixed locations in Canada to help monitor remote forests for outbreaks of fire and in dealing with oil spills. FEMA and the American Red Cross use mobile satellite communications systems during hurricanes and floods and in combating forest fires. To facilitate disaster management, special arrangements are available to governments, municipalities and other organizations that need advanced communications capabilities during natural disasters, industrial accidents, and other emergency situations. These include short-term rentals, special service rates (below US$ 1/min) and 24-hour customer support. A similar disaster warning system, covering 250 strategic locations along the cyclone-prone east coast of India, has been in operation for some time. The system enables decision makers to take appropriate measures to counter impending disasters in a timely manner.

30. Qualcomm, a mobile system using existing Ku-band satellites in Australasia, Europe, North America and South America, provides low-speed data and localization services via mobile terminals. There are approximately 175,000 Qualcomm units in use worldwide, many of which are used for hazardous cargo tracking. Another mobile satellite data system is Orbcomm, a low-Earth orbit (LEO) system operating in the very high frequency (VHF) band, which has been providing commercial data-only service in North America since early 1996. The small Orbcomm units make them particularly suitable for use as personal emergency beacons and for tracking vehicles and equipment.

31. Several new LEO, medium-Earth orbit (MEO) and regional geostationary Earth orbit (GEO) systems are planned; they would provide mobile voice, data, short messaging and paging services that could be of use during emergencies. Iridium, a global consortium, will initiate a LEO system consisting of 66 satellites in 1998. Users will be able to access services via small hand-held mobile units with omnidirectional antennas at a planned cost of US$ 3/min for voice and data transmissions of up to 2.4 kbps. Globalstar, another LEO system consisting of 48 satellites,

*Further details on these systems are presented in the UNISPACE III background paper on space communications and applications (A/CONF.184/BP/5).

is to begin operations late in 1999 and to offer services at a cost of approximately US$ 1/min. ICO Global Communications is implementing an MEO satellite telephone system with 10 satellites that is expected to become operational in the year 2000, at a cost of just US$ 1/min.

32. Of special interest to the disaster management community are special programmes put into place by satellite operators (such as Inmarsat) that are designed to provide free or low-cost access to satellite capacity during emergencies. Operators of some of the planned systems have already announced their own programmes for satellite access during disasters. Iridium, for example, has plans to offer 1,000 minutes free to handsets allocated to disaster mitigation personnel.

3. Geostationary telecommunication satellites

33. Many geostationary satellite systems (e.g. International Telecommunication Satellite Organization (INTELSAT), Eutelsat, Panamsat, Indian National Satellite system for Television and Telecommunications (Insat), Orion, Anik, Palapa)* are used for main-route or back-up communications in telephony, video and data transmission. These systems play a key role in news gathering and broadcasting and can therefore contribute to increasing public awareness of disasters and to the mobilization of international support during emergencies.

34. Several satellite operators are very much aware of the potential contribution of their systems to disaster management and have put appropriate contingency plans into place. For example, the Nippon Telegraph and Telephone Corporation (NTT) of Japan uses a domestic very small aperture terminal (VSAT) system for disaster back-up communications. VSATs with fixed, small-diameter (0.95-metre) antennas are situated at a total of 17 NTT branch offices and other main buildings throughout Japan for bidirectional communication with the hub stations. Additionally, mobile VSATs with antennas 0.75-metre in diameter are stationed at 23 out of 222 NTT service centres. This configuration ensures communication routes between NTT main and branch offices and service centres during and in the wake of natural disasters, allowing telephone calls, facsimile messages and data communications.

35. Commercial operators of Ku-band and C-band satellites offer portable stations for use during emergencies. Such equipment are provided, for example, by INTELSAT, TELESET, European Telecommunications Satellite Organization (EUTELSAT), ITALSAT and various operators in the Russian Federation and the United States. INSAT operates a disaster warning system of community-based VSATs along the eastern shores of India. In the United States, FEMA leases Ku-band capacity, equivalent to two T1s (2x150 Mbps, or 24 voice channels each), on a commercial Ku-band satellite at all times so that they can have immediate access. The Ku-band terminals are mounted on trucks and on deployment are linked to transportable telephone switches to provide telephone services to disaster field posts.

