SPACE TECHNOLOGY APPLICATIONS

FOR NATURAL DISASTER MITIGATION

Proceedings of the First United Nations and JUSTSAP
Joint Symposium
on Space Technology Applications
for Natural Disaster
4 - 5 November 1997
Hawaii, USA

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(JUSTSAP)

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PREFACE

The First United Nations and JUSTSAP Joint Symposium on Space Technology Applications to Natural Disaster Mitigation was held at the Mauna Lani Bay Hotel, Kona, Hawaii. USA on November 4~5 1997.

The purposes of this symposium were to exchange information and opinions on disaster management and emergency response, and to attempt to create a new project on disaster management and emergency response using satellite data.

This was the first symposium to be held jointly by the United Nations and JUSTSAP to going on understanding of the current status of participating countries, in particular, the Southeast Asian countries of, Indonesia and the Philippines, because
severe weather conditions leave caused disasters which killed more than 900 people in this region over the last two decades. Two participants were invited from Indonesia and the Philippines to speak on their respective situation and have they were dealt with.

The United Nations Centre for Regional Development and JUSTSAP will continue to hold this Joint Symposium on Space Technology Applications to Natural Disaster Mitigation in order to realize a much safer world in the 2lst century.

Hideki Kaji
Director
United Nations Centre for Regional Development

Takaji Kuroda
Vice Chairman
Japan-U.S.Science, Technology and Space Applications Program

PROGRAMME OF SYMPOSIUM

Nov. 4 8:oo - 9:00 Registration

Opening Ceremonies

Mr. Takaji Kuroda, Chair

9:00- 9:10 Word of Aloha

Mr. Takaji Kuroda

JUSTSCAP Vice Chairman- Japan

Corporate Chief Engineer, NEC Corporation

9:10- 9:30 Introductory Remarks

Dr. Hideki Kaji, Director

UN Centre for Regional Development

Dr. Shelly Mark (for Dr. Seiji Naya)

Senior Advisor, Dept. of Business, Economic

Development and tourism, State of Hawaii

9:30-10:00 Self-Introduction of All Participants

10:00-10:20 Refreshment Break

UN/JUSTSAP DMO Symposium-Part1

Dr. Hideki Kaji, Chair

10:20-10:30 Opening Remarks

Mr. Stephen Day, Managing Director

International Ventures Associates Ltd.

10:30-11:00 US and International Initiatives for Coordinated Satellite Applications for Disaster Management

Dr. Louis Walter

NASA Headquarters

11:00-11:30 Integrated Remote Sensing and Spatial Information Technology for Wildfire and Haze Disaster Management in Indonesia

Dr. Agus Kristiyono. Head

Sub -Directorate for Airborne and Spaceborne Technology for Naturai Resources Inventory

Agency for Assessment and Application of Technology, Indonesia

11:30 - 12:00 Disaster Management and Intemational Cooperation

Dr. Yujiro Ogawa

Disaster Management Pianner

United Nations Centre for Regional Development

12:00 - 13:30 Hosted Lunch

UN/JUSTSAP DMO Symposium -Part 2

Mr. Stephen Day, Chair

13:30-14:00 Advanced Land Observating Satellite (ALOS) :

Mission objectives and Payloads

Mr. Tsuguhiko Katagi

ALOS Project Manager, NASDA

14:00-14:30 Applications of Remote Sensing to Volcanic

and Earthquake Disaster Mitigation in the Philippines:

Dr. Emmanuel C. Ramos, Deputy Director

PHIVOLCS. The Philippines

14:30-15:00 Natural Disaster Satellite Observations, Mitigation and

Assessment: Bilateral Opportunity

Dr. Murray Felsher, Director

North American Remote Sensing Industries Association

15:-15:20 Refreshment Break

15:20-15:50 SAR Data Applications to Monitoring Earthquake

Disaster and Volcanic Surface Displacement

Dr. Hiroshi Ohkura, Head

Remote Sensing Laboratory

National Research Institute for Earth Science

and Disaster Prevention, Science and

Technology Agency

15:50-16:20 Managing Natural and Manmade Disasters in Hawaii

Mr. Roy Price. Vice-Director

Hawaii State Civil Defense

16:20-16:50 Review of International Astronautical Federation (IAF)

Initiatives Related to Disaster Mitigation

Mr. Neil Helm, Deputy Director

Institute for Applied Space Research

George Washington University

Nov. 5 **UN/JUSTSAP DMO Symposium - Part 3**

Dr. Kohei Arai, Chair

9:00 - 9:20 Study of Disaster Mitigation and Emergency Management Using Satellites

Mr. Yoshiaki Suzuki, Director

Space Communications Division.

Communications Research Laboratory

9:20- 9:50 Concept of the Global Disaster Observation Satellite System (GDOS)

Mr. Takeshi Orii. Assistant General Manager

Space Systems Division, NEC Corporation

9:50 - 10:10 Refreshment Break

10:10 - 11:40 **Panel Discussion**

Mr. Neil Helm, Dr. Munay Felsher, Dr. Agus Kristiyono, Dr. Yujiro Ogawa, Dr., Emmanuesl G. Ramos, Dr., Louis Walter

11:40 -12:00 Concluding Remarks

Mr. Stephen Day, DMO Cc~Chair - USA

Words of Aloha

by
Mr. Takaji Kuroda
JUSTSAP Vice-Chairperson /Japan,
Corporate Chief Engineer, NEC Corporation

Distinguished guest Ladies and Gentlemen, It is my great honor to participate in the first UN/JUSTSAP Symposium for the Disaster Mitigation and Observation. At first I would like to introduce the fact that this room is a memorable place for Space Related Peoples. In 1987, Spark Matsunaga originate an idea of International Space Year celebrate 500 years of anniversary of discover of American continent in 1992. Actually we gathered at this room and agreed to assign 1992 as ISY. After we agreed he proposed his head of UN and got authorization of ISY. In 1992, as you know, many events for ISY took place in the world. Peoples gathered this room were Spark Matsunag, Dr. Edelson, Prof. Saito. Honorable Tetsuo Kondo, Dr. Sekimoto and many other distinguished members.

JUSTSAP, previously named Japan-U.S. Cooperation in Space Program, was created in 1990 to discuss freely without any official hat or cap by participants from industries, government and academia on the subject of manual interest between U. S. and Japan in the field of Space Development and Utilization. In 1995, we changed our name as JUSTSAP to include other science and technologies rather than space related technologies. In 1996, we have decided to offer other countries in the Asia-Pacific to join with us and expand our activities to those countries.

It is our great honor to have experts from United Nations, Indonesia and the Philippines to exchange ideas for disaster mitigation and management utilizing space technology at this time. The global is only one and we are all passenger of space ship the globe. We have to protect the globe from disaster and environmental changes by Governmental and Private Activities including international cooperation. I hope this symposium will be very fruitful and give positive progress toward the 2lst century.

Finally. I would like to say p[ease enjoy the Hawaiian life while you are here.

Thank you very much for your kind attention.

Introductory Remarks

by
Hideki Kaji
Director
United Nations Centre for Regional Development

It gives me great pleasure to deliver the introductory remarks at this UN/JUSTSAP symposium on Space Technology Application for Natural Disaster Management co-organized with Japan-US Science, Technology and Space Applications Program (JUSTSAP) and United Nations Centre for Regional Development. (UNCRD)

This symposium is organized to identify the requirements problems and of developing countries in space technology application to damage observation and mitigation of natural disasters caused by earthquake, typhoon, cyclone, flood, volcano eruption and so on, and to summarize recommendations to be considered at the working groups on Disaster Management and Observation (DMO) of JUSTSAP.

As you know, the establishment of the observation and monitoring system on natural disasters has been agreed on its endorsement by the US-Japan Leader Gathering for Friendly Discussion held in Kyoto in 1992, as the most priority programme of JUSTSAP. Thus, the working group DMO has proposed the Global Disaster Observation System (GDOS) to complement the conventional observation satellite programmes, and to provide timely information to disaster research and implementation organization in the world. I appreciate the excellent idea of the system and do hope that the system may become reality through the every global effort.

United Nations Centre for Regional Development UNCRD was established at Nagoya, Japan, in 1971, under the agreement between United Nations and the Government of Japan. Its mandate is to enhance the capabilities of central and local government officials in developing countries who are related to regional development.

UNCRD'S main activities are, therefore, to organize training programmes, to conduct joint researches with respective counterparts for problem identification and policy recommendation and to provide a technical assistance for plan formulation on regional development. The disaster management programme is one of its Six programmes which UNCRD is currently implementing. The programme has been launched since 1986, under the recognition that vulnerability to disasters in developing counties is increasing in recent years as their economies grow. Because huge number of unstrengthened houses are tend to be constructed in disaster prone areas such as water bed or steep slope due to rapid urbanization and population immigration and many of development projects are implemented without consideration of disaster preventive technology, resulting in vulnerable land use which causes flood or landslide disasters. This recognition was also the basis on which International Decade for Natural Disaster Reduction (IDNDR) was designated by the United Nations, commenced in 1990. The idea of IDNDR is to intensively promote Technology Transfer to developing countries in the field of natural disaster management during the last decade of 20 the century so that future generation will be able to enjoy safe society. Since it was launched, UNCRD has involved in this programme as one of the key agencies among UN systems.

Here, I would like to introduce some of the projects witch UNCRD's Disaster Management Programme has conducted so far. In research field, we are now conducting the development of seismic risk assessment in urban area in cooperation with State Seismological Bureau of China since 1994. The purpose of this project is to develop the tools for assess the seismic risk of urbanized mega cities in developing countries. Risk assessment is recognized as fundamental process to formulate the proper urban planning to strengthen their cities against natural disaster that may attack. Second research project is the development computer system of disaster management. The Great Hanshin Awaji Earthquake attacked Kobe City area in January 1995. Its casualties exceeded 6000 persons and losses were counted more than 100 billion US dollars. It be came clear that Disaster Management System in Local Governments were not operated well enough to minimize the damage of earthquake. Based on the lessons learned from this earthquake, we are now developing the new disaster management system using computerized model including GIS and Satellite Images. Next is the training programme of urban disaster management for local government officials in developing countries. We receive several missions to Japan in each year to give a training of urban disaster management, That includes theory and concept of disaster management, disaster prevention and mitigation plan formulation and field study of urban disaster management systems and facilities of Central and Local Government in Japan. Last project I want to introduce is the human data base establishment of disaster management experts in the world. We call this database as United Nations Human Information Network for disaster management (UN HiNET). The number of registered experts are now more than 1100. The purpose of this data base is to establish the network of researchers, governmental officials, consultants and others who are involved or interested in disaster management field. We hope that this data base will be used to identify the resource persons when people need to get some help or advise to solve the problems they ale facing.

Ladies and Gentleman, we really expect that this symposium provide new in puts to our future activity and contribute.

Introductory Remarks

by
Dr. Shelley Mark
Senior Advisor, Dept. of Business, Economic Development and Tourism,
State of Hawaii

Mt. Kuroda, Dr. Kaji and distinguished delegates and friends! It gives me great pleasure to be here at this beautiful resort on one big island to extend greetings and make some introductory remarks at this meeting of the United Nations Center for Regional Development(UNCRD) and the Japan-U.S. Science Technology and Space Applications Programme(JUSTSAP). My only regret is that our director, Dr. Seiji Naya who also serves us vice chairperson of JUSTSAP, can not be here to extend official greetings but I am happy to be in place. Dr. Naya as some of you know is presently in Okinawa with Governor Cayetano to work out arrangements for a partnership program to apply science and technology knowledge to problems of mutual concerns. These issues are close to some of the areas we have worked on at JUSTSAP over the years, and I am sure we will draw upon the wisdom of JUSTSAP as we proceed with our projects.

At this time, I would like to make just to see introductory comments. First I would like to comment the JUSTSAP leadership working so diligently with UNCRD to organize today's symposium and appearing closely to a basic objectives of the organization, which is to apply the findings of our science technology and spatial experience and experiments to deal with major global problems, in this case, the management and mitigation of natural disasters. Second, I am pleased that with today' s meeting, the bilateral partnership which marks JUSTSAP was evolved toward a focused attention on problems that also affect others Asia-Pacific countries. In this program, I note representations from Indonesia, the Philippines, and the Peoples' Republic of China. Our hope is that we will build on the solid organizational and programmatic structure of JUSTSAP and evolve toward a multilateral institution including most of the Asia-Pacific countries in the future. Third, and not least, I would like to express our appreciation to DR. Kaji and his colleagues at UNCRD for their initiatives and effort in corresponding today' s symposium as a milestone in the United Nations International Decade for Disaster management and mitigation. Our hope is that the United Nation, perhaps with the benefit of Mt. Ted Turner' s contribution, will continue its cooperative programs with JUSTSAP and also the State of Hawaii.

I can think of several relevant and important areas. For example, sustainable development, preservation of scarce species and resources, urban planning to facilitate disaster management land use controls to protect water and forest resources and prime agricultural lands and the application of science and technology to cope with problems of remote areas. So I conclude with a warm welcome on behalf of the state of Hawaii. Aloha and let the games begin.

Now we are attending the meeting in Okinawa so that Jim will be here tomorrow. Importance of the Bilateral partnership between USA and Japan was enhanced for global. From the point of view of Globalization, expansion of our activity is desired. In this connection, this joint symposium between United Nations and JUSTSAP is timely

Opening Remarks

by
Mr. Stephen Day
International Ventures Associates Ltd.

The first JUSTSAP meeting was held in November 199O. At that time pioneering meeting which was led by Dr. Burt Edelson, other "Pioneers were present, some with crazy Oeas such as launching a 77 satellites construction for mobile communications. Durrel Hillis (Motorola) was one of the participants who led the development of the now 66 IRlDIUM satellites in orbit. Other participants included low cost satellite manufacturers (e.g. Lockheed) and Launch providers. Now these are multiple corporations(ICO, GLOBALSTAR, ORBCOM, EZIPSOSAT, TELEDESIC, etc.) all aiming at the mobile communication business with constructions of multiple low cost satellite systems. It has become the conventional wisdom.

Back in 1990, we also said avoid for another multi-satellite system to provide continuous high resolution (eg 1 meter) remote sensing of the Earth. One proposal from COMSAT was the formation of a Global organization similar to INTELSAT and IMARSAT, called INREMSAT(International Remote Sensing Satellite System). This model was refined by the Japanese aerospace participants in to GDOS(Global Disaster Observation Satellite System). This 24 satellite system has considerable merits, but still remains a concept. The COSL of such a system is high and the benefits are still difficult to quantify- though times are changing with mass production of satellites and multiple simultaneous launches. Seven years ago, internet was essentially non existent. Now there are 35 45 million web users, growing at 10% a month, GEMS(Global Emergency Management System) is up and running providing an on line searchable data base with linkage. Imaging capabilities are also available on internet, for example, to monitor near real time movement of hurricane. The power of the web is only just begging to be felt for user applications of disaster monitoring and mitigation. Also, the United Nations international decade for natural disaster reduction(IDNDR) with 2 years left to run. Acting promotes the use of advanced technologies to mitigate disasters. it is a pleasure to be associated with United Nations(Center for Regional Development) for our joint 1997 conference, and to have Dr. Kaji(Director) participation.

