Global Emergency Observation, Warning & Relief Network

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ABSTRACT

The decade of the 1990's has been proclaimed by the United Nations to be the International Decade for Natural Disaster Reduction (IDNDR). During the first four years of the IDNDR, little progress has been made in mitigating the problem of providing prompt and effective warning and relief for natural disasters on a global scale. There exists a documented need for improved communications and information distribution to provide adequate warning in the face of impending disasters and facilitate the response after a disaster has occurred. The Global Emergency Observation Warning and Relief Network (GEOWARN) is proposed as a system that can potentially fill the existing gaps in the disaster management capabilities by providing a mechanism for the timely processing of information both before and after an event has occurred. The improved information management capabilities that would be provided by the GEOWARN system would complement the activities of existing international and national disaster management and meteorological agencies, as well as local government and private response organizations.

The GEOWARN system concept originated as a student design project at the 1993 International Space University (ISU) Summer Session. The student design team, composed of 38 students from 16 countries, formulated a proposed system design that would utilize existing remote sensing resources augmented by additional satellites and airborne sensor platforms linked together via a computer network. This network would be configured around five control centers called Multi-National Centers which would host an extensive Geographical Information System to perform the task of providing global disaster warning and relief support. To support the potential development of GEOWARN, the NASA Marshall Space Flight Center performed a study to assess concept feasibility. This study has resulted in several recommended modifications to the ISU system concept. It was concluded that a system design which optimizes the use of existing resources can result in significant improvements in disaster warning and management capabilities for most of the world. This paper presents the results of the feasibility study, including a general overview of the GEOWARN concept and the elements comprising the system.

INTRODUCTION

The impact of natural hazards on humanity is an ever-increasing problem. Natural disasters cause more that US $100B worth of damage and claim more than 150,000 lives annually. The increasing impact of disasters has drawn the attention of disaster relief officials, humanitarian organizations and governments worldwide. The United States Government, the United Nations, and other governments to begun to focus effort on mitigating the deleterious effects of natural hazards on the human population and supporting infrastructure. No technological breakthroughs are required to implement a global system capable of performing the functions required to provide sufficient information for prevention, preparedness, warning, and relief from natural disaster effects. The Global Emergency Observation Warning and Relief Network (GEOWARN) has been proposed as a system which would combine the elements of remote sensing, data processing, information distribution, and communications support on a global scale.

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, comprising 100 graduate and post-graduate level students from 30 countries, 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 GEOWARN system include data collection, data processing and management, information distribution, and communications support. Data will be collected via space-based, airborne, and ground-based remote sensing platforms. The data processing and data management elements the GEOWARN system will include geographical information systems, simulations of hazard phenomena and data bases. Data will be processed into usable products based on specific information requirements, then transmitted to the appropriate government and private disaster management agencies. The GEOWARN system will provide value-added information to disaster management officials to support preparedness, warning, and relief activities. The primary motivation for the GEOWARN project is a clear need to provide warning and relief support to those countries and regions of the world that currently do not enjoy these services. Furthermore, the United Nations (UN) has declared the decade of the 1990's to be the International Decade for Natural Disaster Reduction (IDNDR). The GEOWARN system would support the third main objective of the IDNDR: ready access to global, regional, national and local warning systems and broad dissemination of warnings.

The National Aeronautics and Space Administration (NASA) is supporting the activities of the IDNDR. NASA's unique remote sensing, data processing and communications assets provide information that could result in improved warning and relief capabilities. GEOWARN could utilize NASA assets to provide immediate benefits from NASA's Mission to Planet Earth program and the U.S. Information Superhighway initiative.

A PROMISING CONCEPT FOR GLOBAL WARNING AND RELIEF

There are many immediate and tangible benefits of the GEOWARN system. The most significant is that it would save lives and reduce human suffering throughout the world. It 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. GEOWARN would utilize existing technologies in an innovative and efficient manner to provide many benefits to regions of the world that normally would not derive the benefits of technology. GEOWARN would contribute toward a significant improvement to the disaster warning and relief capabilities for many parts of the world, including the United States.

