Tele-education experiment in the field of Remote Sensing and GIS

Jun Nogami*, Michiro Kusanagi and Rajesh B. Thapa*****

*Project Researcher, jnogami@ait.ac.th
** STAR Program Coordinator, Visiting Professor, Ph.D., kusanagi@ait.ac.th
***Research Asistant, st028205@ait.ac.th

Space Technology Applications & Research Program (STAR),
School of Advanced Technologies (SAT), Asian Institute of Technology (AIT)
P.O.Box 4, Klong Luang, Pathumtani 12120, Thailand
Phone: +66-2-524-6406, FAX: +66-2-524-5597

Abstract

Remote Sensing (RS) can provide the enormous time series data at different level of scale and Geographic Information System (GIS) can manage, aggregate, analyze and find the potential solutions for specific purpose based on RS datasets as well as socio-economic datasets in spatial dimension. RS/GIS deserve the broad application from science to business as well as political issue that has been already demonstrated from many previous researches. The leading institutions such as AIT/STAR, Thailand and CSSTE-AP, India are serving Geo-informatics education and training at graduate level or equivalent in the Asia Pacific region. However, these institutions are unable to give access to everyone because of limited space, time, resources and cost in some extent. The experiences from USA, Canada and Europe have showed that the distance learning through Tele-education system using Internet technology is very practical, resourceful and cost effective.

The RS/GIS education system at Gigabit rates Internet satellite age is now under investigation in STAR program. This will be realized when Japanese NASDA WINDS Satellite is placed in orbit around 2005. As precursor, AIT will be participated in i-Space pilot experiment "*Asia e-learning Pilot Experiment by Multi-point Distant Learning Network System*" with University of Tsukuba and KDDI under NASDA. The pilot experiment will be started in this year as a model case in AIT and will find its potentiality for widening and strengthen the educational activities of STAR program. In this paper, an outline of pilot experiment system and applicability of such Tele-education system to RS/GIS education using high data rate satellite link will be presented.

Keywords: distance education, *e*-learning, NASDA i-Space project, RS/GIS education

1. NASDA WINDS Project

NASDA, Japanese Space Agency, promotes *"i-Space Utilization Experiment"* as a part of the R&D work on space infrastructure towards life with wideband Internet. In this project, several R&D and verification tests will be performed in many areas, such as Internet, Education, Medical Science, Disaster Monitoring and Mitigation, ITS (Intelligent Transportation System) and so on, using three new satellites, i.e. Wideband Inter-Networking engineering test and Demonstration Satellite (WINDS), Engineering Test Satellite VIII (ETS-VIII) and Quasi-Zenith Satellite System, wherein the development is in progress now.

The major objective of the WINDS project is to develop and verify the main technologies for future ultra high-speed satellite communication. The WINDS satellite communications system aims for a maximum speed of 155Mbps (receiving)/ 6Mbps (transmitting) for homes using 45cm aperture small antennas, and an ultra fast 1.2Gbps for official use. The function will be operated all over the Asia Pacific region including Japan. The technology for the Ka-band multi-beam antenna with a high-powered multi-port amplifier can achieve fixed ultra fast communications all over Japan and in major Asian cities, such as Seoul, Beijing, Shanghai, Hong Kong, Bangkok, Kuala Lumpur and Singapore. At the same time, flexible power distribution to each communication area can cope with the regional communication demand and the rain attenuation. In addition, the Ka-band active phased array antenna technology makes it possible to control the antennas communication direction rapidly and electronically, thus communication can be carried out quickly to specific areas with demand.

Currently, NASDA and Communication Research Laboratory (CRL) are engaged in the study to achieve the planned launch date of WINDS on the year 2005. NASDA has so far conducted nine Pilot Experiments as part of the i-Space Utilization Experiment Project since the year 2001 for the various areas of applications, such as education and medical fields. In this year, NASDA is conducting eight new experiments, along with the subjects carried over from year 2001. The plan described here is one of the new selected subjects last year 2002. The first phase of this experiment was planned from 1st Nov 2002 to 31st Oct. 2003 and it might be extended up to three years if approved by "the Committee to select *i-Space Pilot Experiment* Subjects".

