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Paper Session III-B - The Global Emergency Observation, Warning and Relief Network (GEOWARN); Utilization of NASA's Mission to Planet Earth in Disaster Management

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The Global Emergency Observation, Warning and Relief Network (GEOWARN);

Utilization of NASA's Mission to Planet Earth in Disaster Management

by

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Abstract

The United Nations has proclaimed the decade of the 1990's as the International Decade for Natural Disaster Reduction (IDNDR). The Global Emergency Observation Warning and Relief Network (GEOWARN) was conceived in response to this initiative as a system that could improve disaster management capabilities by providing a mechanism for the timely processing and dissemination of remote sensing and other disaster related information. Improved information management capabilities would complement the activities of international and national disaster management agencies, as well as local government and private response organizations. The GEOWARN system concept originated as a student design project during the 1993 International Space University (ISU) Summer Session. The student team developed a system design that would utilize data from existing remote sensing resources augmented by additional satellite and airborne sensor platforms and an extensive Geographical Information System, linked via a computer network. This network would contribute to the task of providing global disaster warning and relief support. The NASA Marshall Space Flight Center performed a subsequent study to assess the concept feasibility. and refine the ISU concept. It was concluded that a system design which optimizes the use of existing resources can provide significant improvements in disaster warning and management capabilities worldwide. It was also concluded that NASA resources and the Mission to Planet Earth Program could make valuable contributions toward the implementation of the GEOWARN system. This paper presents the results of the feasibility study, including a general overview of the GEOWARN concept and the elements of the system.

Introduction

The impact of natural hazards on humanity is an ever-increasing problem, especially as the population increases and migrates to vast urban centers. Natural disasters have caught the attention of public officials, as well as disaster management, relief, and humanitarian organizations worldwide. There is a significant thrust in the United States Government, the United Nations, and governments around the world to focus efforts on mitigating the deleterious effects of natural hazards on the human population and supporting infrastructure. To emphasize the need for disaster mitigation on a global scale the United Nations (UN) has declared the decade of the 1990's to be the International Decade for Natural Disaster Reduction (IDNDR). Fortunately, technology exists which can make a significant impact on reducing the effects of natural disasters. Indeed, no technological breakthroughs are required to implement a global system capable of providing sufficient information to aid in the prevention, preparedness, warning, and relief from natural disaster effects. The Global Emergency Observation Warning and Relief Network (GEOWARN) would combine the elements of remote sensing, data processing, information distribution, and communications support on a global scale to support natural disaster mitigation. GEOWARN would contribute toward a significant improvement to the disaster warning and relief capabilities for many parts of the world, including the United States.

Origin of the GEOWARN Concept

The GEOWARN Concept was originally developed at the 1993 Summer Session of the International Space University (ISU) hosted in Huntsville, Alabama, USA. During the ten weeks of intensive interdisciplinary space studies, the international student body engaged in the development of two student design projects. GEOWARN was one of the design projects and was supported by 38 students from 16 countries in America, Europe, Africa, and Asia. The four primary functions of the proposed GEOWARN system include data collection, data processing, information distribution, and communications support. The GEOWARN system will provide value-added information to disaster management officials to support their preparedness, warning, and relief efforts. Data will be collected via existing and planned space-based, airborne, and ground-based remote sensing platforms. The data processing elements the GEOWARN system will include historical data, geographical information systems, relational data bases and simulations of hazard phenomena. Data will be processed and converted to usable products based on specific information requirements, then transmitted to the appropriate government and private disaster management agencies.

There are many immediate and tangible benefits of the GEOWARN system. The most significant is the reduction in human suffering throughout the world. The system would also result in economic savings by reducing the extent of damage through preparations that could be made with adequate warnings or by more efficient disaster response activities. When compared to the total economic impacts of disasters, the cost of implementing GEOWARN is relatively small. These costs would be compensated for very quickly by the cost avoidances realized. GEOWARN does not require any new technology, rather it is a system which would utilize many existing technologies in an innovative and efficient manner. As such, GEOWARN would provide many advantages to regions of the world that normally would not derive the benefits of technology.