Further out, although viewed as a low risk problem by some, we should not remain uninformed about the 500 to 2000 large asteroids in the Earth' s orbit that are capable of calamitous climate change on impact! For a few million dollars of funding, scientists could track all of the asteroids and present the world community with timely options-17 only as an insurance premium. Furthermore, last year we had only 4 months warning of a 1400 root asteroid that missed the Earth by a mere 280 thousand miles. The disaster monitoring what have we accomplished? mitigation group of JUSTSAP has been effective at communicating and stimulating others about using satellites for disaster monitoring. But so far, we have not yet been effective at initiating concrete proposals. Therefore I would like to propose the "Kona Challenge" : Launch is to develop one or two concrete, value added projects that we can get financed (externally) and produce tangible results by November 1998. As Dr. Shelly Mark (State of Hawaii Government) says 'Let the Games Begin".

Going back to Nov. 1990 (COMSAT: INMARSAT and INTELSAT), at the meeting, the participant from Motorola proposed 77 satellites in the world, now a day 66 satellites are on orbit. 24 satellite WEDCS, GDOS system initiatives do not work so far.

But it will be OK like a INTELSAT program 45 million of internet users and FEMA MAPSAT(URL would be shown in the DMO meeting) initiatives would be low cost approach. Existing assets should be utilized first and step by step approach.

An Expectation on Remote Sensing Technology for Disaster Management and Response

by

Dr. Kohei Arai

Professor, Dep. of Information Science, Saga University

He has briefly summarized for the current activities relating to the disaster management and emergency response in Japan for the period from Nov. last year to Oct. this year. Major topics of the activities are Disaster Management Meeting for Asian Countries followed by the US-Japan Earthquake Policy meeting. He also enhanced an importance of the emergency response in particular South East Asian countries where the most worst disasters in the world were occurred in for the decades. He introduced all the agenda items of this symposium and also enhanced a submission of the extended abstracts from the presenters. It was due on the end of the JUSTSAP meeting here in Hawaii.

U.S. and International Initiatives for Coordinated Satellite Applications for Disaster Management

by
Dr. Louis S. Walter
NASA/Mission to Planet Earth, George Washington University

National Disaster Information Network(NDIN)
VP Security and NOAA/CIA initiatives was started in April 1997
Private sectors, FEMA Providers are involved in
FEMA funded 30 M$ for mitigation
Pacific Disaster Center
Advanced System Center(USGS(RESTON)
International efforts
Global Disaster Information Network(Red Cross UN High Commission for Refugees are leading)
ISRO has submitted proposal to the Indian government for disaster monitoring system utilizing IRS satellites data
CEOS Integrated Global Observing Strategy(long term climate, atmospheric chemistry, forestry, ocean biology disaster)
UNISPACE Ⅲ is to be organized in 1999
Global Risk Management System, 2000(focus on 10 - 20 Megacities) was proposed by USGS

Integrated Remote Sensing and Spatial Information Technology for Wildfire and Haze Disaster Management in Indonesia

Agus Kristijono
Directorate of Technology for Natural Resources Inventory
Deputy for Natural Resources Development
Agency for the Assessment and Application of Technology (BPP Teknologi)
Republic of Indonesia

Abstract

Global phenomena associated with ENSO (El Nino Southern Oscillation) have been so interesting that receive more and more attention from international scientific communities. One of the most devastating impacts of an intense and prolonged ENSO in 1982-83 was severe drought and wildfires in Kalimantan, Indonesia. Learning from the experience of having severe drought and wildfire of 1982-83 and today's ENSO episodes, it is anticipated to utilize and integrate remote sensing and spatial information technology to support wildfire and haze disaster management in Indonesia. An integrated system based on hierarchical approach is suggested and outlined in such a way that integrates GIS and remote sensing technology in three different, yet hierarchically interrelated levels. The top level, which is intended to detect irregular and unpredictable event like ENSO is suggested to utilize TOPEX/Poseidon sea level data. The lower level, which is intended to detect and monitor drought, hotspot, and haze is recommended to utilize NOAA/AVHRR data, supported by GIS database and spatial analysis. The bottom level, which is dedicated to evaluate and provide detail informations concerning the extent of hazards associated with drought, wildfire, and haze is suggested to utilize high-resolution remote sensing data (SPOT, Landsat TM, ERS, Radarsat, etc.) and supported by GIS database and spatial analysis and modeling.

1. Introduction

Following an intense development of ENSO (El Nino Southern Oscillation) episode in May 1997, many areas in western Indonesia have been experiencing a very intense dry season that causes severe drought, devastating wildfires, and hazardous haze. A similar condition occurred during the 1982-83 ENSO episode. The ENSO episode signified the occurrence of drought and forest fires in Kalimantan during August to October 1982 and March to May 1983. The drought and wildfires damaged 3.5 million hectares of forest and agricultural lands of Each Kalimantan alone with an estimated loss of standing timber and growing stock that worth more than five billion U.S. dollars.

An ENSO episode is observable with the help of remote sensing technology. Sea level data acquired from TOPEX/Poseidon satellite have been proven useful to detect the 1997 ENSO episode. In addition, NOAA/AVHIRR satellite images have also been proven effective for detecting its subsequent impacts such as drought, wildfires and haze occurred in Indonesia. High resolution satellite imageries, such as SPOT satellite Images have been used to evaluate the burned areas

GIS is commonly defined as a computer-based technology specifically designed to deal with geo-referenced spatial information. GIS technology has been widely utilized as a powerful tool for spatial analysis and modeling. When this spatial information technology and the aforementioned remote sensing technology are combined, their synergy would provide a powerful tool for developing a reliable system to support drought and wildfire disaster management. This paper reviews the use of remote sensing technology, particularly of TOPEX/Poseidon, NOAA/AVHRR, and SPOT data for various purposes related to ENSO episode, drought, and wildfires. This paper also suggests a hierarchical approach for integrating remote sensing technology with GIS-based response system and post hazard ebaluation in supporting drought and wildfire disaster management.

2. Remote Sensing Technology for Drought and Wildfire Hazards

Remote sensing can be simply defined as an observation on an object(s) without touching the object(s). This technology is performed with various type of sensors mounted on various platforms, ranging from aircraft to satellite.

2.1 Detection and monitoring ENSO with TOPEX/Poseidon satellite

An ENSO (EI Nino Southern Oscillation) episode is characterized by dwindling or even reversal of trade winds across the southern Pacific (Amaral 1997) Under normal conditions, the trade winds blow westward, forming a convective loop called Walker circulation
(Fig. la). Once every four to seven years. Walker circulation collapses that causes the trade winds to blow eastward (Fig. lb). The famous term for the occurrence of this phenomenon is ENSO episode

Fig.1 Graphical representation of El Nino: (a) normal conditions, (b) El Nino conditions (source Amaral 1997)

The reverse direction of trade winds of an ENSO episode causes an eastward flow of warm surface water across the tropical Pacific Ocean and accumulations of the warm water along the Peruvian coast. The movement and accumulation of the warm surface ocean water cause certain sea level patterns over tropical Pacific. These patterns can be detected by TOPEX/Poseidon altimeter satellite from its orbit l,336 kilometers (830 miles) above the Earth's surface (NASA JPL 1997). TOPEX/Poseidon satellite data has been used for monitoring the dynamic of the Pacific Ocean's surface water movement and accumulation during the 1997 ENSO episode as presented in Fig.2. Notice that the images correspond with graphical representation of an ENSO episode depicted in Fig 1.b.

Fig.2. Ocean surface water movement and accumulation during 1977 ENSO episode
(source: NASA JPL 1997)

2.2. Detecting and monitoring drought with NOAA/AVHRR satellite

ENSO episodes have been proven to trigger global effects such as drought in Indonesia and Australia, heavy rains to the west coast of South and Central America, and so forth. The 1997 ENSO episode has been proven to cause severe drought in Indonesia that triggers subsequence devastating wildfires and extensive hazardous haze over the islands o f Sumatra and Kalimantan

Drought has a direct impact on vegetation to dry out. Normalized Vegetation Index (NDVI) algorithm using NOAA/AVHRR satellite data has been proven effective to distinguish stress vegetation from healthy vegetation Fig.3 demonstrates the NDVI algorithm to monitor drought in Kalimantan Island. Notice the extent of dry areas that tends to increase extensively in July 1997.

Fig. 3 monitoring drought with NDVI of NOAA/AVHRR satellite data
(source: LAPAN 1997)

2.3 Wildfires and haze with NOAA/AVHRR satellite

NOAA satellites are equipped with thermal infrared sensor that can be used to measure earth’s surface temperature. Thermal data acquired from the AVHRR thermal sensor can be used to detect 'hotspots'- earth surface with temperature of more than 40 degrees centigrade. The distribution of hotspots has been proven useful to pin point as well as to monitor wildfire locations in daily basis.

In addition to detect hotspots, NOAA/AVHRR data can also be used to derive haze distribution by combining near infrared and visible data. In this combination haze appears as clusters of yellowish color, whereas cloud as clusters of white colors.

Hotspots and haze distribution can be combined in one image that has been proven useful in supporting wildfire and haze watch, as demonstrated in Fig. 4.

Fig.4 Detecting and monitoring hotspots (red dots) and haze (yellowish clouds) with NOAA/AVHRR satellite data (source: Meteorological Service Singapore)

2.4. Burned Area Analysis and Evaluation

To analyze and evaluate wildfires in a confined area needs more detailed information that cannot be provided by NOAA/AVHRR satellite data whose spatial resolution is 1 km. With spatial resolution 20 meters, SPOT satellite data provides more resolving power for wildfire analysis and evaluation.

FCC (False Color Composite) imageries derived from SPOT satellite data have been proven useful for analyzing and evaluating a wildfire occurred in an area near Banjarmasin, South Kalimantan Healthy vegetation appears red in a FCC image and the burned area appears dark brown. Thus an analysis and evaluation of wildfire occurred in a confined area can be performed with ease using visual interpretation as demonstrated in Fig.5. a (before wildfire) and Fig.5.b (after wildfire).

To make wildfire analysis and evaluation objective, visual interpretation needs to be supported with digital image processing techniques, such as NDVI (Normalized Different Vegetation Index) analysis. Fig.6.a and Fig.6.b are results of applying NDVI algorithm to the same satellite image presented in Fig.5.a and Fig.5.b. Notice that unlike FCC, NDVI detects a substantial loss of healthy vegetation in a quantitative fashion.

(a) July 1997 (b) September 1997

Fig.5. SPOT false color composite (FCC) for evaluation of wildfire (Source: CRISP 1997)

Fig, 6 Evaluation of a confirmed burning area using NDVI algorithm
(Souce: Kristijono and Sanjaya 1997)

3. **Potential use of GIS technology.**

GIS is commonly defined as a computer-based technology specifically designed to deal with geo-referenced spatial information. The smallest spatial information of a GIS is called entity, which is represented by points, lines, and polygons or areas. All entities of a GIS and their associated attributal information are stored in a GIS database as depicted in Fig.7.

Fig. 7. A GIS database model (modified from Dangermond 1990)

When a GIS is applied for wildfire hazard assessment and contingency planning, for example, a point can be used for representing individual hotspot, a line for a river segment, and a polygon for an extent of burning area or a village. All of these entitles must be stored in digital forms. The most common way to do so is to 'digitize' or scan a paper map that contains fire hazard related information as depicted in Fig.8.

Because all GIS entities are geo-referenced, GIS database can be used for performing spatial analysis to support response plans of wildfire hazard on a confided area such as where is the location of a particular hotspot?, how far is the distance of this hotspots to the nearest river and village?, how large is the extent of the burning area of this hotspot?, and so forth.

Fig. 8. Wildfire hazard information (USDA Forest Service 1997)

4. Integrated Remote Sensing and Spatial Information Technology for Wildfire and Haze Disaster Management

The wild fire hazard related information of a confined burned area depicted in Fig.8 was prepared by manually overlaid results of Interpreting remotely sensed data over a topographic map and scanned into digital map (Dull 1997). Such an approach proves the usefulness of integrating remotely sensed data with geo-referenced spatial data for preparing a contingency plan for fire hazard response system.

The same approach would be proven useful for the higher and the lower levels. When every patch of drought area or every hotspot detected by NOAA is geo-referenced and stored in a GIS database, further field verification and action would be very effective In addition, further investigation and evaluation using higher resolution remote sensing technology can be effectively directed to the suspected area. Thus, it is imperative that remotely sensed data and spatial information technology be integrated at all level, in such a way that supports the key measures of wildfire and haze disaster management.

To accomplish the successfulness of the aforementioned integration, a hierarchical approach needs to be applied. The approach, as illustrated in Fig.9, integrates the use of remote sensing technology in three hierarchical levels.

Fig. 9. Hierarchical Approach applied to the use of Remote Sensing Technology for Drought and Wildfires Monitoring, Prediction. and Response System (modified from Haber 1990).

Each level is placed in the hierarchical structure based on its degree of certainty of their associated events/processes. The most irregular and unpredictable one is placed in the top event/process domain, whereas the most regular and predictable one is in the bottom domain. In such a hierarchical approach, TOPEX/Poseidon is designated for detecting irregular and unpredictable events such as an ENSO episode, which is considered to be associated with the top level of the event/process domain. Higher resolution remote sensing technology such as NOAA and SeaWiFS with the lower domain and designated for detecting moderately predictable events such as drought, hotspots, and haze. And finally, SPOT, Landsat, or the like is considered to be associated with predictable event/process and is placed in the low domain.

In addition, the hierarchical approach deals not only with structuring process/events associated with wildfires and haze disaster. It deals also with interfacing one level to the other as interdependent entities. In this sense it is clear that the occurrence of wildfires are associated with the occurrence of ENSO episodes. As a consequence,' to prepare a mitigation and response system for wildfire and haze disaster based on the hierarchical approach requires information about wild fire and biomas loss based on the occurrence of hotspots.