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*Further details on these systems are presented in the UNISPACE III background paper on space communications and applications (A/CONF.184/BP/5).

4. Navigation and geo-positioning systems

36. The Global Positioning System (GPS) and the Global Orbiting Navigation Satellite System (GLONASS) provide position determination that is used for localization, tracking of equipment and vehicles, and emergency personal beacons. Such navigation and geo-positioning systems* support a wide variety of activities related to disaster management.

37. Geo-positioning systems, in conjunction with data communications satellites, are used to track hazardous cargoes, including radioactive materials. With GPS ground receivers, it is also possible to detect relative ground motions as low as a few millimetres a year between points separated by hundreds of kilometres. Utilizing the maximum precision of GPS, scientists are able to monitor movements of tectonic plates and other seismic hazards. Such monitoring permits the assessment of earthquake risk. The data are also useful in predicting the eruption of volcanoes and the occurrence of landslides. GPS technology, in conjunction with complementary instrumentation, also allows the worldwide study of atmospheric water vapour and provides data needed for understanding potentially hazardous climatic phenomena.

5. Internet and other broadband applications

38. Rapid growth in demand for Internet, multimedia and other broadband services has prompted the development of new broadband satellite constellations in both LEO and GEO. These services can now be used for disaster management. In some countries, the Internet already facilitates public access to map-based information that is useful in reducing vulnerability (e.g. maps showing the locations of flood-plain areas relative to planned building sites).

39. Teledesic, a LEO broadband system consisting of 288 satellites, should be available in the year 2002. It will allow Internet connections via low-power terminals connected directly to computer networks or individual personal computers at speeds of up to 2 Mbps during uplink and up to 64 Mbps during downlink. Several other LEO systems are planned, including M-Star (72 satellites), Celestri (63 satellites), and SkyBridge (64 satellites). Planned GEO broadband systems include Spaceway, Cyberstar, Panamsat and Orion.

6. Remote sensing satellites

40. Remote sensing satellites** provide data that have proved useful for a wide range of applications in disaster management. These include the mapping and monitoring of hydrological and seismic hazards, variables affecting climate and weather, land use, the extent of damage due to volcanic eruptions, oil spills, forest fires, the spread of desertification, and the forecasting of floods and droughts (see table 1).

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*Further details on these systems are presented in the UNISPACE III background paper on satellite navigation and location systems (A/CONF.184/BP/4).

**Further details on remote sensing satellites can be found in the UNISPACEIII background paper on the management of Earth resources (A/CONF.184/BP/3).

Table 1. Examples of the uses of space remote sensing in disaster management

Hazard	*Disaster management phase*		
	Mitigation	*Preparedness (warning)*	*Relief*
Earthquakes	Mapping geological lineaments and land use[a]	Geodynamic measurements of strain accumulation[b]	Locating stricken area and mapping damage[c]
Volcanic eruptions	Topographic maps[d] and land-use maps[a]	Detection and/or measurement of gaseous emissions[b,d]	Mapping lava flows, ashfalls, and lahars[a] and mapping damage[c]
Landslides	Topographic maps[d] and land-use maps[a]	Soil porosity; rainfall, slope stability[b,d]	Mapping slide areas[c]
Flash floods	Land-use maps; satellite estimates[a]	Local rainfall measurements[b,d]	Mapping flood damage[c]
Major floods	Flood-plain maps;[b] land-use maps [a]	Regional rainfall; evapo-transpiration[b]	Mapping the extent of floods[a]
Storm surges	Land-use and land-cover maps[a]	Sea state;[a] ocean surface wind velocities[b]	Mapping the extent of damage[c]
Hurricanes	Positions and intensities[a]	Synoptic weather forecasts[b,d]	Mapping the extent of damage[c]
Tornadoes		Nowcasts; local weather observations[b]	Mapping the amount and extent of damage[c]
Droughts	Soil wetness; vegetation index[a]	Long-range climate models[b,d]	Monitoring vegetative biomass; station communications[a]

[a]Already operational or needs very little research.
[b]Research and development required.
[c]Requires improved spatial or temporal resolution.
[d]Requires improved observation capability.

