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Satellite-based Distance Education in India

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Issue 12: India - EDUSAT

1. Introduction

EduSat is the first satellite of India designed specifically to serve the educational sector. It was put into geo-stationary orbit by the GSLV-3 launch vehicle (on September 20, 2004) by the Indian Space Research Organization (ISRO).

Basic Details on EDUSAT

- Satellite: Edusat (GSat 3)
- Position: 74
- Norad: 28417
- Cospar number: 2004-036A
- Operator: Ministry of Education India
- Launch date: 20 September 2004
- Launch site: Satish Dhawan Space Centre
- Launch vehicle: GSLV (F04)
- Launch mass (kg): 1950
- Dry mass (kg): 820
- Manufacturer: Indian Space Research Organization (ISRO)
- Model: I-2K
- Orbit: GEO
- Expected lifetime: 7 yrs.
- Beams:
    - C-band South Beam (Ku)
    - C-band West Beam (Ku)
    - C-band Central Beam (Ku)
    - C-band NorthEast Beam (Ku)
    - C-band North Beam (Ku)
    - C-band Wide Beam (C)
    - C-band National Beam (Ku)

2. Launch Station for GSLV

Satish Dhawan Space Centre (SDSC) SHAR, the launch station for GSLV, is located at 80 km north of Chennai on the east coast of India.


Satish Dhawan Space Centre (SDSC)

The facilities at SDSC include:

- Mobile Service Tower, Umbilical Tower and Launch Pedestal
- Solid Motor Preparation Facility
- Subsystem Preparation Facility
- Hardware Storage Facility
- Liquid/Cryogenic Propellant Storage and Transfer Facility
- Stage Preparation Facility for Cryogenic Stage
- Automatic Checkout and Control for Propellant Filling
- Safety and Fire Fighting Systems
- Satellite Preparation Facility
- Launch Control Centre and Mission Control Centre
- Precision C-band Radars and S-band Radar for tracking
- Telecommand System
- Intercommunication, CCTV system, Data Links, Range Timing System, Real Time Systems and Specialist Display System, Meteorology and Technical Photography
- TM data receiving stations

Second Launch Pad (SLP)

The state-of-the-art Second Launch Pad (SLP) has increased the frequency of launches from SDSC and the new facility is designed to reduce the occupancy time for the integration and launch.

Second Launch Pad (SLP)

3. Geosynchronous Satellite Launch Vehicle

EduSat was launched by the third flight of ISRO's Geosynchronous Satellite Launch Vehicle.

The 49 metre tall GSLV is a three stage vehicle. The first stage, GS1, comprises a core motor with 138 tonne of solid propellant and four strap-on motors each with 40 tonne of hypergolic liquid propellants (UH25 and N204). The second stage has 39 tonne of the same hypergolic liquid propellants. The third stage (GS3) is a cryogenic stage with 12.5 tonne of Liquid Oxygen and Liquid Hydrogen.

The Aluminum alloy GSLV payload fairing is 3.4 m in diameter and is 7.8 m long. GSLV employs various separation systems such as Flexible Linear Shaped Charge (FLSC) for the first stage, pyro actuated collet release mechanism for second stage and Merman band bolt cutter separation mechanism for the third stage. Spacecraft separation is by spring thrusters mounted at the separation interface. The three-axis attitude stabilisation of GSLV is achieved by autonomous control systems provided in each stage. Single plane Engine Gimbal Control (EGC) of the four strap-ons of the first stage are used for pitch, yaw and roll control. The second stage has Engine Gimbal Control (EGC) for pitch and yaw and hot gas Reaction Control System (RCS) for roll control. Two swivellable vernier engines using LH2 and LOX provide pitch, yaw and roll control for the third stage during thrust phase and cold gas system during coast phase. The Inertial Guidance System (IGS) in the Equipment Bay (EB) housed above the third stage guides the vehicle till spacecraft injection. The closed loop guidance scheme resident in the on-board computer ensures the required accuracy in the injection conditions.

EduSat was configured to meet India's growing demand for distance education using an audio-visual medium, employing direct to home (DTH) quality satellite broadcasting with interactive capabilities.

EDUSAT
Source: http://www.isro.org/edusat/Page2.htm

The satellite has multiple regional beams covering different parts of India - five Ku-band transponders with spot beams covering northern, north-eastern, eastern, southern and western regions of the country, a Ku-band transponder with its footprint covering the Indian mainland region and six C-band transponders with their footprints covering the entire country.