The implementation of the aforementioned hierarchical approach to support wildfire and haze disaster management is suggested in a general procedure as the follow:

1. Establish an early warning system for the occurrence an ENSO episode that triggers a potential drought hazard in Indonesia based an TOPEX/Poseidon sea level data.
2 When a potential drought hazard is triggered, activate a drought monitoring system based on NDVI algorithm applied to NOAAJAVHRR data. Monitoring should focus on areas which previously experienced drought and wildfires hazards. Issue wildfire warnings for areas experiencing extremely low NDVI values, especially those areas close to people activities. Support with GIS database and spatial analysis to determine hazard zones.
3 Activate a regional hotspot and haze monitoring system to early detect the occurrence of wildfire and haze hazards based on NOA,VAVHRR data. This system must be linked to the drought and monitoring system outlined in procedure 2.
4 Develop of contingency plans for areas being experiencing wildfire and or haze hazard. Use high-resolution remote sensing data available (i.e., SPOT, Landsat TM, ERS 1/2, Radarsat, Earth Watch,etc.) Support with GIS database and spatial analysis and modeling.
5 Map, evaluate, and assess the impacts of drought and wildfires. Store the results in a GIS database to support procedure 2,3, and 4 for next ENSO episode.

Concluding Remark

The idea of integrating remote sensing technology spatial information to support wildfire and haze disaster management suggested in this paper comes from awareness of international scientific communities on the global impacts of ENSO phenomena including drought and wildfires in Indonesia and South east Asia. The efforts they spent, including putting their works and ideas on the web are so numerous. I would like to acknowledge some of them for their encouraging efforts: Centre for Remote Imaging Sensing and Processing of National University Singapore, Meteorological Service Singapore, NASA JPL - USA, and USDA Forest Service - USA. Finally, I would like to express my gratitude to UNCRD for providing the opportunity to communicate my idea to the international community in this recognized international workshop.

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Disaster Management and International Cooperation

by

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UNDERSTANDING RISKS

First step of disaster management is to understand risks. Before some events occur, we try to catch up the possibilities of occurring certain events. According to the development of weather watching systems, we can get certain information for meteorological phenomena. Volcanic eruptions have some precaution that we can catch the possibility of occurrence of the events. Earthquake is still far from to understand of occurrence of the events.

UNDERSTANDING VULNERABILITIES

On the other hand, disaster is the sequence of the event which causes certain damages in human activities. As the risk is the possibility of event times the sequence of event, we have to understand the vulnerabilities which cause the sequence. Land use, deforest, land slope, pavement on urban area, mass housing in cities and others are some of indicators of vulnerabilities of our society.

UNDERSTANDING DAMAGES

Satellite images are used to identify the sequences of event such as flooded area by typhoon No. 10 in Japan in 1986, Forest fire in China in 1987 For the earthquake damages, some effort are done in the Great Hanshin Earthquake in January 17, 1995.

Deformation of land surface in Awaji Island

Urban conflagration in Kobe City area

Liquefaction of reclaimed land in Kobe City area

For the damage of infrastructures, buildings are still hard to identify from satellite image.

INFORMATION

Many big cities in developing countries are quite vulnerable against urban hazards such as flood, earthquake. Once disaster attaches big city, mass of damages in widely spread area come out in short time as a sequence of the event. Then local authority may face the difficulty of quick collection of damage data and treatment of collected mass data to utilize for disas8er management. Such lack of information causes miss judgment and delay of emergency response. Now a day, systems for mass data collection and mass data processing for disaster management are requested to avoid miss judgment and delay of emergency response. Important point when we deal disaster information is the concept of space. As disaster always spatial characteristics. Disaster related information are only able to manage through spatial data which is included in disaster related information. Really disaster management activities are mostly "where" and "where to where".

RADIUS PROJECT

RADIUS is Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disaster. United Nations set up **International Decade for Natural Disaster Reduction (IDNDR)** from 1990 to 2000. RADIUS is one of promotion project that IDNDR Secretariat coordinates directly to develop practical tools for the development of seismic risk assessment based on the analysis of the case studies in 10 Mega-City in developing counties to offer the tools to assess the seismic risks of city. Most big cities which are hard to implement risk assessment which is a base of disaster mitigation plan to strengthen their cities against earthquake by themselves. Application of space technologies are really needed to assist the disaster management which include finding risks, vulnerabilities and damage information to prepare disaster mitigation activities in pre-event phase and disaster response and recovery activities in post-event phase.

Advanced Land Observing Satellite (ALOS): Mission Objectives and Payloads

by

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ABSTRACT:

This paper introduces Japanese high-resolution earth observation satellite called ALOS (Advanced Land Observing Satellite), which is the satellite for cartography, environmental and hazard monitoring. The National Space Development Agency of Japan has recently conducted the investigation of users' requirements and preliminary studies of hardware for the ALCS. As a result, the ALOS will equip both optical and microwave sensors to achieve the requirements. Especially, the optical sensor will be so-called "three-line-sensor”, and will have a capability of 2.5 m resolution for accurate mapping. The ALOS will be launched in 2003 by the Japanese H-IIA rocket.

KEY WORDS: ALOS. PRISM, AVNIR-2, PALSAR

I -INTRODUCTION

There are many remote sensing satellites in orbit and in planning stages. Some satellites, e. g., the NOAA's and the ADEOS-Ⅱ [1] dedicate to global observation. On the other hand, high-resolution capable satellites, e. g. , the Landsat the SPOT and the JERS-1 [2] provide useful data for regional observation. However, users' requirements for spatial resolution have risen, and the observation objectives have widened. To gather requirements for land observation, an investigation has been conducted, and the feasibility of Advanced Land Observing Satellite (ALOS) which will realize the users' requirements, has been confirmed by the National Space Development Agency of Japan (NASDA).

2 -MISSION REQUIREMENTS

2.1. Mapping

Maps are important not only for traveling but also for managing a country's resources: e.g., cultivated area, forest, and so on. In Japan, l/25,000 maps covers whole Japanese territory, and are revised about every five years by the Geographical

Survey Institute. However, according to Fig. 1 [3], "paper" maps larger than 1/31,680

scale cover only 31% of the whole world. Especially, in developing countries, more than 90% are unmapped in this scale. Also, in recent years, Geographical Information

System (GIS) has been developed eagerly in many countries, however, enough “digital” geographical data has not been gathered yet. The “digital” data of wide area could be collected by remote sensing efficiently, particularly, from space. GIS is so efficient way to manage the countries’ resources because of its capability and flexibility, that making/revising precise maps on GIS, using remote sensing data, are helpful to the “sustainable development”. These maps are useful to environmental monitoring, too.

According to our recent investigation, to make/revise l/25,000 scale maps needs 2.5m horizontal resolution for determination of land conditions, and 5 m vertical accuracy for drawing contours. Also, multispectral bands of 10 m horizontal resolution are required for classification of land cover, such as vegetation, forests, etc.

Fig. l. Availability of Topographic Map [3].

2.2 Hazard Monitoring

In the early 1995, Hanshin area in Japan suffered severe damage from a tremendous earthquake. Dislocations of land and soil liquefaction, which were caused by the earthquake, were observed by high-resolution observing satellites, e.g., the JERS-1 and the SPOT-2 [4]. The usefulness of such kind of satellites for hazard monitoring was confirmed by their results. The users ' requirements for hazard monitoring are "as prompt as possible." and "as precise as possible”. According to our study, to choose adequate orbit and employ pointing mechanisms lets a polar orbiting satellite to observe damage area within 24 hours in average.

3 – PAYLOADS AND ALOS SATELLITE

Following payloads and a satellite will be able to satisfy the users’ requirements described in section 2.

3.1. PRISM

The Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) is so-called "three line sensor" which has three telescopes to obtain three different views simultaneously. To achieve good accuracy of ground height, fore and aft telescopes are inclined about ±24 degrees from nadir, which corresponds to B/H=1 at 700 km altitude. Another telescope looks at nadir direction. The horizontal spatial resolution of PRISM is 2.5 m, and its swath width is 70 km for nadir looking and 35 km for stereo mapping.

3.2. AVNIR-2

Multi-spectral part, Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) has its own telescope which has ±44 degrees (cross-track) pointing capability for observing damaged area promptly. AVNIR-2, which has four channels from 0.4 to 0.8 μm, observes 70 km width with 10 m spatial resolution at nadir. The characteristics of PRISM and AVNIR-2 are shown in Table 1.

Table 1. PRISM and AVNIR-2 characteristics.

	AVINR-2	PRISM
Wavelength(μm)	0.42-0.50	0.52-0.77
	0.52-0.60	(nadir, forward, backward)
		(B/H=1)
0.76-0.89		
S/N	200	70
IFOV	10m (nadair)	2.5m
Swath Width	70 km	70 km/35 km
Gimble Angle	±44deg	±1.5deg

Due to its high-resolution, the PRISM will generate huge data rate, about 1 Gbps. Around the ALOS launch, two Japanese Data Relay Technology Satellite (DRTS) which will have 240 Mbps communication links to ground will be available, and the ALOS has a plan to use them. Therefore, the ALOS should employ data compression technique to squeeze its data rate into 240 Mbps or less.

3.3. PALSAR

The Phase Array type L-band Synthetic Aperture Radar (PALSAR) is Japanese second spaceborne SAR developed by NASDA and JAROS/MITI, which will be L-band radar and have a capability of pointing from 20 to 55 degrees incidence angle. The goal of the PALSAR' s performance is 10 m (two looks) spatial resolution and 70 km swath width. The PALSAR will have another attractive observation mode which is SCANSAR mode. The mode will allow us to get about at least 250 km width SAR images, which is about three times wider than conventional SAR images. These pointing and SCANSAR

capabilities are realized by employing the active phased array technique to the PALSAR.
Table 2 summarizes the PALSAR characteristics

Table 2. The PALSAR characteristics.

Mode	High Resolution	SCANSAR
Frequency	L-band	
Polarization	HH/VV/HH&HV/VV&VH	
Resolution	10m	100m
Number of Looks	2	10
Swath Width	70km	
Incidence Angle	20-55deg	
S/N	15 dB	
S/A	25 dB	

3.3. ALOS Satellite

In order to support and achieve the high-performance of sensors, the ALOS satellite will have several outstanding capabilities. First one is precise determination of position and attitude. The ALOS will equip a star-tracker for accurate attitude determination, and also will equip a GPS (Global Positioning System) receiver for its precise position determination. The goal of the ALOS is one pixel (2.5 m) error after 1000 km flying.

Second one is mass data handling capability. In order to handle huge data generated by three mission instruments, the ALOS will have mass data memories on board. The memories will have 706 Gbit storage capacity and handling capability of 240 Mbps data rate. Also, the ALOS will equip a high data rate transmission capability via DRTS. It will allow us to get ALOS data in real time, and it is necessary to hazard monitoring. Table 3 shows the ALOS characteristics

Table 3. ALOS Spacecraft characteristics.

Launch	early 2003
Launch Vehicle	H-IIA
Spacecraft Mass	about 3,900 kg
Generated Power	about 7 kW
Orbit	Sun-Synchronous Near Recursive
Repeat Cycle	46 days
Altitude	691.65km

4- CONCLUSION

The NASDA is now conducting the ALOS preliminary design (main constructor: NEC Corporation) including the PRISM, theAVNIR-2 and the PALSAR since last fiscal year, and currently test of Bread Board Model (BBM) for the sensors are under contract. Fig. 2 shows the tentative ALOS developing schedule. The ALOS will be launched in 2003 and will contribute to the regional observation, such as mapping, environmental monitoring and hazard monitoring.

Fig. 2 The ALOS tentative development schedule

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Applications of Remote Sensing to Volcanic and Earthquake Disaster Mitigation in the Philippines

by
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PHIVOLCS

1. Objectives

The applications of remote sensing in the Philippines date back to the use of aerial photographs for interpreting topography, geology, land-cover and other civil and military applications in the early 1 940' s. As with the changes and advancement in the remote sensing technology, the applications has evolved, fueled both by the technological changes as digital data has become widespread and more available, as computer technology had made both the software and hardware accessible to Filipinos, and as geological events and population growth in the Philippines interacted to raise the level of risks. This paper presents a summary of applications of the remote sensing technology to volcano and earthquake disaster mitigation in the Philippines, and list some possible changes that local disaster workers would hope to see to improve our chances of survival in the next earthquake and volcanic eruptions.

2. Background

The geological and geographic condition of the Philippines brings about the existence of geological and other natural hazards. The tectonic region around the Philippines is complex, composed of colliding ocean floors, active faults, active volcanoes, and frequent earthquakes. This is illustrated in Figure 1 which shows the various tectonic and physical elements of the Philippine region. As part of the Circum-Pacific ring of earthquake and fire, tectonic processes are causing two large oceanic plates to converge in the region of the Philippines causing seismicity and volcanism. The western region of the Pacific ocean floor known as the Philippine Sea Plate is presently moving northwesterly and colliding with the archipelago, generating the Philippine Trench and its associated earthquakes and volcanism. On the west, the South China Sea floor is moving to the southeast, converging with the archipelago causing the creation of the Manila Trench system and its associated earthquakes and volcanoes. These two systems of converging plates are thus generating earthquakes and volcanism along a narrow zone occupied by the islands that form most of the Philippines, The earthquakes and volcanic activity also cause some other hazards, including tsunamis that cause local destruction and deaths. The geographic position of the country makes it also vulnerable to typhoons, which regularly visit the country, creating an average of about 26 times per year of days of rains, floods and hurricane winds. In combination with the fresh and loose volcanic ash deposits, the rains bring lahars or volcanic mudflows that had been a regular havoc since after the eruption of Pinatubo Volcano in 1991.

Remote sensing is useful in all spectrum of geologic disaster mitigation and reduction in the Philippines. One major application that is regularly employed is the use of remote sensing for geologic mapping of volcanoes and faults. There are about 22 active volcanoes in the Philippines and only two of these had been geologically mapped at the scale of 1:50,000, owing mostly to the difficulty of gathering fresh field information on tropically weathered volcanic slopes, and due to the recency of the desire to know the geological details of these volcanoes. Faced with such a task, the most practical approach would be to use remote sensing in mapping the extent of the recognizable geologic deposits, to identify the individual features that may relate to recent volcanic events, and to assess the nature and magnitude of the hazards that each volcano may pose.

3. Recent applications on volcanic disaster management

Using LANDSAT, ERS, Radarsat and SPOT data, the PHIVOLCS had made some attempts to employ remote sensing to geological mapping, although this had not been in a widespread and systematic scale. At present, the PHIVOLCS is working on a project sponsored by the UNESCO in using remote sensing for geological mapping of volcanoes. Called GARS-Asia Program, this project is employing the lessons learned by an earlier GARS (Geological Applications of Remote Sensing) in Africa to volcanic hazards in South East Asia. The GARS-Asia project involves the participation of various European Union countries with remote sensing capability in mapping selected Philippine volcanoes. Three volcanoes in the Philippines had been chosen for the GARS-Asia project: Taal Volcano, Canlaon Volcano, and Bulusan Volcano. Taal Volcano is the most active volcano in the Philippines, and its location near Metro Manila coupled with its explosive phreatic eruptions, had justified it to be included in the IDNDRlist of high risk Decade Volcanoes. Canlaon Volcano is located in Central Philippines, in the island of Negros, and most of its recent eruptions had been small phreatic explosions, although the possibility of having a large magmatic activity is indicated by the presence of young and extensive lava and pyroclastic flows on the slope of the volcano. Some of these deposits may be of historic ages, and this would need to be verified by a detailed geological study of the volcano. A small phreatic eruption of the volcano in 1996 caused three deaths in a group of 21 hikers that were unfortunately near the crater at the time of its small explosion.