2. i-Space Pilot Experiment *"Asia e-learning Pilot Experiment by Multi-point Distant Learning Network System"*

2.1 Purpose of this experiment

In the future *e*-learning based on WINDS, it is considered that new technologies will be implemented both in the satellite network and the style of *e*-learning as follows;

- **Network**: The WINDS network will include on-board ATM switch. Hence, a Mesh-type network topology can be configured flexibly with this switch. Furthermore broadband communications will be possible on smaller-size antennas than existing VSAT systems.
- **Style of *e*-learning**: In future, flexible configuration of *e*-learning class including both-way, multi-point and broadband discussion is expected. It would be different from the traditional one way (or broadcast only) style of *e*-learning. In such a new style of *e*-learning, several kinds of traffic will be requested with different quality requirements, as different media and from different locations simultaneously. The management of *e*-learning will be integrated by Instructional Design (ID) technology, including web-based portal site.

This Pilot Experiment focuses on ATM switching function, which will be implemented on WINDS. The main target of this experiment is that multi-point / multi-media distance learning system could be put into practice soon after the launching of WINDS. In order to achieve this target, Mesh-type topology and demand-assign satellite network using existing satellites and its *e*-learning application will be used so that we could consider technical requirements and its impact on the other application, and contribute to the development of the next generation's *e*-learning application. The purpose of pilot experiment is to study the ID technologies on WINDS environment and to list-up the requirements to satellite networks from multi-point *e*-learning based on ID technologies.

2.2 Structure of the Pilot Experiment

The first stage of this pilot experiment is to be done by NASDA, KDDI, University of Tsukuba (Japan), Asian Institute of Technology (*AIT*, Thailand) and Multimedia University (*MMU*, Malaysia).

The details assigned responsibilities of each participant are shown in Table-1. This system will be extended to other universities and institutes in GMSARN (Great Mekhong Sub-region Academic Research Network) in the next stage.

Table-1: Participants and their Responsibilities

Participants	Responsibilities
NASDA	- Total management of the Experiment - Total planning of the Experiment - Total verification of the Experiment - Verification of Communications Test - Implementation of Distance Learning System - Basic technology toward WINDS
University of Tsukuba	- Distance learning experiment - Implementation of servers, arrangement of distance learning classroom - Development of *e*-learning material based on Instructional Design (ID) - Development of know-how to indicate for remote site - Study for development of applications on utilization experiment - Introduce access grid method - Co-ordination with participants in Asia
KDDI	- Total design of the pilot Experiment System - Testing of the Pilot Experiment System - Provision of Antenna / RF equipment at Hub station - Implementation of Video conference system - Japanese radio license - Technical support to the participants in Asia - Implementation of *e*-learning platform in the initial stage
AIT / MMU	- Radio license for VSAT in Thailand and Malaysia - Installation, operation and maintenance of VSAT - Distance learning experiment - List up requirements to applications for utilization experiment

2.3 Background

It is identified that the distant learning can contribute in eliminating digital divide and shortage of schools / teachers in many Asian countries. An *e*-learning environment would be arranged in these countries, which is important to develop cost-effective system that can be bearable to the students. It is considered that the multi-point *e*-learning system using new technologies to be implemented on WINDS will be able to provide cost-effective *e*-learning environment.

However, we do not have the experience of Instructional Design (ID) on the Mesh-type satellite network such as WINDS at this stage. In developing an effective *e*-learning network on WINDS and in eliminating digital divide in Asian countries, prototype *e*-learning network should be developed immediately as a Pilot Experiment, and an experience of Instructional Design (ID) toward WINDS network is needed.

Every satellite network system, which has been used for the conventional *e*-learning experiment, consists one or both of the following problems:

a. The network is based on point-to-point connection, or the combination of point-to-point connection. In this type of network, as the number of site increases, the required satellite capacity also increases drastically, and therefore, does not meet cost requirements very well.

b. Since the network is configured as Star-type topology (Figure-1), teachers / contents should be located at hub station. The load on a particular teacher would be much heavier than the others. The system has long delays of multicast traffic because of a double-hop connection.