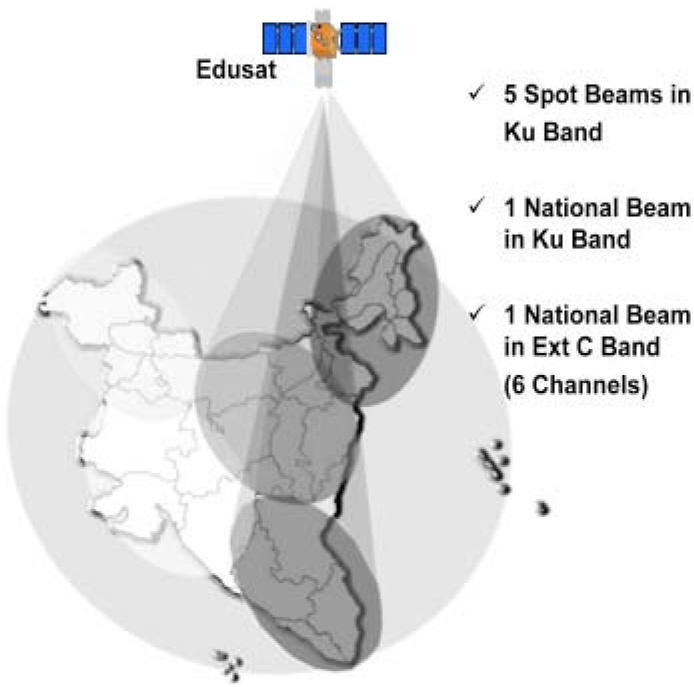


Fig. 1 - EDUSAT Coverage

EduSat was created primarily for the purposes of providing connectivity to school, college and higher levels of education and also to support non-formal education including developmental communication. The satellite was designed to provide service for seven years.

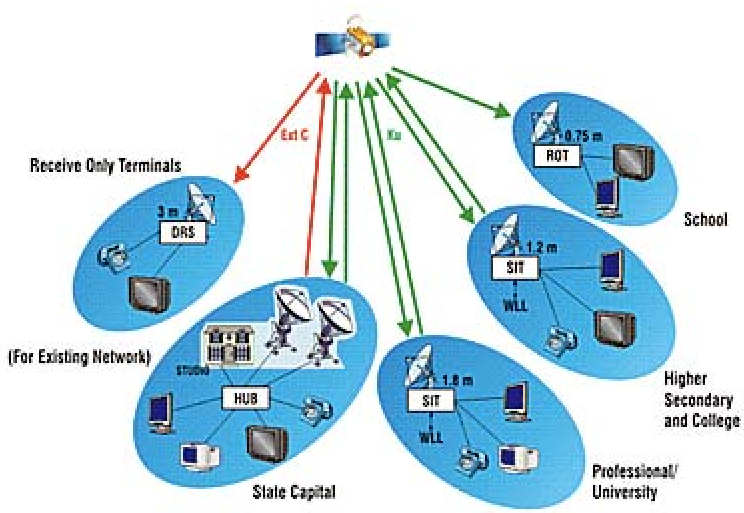


Fig. 2 - Connectivity through EDUSAT

Seven different educational organizations have been provided bandwidth on the national beam of the EduSat network. These are noted in Table 1 including the number of nodes installed at those locations. The national beam network operates at Ku-Band (14/11 GHz) frequency. One of the transponders of the geo-stationary satellite, i.e. GSAT - 3 (740E), is utilized to operate this broad footprint, as is shown in Figure 2. State networks receiving one of the regional beams continue to be upgraded. Schools in different states are connected through Sarva Shiksha Abhiyan (SSA), the Education For All project. The tribal area of Madhya Pradesh has been covered in the Indira Gandhi National Open University national beam. A pilot project was inaugurated to network 800 primary schools, 100 secondary schools and 75 higher secondary schools with a hub at Sidhi district headquarters. UGC terminals were also been installed in several colleges/universities in the remote areas.

Customer Name	Total # of Nodes for Each Agency	Installation and Commissioning Completed
Indira Gandhi National Open University	134	129
National Council of Educational Research & Training/Central Institute of Educational Technology	100	71
ARVN	11	11
Indian Space Research Organisation	9	9
University Grants Commission/CEC	58	50
All India Council of Technical Education	103	83
Department of Space and Technology	20	10
Total	441	406