Bulusan Volcano is an andesitic volcano in the southern tip of Luzon and is located inside a large dacitic caldera. Some of the recent accomplishments of the GARS-Asia project include the generation of a semi-detailed (1:50,000) geologic map of the Bulusan Caldera, and geologic field surveys this summer may yeild a detailed stratigraphy of the volcano that would be useful in the assessment of actual hazards from Bulusan, and from the larger caldera system.

The application of remote sensing to Pinatubo' s 1991 eruption were mostly after the 1 991 eruption, although to some extent the accurate prediction of the 1991 eruption was made possible by the early detection of the increasing S02 levels before the large explosions started. This was done using a ground-based correlation-pectrometer, and the abrupt increase in S02 indicated the involvement of magma in thes ongoing seismic crisis. Figure 2 shows a map of the effects of the eruption of Pinatubo, and the cumulative effects of the lahars (volcanic mudflows) from the volcano that occurred yearly from 1991 to 1995. This figure was generated from field surveys, aerial surveys, and from the interpretation and analysis of remote sensing data.

The 1991 eruption of Pinatubo directly threatened at least 50,000 people, and
about 200,000 people were displaced both as part of the government's evacuation scheme, and some, under their own accord. The direct casualties of the eruption was around 350 people, a very small percentage compared to the number of threatened lives. In such tropical conditions, where ash emissions from volcanoes cause the thermal disturbance that generate rains, lahars (or volcanic mudflows) become an integral part of the threat from the volcano. Also, the regular typhoons brought heavy rains that mixed with the deposits and caused the lahars to recur regularly every year. The lahars are more threatening than the direct impact of the eruption, mainly because these flows traveled at father distances. The 7000C hot pyroclastic flows that totaled about 7 cubic kilometers in volume were mostly confined within 10 km of the summit at the slopes that were largely uninhabited. The lahars were fed by these pyroclastic flows, and the water-pyroclastic mixture were able to flow as far as 40 km from the volcano. In terms of area, the lahars covered as much as twice the area of the pyroclastic flows, but most of these occurred at the areas where the villages are located. A large part of the destructive effect of the lahars rest on their not being confined to the existing river systems. The lahars both tended to overtop their channel confinement due to sheer volume, and to their audacity to deposit materials in their path, causing these flows to create new channels that were not used by the rivers in the recent past. Both of these cause a natural shift in the channel that the lahars use, causing destruction not only to old riverbank communities, but threatening a much larger region. In fact, lahars of Pinatubo have caused more deaths after the 1991 eruption, than those that were killed directly. As of 1995, a total of about 1,500 deaths had been attributed to lahars that thereafter flowed seasonally, albeit with decreasing

volume and frequency. The mapping of these extensive lahar deposits was facilitated with the use of remote sensing. In one river alone, the Pasig Potrero River south-east of the volcano, the lahars covered about 60km2 of an area that were previously populated and/or cultivated. And as the changes in channel location occurred through the past seven years, the need to regularly update and revise the maps of the lahar deposits would not be possible without the application of any remote sensing technology. Most importantly, lahar and channel mapping updates would need to be made with remote sensing not only for producing geologic maps, for the continuing need to assess the hazards and risks that these flows pose on the surrounding villages and cities.

In response to this continuing threat from lahars, the government had embarked on building dikes and containment structures to control the area where the lahars are flowing. Although this task proved useful only in delaying the threat by a few events in the past (only a few weeks or days during the rainy seasons) the government had worked on building a large system of"mega-dikes" and drainage-control structures around Pinatubo's most active river system. This system was completed last year, and would yet need to prove its worth in the next lahars. Figure 3 shows a composite ERS imagery taken from various dates, and indicating the amount of change that had been occurring around Pinatubo in the past years.

The ongoing E1 Nino has its positive contributions for the people around Pinatubo. Yearly since after the 1991 eruption, lahars had regularly been caused by the seasonal rainfall, but the reduced rains in the past two years had been in favor of those living close to, the lahar channels. Thus, the reduced rains brought by E1 Nino had worked in favor of the threatened residents, and those advocates of building civil structures to control lahars.

The application of remote sensing in the forecast of volcanic eruptions routinely is yet to be realized. In a project with ERSDAC of Japan, PHIVOLCS is currently working on a regularly radar imaging and routine interferometry of two volcanoes in the Philippines. In this project, a set of radar images are taken for two volcanoes at a repeat rate of once every 45 days. Some retroreflectors are installed to be used for registry of the radar data, and it is hoped that any inflation that magmatic intrusion may cause can be detected and mapped prior to the eruption of the volcano. The test sites for this project are Mayon and Pinatubo Volcanoes, and the objective is to devise an algorithm that can be routinely applied for predicting volcanic eruptions using radar interferometry.

The use of remote sensing in coordinating and directing emergency response still need to be effectively employed in the Philippines. It is hoped that a method for assessment of volcanic eruption damage can be made regularly in erupting volcanoes, and that this be used in managing resources and in directing rescue and relief operations during emergencies.

4. Recent applications on earthquake disaster management

For earthquakes, the use of remote sensing in geologic mapping of faults had been employed to a large extent. Most of the geological maps available in the country had benefited from one form or another of remote sensing technology. Figure 4 shows the structures that generate earthquakes in the Philippines, some of these had been identified using remote sensing technology. Large fault systems are readily recognizable in many forms of imageries, but the recent availability of radar images had been very useful since these are capable of penetrating the clouds that shroud the mountains in the tropical areas.

One useful potential application of remote sensing of earthquake faults is the development of methods in distinguishing which faults are active faults from those that are not as threatening. Figure 5 shows a mosaic of radar imageries covering the central part of Luzon. Manila Bay is found in the center of the figure, and Pinatubo Volcano is on the western edge of the land. On the northeast part, a large fault is visible, and this was the site of a very destructive 7.8 Magnitude earthquake in 1990. Other faults are recognizable although not all of these can be considered active. The task of distinguishing active faults is usually done on the ground through trenching and detailed geological work, or else the next earthquakes sometimes make the task easier for geologists. Although there are some impressive and very informative applications of radar interferometry in the detection and measurement of displacement fields along faults, all of these had been undertaken after the large earthquakes had done the damage. One potential site for using this effectively before a disaster is in Metro Manila where large scale deformation is occurring along north-easterly trending structures near the shore of the Laguna de Bai (Figure 6). These structures appear to be a continuation of a large fault that traverses Metro Manila, the Marikina Valley Fault System. It is yet unknown how the present deformation processes are related to the fault and whether all of this would relate to a large earthquake in the future. It would thus be very useful to detect the nature and rate of these deformation along such faults before the earthquakes affect large communities like Metro Manila.

5. Summary

Aside from applying satellite technology to geologic mapping of volcanic and earthquake fault mapping, the other applications of the technology to the spectrum of disaster management tasks in the Philippines is very limited. The main problems encountered in the application of remote sensing for volcanic and seismic disasters in the Philippines had been access to data in a timely manner. As a developing country, the Philippines had not had the chance to develop its own technology base for regularly gathering its own space imageries. Most of the imageries that are useful for geoscientific work are available only for a large price. This situation had been alleviated lately my collaborative work with other, more developed countries. However. it would be of great contribution to the disaster work in the Philippines if a regular availability of remote sensing imageries will be made available for use during volcanic and seismic crises.

Experimental work are being undertaken to address the problem of using remote sensing for volcano prediction and earthquake anticipation. Regular radar interferometry work with ERSDAC of Japan is being undertaken for Mayon and Pinatuho Volcanoes, and imageries will be acquired every 45 days tr) detect any ground deformation that may be associated with eruptive volcanoes. Hopefully, procedures will be formulated for using the technique in regular monitoring of volcanoes and detection of abnormal activity

Figure 1. Various tectonic and geomorphic elements of the Philippines.

Figure 2. Effects of the 1991 eruption of Pinatubo Volcano.

Figure 3 Bird's eye view of Pinatubo, showing changes on the slopes before and after the 1991 eruption.

Figure 4. Sources of earthquakes in the Philippine archipelago.

Figure5. Mosaic of radar images for central Luzon. The volcanoes and faults are readily visible.

Figure 6. Map of southern portions of Metro Manila. The right side is Laguna de Bai.
The thick lines are fissures whose movements are currently affecting structures.

NATURAL DISASTER SATELLITE OBSERVATIONS, MITIGATION. AND ASSESSMENT: A BILATERAL OPPORTUNITY

by

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As I write this, every Earth-viewing system orbiting our world is, or began life, as a government-owned sensor, mounted in a government-owned spacecraft, launched by a government-owned rocket. The image information it acquires is downlinked to a government-owned ground station, where government-owned technicians apply government-owned software packages embedded in government-owned computers to metamorphose zeros and ones into government-owned image information.

Today, in the electro-optic arena, one can readily purchase 79-meter, 4-band MSS space-derived imagery from Space Imaging EOSAT (SIE); or 30-meter, 7-band Landsat-4 and -5 Thematic Mapper imagery from that same source; or 20-meter, 3-band XS imagery from SPOT; or 10-meter, panchromatic black-and-white imagery, also from SPOT; or 5-meter, TM-band-like Indian IRS-1C/D imagery; or multi-polarization and multi-resolution radar imagery from Radar-sat, ERS, or JERS. And every one of these birds carries a government Vehicle Identification Number.

But know that within the next three years will be launched into low Earth orbit, by the U.S. private sector, a series of sun-synchronous polar-and equatorial-orbiting spacecraft mounting a variety of sensors, each of which will continuously view the whole Earth's surface at a combination of spatial and spectral resolutions hitherto nor available to the public. And the only participation by the U.S. government was to grant the license for them to do so. By the time we meet again in November, 1998, we will be looking at imagery acquired by two of those commercial licensees, Space Imaging EOSAT and EarthWatch.

The road from government-monopoly to private-sector ownership has not been entirely smooth. The fact that there will soon be an ability to synoptically view the surface of the Earth by someone other than a governmental body has been both an anathema and a malediction to some --- and a blessing and benediction to others. Wearing my hat as Director of NARSIA ---the North American Remote Sensing Industries Association --- places me, of course, among the latter. I firmly believe that the long-awaited unleashing of true commercial forces in the remote sensing arena will result in the rapid acceptance of this image information in many applications areas and the growth of an exceptionally important remote sensing industry. The early adapters of these temporally designated, scalable, geo-located, digital data and imagery sets will certainly include those individuals who must deal with the observation, delineation, monitoring, mitigation, mapping, assessment, and planning aimed at the whole spectrum of natural hazards.

At last year's meeting I presented, and then distributed to you a series of viewgraphs that summarized the pertinent characteristics of each of the five systems then expected to fly. There has been little change since then, other than (1) GDE is not now expected to enter the commercial fray as an independent flyer; and (2) SIE has finally named its commercial bird --- it's called IKONOS-1. Instead of re-presenting these viewgraphs in full, allow me to offer them to those of you who have not already seen them by asking you to hand me your business cards sometime this week, and I will make certain they are forwarded on to you.

What I will do today is to summarize the technical parameters of each commercial sensor, and mention the potential applications of each in areas of remote sensing that have brought us together this week, namely natural disasters. My concluding remarks will contain a modest proposal aimed at providing a novel direction to our annual meetings, based on the fact that (1) the imagery from these commercial satellites will soon be available to all who wish to purchase them, and (2) no one has yet thought to provide a roadmap utilizing this imagery in a combined, coherent fashion so as to construct an image information thoroughfare optimized for those government executives dealing with natural hazards. But I am ahead of myself.

U.S. Government licensing procedures have resulted in now four primary contenders seriously bending metal to take advantage of what they see is a major global market in satellite remote sensing. Keep in mind that hundreds of millions of dollars of shareholder capital have already been placed at risk by these companies, an action not lightly taken without careful contemplation, consideration, and fiscal due diligence. In alphabetical order, the first of these companies is Earth Watch.

Earthwatch, which began life as WorldView by several Lawrence Livermore scientists, was merged with a Ball Aerospace Company effort and renamed three years ago. The 3-meter panchromatic EarlyBird sensor, a near-replicate of the Clark instrument now undergoing environmental testing at NASA's Goddard Space Flight Center, will probably be the first commercial bird to fly. It is now scheduled for an early first quarter 1998 launch. The EarthWatch follow-on satellite, the 1-meter panchromatic QuickBird is due up in late 1998. Spatial resolutions of multispectral bands will increase from EarlyBird's 15 meters to 4 meters with launch of QuickBird.

Six-by-six kilometer pan and 30-by-30 kilometer multispectral swath width coverage is far narrower than we are used to dealing with in SPOT, Landsat, AVHRR, etc., but 90,000 square kilometers of the Earth's surface are expected to be collected on each orbit, and 34.2 million square kilometers collected each year. Especially pertinent for disaster work is the 2-3 day EarthWatch revisit time offered by the high-latitude equatorial orbit. Note that a broken levee on the Mississippi can be easily resolved at 1-meter, as can a lava flow emanating from a volcanic fissure or caldera. If all goes as expected. Earthwatch plans to send two of each bird into space, the second pair duplicating the first in all respects.

The second company is Orbital Sciences Corporation. Orbital has pursued its own business plan whereby it sees itself as the first vertically, wholly integrated space company. Originally a builder of launchers and spacecraft, Orbital expanded into the telecommunications world with its ORBCOMM subsidiary. Already a player in the space remote sensing world with its SeaStar activity, Orbital cemented its presence in that field with expansion of its ORBIMAGE subsidiary through a series of recent acquisitions, highlighted by purchase of Fairchild Space Company, MacDonald Dettwiler and Associates, and, most recently, CTA Space Systems, builder of the NASA Clark sensor. Orbital's entry into the high-resolution commercial Earth-viewing business, ORBVIEW-3, will be launched during 1999, with a duplicate planned two years later. The 10:30 a.m. equator crossing time replicates earlier Landsat crossing times to provide data continuity and facilitate comparative imagery studies. Expected data sets include l-meter panchromatic, 4-meter multispectral, and 8-meter hyperspectral images. Inclusion of the hyperspectral sensor on OrbView-3 is relatively new, occasioned by an award from the U.S Department of Defense. It is expected that this hyperspectral capability, if properly understood, merged, and marketed, will enhance this instrument's capabilities in mapping and assessing damage areas across the breadth of natural disasters, particularly those affecting land areas, as fires, tornadoes, floods, and hurricanes.