Based upon an extensive characterization of natural hazards, and an evaluation their impacts on humanity, the ISU student design team developed a set of functional and technical requirements for a global warning and relief system. A plot of the average annual global economic losses versus the number of deaths attributable to each of nearly 40 hazards was developed and is shown in Figure 1. Immediately apparent from the plot is that the vast majority of damage and death results from only six natural disasters. The most significant annual economic and human loss is incurred from drought and infestation. In fact, more than one third of the world's food supply is lost to drought, infestation, and crop disease every year. The six primary disasters fall into two classifications, rapid-onset disasters and long-term disasters. Rapid-onset disasters include floods, cyclonic storms, and earthquakes. Long-term disasters include drought, infestation, and crop disease. It was assumed that the six primary disasters would drive the requirements for the GEOWARN system, and that if the GEOWARN system satisfied the requirements for the these disasters then it would satisfy the requirements for virtually all other natural disasters.

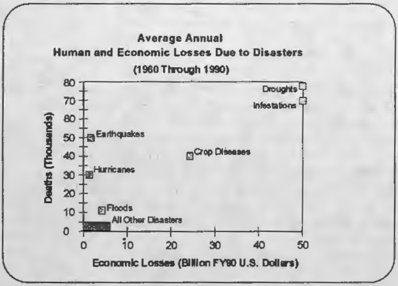

Figure 1. Disaster Priorities Identified by ISU

Based on the technical requirements derived for the system elements, the ISU design team developed an architecture for the GEOWARN concept which is depicted in Figure 2. The ISU students envisioned GEOWARN as an international consortium open to all nations. Existing and planned weather and remote sensing satellites would be utilized as part of the GEOWARN space-based remote sensing element, but to obtain the temporal, spatial and spectral coverage required for full system implementation, the ISU team proposed the development of six new satellites that would be placed in polar orbits equally spaced around the globe. The sensor suite onboard these satellites would be comprised of visible, infra-red, and passive microwave detectors. Augmenting the space-based remote sensors would be a fleet of 30 aircraft dispatched from 20 different locations around the world to provide rapid response capability for disaster relief. These aircraft would be outfitted with a sensor pod of visible, infrared, and synthetic aperture radar sensors. Other sources of information external to the GEOWARN system would include ground based sensors such as earthquake sensors and weather radars. Data processing and information distribution would be accomplished at five Multi-National Centers (MNC's) located on the five major continents. Each MNC would maintain extensive data bases, archives, simulations and geographical information systems for a specific region. GEOWARN Headquarters would function as a management center. Data and information would be shared between MNC's via existing telecommunications systems, the Internet or direct satellite data links when required.

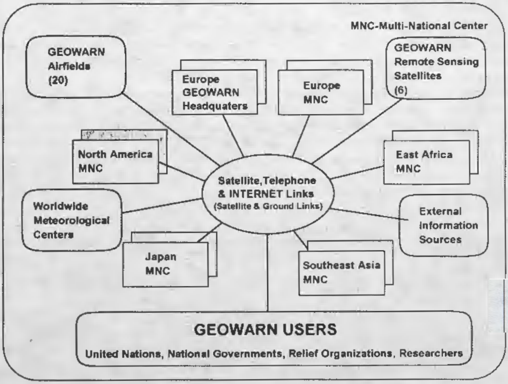

Figure 2. ISU Proposed GEOWARN Architecture

The NASA Marshall Space Flight Center GEOWARN Feasibility Study

In an unfunded concept feasibility study begun in November, 1993, the Program Development Office of the Marshall Space Flight Center (MSFC) undertook to examine in detail the work done during the ISU '93 Summer Session. A team of fifteen engineers and scientists, which included a student from the ISU GEOWARN design team, evaluated the merit of the concept. The goals of the feasibility included: 1) assessment of the technical, programmatic, and implementation aspects of GEOWARN; 2) identification of remote sensing, communication and data processing requirements; and 3) identification of space based, airborne, and ground based GEOWARN elements. The study results were documented in May, 1994.

The MSFC Feasibility Study concluded that since the GEOWARN system is primarily an information resource rather than an operational or monitoring organization, the system could be managed within the established disaster management agencies of the GEOWARN participants. Decentralized international, national and regional management and coordination of GEOWARN elements might provide a more efficient alternative to the Multi-National Centers proposed in the ISU study. The decentralized organization structure would allow individual countries to utilize GEOWARN elements within the framework of their established disaster management agencies and potentially have more control in defining products best suited to their needs. The MSFC study did not attempt to define a detailed system architecture because there were numerous issues that require further study.