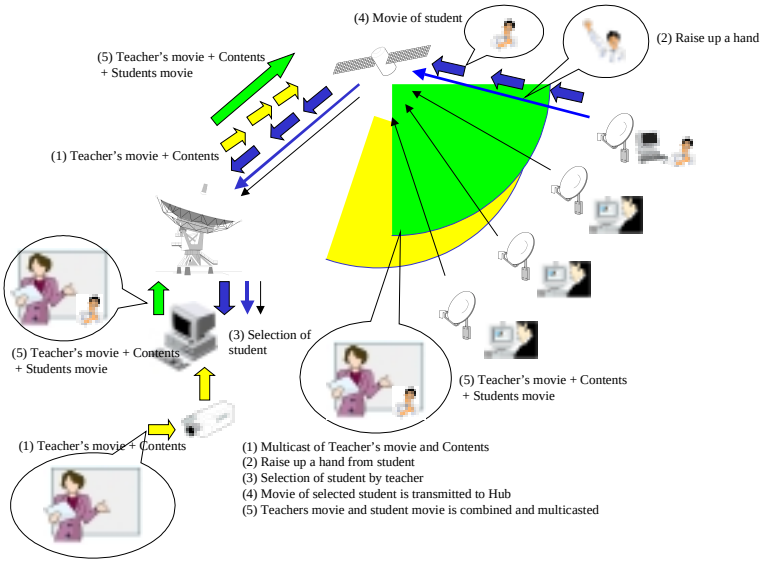

Figure-1. Application Image of Distance Education on Star-type Network Topology

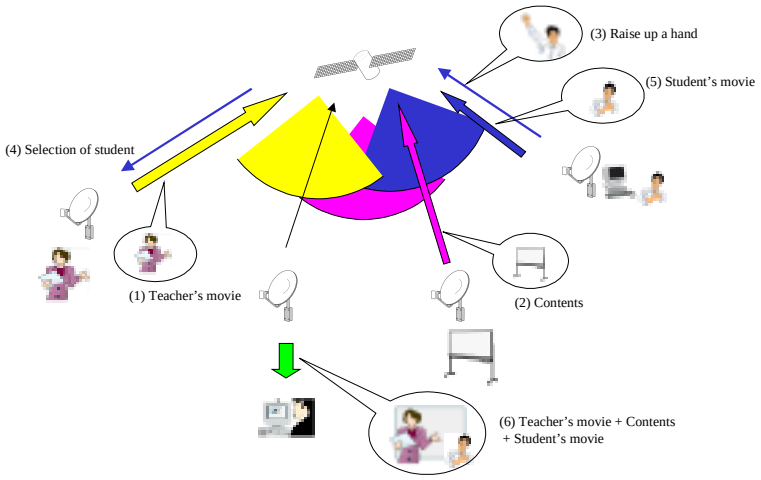

Figure-2. Application Image of Distance Education on Mesh-type Network Topology

In the future, multimedia distant learning for high-grade students, teachers and contents are expected to be located at multiple sites. Then various Quality of Services (QoS) will be required depending on the type of the class. Furthermore, if the participants increase, the effective use of satellite capacity based on the multiple-access technology will be expected in order to develop cost-effective *e*-learning network. While it is difficult to satisfy the above requirements on the existing satellite network, the new technology to be implemented on WINDS will be able to provide dynamic Mesh-type topology (Figure-2) for flexible assignments of satellite capacity and QoS control. Therefore any two sites could be connected as single-hop connection, and multi-site allocation of teacher / contents will be available. The implementation of the above network is very important to provide high- level distance education, which includes two-way discussion, multi-teacher environment, and so on. But, we don't have enough experience to operate the above type of network systems, so that the impact from the satellite network to the applications hasn't been known. This Pilot Experiment will contribute in studying appropriate specifications for the future *e*-learning applications, which will be operated on WINDS.

2.4 Details of Pilot Experiment

Implementation of a satellite network system to simulate WINDS: WINDS will be able to provide Mesh-type network topology and bandwidth sharing by Demand-Assign Multiple Access (DAMA) environment. The *e*-learning platform in such an environment will have new requirements compared with those on existing satellite networks. It is noted that the experiment system, which simulates a part of WINDS environment, will be implemented on an existing Ku-band satellite. Satellite communications in this pilot experiment will have the following functions:

- The system is connected to terrestrial IP network via a Router. The terrestrial routing protocol is translated to satellite protocol at the system then the satellite capacity for the traffic is assigned.
- MF-TDMA (Multi-Frequency Time Division Multiple Access) channel assignment is adopted for establishing satellite links so that the effective use of satellite capacity would be available.
- The system can configure both Star and Mesh type network topology. However the topology in the Pilot Experiment is Star-type initially because of the limitation on the existing satellite and software.
- Committed Information Rate (CIR) can be arranged for each VSAT in order to ensure an appropriate data rate.