Resource21, the third company expected to launch a commercial remote sensing satellite, is a bird of a different color. One of the major partners, Boeing, has described it as a satellite with a specific customer in mind. Resource21 is aimed at agribusiness and renewable resources. Instead of seeking to take over aerial survey and cartography market niches, which are primary goals of the other "high-resolution" pan instrument builders, Resource21 has chosen in essence to "fine-tune" existing SPOT and Landsat imagery by selecting bands and resolutions optimized for applications such as senescence studies, crop yield predictions, crop production estimates, and forest inventory evaluations. Planned for 1999/2000 launch, the sensor will carry four visible/near-infrared bands at l0-meter resolution, coupled with a 20-meter IR, and a broad-band 100-meter IR to provide a combination which will result in false-color multispectral imagery of best use to a (hopefully) waiting global renewable resources market. No panchromatic band is planned.

Resource21 boasts a relatively high ground location accuracy. Parameters include, (1) very broad area track coverage, (205 km cross track by 1.000 km- to 4,000 km-along track), and (2) frequent tilt revisit time (at the equator, twice in 25-minutes minimum revisit time with cross track tilt; at plus and minus 30 degrees latitude, 2-t0-3 times in 25-t0-50 minutes, and twice weekly with nadir view only). These parameters will result in a monitoring capability certain to be of value to those involved in large-area post-disaster assessment and management, such as is necessary with over-bank river floods, flood plain mapping, earthquake damage, land subsidence due to massive fluid withdrawals, and tsunami-related barrier island overwash and coastal inundation.

Alphabetically last, but certainly not least of the four commercial companies is Space Imaging EOSAT, (SIE). Well capitalized, SIE is the most mature company of the group of four. It shared its only major weakness with the other competing firms; that weakness being that it had no history in marketing and image information distribution. That has all changed, with the announcement made shortly after our meeting on Oahu last year, of the total absorption by Space Imaging, Inc. of the Earth Observation Satellite Company (EOSAT). Since the demise of Land-sat-6 in 1993, EOSAT had attempted to redefine itself by seeking a way to bring to bear its only true, and admitted strengths: (1) a global understanding of customer remote sensing imagery requirements; and (2) an in-place, worldwide data distribution network --- strengths precisely matching Space Imaging's weaknesses. It was only a matter of time before the long arm reached from Thornton CO to Lanham MD to claim the corporate prize, and it has now done so. Now called Space Imaging EOSAT (SIE), a Lockheed-Martin company, it is positioning itself to capture what it considers to be the prime market segments that can be derived from satellite remote sensing. Those market segments all fall under the general heading of "cartography," including all aspects of GIS that employ an image-map as the basic foundation upon which are superimposed disparate digital data sets. The SIE system, recently named IKONOS-1, is scheduled for a first-quarter 1998 lift-off. The sensor package includes a l-meter panchromatic band and four visible/near IR bands which are close to the primary Landsat Thematic Mapper bands. However, unlike TM they boast a 4-meter spatial resolution. Further, the Landsat-like 10:30 a.m. equator crossing will result in compatibility with Landsat interpretations, and the very high ground location accuracy will allow an excellent mapmaking capability, assuring it a role in most natural disaster applications.

These are the four commercial entities that are serving as pioneers in U.S. commercial satellite remote sensing. As an individual and as director of NARSIA, I look forward to the marketing success of the image information products to be derived from these satellites, including the merging of these data with other digital image vector, and tabular data sets.

But the purpose of my address today transcends the mere recitation of technological "things-to-come." This is the fifth annual meeting of this group --- the fourth that I have attended. At each of these meetings we have been honored with broad attendance from academe, industry, and government, representing both the U.S. and Japan. And one need merely look at the JUST-SAP letterhead to confirm the fact that the Workshop leadership replicates that broad participation. I maintain that it is to the benefit of this tripartite constituency of both countries that a strong, viable, global remote sensing industry be promoted and maintained.

As a general statement, there is no such thing as too much cooperation. As a general statement, the private sector of both our countries should be encouraged to provide input into proposed government activities of both our countries as early in the government planning cycle as possible. For its part in the United States, NARSIA supports a clear statement of the U S. government's role in pre-competitive research and technology development of sensors optimized for visualization of natural disaster phenomena. That's the role of government, and we have been vigorously supporting that role. Granted that the role of the private sector in Japan is somewhat different than it is in our own country, it is up to Japan's industrial sector to define that role to a point that makes it possible far U.S, remote sensing companies and Japanese remote sensing companies together, jointly, in hand with their university colleagues, to approach their respective governments with a single roadmap and plan for delineating future sensor research and development in those pre-competitive areas dealing with applications optimized for global natural hazards.

The millions of frames of satellite imagery of Earth acquired in the past quarter-century and now residing in archives worldwide are but a harbinger of further millions soon to join them. If nothing else these images have certified the global interdependence of all terrestrial systems. These same images have informed us --- in near real time --- of the constant delicacy and continuing upheaval of our so-called "solid" Earth. The up-close litany of earthquake, flood, fire, hurricane, tornado, tsunami, volcanism, lightning, cyclone, subsidence, avalanche, mudflow, and drought appears before us via instantaneous global television. Synoptic satellite images only further demonstrate human frailty and inconsequence when pressed against the ephemeral nature of our planetary environment. In terms of dollars some $480 billion dollar losses were incurred by the global economy due to natural disasters during the years since launch of Landsat-1 in 1972. Would that a coherent program incorporating satellite imagery specifically for disaster-related functionalities were in place since that time. I suspect that the economic results would not have been as disastrous --- not to mention the unknown numbers of lives that could have been saved, world-wide.

I relate to you a short anecdote that serves as my own personal touchstone. In the mid-1980's, prior to the initiation of the current IDNDR --- the International Decade for National Disaster Reduction --- I served as a consultant in cooperation with a university and a not-for-profit research organization that submitted a proposal to a U.S. federal science agency whose name I need not mention, but whose initials are N-S-F. The thrust of that proposal was to establish a mechanism for employing satellite imagery from then existing sensors to help assess huge-area natural disasters. The proposal was turned down. The debriefing we received showed that the peer reviewers all felt that the proposal, though technically interesting and competently written, there really was no hope of satellite imagery adding anything of value in natural disaster assessment and evaluation. Such were the times then, and, to a large degree and despite the growing acceptance of the role of satellite imagery in some quarters, such are the times now.

What can we --- here, in yet another November, on yet another Hawaiian island, gathered in this most pleasant of venues, sitting placidly atop a cauldron of churning magma --- what can we do to move the political system at least one step closer to employing already existing technology and preparing for coming technology, against an always surprising natural environment? And mind you, please know that the problem is not a technological one --- it is a political one. We here in this room know that satellite remote sensing can provide image information data sets and products that are of enormous use to those officials, in every level of government worldwide, responsible for the whole continuum of natural disaster operational tasking --- from mitigation to observation to assessment, and everything in-between. The fault lies mainly with us because we have not successfully transmitted that fact to those government officials, and more important, to the public at large. And here I emphasize the point that public understanding is a *sine qua non*. Without an understanding, accepting, aware, and proactive public constituency, government entities do not move. I speak specifically to all levels of government, be that government a federal republic with 50 states from Alabama to Wyoming, or be that government a constitutional monarchy with 47 prefectures from Aichi to Yamanashi. The public cannot know, unless it is told. The public cannot act, until it is informed. We, as stakeholders and keepers of the technology, must engage in pro-active outreach. Outreach begets public awareness; public awareness begets public acceptance; public acceptance begets public demand; and public demand becomes the fuel for the technological engine that has, through the centuries, moved humankind ever upward to higher levels of living standard and grace.

The bilateral opportunity referred to in the title of this talk speaks to the modest proposal that I present to you now, Many governments have established, at many levels, emergency management organizations chartered to serve as central switchboards for many types of natural and maninduced disaster events. And many of these governments, as space-faring nations, have formed a loosely cooperative Committee on Earth Observation Satellites (CEOS). But no one, anywhere, has attempted to merge both the application of natural disasters to the tool of satellite remote sensing in a single, committed organization. I propose that the Japanese and U.S. industry and university representatives here today, in the Workshops to follow, prepare a Charter and Concept of Operations for a bilateral organization whose function it is to serve as an advocate for current and future ground and space segment satellite remote sensing technologies, specifically optimized for application to all aspects of natural disaster mitigation, observation, and assessment. I propose that this organization also be enabled to serve a primary outreach function through such activities as a cooperative web site and newsletter. Further, I propose that resources be sought to headquarter this organization here in Hawaii, with an eventual satellite office on the U.S. mainland and one in Japan. Initial work can be concentrated on natural disasters endemic to both Hawaii and Japan, as those associated with volcanism. I see this as a non-federal, joint private-sector/university/local government advocacy venture, whose funded activities will serve as research demonstrations and technology test-beds in the one specific, but global application that is the subject of this meeting. For its part NARSIA will serve to inform its membership, and the U.S. private sector remote sensing community as a whole of this activity, and will provide whatever additional support it can in securing funding for its success.

I place this proposal on the table for your consideration and action I Iook forward to your comments. Thank you for your kind attention.

SAR Data Application to Monitoring Earthquake Disaster and Volcanic Surface Displacement

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ABSTRACT

Surface changes and displacement caused by earthquake and volcanic activities can be detected by satellite radar interferometric technology using L-band JERS- I SAR images. For the detection of the surface changes of the Hyogoken-nanbu earthquake, collapsed non-wooden buildings and guarys were detected by comparing pixel brightness between a pair of images before and after the earthquake. And furthermore, interferometric analysis shows 0.6 meter surface displacement along the radar line-of-sight direction around Kobe City and 1.1 meter displacement in AwaJi island where epicenter is located. Far the detection of volcanic body deformation in Iwo-jima, the interferometric analysis shows concentric circular subsiding displacement that agrees with the results of ground measurement.

INTRODUCTION

A synthetic aperture radar (SAR) is an active microwave sensor which can take images of objects in a high spatial resolution through clouds and at night. This observation ability is suitable for monitoring earth surface under all wether conditions and at all time. The ground surface change caused by some event may be detected by comparing brightness of the objects between a pair of images before and after the event. Moreover, satellite interferometric SAR (INSAR) technology, which involves interferometric phase comparison of successive SAR images, realizes the measurement of very small (1 cm or less) surface changes and displacement over large swath (several l0s of km) However two important conditions must be observed for detecting and measuring surface changes with INSAR (T. Dixon, 1995) (1) Changes between successive images must not be too large, and more specifically, the displacement gradient across a pixel must fall within some value. (2) The radar-scattering characteristics within each pixel must remain similar in the time between the two image acquisitions. Specifically the root-mean-square (rms) position of the surface scatters within a pixel must remain constant within a fraction, say 10 to 20%, of the radar wavelength. For the condition (2), images in an arid region like a desert area have the tendency to perform well. Massonnet *et al,* (1993 and 1995) reported the detection of surface changes and displacement caused by an earthquake in a desert area and volcanic activities in the Mediterranean region with the C-band SAR of ERS-1, whereas this paper reports works using L-band SAR of JERS-1, and the regions of concern are the temperate humid zone and the subtropical oceanic zone

DETECTION OF SURJFACE CONDLTION CHLANGES OVER KOBE CITY

<u>Hyogoken-nanbu Earthquake</u>

On 17 January 1995 a strong earthquake of M 7.2 struck Kobe city (Figure l) and Awaji Island, causing

6,310 causalities and missings, and destroying 209,043 houses. A fault with movement of about 1 m appeared on the ground surface in the northwest part of Awaji Island. No fault appeared on the ground surface in Kobe city area. Figure 1 shows the location of Kobe city.

SAR images over Kobe city

In order to detect the ground surface changes which are supposed to be caused by the earthquake, comparison of two different JERS-1 SAR images acquired before and after the earthquake was carried out. The path and row of the two images are D071-244 and the acquisition dates are 5 January 1994 and 5 February 1995 respectively. The latter is the first image acquired after the earthquake. The former (Figure 2) is required in the same season as the latter, but only one year earlier.

Comparison process

The outline of the comparison process is as follows (Figure 3).

1) Reconstruct two 3-look power images from the two level 0 images (SAR signal images). The power image of the first scene is shown in Figure 2.

2) Coregistrate the latter image to the former by resampling the latter one.

3) The histogram deviate from that of the normal distribution however the square root of the power images has a histgram of the normal distribution.

4) Correct pixel values of the latter image with a formula derived by the linear regression analysis between the both images. Here, the regression analysis was conducted all over the images except a portion around the right-bottom corner where in the latter image, pixel are not part of the scene.

5) The difference image is made by subtracting the first image from the second one.

6) The difference image is superimposed on the second image using the Munsell color systerm. Its three parameters, hue, value, and chroma were put into correspondence to the difference image, the second image and a constant value (=0.5), respectively. The difference image was converted into hue so that the minimum pixel value shows blue, the mean value shows green and the maximum value shows red. After this conversion, the portion where the amount of backscattering increased in the latter image appears in yellow or

Fig.1. Location of Kobe city

Fig.2. JERS-1 SAR images over earthquake damaged area in Kobe city

red, and the position where the amount of backscattering decreased appears in cyan or blue.

Figure 4 shows the superimposed image. It covers an area of about 16 km X 13 km with a pixel size of 12.5 m. Since none of ships were at the same position in the first and the second images, they appear in red and blue along the coast and in the sea. It is highly likely that red colored portion in the land area shows large scale buildings built in the period between the two images. For example, the red portion indicated with the character "A" in Figure 4. However the red parts indicated by "B",close to a whart, is a subsided and destroyed rock face It is very likely that cyan or blue colored portions were places where buildings were collapsed. The areas indicated by "C" and "D" are in Nagata ward of Kobe city where a great fire broke out and many houses were clasped. Small portions which are colored from cyan to blue were scattered in this area "E" and "F" correspond to collapsed non-wooden buildings. The blue colored are indicated by "G" is a container terminal. It is assumed that there were many containers when the first image was taken, and there were only a few containers left when the second image was taken.

Fig.3. A flow chat of detecting changes of surface condition

Fig 4 Superimposed difference of images on the image after the earthquake.
The difference image, the second image and constant value (=0.5) is assigned hue, value and chroma, respectively.