41. Information from remote sensing satellites is combined with other relevant data in geographic information systems (GIS) in order to carry out risk assessment and help identify areas at risk such as flood zones. The ready availability of flood-zone maps tends to discourage the development of housing in areas susceptible to flooding and reduces the magnitude of damage and human suffering caused by any subsequent floods.

42. Outbreaks of cholera in Bangladesh have been associated with seasonal coastal algal blooms and El Niño warm events. El Niño events have also been linked to outbreaks of disease (e.g. typhoid, shigellosis, hepatitis, viral encephalitis, eastern equine encephalitis, malaria and dengue) in other parts of the world. Remote sensing measurements, for example, of ocean colour, sea surface temperature and topography, are useful in mapping algal blooms and in forecasting the onset of El Niño events. These observations indicate the feasibility of devising an early warning system for predicting and monitoring cholera and other diseases based primarily on satellite data.

43. Using the techniques of interferometry and radargrammetry, data from radar satellites are used to forecast volcanic eruptions and earthquakes and form the basis of public warnings by disaster management organizations. Images from the RADARSAT satellite were used in 1996 in the control of a major oil spill off the coast of Wales and in the analysis and preparedness measures in the Canadian flood in 1997.

44. Ongoing research and development will lead to improvements in the measurement of several remotely sensed parameters. These improvements will enhance further the utility of remote sensing satellites for disaster management (see table 2).

C. Economic and social benefits

45. The benefits to society of the use of space technology in disaster management relate to its cost-effective use in the reduction of the impacts, both long-term and short-term, of disasters. Some notable examples of the beneficial application of space technologies are presented below.

1. Emergency communications

46. Natural disasters tend to destroy or severely disrupt terrestrial telecommunication networks. Satellites play a vital role in enabling critical activities, such as the collection and dissemination of disaster and emergency news, the issuance of warnings, the provision of back-up communications for the continuation of government and business activities, and the transmission of data from remotely located sensors, to continue.

Table 2. Remote sensing applications in disaster management to be enhanced by research and development

(R and D = research and development; SAR = synthetic aperture radar)

R and D activities	*Technological approach*	*Applications*
Soil moisture maps and measurements	Passive or active microwave; thermal mapping	Flood warning; drought assessment
Rainfall, rainfall rate	Passive or active microwave; thermal remote sensing of cloud top temperatures	Flood warning; drought assessment
Storm-track monitoring	Improved spatial resolution from geosynchronous orbit; atmospheric winds (lidar); surface winds (scatterometer)	Improved landfall predictions in space, time, and intensity
High spatial resolution mapping	Pointable imagers; improved detector arrays; lower orbits	Detailed land-use and land-cover maps; assessment of landslide vulnerability; topographic mapping; risk mapping of urban and industrial zones
Topographic mapping	Interferometric SAR; high-resolution off-nadir imaging	Flood-plain models; landslide vulnerability; volcanic vulnerability
SAR interferometry	Repetitive SAR observations	Surface deformation for earthquake risk assessment; volcano warning

47. A specific example of the use of satellite technology for emergency communications is the International Search and Rescue Satellite System (COSPAS-SARSAT),* the space segment of which is provided by several nations. Receivers on board several meteorological and navigation satellites are tuned to pick up signals emitted from transmitters activated in distress situations (such as a sinking ship or persons injured in a wilderness area). These signals, depending on the satellite and transmitter features, may take anywhere from a few minutes to a couple of hours to locate the point with an accuracy of about 1 kilometre, or far less if integrated GPS is used. Several thousands of sailors, airline passengers and other individuals in distress owe their lives to this system, which has been operational for over a decade. COSPAS-SARSAT has recently been augmented by geostationary satellite search and rescue payload systems, such as the one on INSAT, which has served to reduce the time for detection of disasters. In addition to COSPAS-SARSAT, the data collection system (DCS) carried on United States geostationary satellites is used for disaster mitigation by many countries. DCS provides data relay from ground-based sensors in a wide variety of applications, ranging from the monitoring of earthquakes to the measurement of rainfall.