Table 1 - Installation, Commissioning and Integration of SITs

4. EDUSAT Application Technology

Technological innovations create demand for improved designs. The quest has always been for improved performance, which is particularly true in telecommunication where technological advancement has triggered demand for better and larger capabilities for carrying information. Starting in the mid 19th century, the electric telegraph spread round the world and provided speedier communication, but it remained an asynchronous communication system. The telephone, another 19th century invention, provided the first synchronous interactive communication system by using a communication channel capable of carrying the human voice both ways in real time. The 20th century witnessed a similar technological development, first with radio, which in its initial phase provided wireless communication for ships at sea and then triggered broadcasting and in the recent times has placed mobile telephones in the hands of people around the world. While a picture is worth a thousand words, then a video is worth a thousand pictures. The video teaches us, entertain us, and bring our fantasies to life. Video along with audio adds realism to human communication. Television, as the next great innovation, is currently in the transition between one-way broadcasting and two-way interactive services, made possible by digital technology. Many of the advantages of digital technology have been enabled by the development of the modern radio communication systems of mobile telephony, satellite networks and digital video broadcasting.

The convergence of television and computers has been a major step in the enhancement of digital video broadcasting. Today, digital TV broadcasts are just long streams of bits that can contain any data broadcasters want to add to their signal. Data is sent along with the video and audio. For the last few decades, television has changed the way viewers see the world and how they learn and communicate. Broadcasting has traditionally referred to the "one-to-many" one-way services used for the distribution of audio and video while telecommunication has meant a "one-to-one" two way service, such as telephony and data transmission. With the growth of the Internet these distinctions have become less pronounced. People are able to receive broadcasts on TV sets, but engage in telecommunication with their PCs connected to the Internet. The convergence of these technologies implies providing two-way communication in the services that have remained one-way for long time. It is expected that in coming times, TV sets will no longer be restricted to receive-only services, but will also support two-way interactive services. Two-way communication in a conventional broadcasting system entails the implementation of return channels, such as from TV sets back to a TV station. The return channels may be carried by wire connections, by terrestrial radio channels or via satellite channels. The digital video broadcasting through satellite using return channel via satellite is known as Digital Video Broadcasting, Return Channel via Satellite (DVB-RCS). The DVB-RCS is a system that allows two-way communication between the Satellite Interactive Terminals (SITs) installed at customer's sites.

DVB-RCS systems are based on VSAT technologies (two-way interactive data networks) that can serve up to several hundred thousand users using a distributed gateway providing integrated services. VSATs (Very Small Interactive Terminals) are a much easier way to provide interactive broadband communications over satellite compared to existing terrestrial access networks (based on dial-up modems, leased lines and cable modems). The natural multicasting characteristics of the satellite, the wireless access and the fixed station connectivity are some of the major advantages of DVB-RCS. In a nutshell, DVB-RCS is a satellite-based access technology that allows users high-speed access to the Internet and its value added services. The DVB-RCS system supports communication channels that operate in two directions: a forward channel from the hub station to many terminals and a return channel from each terminal to the hub station. As with any satellite based communication system, DVB-RCS requires at least three stations, two on the Earth and a repeater station on the satellite as shown in Figure 3.

In the space segment, the satellite is shown as are the transmission paths through the atmosphere. The ground segment shows how the Earth stations communicate via the satellite, and how the user terminals interface with the terrestrial networks and the satellite system. A typical user terminal in a digital satellite communication system is comprised of an antenna system - the outdoor unit or ODU, the receiver/transmitter unit - indoor unit or IDU, and the peripherals such as a multimedia personal computer or wireless device.

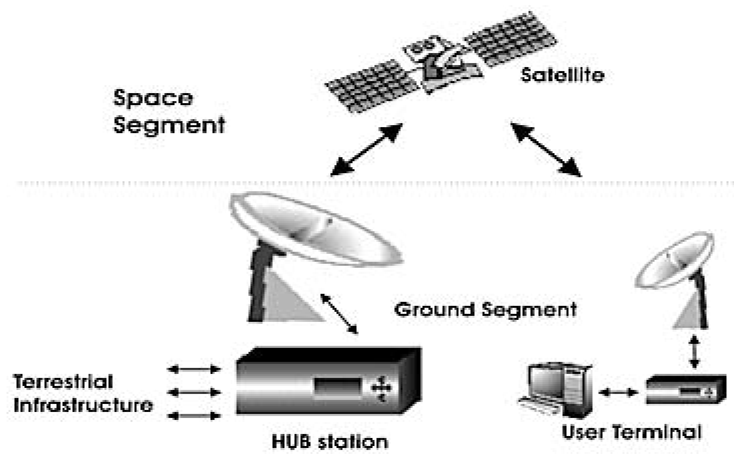
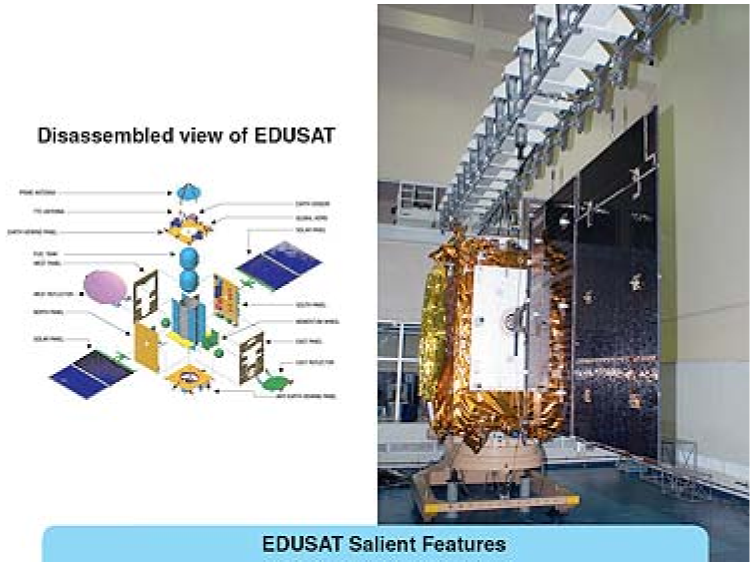