Figure-3. SKYCAST-Lesson Software developed by KDDI

Implementation of a multi-site distance learning system: Multi-point distance learning system will consist of the above satellite network and SKYCAST-Lesson software developed by KDDI (Figure-3) as an IP application for distance learning. If we use other IP applications on a satellite network system, we would have several problems due to the delay of satellite segment, variable quality of services between locations, and other satellite-originated conditions. Since the SKYCAST-Lesson of the KDDI is experienced enough in providing commercial services to a Star-type satellite network, it is considered that the implementation of *e*-learning network using SKYCAST-Lesson would be easier to simulate WINDS than the implementation of other applications.

The SKYCAST-Lesson is a server-client type TV conference system, which provides functions for distant learning and discussion via satellite. It consists hub site for servers, management / teacher clients, and remote VSAT site for student server and client. MPEG-4 encoding is adopted for the movie, which is encoded / decoded to / from 800 kbps from teacher to students, and 50 kbps from students to teacher, in its maximum. A teacher will be able to provide a lecture using real time movie with camera and VTR and identify the response from students. Furthermore the viewing of the document, which is previously multi-broadcasted, can be controlled by the teacher, and the teacher can identify the attendance of students. It is also equipped with Q&A functions using easy statistics, chat, and helpdesk functions. The two-picture mode, which provides the teacher's and student's movies simultaneously, is available in the class with SKYCAST-Lesson. The movie from the selected student is stored in the transfer server via satellite. At the same time the movie from the teacher will be stored at the transfer server via in-station LAN. There after, both movies will be multi-broadcasted to each VSAT. Pre-created Microsoft Power Point or HTML documents can be used as teaching materials. Pre-registered files can be partly controlled by the teacher.

"*e*-learning" Equipment: The "*e*-learning" is based on the implementation of virtual campus on the Internet. To do so, a portal called Learning Management System (LMS) is implemented, and then, the virtual campus will be implemented on LMS. The student's history of the course selection, score, contents of the class, submitted report, history of the homework, and all other profiles of a particular student can be recorded on the portal. Furthermore the learning contents for the teachers will be displayed. The basis of "*e*-learning" is Web Based Training (WBT). It is reported that if the students only listened in the lecture, they would remember only 5% of the contents one week after the lecture. However, they say it would increase to 30% if they reviewed at home, and would increase to 75% if they had some practice or other real experience. Basically, a real experience is needed for true "learning". A similar experience of Virtual Reality is available through WBT where LMS manages WBT function effectively.

The students will be able to review the pre-designed contents such as the lecture material through PDF or Power Point on the LMS. Other tools for the course will also be prepared. Examples of the many integrated course tools are electronic bulletin board, *e*-mail, on-line chat, maintenance of the score and its notification, control of access right, quiz with automatic marking, calendar, web space for the students, search for contents of the course, whiteboard, syllabus tools, submission / collection of homework, Web course builder and so on, and then one can select whether to use the tools or not. Course Navigator and Course Map are also available so that one can identify the outline of the course.

There are two facilities in LMS i.e. Server and Web Browser. The apache server is used as http server on LMS that include two modules one is written in Pearl as CGI (Common Gateway Interface) and another written in C language. Because of supporting capability of Netscape and Internet Explorer the UNIX, Windows, Macintosh and other platform can be used easily.

Distance Learning Experiment: As a first step multi-point distance learning experiment will be carried out with the above system in AIT and MMU, connected with University of Tsukuba via a satellite network system. After the participants have become familiar with the system, the distance learning experiment will be enhanced effectively in other Asian universities.

Development of Instructional Design technology: The key technology of "e-learning" is the combination of WEB technology, two-way multimedia technology and educational cognitive science and technology. It requires a new concept of Instructional Design (ID) to combine with, and plays as a director who can manage and support communication between educator and web designer effectively. The ID technology will be established soon.

To study the requirements of the future "*e*-learning" platform: As part of the application development, we take into account the features of WINDS, namely Mesh-topology and bandwidth sharing, as the requirements of the future *e*-learning platform. Due to such initial work, implementation of *e*-learning platform running on WINDS will be available after launching the WINDS'. From this experiment,

the requirements of the satellite network system and *e*-learning platform from the educator and students will be listed up. Furthermore, these works are expected to contribute in eliminating of digital divide, to develop education systems for the next generation, and to implement networking effectively between Asian universities.