2. Hazard forecasting and monitoring

48. By allowing society time to prepare for or avoid an impending hazard, forecasting and early warning systems have dramatically reduced deaths, injuries, property damage and other economic losses. Space technologies, particularly telecommunications, remote sensing and geo-positioning, are a key component of these systems. Space technology also provides timely and comprehensive information on ecological conditions conducive to support the massive development of desert locusts, thereby helping countries to apply appropriate combative measures in the field and ultimately to enhance food security (e.g. the African Real-Time Environmental Monitoring using Imaging Satellites (ARTEMIS) and the Direct Information Access Network for Africa (DIANA), both of the Food and Agriculture Organization of the United Nations.

49. Remote sensing imagery from satellites is readily applied in the mapping of zones threatened by a wide range of hazards. This information helps to reduce risk by informing communities of the probability of certain hazards and of the need to include risk as a factor in making investment decisions. In this manner, for example, the human settlement of zones at risk of flooding may be reduced. Similarly, buildings to be located in known earthquake-prone zones may be constructed to standards that reduce structural damage caused by eventual earthquakes.

50. Data from meteorological satellites are of direct value to disaster management, for example in (a) monitoring severe storms of various kinds, (b) estimating heavy precipitation, both rain and snow, and (c) estimating tropical cyclone strength. The National Oceanic and Atmospheric Administration (NOAA) of the United States produces rainfall estimates from its geostationary satellite system every few hours for heavy precipitation events and for hurricanes that cross coastlines and continue overland. Additional data, such as soil wetness index, are used to assist in monitoring floods. The Advanced Very High Resolution Radiometer (AVHRR) is being used operationally for monitoring volcanic clouds that are hazardous to aircraft, as well as for monitoring extensive wildfires, such as those that occurred in Indonesia in 1997. The Total Ozone Mapping Spectrometer (TOMS), first launched aboard Nimbus-7, has also proved useful for monitoring explosive volcanic eruptions. Moreover, AVHRR, with spectral bands capable of measuring vegetative biomass, is also being used operationally for drought monitoring in the United States and elsewhere (e.g. the Famine Early Warning System (FEWS) in Africa and the National Agricultural Drought Assessment and Monitoring System (NADAMS) in India).

51. The FEWS project is an example of the operational use of satellite technology in disaster management with clear benefits to the local population. The aim of FEWS is to reduce the incidence of famine in sub-Saharan Africa by monitoring the agricultural growing season. Monitoring is carried out through “greenness maps” derived every 10 days from AVHRR data. The maps allow analysts to monitor the development of vegetation in agricultural areas,

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*Space system for tracking ships in distress (COSPAS) of the Russian Federation and Search and Rescue Satellite-Aided Tracking System (SARSAT) of the United States.

comparing contemporary data with similar maps obtained continually since 1982. In addition, every 10 days, rainfall estimates derived from geostationary weather satellites are also compared with long-term averages. Additional information, such as *in situ* rainfall, field agricultural information and commodity price data, are taken into consideration in assessing famine risk using the FEWS approach.

52. Information on surface winds from the NSCAT microwave scatterometer (an instrument that was carried on board the Advanced Earth Observation Satellite (ADEOS) has significantly improved weather forecasting; 72-hour forecasts have been made with the same accuracy as was previously achieved 48 hours in advance. The recently launched Tropical Rainfall Measuring Mission (TRMM) is designed primarily to study the energetics of precipitation over tropical oceans. It is likely that techniques developed for TRMM for measuring rainfall will eventually be applied to the measurement of rainfall over land, thereby providing valuable information for disaster management applications such as flood and drought assessment. Analysis of European remote sensing satellite (ERS-1) scatterometer data over the Indian Ocean indicates a dramatic reversal in the wind direction over the west Arabian Sea three weeks in advance of the monsoon, followed by a large increase in wind velocity coinciding with the monsoon onset, a useful result relevant to the issuing of monsoon predictions.