THE PRINCIPLE OF REPEAT PATH INTERFEROMETRIC SAR

In order to detect surface changes, at least two images must be acquired before and after the change. Namely a single-antenna SAR system that revisits the same position and images the same area on the ground to get the successive images. The interferometric analysis of such SAR images is called repeat pass interferometric SAR. Kimura *et al.* (1995) introduced equations expressing the sensitivity of the interference phase shift to topographic altitude variation and surface displacement. They produced typical values of the sensitivity of ERS-1 SAR. Referring to these equations a few typical values of JERS-1 SAR are produced here. Figure 5 shows the geometry between two antennas and the ground surface in the plain containing the radar line-of-sight (i.e. a range direction), and orthogonal to the Azimuth. Figure 6 shows the corresponding displacement on the ground surface. Let T 1 be the position of a ground target when seen by the satellite in the first pass, and T2 be the position of the same target in the second pass The displacement can be decomposed into a horizontal component *Dx* and a vertical component *Dz.* Although a second horizontal component *Dy* exits in the azimuth direction, we give no consideration to *Dy* because INSAR has no sensitivity to the azimuth direction. The phase change in SAR interferometric analysis can be approximated by

$$Ø=4\P/\lambda \{B \sin(\theta-\alpha)+ Dx \sin\theta- Dz \cos\theta\} \qquad (1)$$

where λ, B, and α denote wave length, the base line, the look angle and the inclination angle respectively. The altitude of ground surface is given by

$$z = H - r \cos\theta \qquad (2)$$

where H is altitude of the satellite from the datum level and r is slant range.In general B is not zero. Dx << B and D≈<<B. Given those conditions, the phase shift rate in the interferogram caused by topographic altitude variation is

$$d Ø/dz = 4\P B \cos(\theta-\alpha)/ \lambda r \sin\theta \qquad (3)$$

Supposing B = 500 m and $\alpha= 0^{o}$, then

$$d Ø/dz = 4.502 \times 10^{-2} \quad \text{(radian/m).} \qquad (3')$$

Fig. 5 Geometry between two antennas and the ground surface in a plane containing the range line-of-sight.

Fig.6. Geometry of target displacement on the ground Face.

This expresses that one phase fringe in the interferogram corresponds to a topographical altitude varieties at 140 m. The phase shift rates caused by horizontal displacement and vertical displacement are, respect to

$d Ø/dx = 4¶/ \lambda \sin\theta$

and

$d Ø/dz = -4¶/ \lambda \cos\theta$

A positive sign in the right hand side of Eq. 4 expresses that displacement in the positive direction of coordinate increases the phase and that in tbe negative direction decreases the phase. A negative sign, right side of Eq. 5 expresses that upward displacement decreases the phase and downward displace???

increases the phase. Equivalently, displacement pointing away from the satellite along the range dir?? increases the phase, and displacement pointing to the satellite decreases the phase. For JERS-1, the ??of the two rates are

$d Ø/dx = 35.1$ (radian/m) (4') and $d Ø/dz = -40.3$ (radian/m).

Namely the one fringe in tile interferogram corresponds to 18.6 cm of horizontal displacement and –15.2 vertical displacement. Comparison of Eq. 4' and Eq. 5' with Eq. 3' shows that the phase rates caus??displacement are remarkably larger than that caused by the difference in topographic altitude. It is even so if the base line is short or the displacement is large, and the phase shift caused by the displacement u ?? dominate over the phase shift caused by topographic effects.

DETECTION OF SEISMIC DEFORMATION OF HYOCOKEN-NANBU EARTHQUAKE

Image Processing

JERS-1 SAR images acquired on 10 October 1993 and 22 March 1995 are used for the analysis of the s??change detection. The image acquired before and after the earthquake are defined as the master and images respectively.

Single Lock Complex image. Phase reserved complex SAR image is necessary far generating interferogram. We made the phase reserved single lock complex (SLC) SAR images from level 0 data ERGOvista SAR Processer.

Interferogram Containing Fringes due to Topography and Surface Changes. After coregistrating the two images by subtracting the phase of the conjugate of the master SLC image from that of the slave. Interferogram has fine fringes called orbital fringes. Figure 7 shows the interferogram after removing orbital fringes.

Removing Topographic Fringes. To remove the topographic fringes we simulated topographic fringes, ?? are phases of a complex images, from a digital elevation model (DEM) of 50 m mesh size Figure 8 shows a stimulated interferogram containing only the topographic fringes. One cycle of the fringes correspond elevation variation of about 140 m. Subtracting the phase of the topographic fringes shown in Figure 8 that shown in Figure 7, the resultant interferogram corresponds only to surface changes or s? displacement. The final interferogram, shown in Figure 9, is a mosaic image over Kobe city and the no part of Awaji Island.

Fig. 7: An interferogram after removing Orbital fringes

Fig.8. Simulated interferogram containing only topographic Fringes.

Fig.9. The final interferogram containing only fringes caused by surcace displacement.

Estimation of Displacement In Figure 9 one fringe corresponds to 17.9 cm of horizontal displacement or –15.6 cm of vertical subsidence However without any hypothesis such as there are no horizontal displacement etc., only that we can measure is the range direction component of the displacement. Then one cycle of fringes corresponds to the displacement of half wave length, 11.75cm, because the wave length of JERS-1 is 23.5 cm. In Figure 9 positive phase shift varies color in order of red-yellow-green-blue-purple-red and the viewing direction is 95' in counter-clockwise from the top. Five phase cycles of negative phase shift around Kobe area mean that the displacement in the direction towards to the satellite is at least 58.8 cm. Also, nine phase cycles of positive phase shift in AWaji Island mean that the displacement away from the satellite is at least 105.8 cm. The time interval of the two images is almost one and half year. This means that interferometic SAR with L-band is capable of long period detection task.

DETECTION OF VOLCANIC BODY DEFORMATION IN IWO-JIMA

“Iwo-jima” (Sulphur Island) is a volcanic island located in 24º 45’N and 141’ 20’E (Figure 10, Figure 11). It is one of the “Kazan Retto” (Volcanic Islands) in the lzu-ogasawara arc, formed above the subduction of the Pacific plate beneath the Phillipines Sea plate. Figure 11 shows the level contours. Generally this island has a tendency to uplift. The shoreline on which Captain Cook's surviving crew landed in 1779 is now 40 m above sea level. National Research Institute for Earth Science and Disaster prevention has been monitoring its volcanic activity since 1976. More than 20 sunreyjng targets were set up there for conventional measurement (Kumagai, 19S5) Figure 12 and Figure 13 show vertical diSplacement at some of the targets. In 1995 a subsiding area was measured in Motoyama. The maximum relative subsidence of –25.3 cm from 1993 was observed at No. 17 target. We discuss the usefulness of interferometric SAR for detecting this subsidence in the following section.
the fouowtng secdon

Fig. 10 Location or lwo-jima.

Fig 11. Topography of lwo-jima.

Fig. 12 Vertical displacement by ground measurement vs. time

Deformation of the Volcanic body

Two images of JERS-1 SAR, path-row D056-259, acquired on 28 June 1993 and 16 July 1995 have been used for this analysis. The procedure of image processing is the same as that for analyzing the Kobe earthquake. Figure 14 shows the master SLC image. The interferogram before removing the topographic fringe is shown in Figure 15. Figure 16 shows the simulated topographic interferogram. Here one topographic fringe is 181 m in height. The final interferogram sbown in Figure 17 shows subsiding displacement with

concentric circular contours in Motoyama The appearance of the concentric circular contours

agrees with the knowledge of volcanology. In Figure 17 one fringe corresponds to 17.9 cm of horizontal displacement or - 15.6 cm of vertical one. With the hypothesis that there is no horizontal displacement, the existence of three fringes in Figure 17 indicates subsidence of more than 54.6 cm at the center of the circular fringe. We note that the time interval between the acquisition of the master Disaster and the slave images is over two years

Fig.13. Spatial distribution of vertical displacement by ground measuremen between 1993 and 1995

Fig.14 A master SLC image of Iwou-Jima on 28 June 1993. This image is compressed three times in the azimutih direction.

Fig. 15. An interferogram after removing orbital finges.

Fig. 16. Stimulated interferogram containing only topographic fringes.

Fig 17. The final interferogram containing only fringes caused by surface displacement.

CONCLUSIONS

JERS-1 SAR images have been applied to detecting changes caused by Kobe earthquake and to detecting ground surface displacement. Earthquake caused damages are qualitatively analyzed by comparing two images before and after the quake. Each ground surface displacement in the temperate humid zone and in the subtropical oceanic zone is quantified using interferometric techniques. Four conclusions may be drawn from this work:

1) Damages caused by the earthquake can be revealed by mapping the difference image in Munsell color system.
2) For the detection of coseismic deformation of Hyogoken-Nanbu earthquake, a phase interferogram of the images shows about 0.6 meter surface displacement along radar line-of-sight around Kobe City and about 1.1 meter displacement in Awaji Islnad.
3) For the detection of volcanic body deformation in Iwo-Jima the interferogram shows concentric circular subsiding displacement that agrees with the results of ground measurement. The value of the displacement detected by INSAR is larger than that of the ground measurement.
4) This work has demonstrated that the L-band SAR of JERS-1 is useful for interferometrically analyzing surface changes during a relatively long period.

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Managing Natural and Manmade Disaster in Hawaii

by

Mr. Roy Price,

Vice-Director, Hawaii State Civil Defense

Preparedness, Recover, Response and Mitigation are for the Comprehensive Emergency Management, puzzle

According to the assessment, Hurricane, Flash flood, Tsunami, Earth quake, Volcano, Land slid, Urban fire, Power failure, Wild fire, Oil spill, Drought, Aircraft Incident, HAZMAT, Tornado, Dam failure, Radiological and Civil Disorder is the risk ranking

We are losing 50,000 $ due to disaster

Pacific Regional Emergency Management Information System

State Civil Defense(Hawaii Department of Defense):FEMA region IX, Pacific Area Office

Pacific Disaster Center, Maui High Performance Computer Center

He enhanced second disaster

PEACESAT-Digital Equipment

Workable GIS system presentation for emergency management

CATS model for all hazard

Volcano eruption model

Fire propagation model

Downwind hazard model

Global and National Disaster Information Network would be create in the future

Review of International] Astronautical Federation(IAF) Initiatives Related to Disaster Mitigation

by

Mr. Niel Helm

Deputy Director, Institute for Applied Space Research, George Washington University

Communication: Hand held telephone wit LEO

Remote Sensing: New high spatial resolution

Positioning: GPS

Information: WWW

IDNDR magazine number 23 Winter 1995(Source: SPOT Disaster)

Economic loss of 100 Billion $ in 1995(50 Billion $): 1 Billion $ a week

Disaster type Prevention. Warning, Relief

GEM: Global; Emergency Management System

Predict Detect/Warning Monitoring/Assessment Relief

Flood

Earthquake

Hurricane

Drought

Volcanic eruption

Oil spill

Nuclear accident

Study of Disaster Mitigation and Emergency Management Using Satellites

by
Dr. Yoshiki Suzuki
Director, Space Communications Division, Communication Research Laboratory
Projects of the ministration of Posts and Telecommunication

In Japan, MPT and NASDA is going to conduct projects concerning study of disaster mitigation and emergency management using satellites These projects would be carried out aiming to develop the most suitable system based on the results of these projects under the effective cooperation between MPT and NASDA.

<MPT Project>

l. Objectives

This project aims to research the satellite communications network which is necessary for searching activity, rescue and reconstruction on occasion of great disasters , and to contribute to constitute an info-communications system for disaster and emergency management which is suitable for the advanced info-communications society of the 21st century.

2 Necessity

What we learned from the great disasters such as the Great Hanshin Earthquake and the Nahotoka Oil Spilled Accident which we have experienced recently made us aware that a disaster and emergency management communications system is necessary to grasp situation of disasters or accidents, and that utilizing space communications technologies is effective means to overcome difficulties in communications under geographical restrictions.

At present, the info-communications systems for disaster and emergency management are being developed by each related organizations in Japan. However, from now on, it is expected to constitute the more effective system with the more functional interconnection among the networks of these organizations and with the introduction of new space communications technologies in the field of communications, broadcasting, positioning and earth observation.

Moreover, the disaster and emergency management system is expected to be able to have the interconnection in counter-measures which are conducted under international cooperation. ESA has already started the same kind of research projects and they have indicated their intention to begin cooperative project with Japan. In addition, last December, JUSTSAP agreed to examine "Emergency Communications Management".

Under these circumstances, MPT considers "Study of disaster mitigation and emergency management using satellites" as an urgent theme.

3 **Technology Development/Study Items**

(1) Clarification of required functions for the disaster and emergency management system

(2) Examination of info-communications technologies applied to the disaster and emergency management system

(3) Examination of the most suitable system

(4) Demonstration of the usefulness, interconnection, and interoperability through
an experiment using a pilot system

4 Development/Study Schedule

1998 To execute the following researches concerning disaster and emergency management system

- Clarification of functions
- Examination of the offered info-communications technologies
- Examination of the most suitable system
- Examination of the pilot experiment system

1999 To make an experiment using a pilot system

- Experiment using COMI~:TS. Domestic Commercial Satellites, INTELSAT
- Consideration on cooperation with ESA under JEG project
-

<NASDA Project>

1. Objectives

This project aims to examine the possibility of the contribution to the observation and the counter-measures of the terrestrial disasters using the applied technologies such as Earth Observation Satellites which have been researched and developed up to the present. It also aims to study the experiment system, to identify measures for utilizing the space technology and to clarify necessary items for technological development.

2 Necessity

At present, regarding earthquakes, floods, eruptions and any other kinds of disasters, National Authorities have established observation points on the ground and the ocean so as to cope with an occurrence of disasters and following secondary disasters. They have also conducted regular observation and grasped situation using planes. Meanwhile, the observation from space is considered to be effective because of following reasons:

l. To be able to observe wide areas (observation of wide areas on the ocean and crustal movement and so on)

2. To be able to make observations and transmit information in anywhere

3. To be able to make continuous and regular observations

Moreover, it would be highly possible to make operations such as disaster observation on the ground or ocean more effective and advanced by using satellites in orbit. From these reasons, it is necessary to start an examination on an experimental system immediately.

3 Specific Study Items

(1) Set up the conditions for mission requirement

a. Research of disaster observation data users

- Investigation of names of organizations which is utilizing data and actual examples of utilization

b. Research of requirements for information about disaster observation

(a) Disasters (earthquakes, eruptions, landslides, floods and so on)

(b) Contents of demand for information about observation

- Contents of information, accuracy of information, instantaneous field of view(IFVO), observation area, frequency, time to take from observation till providing data

(2) Examination of necessary system

a. Arrangement of conditions of mission requirement

observation objectives, observation sensor, observation frequency, forms of providing data

b. Examination of total system

Examination of economically and operationally superior system

c Constitution of Satellite System

downsizing, number, orbit altitude, angle of inclination of an orbit, geostationaly orbit

d. Required functions for Satellites

direct data transmission for users, DCS(Data Collecting System) function

e Examination of the data transmission network

from observation to providing data

f. Examination of the ground system

Ground system based on users' needs

4 Study Schedule

In FY 1998, NASDA would conduct needs research and system examination, examine all necessary technological problems. After that NASDA would research element technology and examine experiment systems

Concept of Global Disaster Observation Satenite System (GDOS) and Measures to be taken for Its Realization

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Abstract

The Global Disaster Observation Satellite System (CDCS) is a concept for the establishment through international cooperation of a disaster prevention system making use of rapidly evolving Earth observation satellite technology in order to minimize the damage caused by various types of man-made and natural disasters.