R&D factors in the Pilot Experiment: As results of the above works, the following objectives are also expected in the development of network utilization technology:

- Synchronization of technology for simultaneous transmission from several sites
- Flexible control of satellite bandwidth assignment for simultaneous trans-mission from several sites

2.5 Overall Configuration of Pilot Experiment System

Overall configuration of the Pilot Experiment system is shown in Figure-4. The Pilot Experiment System will consist of a hub station antenna, hub RF equipment, distance learning network system and *e*-learning platform. Distance learning network system will be able to provide bandwidth sharing by a multi-carrier, multi-rate, multi frequency-time division multiple access, and also Mesh-type topology network using the Network Control Equipment on the ground. The center station is collocated with a VSAT in Japan. The other VSATs are located in AIT and MMU. The maximum information rate available for each VSAT is 1.5Mbps for receiving and 700kbps for transmitting using the existing Ku-band satellite. The *e*-learning platform consists of "video conference" system and WBT system. The "video conference" system is based on SKYCAST-Lesson software, distance-learning application, which was developed by KDDI. It should be noted that the software is now designed to run on a Star-type topology, because of the limitation on the existing satellite. Furthermore, on-demand *e*-learning experiment with WEB contents will be carried out, so that the ID technology can be achieved. The requirements of the Utilization Experiment System using NASDA WINDS will be considered and evaluated after this experiment.

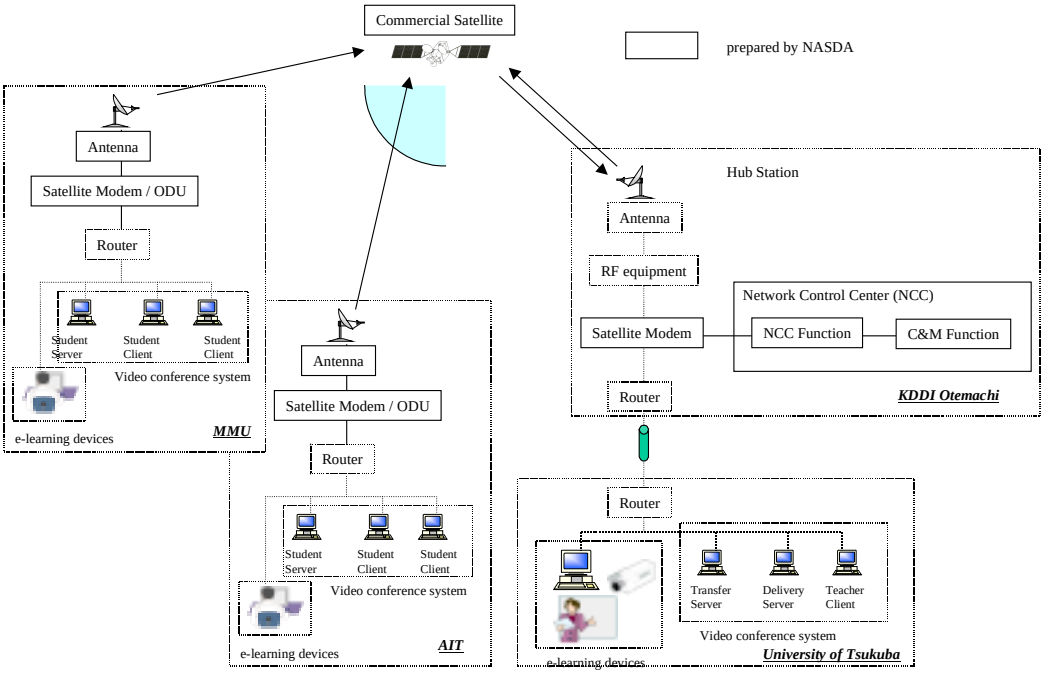

Figure-4. Overall System Configuration of this Pilot Experiment

3. Tele-education experiment in the field of RS/GIS in STAR Program

Remote Sensing (RS) can provide the enormous time series data at different level of scale and Geographic Information System (GIS) can manage, aggregate, analyze and find the potential solutions for specific purpose based on RS datasets as well as socio-economic datasets in spatial dimension. The leading institutions such as AIT/STAR, Thailand and CSSTE-AP, India are serving RS/GIS education and training at graduate level in the Asia Pacific region. However, these institutions are unable to give access to everyone because of limited space, time, resources and cost in some extent.