3. Information exchange

53. Space-related technologies facilitate the communication and dissemination of information and thus play an important role in building public awareness of hazards and in subsequently reducing vulnerability. Among other things, these technologies make possible the broadcasting of appropriate radio and television programmes, as well as the use of computer networks for disaster management purposes (e.g. access to information on hazards or on persons affected by disasters). In addition, the technologies support basic telemedicine applications that can be of significant value during the emergency response phase of some disasters. The World Health Organization (WHO) is increasingly using mobile satellite communications in its field operations aimed at combating diseases or reducing health hazards.

III. INTERNATIONAL COOPERATION

A. Global and regional programmes and proposals

54. WMO coordinates the international World Weather Watch programme, through which national meteorological services can obtain information on meteorological hazards. Observations from land-based stations, aircraft, ships, buoys and geostationary and polar-orbiting meteorological satellites are exchanged worldwide through the Global Telecommunication System (GTS) of World Weather Watch. The data are received and analysed at various meteorological centres at the national, regional and global levels. The forecasts produced are disseminated through GTS and are used by national centres to support the issuance of warnings. Through World Weather Watch, national meteorological services are given technical guidance in a number of areas, including risk assessments, storm-surge modelling, flood-plain modelling and the design of defensive structures and measures (e.g. flood-protection works, windbreaks, shelter belts, building codes, and evacuation planning).

55. Among the current proposals for an international system for disaster management is the Global Disaster Observation System (GDOS), proposed by the Society of Japanese Aerospace Companies. GDOS would consist of a network of already existing and new satellites with capabilities of detecting and monitoring a variety of natural hazards (e.g. wildfires, volcanic eruptions, typhoons and hurricanes) at appropriate spatial and temporal resolutions, on a continuing operational basis. Together, these satellites would, in the event of disasters, provide information on a near-real-time basis that would facilitate emergency response activities. They would also routinely acquire data needed for improving forecasting methodologies.

56. The United States has initiated a study of the feasibility of establishing a global disaster information network. With the broad participation of various key federal agencies, the initial stage of this network has been defined as encompassing the disaster-information communication needs of the United States. However, it has been agreed that, as the network becomes more firmly established in that country, it will be broadened to include similar international needs by involving other nations and the international community of disaster management practitioners.

57. It is generally acknowledged that telecommunications laws need to be modified in order to better meet the needs of disaster management. This recognition has led to the development of the draft convention on the provision of telecom resources for disaster mitigation and relief operations. The draft convention, which is expected to be adopted by States in 1998, would call for the removal or reduction of regulatory barriers to the use or transborder movement of telecommunications equipment, including satellite Earth stations, in disaster relief and related humanitarian applications.

58. A regional programme, Space Techniques for Major Risks Management (STRIM), is currently being developed by the Council of Europe, the European Commission, Centre national d'études spatiales (CNES) of France, and the European Space Agency (ESA). STRIM places emphasis on (a) training of staff concerned with risk management (e.g. civil protection organizations), (b) pilot projects, in cooperation with users, showing in concrete terms the advantages and the limitations of space technology for risk management, (c) exploitation of existing space-segment capabilities, and (d) recommendations for its future evolution.

59. The Committee on Earth Observation Satellites (CEOS) is in the process of defining internationally coordinated requirements for Earth observation capabilities through detailed studies in six project areas. One of the projects, led by the National Environmental Satellite, Data and Information Service (NESDIS) of NOAA, concerns the requirements for satellite (and ancillary) observations to support disaster management.