It was also concluded that a significant disaster warning and relief capability could be achieved through the use of existing and planned remote sensing satellites if timely access to the measurements were possible. Many of these satellites have been proposed as part of Earth Observing System under NASA's Mission to Planet Earth (MTPE) Initiative. While the primary objective of this initiative is to monitor the Earth as an ecological system and understand global climate changes, many of the remote sensing elements of MTPE could be directly applied to natural disaster monitoring. The use of existing and planned satellites reduces the requirement for additional satellites to support the initial phases of the GEOWARN system. Additional satellites would however, provide increased and more frequent surface coverage as they are incorporated into the system. The planned MTPE satellites that could have potential applications to GEOWARN are listed in Table 1.

Table 1. Mission to Planet Earth Remote Sensing Satellites

Year	EOS Mission	MEASUREMENTS
1997	TRMM (Tropical Rainfall Measuring Mission)	Earth's Thermal Radiation Distribution and Variability of Lightning
1998	AM 1 (Sun Synchronous Platform w/ Morning Crossings)	Earth's Thermal Radiation Biological & Physical Processes, Imagery
	Color	Ocean Biomass and Productivity
1999	SEAWINDS	Map Ocean Surface Winds
	ALT RADAR (Altimeter Radar)	Topography of Sea Surface and Polar Ice
	ACRIMSAT (Active Cavity Radiometer Irradiance Monitor)	Variability of Solar Irradiance
2000	AERO 1/SAGE (Stratospheric Aerosol Gas Experiment)	Atmospheric Aerosols
	PM 1 (Sun Synchronous Platform w/ Afternoon Crossings)	Earth's Thermal Radiation Biological & Physical Processes, Imagery Atmospheric Temperature, Humidity Cloud Water, Precipitation
2002	CHEM1	Atmospheric Chemical Species
2003	ALT LASER (Laser Altimeter)	Ice Sheet Topography and Cloud Heights
2004	AM 2	Same as AM 1
2005	ALT RADAR (Altimeter Radar)	Topography of Sea Surface and Polar Ice
2006	PM 2 (Sun Synchronous Platform w/ Afternoon Crossings)	Same as PM 1

GEOWARN will use a broad communications and data management architecture as illustrated in Figure 3. Existing global communications systems such as INTELSAT and INMARSAT, and future communication networks such as IRIDIUM (Motorola), Odyssey (TRW), Goldstar (Loral/Qualcomm), and Project 21 (INMARSAT) will provide a pathway to global communications that would be of great benefit to the GEOWARN system. Data processing could be accomplished in several ways. Remote sensing information could be converted into specific GEOWARN products by the satellite operators at the ground receiving stations or by commercial companies, such as EOSAT, that processes raw satellite data. EOSAT receives data from LANDSAT, and processes the data to generate final products in the form of photographs, magnetic tapes, or compact discs. Another method for processing remote sensing data could utilize NASA resources such as the Distributed Active Archive Centers (DAAC's) which are part of the Mission to Planet Earth's EOS Data and Information System.

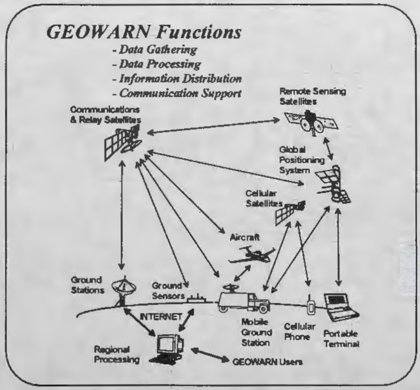

Figure 3. GEOWARN Communications and Data Management Architecture

The EOSDIS will provide data archive, distribution and information management for NASA's Earth science satellites. It will use a distributed open system architecture to take advantage of the institutional capabilities of the participants of the EOS program. The EOSDIS will consist of a number of data facilities networked together to provide large capacity and easy connectivity. Tool kits will be available to users which require as little as a as a personal computer and a modem to access EOSDIS services. The EOSDIS data centers are divided into Internal and External Networks. These networks could provide the framework for distributing GEOWARN information and data products. These products could be generated by the eight DAAC's which will be based at various NASA Center's and other institutions. Each DAAC is responsible for managing a particular type of data as shown in Figure 4. Command uplink and data capture will occur through NASA's Tracking and Data Relay Satellite System (TDRSS) at the White Sands Complex in New Mexico. The Fairmont, West Virginia facility will provide production processing. Affiliated Data Centers are non-EOS data centers that will provide special access to non-EOS data such as National Oceanic and Atmospheric Administration data.