The RS/GIS education system suitable for Gigabit-rates Internet satellite age, which would be realized when Japanese NASDA WINDS satellite is to be placed in orbit around 2005, is now under investigation in STAR program of AIT. As precursor, STAR program is to be participated in the i-Space pilot experiment "*Asia e-learning Pilot Experiment by Multi-point Distant Learning Network System*" described in section 2, with University of Tsukuba and KDDI Corporation under NASDA support. This pilot experiment is focused on the design of RS/GIS related *e*-learning materials and the acquisition of basic data for solving problems that will be considered to encounter during the shift to the forthcoming Gigabit-rates Internet satellite age. Through this pilot experiment, we will find its potentiality for widening and strengthening the educational activities of STAR program. It should be notified that institutional-wide distance learning activities, including planning, coordinating, facilitating, implementing and servicing functions, are carried out mainly by Distributed Education Center (DEC) inside AIT.

As for the AIT/STAR side, it is desired that the multi-point / multi-media distance learning system implemented by this pilot experiment will be applied to the following plans in the near future.

Table-2: Evaluation Items that will be surveyed in AIT during and after the Pilot Experiment

Purpose	Evaluation Items
To clarify the requirements to *e*-learning applications used on WINDS	1. To summarize the usage of applications (frequency, satisfaction, etc.) 2. To summarize the requirements to the future applications
To clarify the impact from applications on WINDS to the network and IP traffic	1. To evaluate the impact from the traffic of TV conference to the other IP traffic 2. To propose the function required to the WINDS and related ground equipment for the *e*-learning on WINDS
To establish the style of future *e*-learning on WINDS	1. To survey (1) easiness of understanding (listening, display of teaching material) (2) easiness of Q&A (3) usability of exercise and teaching material, from students by questionnaire 2. To survey (1) easiness of lecture, (2) easiness to receive queries from students and feedback to them, (3) difficulty to operate the system, (4) difficulty to deliver the contents, from teachers by questionnaire 3. To survey (1) difficulty, (2) effectiveness, (3) convenience, (4) effect on the lecture, regarding the ID based contents development to prepare the operation on WINDS
To contribute the education for IT engineers	1. To train students for set-up the system and operations 2. To survey the change of interests before and after the experiment 3. To improve the condition to expand the participants to *e*-learning 4. To survey from teachers for the current effort, requirements to use WINDS, and needs to *e*-learning with satellite

3.1 List-up of requirements for Tele-education

During and after the pilot experiment, both the educators and the students in STAR program will list up the user-side requirements for the satellite network system and *e*-learning platform, in order to contribute in improving the functionality of next-generation distance education system. As shown in the Table-2, we have to evaluate the impact from the traffic of TV conference to the other IP traffic and propose the function required to WINDS. We will also survey the difficulty, effectiveness, convenience and technological issues on the lecture, regarding the Instructional Design (ID) based contents development to prepare the operation on WINDS. Well-trained students and educators who will have sufficient knowledge about *e*-learning course-work through this experiment are supposed to be very useful for engineering education in the future.

3.2 *e*-learning RS/GIS course work material development

From this year 2003, the ID and *e*-learning course work materials development have been started in STAR program. Web-based course materials for RS, GIS, Space Technology, Satellite Design, Earth Environment, and so on, will be designed. The significant effort will be carried out for designing *e*-learning course materials for graduate and under-graduate level education as well as various application trainings in GMS regions. It is expected that the number of people with knowledge of scientific and engineering aspects in earth and space systems would be increased into South East Asian countries at a significant rate.

3.3 Distance education network among institutes and universities of GMSARN

In the future stage, AIT will develop web-based two-way multiple-site distance learning system among the universities and research institutes in GMS regions. It is expected that the number of *e*-learning course work designers and talented IT engineers would be increased through the joint-development of *e*-learning contents among universities, research institutes and private companies in Asian regions, which would also contribute in eliminating the educational divide and digital divide in South East Asia.