60. The secretariat of the International Decade for Natural Disorder Reduction, in conjunction with the United Nations Office for Project Services, the Economic Commission for Europe, the United Nations Development Programme, the United Nations Educational, Scientific and Cultural Organization (UNESCO), WHO and WMO, is working on initiatives related to early warning, the protection of industrial assets in countries with economies in transition, and the potential of public and private sector partnerships. One of the initiatives is the Leadership Coalition for Global Business Protection programme, which involves senior representatives of multinational corporations, selected major cities of the world, United Nations organizations, non-governmental organizations and international risk management officials. The initiative has been spearheaded by IBM Global Services in close collaboration with the secretariat of the Decade. Its aim is to engage corporate and public executives in sustained hazard assessment and risk management for the protection of common social and economic assets.

61. The Council of Europe, through its EUR-OPA programme, has sponsored the creation of an interactive database on space-related system providers, applications and solutions. The database is available to all disaster mitigation experts concerned with both natural and technological disasters and emergencies. Other databases with specific information on space techniques used in disaster mitigation exist on numerous World Wide Web sites in Japan, the United States and countries in Europe.

62. Several regional programmes or projects that depend on the use of space technologies for disaster management are already being planned. These include FUEGO, a project that will consist of a constellation of small satellites to be used for combating forest fires in the Mediterranean area. The Centre of Operational Services for the Mediterranean Environment (COSME) programme network will permit decision makers to access and exchange information and to benefit from services in order to resolve environmental problems. In this network, plans are being made to share data from high resolution satellite images using digital networks. A telecommunications satellite to cover needs in the Mediterranean area is also planned.

B. Education, training and technology transfer

63. Several international and regional organizations are involved in activities (e.g. seminars, workshops, courses, conferences, studies, technology-development programmes) aimed at the promotion of the use of satellites in disaster management, especially in developing countries. These include the Office for Outer Space Affairs, the Asia-Pacific Satellite Communications Council (APSCC), the American Institute of Aeronautics and Astronautics, the Centre for Space Science and Technology Education in Asia and the Pacific, the Confederation of European Aerospace Societies, the International Space University, the secretariat of the International Decade for Natural Disaster Reduction, UNESCO and WHO, as well as several space agencies and universities.

64. The Council of Europe, through its EUR-OPA Major Hazards Agreement, has co-sponsored with ESA a major study of disaster mitigation techniques, entitled “Study of space technology applications: identification of information and systems requirements for natural and technological disaster management”. The study identifies, among other things, national approaches and concrete requirements for all major types of hazards. The Joint Research Centre in Italy supports a wide range of studies into the applications of space techniques to disaster mitigation.

IV. SOME SELECTED ISSUES OF INTEREST TO MEMBER STATES

A. Need for adequate infrastructure for information exchange

65. Despite the importance of adequate information exchange in all phases of disaster management, a number of Member States do not yet have the required telecommunications infrastructure that would support the reception and processing of disaster-related information, both nationally and internationally. Data from a variety of Earth observation, geo-positioning and communications satellites are useful for forecasting and tracking natural hazards, for educating the public and for subsequently issuing warnings of impending disasters. After a disaster has struck, communications are essential for maintaining links among disaster response officials, the government, affected populations, and sources of emergency relief supplies. Communications are crucial to the effective functioning of disaster prevention and relief organizations, whether private, national or international. Communications (among scientists, insurers, the media, the public, disaster response officials, and policy makers) are again crucial in studying hazards and in developing and implementing effective disaster prevention approaches. However, despite their value to development in general and to disaster management in particular, basic telecommunications services remain inadequate in some countries. In others, there is a need for disaster resistant forms of communications. It is therefore extremely important for countries to identify appropriate mechanisms that would lead to the acquisition of the necessary telecommunications infrastructure that they presently lack.

B. Need for higher national priorities for disaster management activities

66. Insufficient attention is being paid in a number of developing countries, particularly those in hazard-prone areas that have not recently experienced disasters, to implement appropriate disaster-management measures. Usually, only a small proportion of disaster-related expenditure is aimed at preventing or mitigating a disaster before it happens. Society as a whole (that is, individuals, the private sector, as well as governments) finds it difficult to justify expenditure in response to events that may happen, especially when confronted with many more immediate problems.