Rather than invest scarce resources in the development of new infrastructure to support the development of a global warning and relief system, the GEOWARN system would be implemented incrementally, capitalizing on existing remote sensing platforms, data centers, and communications capabilities. The ISU study concluded that to fulfill the derived technical requirements, new space-based remote sensing platforms are required to compliment existing satellite observation systems. Aircraft-mounted remote sensing capabilities would also be exploited to allow quick response and eliminate the possibility that a remote sensing satellite may not be in the proper position to make the required observations. Relevant international, social and organizational issues were also considered.

Based upon an extensive characterization of natural hazards, and an evaluation their impacts on humanity, as shown in Figure 1, the ISU student design team developed a set of functional and technical requirements for a global warning and relief system. The vast majority of damage and death results from only eight disasters, all others cause, less than 5,000 deaths and cost less than US $5 billion annually. Droughts and infestations result in significant economic and human losses. In fact, more than one third of the world's food supply is lost to drought, infestation, and crop disease every year. The ISU team chose to omit the inconsiderate use of pesticides and major armed conflicts from further study because these events, were viewed as social problems, not natural hazards. The remaining six disasters fall into two classifications; rapid on-set disasters, and creeping (or long term) disasters. Rapid on-set disasters include floods, cyclonic storms, and earthquakes. Creeping disasters include drought, infestation, and crop disease. It was assumed that these six disasters would drive the technical requirements for the GEOWARN system, and that if the system satisfied the requirements for the these disasters then it would satisfy the requirements for virtually all other natural disasters. Remote sensing, communications and data management elements of the system were identified based on the derived requirements.

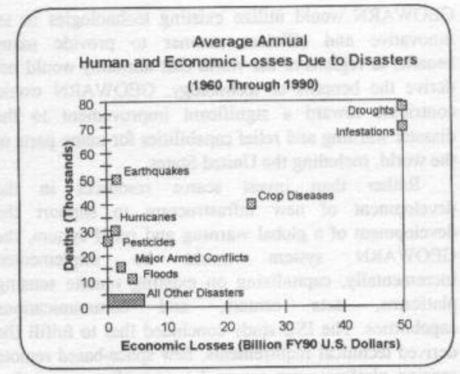

Figure 1. Disaster Priorities Identified by ISU

The ISU design project group developed an architecture for the GEOWARN concept which id depicted in Figure 2. The applicability of many current and proposed space-based assets, such as existing and planned geostationary weather satellites was examined. To obtain the temporal, spatial and spectral coverage required for full system implementation, the team proposed the development of six new satellites that would be placed in polar orbit equally spaced around the globe. The sensor suite onboard these satellites would be comprised of visible, infra-red, and passive microwave detectors. Data from these satellites would be downloaded to two ground stations located in Anchorage, Alaska and Trømso, Norway.

The space-based remote sensors would be augmented by a fleet of 30 aircraft dispatched from 20 different locations around the world to provide rapid response capability if an appropriate satellite platform is not in the proper position. These aircraft are would be outfitted with visible, infra-red, and synthetic aperture radar sensors. External information sources would include ground based sensors such as earthquake sensors and weather radars. Data processing and information distribution would be at five Multinational Centers (MNCs) located on the five major continents. Each MNC would be responsible for a specific region and maintain extensive data bases and geographical information systems. GEOWARN Headquarters would function as a management center and probably be located in Europe. Information would be shared between MNCs via existing telecommunications systems as well as the Internet. The GEOWARN system would use Internet for day-to-day communications but would also have the capability to use satellite links and portable communications systems if lines to a disaster area are not intact.