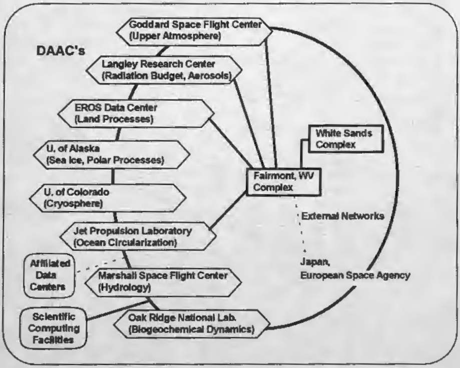

Figure 4. EOSDIS Networking Strategy

Future Studies and Demonstration Projects

The Marshall Space Flight Center Study has identified many potential roles for NASA in the definition of the GEOWARN system and the development of system components. Prior to specifying the details of a final system configuration, an in-depth technical requirements study is necessary to ensure that all critical parameters are addressed by the system. Such a study was not possible in the limited time available to the ISU team. An advanced requirements study will be initiated by MSFC in 1995. To support the planned advanced studies, demonstration projects will also be proposed. These are currently planned at a local, state, and regional level and would make use of space and airborne remote sensing data and elements of NASA's Mission to Planet Earth. Cooperation among several US Government and State agencies is planned. Efforts to involve international organizations in the studies are ongoing. The European Space Agency, the Canadian Space Agency, and other international organizations, have expressed interest in participating in the development of the GEOWARN system. The MSFC study identified a number of agencies throughout the United States and the world that are aggressively pursuing individual projects which could be integrated into the GEOWARN concept. These activities could provide the basis for future cooperative efforts.

Conclusion

The United States is in the enviable position of having instantaneous access to satellite produced weather information for virtually the entire population. The United States also has a highly developed communications and emergency response infrastructure. Unfortunately, much of the rest of the world does not have the same capabilities. This has always been a difficult barrier to overcome when a disaster occurs and rapid access to information and communication is critical. The astounding advances in the computer and communications technology in recent years may allow these barriers to be reduced. The GEOWARN system is a concept that would integrate current remote sensing, data management and communication technologies to provide disaster warnings and aid in disaster response on a global scale.

The primary objective of the Marshall Space Flight Center's feasibility study was to assess the technical feasibility of the GEOWARN concept and identify potential study areas and roles for NASA in defining this system. The study achieved both of these objectives. A thorough assessment of the International Space University study revealed more than sufficient justification for the development of a GEOWARN system. The technology needed to implement a system on a global scale currently exists. There are many related activities currently in progress that would contribute directly to the implementation of a GEOWARN system. These activities and the technology associated with them merely need to be integrated into a cohesive system to provide a significant benefit to humanity in disaster warning and response capabilities.

The development of a global disaster warning system has been considered one of the most promising applications of space technology. It is evident that much of the technology that is used for scientific investigation of the Earth's environment and global communications can be applied directly to mitigate the impacts of natural disasters on humanity worldwide. There is also a potential for the reinvestment and dual use of technologies that have been developed for military purposes. However, in addition to technical solutions, there are many social, political, and legal issues which must be addressed concurrently with the technical activities. Development of the GEOWARN concept will require significant inter-agency and international cooperation. The advanced studies to be performed by NASA will address the technical and, to some degree, the policy issues associated with this promising concept.

There are many potential roles NASA could undertake in the development of the GEOWARN system. NASA has many assets that could be used in the GEOWARN system for remote sensing, communications, and data management. NASA could also participate in the integration of existing international capabilities and activities related to the GEOWARN system. One very significant role for NASA could be to make data from the Earth Observing System available to the GEOWARN system on a near real-time basis. This would provide an additional highly visible application of NASA's Mission to Planet Earth which would provide significant benefits to all of humanity.