67. For disaster management to be truly effective, proactive measures need to be taken. Such measures include, for example, the establishment of early warning systems in all areas prone to hazards, pre-positioning of telecommunications equipment in strategic locations or areas known to be at risk, training and education on telecommunications technology for disaster management, and the enacting of legislation permitting the effective use of telecommunications equipment, including the transborder use of such equipment, during emergencies. Providing adequate financial support to education and training programmes (for example, in the use and interpretation of satellite imagery for disaster management) for civil protection managers and staff, as well as promoting awareness at the community level, is vital to reaping the maximum benefits from satellite systems.

68. A given type of natural hazard varies from one geographical region to another. It is therefore necessary for many countries to develop risk assessment methodologies and operational disaster management approaches that are adapted to the local risks. Identification of the national entity responsible for funding such research and development activity is often made difficult by the multiplicity of services at the national level whose mandates touch on disaster management. Enhanced coordination at the national level would better define user requirements and would ultimately increase the benefits that can be gained from space technology.

69. Although much research has been conducted on the applications of space technology to disaster management, the results have not been sufficiently integrated into operational activities. That would require better consultations at the national level among the various services concerned with disaster management, research organizations and the providers of space technology systems. The operational approaches to disaster management (including the techniques used for converting satellite data into information useful for disaster management) eventually adopted by each country would be of value to others. This information should therefore be shared with the international community.

C. International cooperation

70. At present, no mechanism exists to allow the disaster management community to have efficient and simple access to space assets, nor is there any clear articulation of the specific needs of the disaster management community that would enable owners of space assets to develop resources that cater for those needs. It has been suggested that, to facilitate a dialogue between users and service providers, an organization should be established. This body could, among other things, be responsible for (a) researching the needs of the disaster management community, (b) applying existing assets, and (c) suggesting new applications. The organization would allow for economies of scale and rationalization of the use of current space assets. If structured as a value-added service provider, such an organization could be a business that would market services to governmental and non-governmental disaster managers throughout the world.

71. The draft convention on the provision of telecom resources for disaster mitigation and relief operations (see paragraph 57 above) should be adopted by Member States. Humanitarian organizations are major users of mobile satellite telecommunications equipment. The rapid deployment of such equipment in the field during an emergency should not be compromised by the necessity of obtaining clearance for their importation by national authorities. Related issues are agreements for facilitating communications during disasters (e.g. protocols for use, access priorities, allowed frequencies and favourable tariff structures for emergency communications).

72. International electronic networks that would facilitate information exchange within the disaster management community should be established. Such networks would be helpful in (a) the coordination of search-and-rescue teams from different countries, (b) the research of appropriate remote sensing and satellite communications technologies, (c) the assessment of the impact of disasters (e.g. damages and casualties), and (d) the evaluation of the types of disaster-related equipment and expertise available in countries and from international relief organizations.

73. Bilateral and multilateral development agencies should integrate into their decision-making processes the levels of risks posed by natural hazards. Projects that serve to reduce the risks of natural hazards should be given priority consideration from donor agencies for funding.

D. Access to satellites during emergencies

74. The portion of the total traffic of the world's telecommunications satellites that is used for natural disaster purposes is very small. However, the benefits that society gains from that use are significant. It is indispensable, therefore, to maintain emergency access to those satellites. Similar emergency access should also be ensured for data from geo-positioning and remote sensing satellites. The availability of satellite remote sensing data— often in near real time—is essential to its beneficial and effective usage in disaster management. It should be noted that near-real-time reception of data from satellite sources requires countries to have the appropriate telecommunications infrastructure (see paragraph 65 above). This issue is currently being considered in a CEOS pilot project on disaster management support.

E. Access to relevant information and techniques

75. While data and information derived from satellite observations can do much to assist in the important work of disaster management, they provide only a part of the total information needed for overall disaster management. Countries should therefore ensure that the non-space components of disaster management are adequately supported. Other information, relating to, for example, physical, cultural, and socio-economic conditions, must be available in order to derive useful information from satellite observations. Furthermore, such ancillary data should be made available in digital form in order to facilitate their rapid incorporation into GIS.