THE NASA MARSHALL SPACE FLIGHT CENTER GEOWARN FEASIBILITY STUDY

In an unfunded concept feasibility study, the Program Development Office of the Marshall Space Flight Center (MSFC) evaluated the merit of the ISU

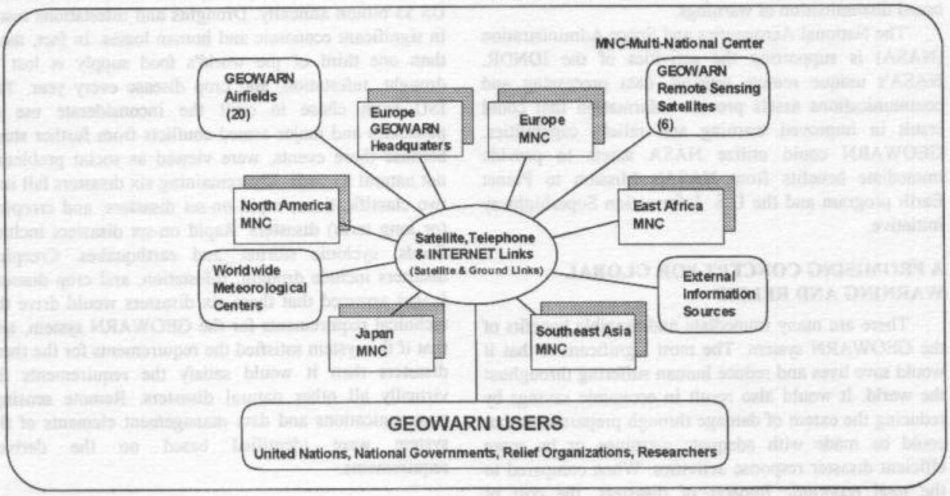

Figure 2. ISU Proposed GEOWARN Architecture

GEOWARN concept. The goals of the feasibility study 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.

Discussions on the GEOWARN concept were held with many organizations within the disaster management community. These organizations included the National Weather Service, United States Geologic Survey, Department of Defense, Department of Energy, American Red Cross, several United Nations organizations and other international agencies. There was a strong consensus among the organizations that a GEOWARN system is needed and would provide a valuable contribution in providing information and communication resources to the disaster management community. A significant conclusion of the evaluation is that there are absolutely no technical impediments to achieving the goals of the GEOWARN system. A plethora of potential system elements were identified during the course of the study that meet the operational requirements. These elements include a remote sensing satellites, ground receiving stations, data processing centers, satellite communications systems, detailed geographical information systems, and user interfaces designed specifically for emergency management officials.

As in the International Space University study, the MSFC study assumed that six primary natural disasters would drive the system requirements. These primary disasters and the parameters that must be known to provide warning or relief support are listed in Table 1. The three disaster types on the left of the table are "creeping" disasters and the three on the right are "rapid onset" disasters. An examination of these parameters shows that this set is applicable to many other types of disasters. This result validates the assumption that was made concerning the applicability of the requirements for the primary disaster types to many other types of disasters.

The Marshall study differed from the ISU study in several aspects of the remote sensing requirements. Rather than deploy six new remote sensing satellites, it was 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 NASA's and Mission to Planet Earth Initiative. While the primary objective of this initiative is to monitor the Earth's ecological system and study global climate change, many of the remote sensing elements could be directly applied to natural disaster monitoring. Additional satellites would however, provide increased surface coverage and reduced imaging turnaround time as they are incorporated into the system.

Table 1. Remote Sensing Parameters for Primary Disasters

Disaster	Parameter	Disaster	Parameter
Drought	Precipitation Distribution Precipitation Quantity Vegetation Distribution Vegetation Health Surface Winds Surface Temperatures Geographic Images	Earthquake	Crustal Motion Geographic Images
Infestation	Precipitation Distribution Precipitation Quantity Vegetation Distribution Vegetation Health Surface Winds Surface Temperatures Soil Moisture Geographic Images	Flood	Precipitation Distribution Precipitation Quantity Snow Distribution Snow Quantity Water Level Water Flow Rates Geographic Images
Crop Disease	Precipitation Distribution Precipitation Quantity Vegetation Distribution Vegetation Health Surface Winds Surface Temperatures Geographic Images	Hurricane	Location of Storm Precipitation Distribution Precipitation Quantity Wind Velocity Surface Temperatures Temperature Profiles Humidity Profiles Geographic Images