3.4 STAR Alumni network

The STAR Alumni Association (STARAA) is in preparation to establish in this year (2003) to develop mutual understanding and promoting joint collaborative project or activities in future among the alumni, and between them and the STAR program. STARAA will be a strong and influential group, with members assuming a leadership role in the promotion of technological change and its management in governments, universities, industries and other sectors, as AIT's main instrument in realizing its mission. We think that the distribution of *e*-learning course materials to users could be made effectively using this STARAA network.

3.5 Promotion Initiative to the Space Technology Education and Research

Now the STAR program of AIT is preparing to launch a new program. This program carries a space technology awareness programs for the proper utilization space resources. This can be potentially helpful in increasing the area of influence and encompass widely spread users from different fields. The space technology awareness program including particularly RS and GIS can be implemented through providing space-related education at different levels. For example, basic space science education can be introduced in high school level and continue increasing the standard of space education towards the undergraduate, graduate and post graduate levels. This is the long term, far-sighted, basic way to make people aware in space technology as well as its application that can produce qualified human resources in space-related fields. Short-term courses like trainings, refresher courses, workshops can be effective for people who have been already trained in different fields such as agriculture, forestry, transportation, disaster mitigation, defence, civil planners and high school and university teachers. Such a program can be supposed to bridge the gap between space application users and space resources, defuse the experience between general users and qualified professionals, make interlink between space users and space development agencies, and distribute information about the most recent technology development, possible applications and integration with associated technologies, and it would play a key role towards promoting and circulating usage for overall development of the Asian region. Our proposed program is a non-profitable education/ research/ training/ consultant program and will build up human resources in Asian sphere of influence through excellence in teaching, research and services in areas of RS and GIS.

3.6 Mobile Distance Education System

After the launch of WINDS, we will receive (100Mbps) and transmit (1Mbps) large-amount of data using 50cm-1m aperture antennas, even if you are in the rural or mountain areas. Thus we are planning to develop some portable and easily transportable satellite-communication antennas and suggest the practical and cost-effective education and training services for rural areas in Thailand as well as in other GMS countries, wherein the ground-based communication infrastructure has not been appropriate. We can provide so-called “caravan-style” mobile classroom in any rural regions, by using vans or mini-buses equipped with small satellite antennas, PCs, web-and-book-based

education materials and image projectors.

3.7 Expendability to Integrated Disaster Monitoring and Mitigation Support System

Now at the STAR program, simple, low-cost, easily transportable flying platforms with high stability, mobility and maneuverability are under investigation and researches are going on. Among them are sky-sport plane, tethered blimp, radio-controlled UAV (unmanned aerial vehicles), new type of flying robot, and so on, either of which can take and transmit a series of aerial photographs on demand in quasi real time.

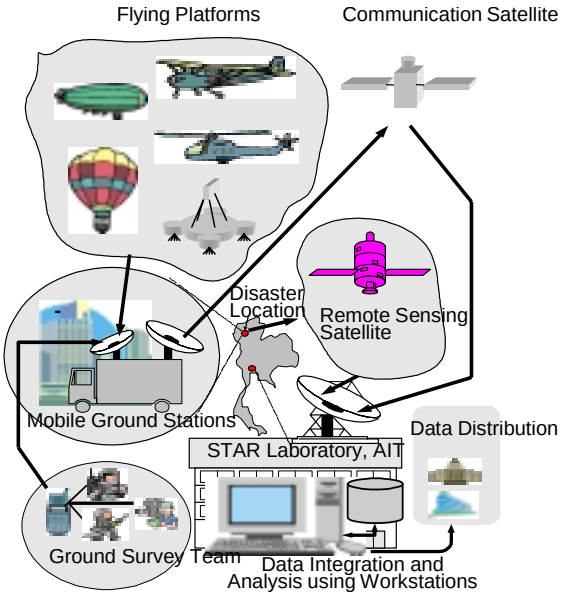

Figure-5. Integrated Disaster Monitor & Mitigation Support System planned by STAR Program, AIT

As shown in the Figure-5, once a disaster occurs and ground-based communication infrastructure may be disrupted, field image data obtained from both flying platforms and ground rescue teams will be gathered in the ground "caravan-style" vans described above staying near the disaster locations and will be transmitted to the research centres in big cities via communication satellites like WINDS. Such integrated data will be combined with RS satellite data, analysed and distributed to authorities and users, as rapidly as possible.

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