The GDOS system has been proposed by the research members (including the authors) of the Society of Japanese Aerospace Companies Inc. (SJAC) as an international observation system having the purpose to acquire images/data of disaster stricken areas for transmission to relevant organizations. The images/data can be acquired at any location on Earth and regardless of the local weather conditions for the 24 hour period immediately after the occurrence of the disaster.

The GDOS system is an upgraded version of the World Environment and Disaster Observation Satellite System (WEDOS) which the authors proposed at various events (including conferences of the United Nations) and incorporates the experiences gained and lessons learned from the Great Hanshin/Awaji Earthquake which occurred in Japan in 1995. The authors propose that the GDOS system would be realized though international cooperation to specifically focus on disaster observation, and would considerably contribute to disaster mitigation worldwide by its integration with conventional disaster prevention systems.

This paper outlines the GOOS system and describes its features, operation, and the measures needed for its realization,

1. GDOS Features

The features of the GDOS system are described as following:

(1) Highly Frequent Observations

Observation of any point on the Earth' s surface can be performed at least one time per day with an observation width of 180 km and 15 meter resolution.

(2) Acquisition of High Resolution Images

Capability to observe the disaster stricken area with a resolution of 2 meters and a ground observation width of 40 km on command from ground control.

(3) All Weather / 24 Hour Observation

Capability to observe the disaster stricken area with a resolution of 5 meters regardless of the time of day and in any weather conditions (including cloud, rain and snow).

(4) Early and Highly Frequent Observation

Capability to acquire a full view of the disaster stricken area within an average time of 2 hours after the occurrence of the disaster and to maintain highly frequent observation at 2 hour intervals for subsequent data acquisition.

2. Examples of Disaster Phenomena Observable by the GDOS System

(1) Earthquakes

Collapse of expressways, large buildings, bridges, etc. Outbreak, spreading and extinguishing of fires. Liquefaction, upheaval, subsidence of land.

(2) Storms, Floods

Typhoons, hurricanes, cumulo-nimbus cloud formations, etc. Submerged areas, collapsed buildings, agricultural damage.

(3) Marine Pollution. Maritime Distress

Areas of pollution, spreading of oil slicks caused by damage to oil tankers, movement of pack ice, ship routing, illegal incursions into territorial waters, ocean debris.

(4) Volcanic Eruptions

Eruption status, changes in neighboring areas, pyroclastic flow, smoke and ashfall distribution.

(5) Landslides

Collapse of slopes, blockage of river now, prediction of endangered slopes.

(6) Climatic Changes

Sea surface temperature changes, direction and speed of ocean winds, effects of El Nino, etc.

(7) Forest Fires

Outbreak, spreading and extinguishing of forest fires.

(8) Agricultural

Growth of crops, drought, insect damage,

3. GDOS System

The GDOS System is composed of a satellite system and a ground system as shown in Figure 1 and Figure 2. The satellite system consists of twenty-four observation satellites and six data relay satellites as shown in Figure 3 and Figure 4. The ground system consists of a Headquarters (HQ), a Mission Management Center (MMC), six Master Ground Stations (MGS), three Observation Satellite Control Stations (OSCS), and multiple Local User Stations (LUS).

(l)Satellite System

The constellation of the GDOS satellites and their orbits, as shown in Figure 3, enables the quick and timely acquisition of disasters sites within an average time of two hours after the occurrence of the disaster. The allocation is four observation satellites in each of six sun-synchronous orbits (total = twenty-four satellites) at altitudes of approximately 700 km and two hour intervals, and allocation of six data relay satellites in geostationary orbit for relay to the nearest Master Ground Station of observation data acquired by the observation satellite closest to the disaster.

1) Observation Satellite and Onboard Sensors

twenty-four observation satellites are categorized into three types as shown in Table 1. The allocation is of four each of type satellites in five orbits of even local node times (except for 6:00 o' clock) and allocation of two each of b-type satellites and c-type satellites into the orbit of the local node time of 6:00 o'clock. The typo of observation sensors onboard each satellite and their main performance characteristics are shown in Table 2. Features of the onboard sensors and observation purposes in the event of disaster and in times of normal operation are shown in Table 3 .

2) Data Relay Satellites (DRS)

There are six Data Relay Satellites positioned in geostationary orbit at 60 degree intervals as shown in Figure 4. Each Data Relay Satellite relays command signals from the nearest Master Ground Station to the nearest observation satellite and vice-versa.The data communication network consists of two routes, that is one route encircles the Earth clockwise using three Data Relay Satellites, the other route encircles the Earth counterclockwise using the other three Data Relay Satellites. Each route can function as an

operational routeor a redundant route in an emergency. Each Data Relay Satellite has broadcasting functions to relay disaster information that has been relayed via the nearest.

Master Ground Station to each Local User

Station when required.

(2.) Ground System

The ground system consists of five sub-systems as shown in Figure 1 (GDOS Data Acquisition and Relay System) and Figure 2 (GDOS System Configuration),

Figure 1 : Data Acquisition and Relay System of GDOS

Figure 2: GDOS System Configuration

Figure 3: Orbital Position of GDOS Satellites

Figure 4: Data Transmission network of GDOS Data Relay Satellites

Table 1:Type/Number of GDOS Observation Satellites with Sun-synchronous Orbits

Local Node Time AM/PM	06	08	10	12	02	04
Observation Satellite-type a	--	4	4	4	4	4
Observation Satellite-type b	2	--	--	--	--	--
Observation Satellite-type c	2	--	--	--	--	--

Table 2:

Onboard Observation Sensors and Main Performance Data

Satellite Type	Sensor Type	Resolution	Observa-tion Width	Variable Angle of Observation Ground Distance
type a	VN-1 Visible and Near Infrared Radiometer1	2m	40km	±43° (±700km)
type a	VN-2 Visible and Near Infrared Radiometer1	15m	180km	±43° (±700km)
type a,b,c	SW Shortwave Infrared Radiometer	15m	180km	±43° (±700km)
type a,b,c	VT Visible Thermal Infrared Radiometer	40m	40km	±43° (±700km)
type a,b,c	SAR Synthetic Aperture Radar	5m	40km	18°-50° (690km)
type b	MR Microwave Radiometer	5-60km (1K)*	500km	
type c	SCAT Scatterometer	50km 2m/s, 20°	1,200km	

*Temperature Resolution

Table 3: Characteristics and Observations of Onboard Sensors

- Operation in Times of Disaster / Normal Operation

Sensor and Features	Observations
VN-1: Optical sensor (Visible and Near-Infrared Radiometer-1) for high resolution stereoscopic color images for detailed observation of disaster areas	Operation in Time of Disaster: Collapse of building and bridges, landslides, soil liquefaction, pyroclastic flow, insect damage, red tides, oil spills, shipwrecks Normal Operation: Mapping, land utilization, potential disaster area map-ping, crop estimation, water pollution, pack ice distribution, illegal incursions into territorial waters, water resource management, creation of databases for disaster information
VN-2: Optical sensor (Visible and Near-Infrared Radiometer-2) for medium resolution stereoscopic color images for wider observation of areas	Operation in Times of Disaster Volcanic ash distribution, volcanic smoke, areas of flooding, red tides, drought Normal Operation: Wide area mapping, water resource management, vegetation index, desertification, pack ice distribution, creation of databases for disaster information
SW : Shortwave Infrared Radiometer onboard all Observation Satellites for 24 hour detection of short wave infrared radiation	Operation in Times of Disaster: Volcanic eruptions, lava now, forest fires, conflagrations Normal Operation: Resources exploration, heated drainage distribution, land utilization, geothermal distribution
VT: Visible and Thermal Infrared Radiometer onboard all Observation Satellites for 24 hour detection of the Earth's surface temperatures	Operation in Times of Disaster: Severe Storms, forest fires, red tides Normal Operation: Observation of El Nino, sea surface temperatures, fisheries information, climatic forecasting, weather forecasting
SAR: Synthetic Aperture Radar onboard all Observation Satellites for 24 hour detection of minute vertical changes and the Earth's surface changes in all weathers	Operation in Times of Disaster: Land upheaval and subsidence due to earthquakes, floods, movement of soil and sand, pyroclastic flow, lava dome, shipwrecks, oil spills Normal Operation: Deforestation, water resources, resources exploration, pack ice distribution, sea-borne waste water disposal, oil spills, oil tanker monitoring
MR: Microwave Radiometer onboard 2 Observation Satellites for 6:00 o'clock local node time detection of water vapor and sea surface temperatures	Operation in Times of Disaster: Observation of rainstorms, localized heavy rains Normal Operation: Observation of El Nino, sea surface temperatures, water resources, weather forecasting, snowfall, pack ice distribution
SCAT: Scatterometer onboard 2 Observation Satellite for 6:00 o’clock local node time observation of wind directions and speeds	Operation in Times of Disaster: Severe storms, shipwrecks Normal Operation: Observation of El Nino, weather forecasting, climatic modeling

l) Headquarters (HQ)

A Headquarters is to be located at a suitable and appropriate location for administration of the following:

1. planning of the construction, operation and maintenance of the total GDOS system
2. planning, budgeting, collection and distribution of the financial expenses incurred in the establishment and operation of the total GDOS system

2) Mission Management Center (MMC)

A Mission Management Center is to be located in the same country of location of the Headquarters for administration of the following:

1. planning of GDOS operation in times of normal operation
2. coordination of GDOS operations among the users management of the functions and operation of the observation satellites
3. management and adjustment of the interfaces between observation satellites and ground receiving stations
4. disaster information exchange between relevant disaster relief organizations
5. notice of disaster occurrence and instruction of disaster observation mode to Master Ground Stations

3) Master Ground Stations (MGS)

Six Master Ground Stations are to be located encircling the Earth in the east-west direction. Each Master Ground Station will liaison with the nearest Data Relay Satellite for the following:

1. reception of observation data relayed via the Data Relay Satellite
2. direct reception of observation data from observation satellites
3. analysis of disaster information and its transmission to relevant disaster relief organizations
4. broadcasting of disaster information to individual Local User Stations via the Data Relay Satellite
5. control and management of functions and operation of the nearest Data Relay Satellite
6. preparation of databases in times of normal operation for use with disaster information obtained in the event of a disaster
7. transmission of observation commands to observation satellites via the nearest Data Relay Satellite
8. continuous monitoring of forest fires, etc.

4) Observation Satellite Control Station (OSCS)

The Observation Satellite Control Stations (OSCS) perform the following:

1. tracking and control of observation satellites
2. sending of observation mode commands to observation satellites in accordance with instructions from the Mission Management Center

Prior to the completion of the Data Relay Satellite network, three Observation Satellite Control Stations are to be located at high latitudes in the initial stage of establishment of the GDOS system. In times of normal operation the Observation Satellite Control Stations back up the Data Relay Satellite.

5) Local User Stations (LUS)

1. The Local User Stations register individual data receiving stations worldwide for utilization of GDOS data and perform the following:

2. direct reception of observation data from GDOS observation satellites

3. reception of processed disaster information via the nearest Data Relay Satellite

4. reporting of disaster information to the relevant disaster relief organizations of the local country

(3) Operational Concept of GDOS

The GDOS system commences disaster monitoring in the occurrence of a disaster in accordance with instructions issued by the Mission Management Center. The observation satellites intensively observe the disaster stricken area every two hours, and the observation data obtained is sent directly to the nearest receiving Local User Station at the request of the relevant authorities of the country where the disaster has occurred.

The information is also simultaneously sent to the Master Ground Station via the Data Relay satellite nearest to the disaster stricken area.

The Master Ground Station transmits available meaningful disaster information after processing and analysis of received observation data to the relevant organizations of the disaster stricken country.

The organizations can obtain the overall dimensions of the disaster by means of integration of the satellite data with data obtained from conventional disaster monitoring systems and can then take appropriate actions for fire fighting, rescue activities, etc.

4. Frequency of Observation

The frequency of observation of the sensors carried onboard the Observation Satellites is assigned such that any point on the Earth' s surface can be observed once a day, and any point on the Earth' s surface can also be observed every two hours or more frequently on command from the master ground station.

To satisfy the above objectives, as shown in Figure 3, four Observation Satellites (OS) orbit on sun-synchronous subrecurrent orbits distanced at every two hours. Additionally, each Observation Satellite is equipped with a visible and near-infrared radiometer with an observation width of 180 km. The optical sensors consisting of a high precision visible and near-infrared radiometer and visible and infrared radiometer are set with left and right angles inclined at (43 degrees to the sub-satellite point, allowing observation to be performed with a frequency of two times within two hours (the second observation follows the first observation 25 minutes later).

The radio-wave sensor of the synthetic aperture radar is able to move in a range of 18-50 degrees in the antenna beam direction, allowing for an observation frequency of once every two hours. Listed in Table 4 are the observation frequencies of the Observation Satellites according to the observation time zones and sensors.

Table 4: GDOS Observation Satellites Local Node Times / Sensor Observation Frequency

Local Node time	0	1	2	3	4	5	6	7	8	9	10	11
Sensor: VN-1, VN-2	---	---	---	---	---	---	---	---	2	---	2	---
SW, VT	2	---	2	---	2	---	2	---	2	---	2	---
SAR	1	---	1	---	1	---	1	---	1	---	1	---
MR	---	---	---	---	---	---	1	---	---	---	---	---
SCAT	---	---	---	---	---	---	1	---	---	---	---	---

Local Node time	12	13	14	15	16	17	18	19	20	21	22	24
Sensor: VN-1, VN-2	2	---	2	---	2	---	---	---	---	---	---	---
SW, VT	2	---	2	---	2	---	2	---	2	---	2	---
SAR	1	---	1	---	1	---	1	---	1	---	1	---
MR	---	---	---	---	---	---	1	---	---	---	---	---
SCAT	---	---	---	---	---	---	1	---	---	---	---	---

5. GDOS Operation

The criteria and parameters of GDOS operations should be determined by a GDOS governing body consisting of representative from countries contributing to the Establishment of the GDOS system. Operations planning for the GDOS system is separated into operation in times of disaster and normal operation.

(l) Normal Operation

As a disaster may take place at any time and at any place on the Earth, the GDOS system is operated continuously for 24 hours each day in readiness to acquire disaster information. The occurrence of disasters may be recognized by comparing data being acquired with data obtained in times of normal operation in order to detect deviations and abnormalities indicating extraordinary occurrences.

Immediately after the detection of any deviation or abnormality, it is analyzed to ascertain whether or not it indicates the occurrence of a new disaster. If it does indicate the occurrence of a disaster, the type and range are identified and then operation of the GDOS system as a disaster observation system is activated.

(2) Operation in Times of Disaster

The GDOS system is operated as a disaster observation system in the event that the GDOS systems itself detects disaster phenomena (e.g. forest fires) or in the event that any relevant organization senses an emergency situation.