As shown in Figure 3, GEOWARN will use a broad communications and data management architecture. The commercial sector has played a major role in the development of global communications systems such as INTELSAT and INMARSAT. Future communication networks will provide a pathway to global communications using global networks such as IRIDIUM (Motorola), Odyssey (TRW), Goldstar(Loral/Qualcomm), and Project 21 (INMARSAT). All of these LEO systems can handle voice, fax, and low rate data. In addition, there have been efforts to develop wireless Local Area Networks (LANs) which may be of great benefit to GEOWARN in the future. The processing of remote sensing information into specific GEOWARN products could be performed by the satellite operators at the ground receiving stations or in distributed data processing centers such as NASA's EOS Distributed Active Archive Centers (DAACs'). There are also commercial companies, such as EOSAT, that processes raw satellite data.

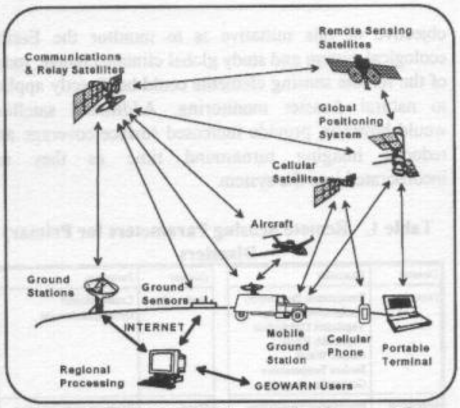

Figure 3. GEOWARN Communications and Data Management Architecture

Geographic information systems (GIS) provide a method to analyze data from several unique perspectives which can then be used to identify relationships between different types of information. The data is organized according to geographic locations and collected as layers in a large data base. These layers of data can include relatively fixed information such as surface elevations or time varying information such as weather conditions. The data layers can also include derived information such as flooding or air pollution models. Data in a GIS can be processed very quickly to provide updated maps, images or provide comparative data on conditions before and after a disaster for use the initial response and damage assessment.

The MSFC study did not attempt to define a detailed system architecture because there were numerous issues that require further study. However, it was concluded that decentralized international, national and regional management of GEOWARN elements might provide an 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 have more control in defining products best suited to their needs. This philosophy allows the GEOWARN architecture to vary for each country. The GEOWARN system would operate as an information resource rather than an operational or monitoring organization.

FUTURE STUDIES AND DEMONSTRATION PROJECTS

The Marshall Space Flight Center Study has identified many potential roles for NASA in the development of the GEOWARN system. These roles are summarized in the potential follow-on activities listed in Figure 4. 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

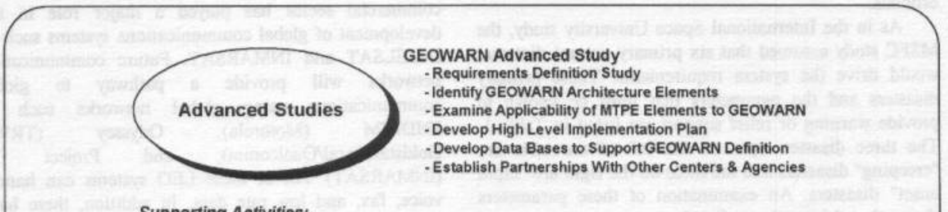

Figure 4. Recommended GEOWARN Follow-On Activities

addressed. In keeping with the incremental development scheme, advanced satellite systems could be incorporated into the GEOWARN system as they are launched, additionally, new satellites may be needed. Future advanced studies will also define the potential elements of the GEOWARN system, particularly the elements which could be provided by NASA. Efforts to involve international organizations in the studies are ongoing. The 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. Development of the GEOWARN concept will require significant inter-agency and international cooperation.

CONCLUSION

The development of a global disaster warning system has been considered as one of the most promising peaceful applications of space technology for many years. 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 great potential for the reinvestment and dual use of technologies that have been developed for military purposes in disaster mitigation and response. The application of space based assets to disaster warning and relief activities is a very open ended problem. There are numerous examples that could be cited as proof of the potential benefits of a global disaster warning system. 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.

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 support. 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.