In both of the above two cases, the procedure followed is that the Mission Management Center operates the GDOS system as a disaster observation system to focus on the disaster, and commences transmission of disaster information to the relevant organizations located in the area of the disaster. The Mission Management Center notifies the Master Ground Station nearest to the location of the disaster that operation of the GDOS system be commenced for disaster observation.

The Master Ground Stations, after receiving instructions from the Mission Management Center, transmit the necessary commands to the nearest Observation Satellite to orient its sensors in the direction of the disaster stricken area to enable observation of the disaster area at the earliest possible time.

6. Roles in Normal Operation

As normal operation of the GDOS system would be for a far longer time than its operation as a disaster observation system, the missions assigned to the GDCS system in times of normal operation should be productive and worthy. Data acquired by the GDOS system in times of normal operation and stored in databases would enable recognition and detection by comparison methods.

The missions planned for the GDOS system in times of normal operation are following:

(1) Creation of Databases for Use in Times
of Disaster

1. creation of databases of detailed stereoscopic maps, to provide information in cases of collapse of buildings, bridges, express ways. , etc. due to earthquakes, etc.
2. creation of databases of synthetic aperture radar data for detection of land movements (upheaval, subsidence, horizontal displacement) for prediction of earthquakes and other disasters
3. creation of wide area maps with medium resolution to provide disaster information such as floods, forest fires, etc.
4. creation of databases of maps indicating
5. hazardous and endangered locations for prediction of landslides, or use for support of restoration activities

(2) Technology Development of Disaster Information Analysis and Pervasion Activities

1. technology development of disaster information analysis using Observation Satellite data
2. establishment of technological standards for analysis of disaster information by integration with conventional disaster information

(3) Water Resources Management

observation and monitoring of water resources and improvement of utilizable water resource monitoring technology

(4) Land Utilization and Land Development

mapping and provision of support and training materials

1. soil distribution surveys
2. upgrading of the accuracy of land utilization maps and land development maps
3. verification of the present status of land utilization and development data

(5) Weather and Climatic Forecasting

1. simultaneous observation of accurate sea surface temperatures and land surface temperatures, and cloud distribution
2. improvement in accuracy of forecasting of climatic changes and localized heavy rains
3. acquisition of precipitation and snow cover information

(6) Agriculture and Forestry

1. vegetation distribution and monitoring of changes
2. upgrading of the accuracy of crop forecasting
3. upgrading of the accuracy of damage estimates for agricultural products and forests due to insect damage, plant diseases, etc.

(7) Fisheries

1. frequent observation of sea surface temperatures
2. upgrading of the accuracy of location of fish schools

(8) Marine Transportation

1. observation and monitoring of pack ice and provision of navigation route information
2. monitoring of ship safety and provision of information for efficient navigation

7. Issues and Measures for the Establishment of the GDOS System

The GDOS system has been discussed as a program that will contribute to decreasing the effects of disasters by providing prediction and timely detection, as well as contributions of the GDOS system in times of normal operation towards upgrading the welfare of the people in each country. The GDOS system is proposed as a global program for use of satellites with the aim of providing a unified and ideal observation system. In reality, there are several issues to be resolved for realization of this program. Matters concerning politics and technical issues are described following:

(1) Issues Related to Politics

l) Formation of International Consensus

As the GDOS system is a global disaster observation system using satellites, it is mandatory that

international consensus is obtained. Especially, summit conferences of
advanced industrial countries and conferences of the United Nations present the best opportunities for viable discussion of this program.

2) Establishment of an International Organization

It would be required that the countries participating in the GDOS system form an international organization for the establishment operation and maintenance of the GDOS system. An international organization such as the World Meteorological Organization (WMO) would be a good model for this purpose.

3) Financing of Construction and Operation

Financing of the establishment and operation of the GDOS system would be discussed by the international organization that would be formed by the participating countries. Each country needs to accept an appropriate financial burden and take a proportional role.

4) Coordination with Commercial Remote Sensing Organizations

Planning is now underway for the commercial launching of high resolution earth observation satellites by various countries, including the United States. As these plans specify and depend on commercial sale of acquired data, almost all have proposed orbits concentrated at satellite locations of 10 o'clock (10cal node time). The satellites and ground systems utilized for these plans may make some contribution to the GDOS system, but would never be able to assume the role and functions of the GDOS system. The planning and role of the commercial earth observation satellite services and their interaction with the GDOS system should be discussed at appropriate international conferences.

(2) Technical Issues

1) Development of Disaster Detection Technology

Development of new technology is required for the timely acquisition of disaster information (e.g. building collapses, landslides, fires, floods, etc.) by processing with comparison to database information collected before and after the occurrence of a disaster.

2) Development of Observation Sensors with Compactness and High Spatial Resolution

To lower the cost of the GDOS system, the size of the satellites deployed needs to be decreased. This requires the development of high spatial resolution and compact visible and near infrared radiometers and synthetic aperture radars.

3) Data Storage

The Master Ground Stations will continuously receive large amounts of data from the twenty-four Observation Satellites via the six Data Relay Satellites. The amount of data will be voluminous and requires conversion to appropriate forms of databases in accordance with application and to facilitate ease of retrieval. Optimum methods for data storage and management needs to be studied.

4) Automated Operation of Satellites

The receiving and processing of attitude and orbit control data of satellites needs to be automated to allow highly accurate and continuous operation of multiple satellites for 24 hours a day and 365 days a year.

5) Management of Observation Data

As the data acquired by the GDOS system will be distributed and used throughout the world, the user data systems need to be compatible. The management of observation sensor data, processed data and databases under the Committee of Earth Observation satellite (CEOS) should be discussed from the initial phase.

6) Demonstration of the GDOS System as a Disaster Management System

As it is the most advanced system being planning in the world, the usefulness of the GDOS system needs to be demonstrated before full implementation. Demonstration tests (including demonstration of disaster information detection) would be required, and could be performed by using a satellite of an already planned satellite system such as the Advanced Land Observing Satellite (ALOS) in order to provide a platform for the testing of proposed high resolution sensors when it is launched.

8. Conclusion

On the conclusion of the Cold War, there now exists the opportunity to directly apply Mankind' s technological accomplishments towards the relief of the disasters that suddenly occur on the Earth and to further advance the welfare of the world's peoples.

The GDOS system concept was proposed to contribute to this objective by providing a very useful and beneficial addition to the global infrastructure. This type of system or a similar system of whatever kind, needs to be realized in some form in the future as a common asset of mankind.

One practical way to realize such a system may not be to launch a dedicated satellite system for this purpose, but to utilize and organize the several types of observation satellites now under planning in various countries, and thereafter to gradually establish a global system towards the goal.

There are several political and technological issues that need to be overcome, however, they can be resolved by international cooperation among the program participants.

Since 1990, such a program has been studied as part of the Japan-U.S. Science, Technology and Space Applications Program (JUSTSAP) which consist of representatives from industry, academia, and government of both countries. Annual workshops have been held in Hawaii to intensively discuss this subject. Since disclosure in 1987 of the Global Observation Satellite system concept which provided the basis for the GDOS system, the original plan has been improved several times and has been presented at international conferences sponsored by the United Nations and the other such organizations.

Due to its nature, a global satellite monitoring system should not be established on a commercial basis but on a governmental level, and it should be constructed and operated by the participating countries and financed especially by the advanced countries.

Recently, global disaster observation has been promoted in the form of international cooperative research among governmental organizations. It is strongly expected that through the adoption on the results of research by the Committee Earth Observations Satellite (CEOS), the establishment of a global disaster monitoring system will be proposed through international cooperation as an asset to mankind. For this purpose, the summit conferences of advanced countries are expected to play an important role.

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QUESTIONS AND ANSWERS

U.S. and International Initiatives for Coordinated Satellite Applications for Disaster Management: by Dr. Louis S. Walter

Q/A El Nino impact

Premature the research on relation between El Nino and the other disaster

Q/A Is the NDIN just a concept

How do you globalized

Using the existing network and expand

Q/A Climate change is caused by Asteroid

Russian 1908 image show the fact (possibility)

NASA Ames Research Center made a research on this fact

Integrated Remote Sensing and Spatial Information Technology for Mitigation Response and Evaluation of wildfire and Haze Disaster in Indonesia: by Dr. Agus Kristijono

Q/A Is a regional formation organized among the countries which were suffered from wildfire

Q/A Is the situation getting better

Q/A NOAA data reception

7 HRPT stations and next year SeaWiFS station

Disaster Management and International Cooperation: by Dr. Yujiro Ogawa

Q/A Which satellite data are most useful for Kobe earthquake for Local Government

That depends on the phase. At the initial phase they need global photos which allow entire damaged area.

Q/A How much budget do you have for natural disaster

100,000 US$ in the UNCRD

Q/A Are there other brunch relating to the natural disaster

Human??? is relating to it. It focus on Emergency recovering, not risk management

Q/N From the Model (Kobe earthquake), did you make a case study for 10 Megacities?

Japanese ALOS (Advanced Land Observing Satellite) Project: by Mr. Tsuguhiko Katagi

Q/A 2.5m and l0m spatial resolution of PRISM

Q/A l/25,000 of map and DEM accuracy

Q/A 240 Mbps

Q/A Fully funded project?

Applications of Remote Sensing to Volcanic and Earthquake Disaster Mitigation in the Philippines: by Dr. Emmanuel G. Ramos

Q/A Radar interferometry

Q/A What is the relationship between PHIVOLCS and national disaster coordinate Council

Q/A Risk Assessment?

Q/A What is the successfully mapping for the active volcano?

Together with USGS, Mt Pinatubo was mapped and predicted

Deformation can bc estimated with SAR interferometry

Q/A Red flag on the Philippines?

Natural Disaster Satellite Observations, Mitigation, and Assessment: A Bilateral Opportunity: by Dr. Murray Felsher

QlA Bilateral organization would not be enough

It can be changed easily

Q/A Data provider?

Q/A How do you private organization interact with CEOS/TT19

Q/A Who pay for it

Q/A Data provide in a timely manner would be nice even if value added and or not

Q/A If it can be provided with a reasonable price

It is not free. It can be provided at l$ per 1Km^2

SAR Data Application to Monitoring Earthquake Disaster and Volcanic Surface Displacement: by Dr. Hiroshi Ohkura

Q/A Beam shape

Q/A C band or L band

Q/A Time change is larger than

Q/A Kobe and Awaji island

Managing Natural and Manmade Disaster in Hawaii: by Mr. Roy Price

Q/A l/12,500 map is preferable

Q/A How is a industry involvement?

Study Of Disaster Mitigation and Emergency Management Using Satellites:
by Dr. Yoshiki Suzuki

Q/A Do you intend to use mobile system

Concept of Global Disaster Observation Satellite System(GDOS): by Mr.Takeshi Orii

Q/A How is the response from the Japanese government

Q/A INTELSAT and IMARSAT

Summary of Panel Discussion
on the use of Satellite Technology for Disaster Management

Panelist: Mr. Niel Helm, Dr. Louis Walter, Dr. Murray Felsher, Dr. Yujiro Ogawa. Dr. Agus Kristijino. Dr. Emmanuel G. Ramos

The panelists were requested to present their views on the requirements of remote sensing systems to be suitable for the present needs of disaster management.

Dr. Yujiro Ogawa mentioned that disaster management is wide-ranging, extending from natural to man-made disaster. He would like to know the real requirements from the disaster management side. He also mentioned about GDCS system. He asked how the 24 satellites are being made available for real disaster management activities.

Dr. Kristijono stressed that remote sensing is currently being used for monitoring of forest fires in Indonesia The repetition cycle of the existing satellites is not enough for the monitoring the spreading fires..
NOAA/A VHRR are not suitable for the monitoring the thermal signatures of the fires due to coarse spatial resolution. Multi polarimetic radar may be useful for the monitoring the burnt areas, and for imaging cloudy areas in the tropics.

Dr. Ramos mentioned a need for high spatial resolution in timely manner. The main objective in detecting disasters is the detection the change. He also indicated the need to map the vulnerability of the people. Mapping of resources that may be at risk is also important. With El Nino, mapping of water resources and monitoring of typhoons are also useful.

Dr. Walter indicated that 1 m resolution of data is already available as well as GDCS type of the system. These systems can be used, for instance, in mapping of flood area. He also indicated that these can be used in detecting the changes that may occur with earthquakes. He also indicated that the private sector can play a role in this endeavor.

Dr. Felsher mentioned the up-coming missions, SRTM 2002 for DEM. Near term future private sector remote sensing satellite of 1 m resolution can be available soon. Hazard management systems for change detection and the other tools are also available.

Dr. Helm mentioned that the training for disaster response including change detection that Dr. Walter presented in the early part of the meeting. He emphasized the importance of educating disaster management practitioners on the beneficial use of space technology.

Dr. Day asked Lockheed Martin response, being a representative of the private sector
Mr. Regalado of Lockheed Martin responded and indicated that as an engineer, a more structured approach would be better. This may involve listing the requirements from all the countries and organizations involved in disaster management. He posed the question of where the funds would come from, and indicated that Lockheed Martin can probably provide its resources. For example, Lockheed Martin has a commercially available cataloging system.

Dr. Walter mentioned that a study of the requirement was already done by CEOS, ESA, Japan, and other such agencies. He also said that the requirements are complicated, ranging from disaster preparedness and warning, disaster response which is the basic function of governments, disaster relief, and then back to planning and preparedness. FEMA' s task is only nationwide and thus international participation in disasters is beyond its mandate. He also indicated that response is different for each level, and that all of these have different types of requirements.

Dr. Felsher mentioned NIMA, task force of the national defense

Dr. Walter mentioned cartographic database is transferred to the thousands of counties, and that the international data bases may soon bc available.

Dr Ramos said the requirements changes and are complex.

Dr. Edelson said that technology is growing so rapidly such as data mining, data warehouse. Disaster data system should include historical data, GIS, data mining, etc. A suitable data management system should contain data acquisition records, and be able to store, process and distribute the data.

Dr. Felsher mentioned that some disaster related data is on the web.
http://www.watch.com/
Dr. Helm said that storage system is getting bigger, faster and cheaper

Dr. Kuroda said that requirements for disaster response varies. For instance, responsibility of the disaster response depends on the different ministries.

Dr. Ogawa agreed, and stressed on the importance of the training and education.

Dr. Felsher responded by saying some information are available at
http:/www.sopt.com/ and http:/www.spaceimage.com/

Dr. Ramos said that he appreciates being here and to hear the discussion on JUSTSAP. He also indicated that availability of demonstration projects would be highly appreciated.

Dr. Felsher announced the Australian conference July 1998

(Drafted by Emmanuel G. Ramos)

JAPAN-U.S. SCIENCE, TECHNOLOGY & SPACE APPLICATIONS WORKSHOP

Mauna Lani Bay Hotel

November 5-7, 1997

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