Fig. 3 - Satellite System

The Satellite

Geosynchronous orbiting satellites, those located 36,000 kilometers above Earth, are mainly used for fixed satellite services, namely for broadcasting and for communication. INSAT (Indian National Satellite System) is an example of such satellite. Currently, INSAT-2B, 2C, 3B and EduSat operate from this orbit, which better positions them to provide line-of-sight, always-on signals to the territories they cover. While data broadcasting, including Webcasting of live lectures and transmission of recorded video lectures, can be very expensive for point-to-point networks, this task is ideally suited to the point-to-multipoint capabilities of satellites, where onboard transponders act as radio relays to provide increased power over an RF band.



Salient Features of EDUSAT
Source: http://www.isro.org/edusat/Page3.htm

The principal parameters of broadband satellites include the bandwidth over which they operate and the power they can deliver. The bandwidths of DVB-RCS channels are typically 36 or 72 MHz. The forward and return links of DVB-RCS networks typically use Ku band frequency (14/11 GHz). C-band is now used in some VSAT systems, particularly those operating in areas with heavy rainfall that degrades link budgets at higher frequencies.

EDUSAT Dish
(Flash Player 7 or higher required for viewing)

The Hub-station

In data communication satellite systems, terrestrial hubs are used to link to and from terminals and convey services like virtual classroom. The DVB-RCS system operates as a star configuration, thus its central station is called a "Hub." This station implements the forward link via a conventional DVB-S chain (similar to digital TV broadcasting); the return link is implemented using the DVB-RCS standard. The Hub station is usually a high performance earth station with an antenna diameter of 6 to 9 meters. An important Hub function is to map the traffic of all remote terminals belonging to each user group. The Hub consists of microwave equipment for the transmission and reception of signals and a control center for managing network traffic. This station also hosts interfacing equipment supporting a wide range of terrestrial interfaces. The India Space Research Organization is presently managing the hub of EduSat stationed at the Space Application Centre (SAC), Ahmedabad. The EduSat Hub is primarily responsible for carrying Internet Protocol (IP) traffic between the Interactive Terminals (SITs) and overall network management.

The User Terminals (remote terminals)

In contrast to the Hub station, the remote terminals are much simpler in cost and in operational complexity. To minimise total system costs, DVB-RCS networks are designed to have a single expensive hub and a large number of much smaller remote terminals. User terminal consist of an outdoor unit and an indoor unit. Outdoor units include a dish antenna, generally 0.55 to 2.4 m (1.2 m in EduSat) in diameter, which can be wall, roof or ground mounted, while the indoor unit provides for signal processing (modulation, demodulation, multiplexing, demultiplexing, synchronization and routing) and supports the user interfaces. The indoor box is usually smaller than the size of a domestic VHS/Disc recorder. Depending upon the functionality and capability of devices, user terminals are primarily of two types:

EDUSAT Computer
(Flash Player 7 or higher required for viewing)

Satellite Interactive Terminal (SIT)

A Satellite Interactive Terminal is a user terminal with the capability to communicate via a return channel. A typical SIT with 1.2 m antenna for low data rates can be a connecting device into a computer or TV set for interaction. Connectivity can be further extended to nearby areas using wireless local loop (WLL). Similarly, satellite interactive terminal for high data rates with 1.8 m antenna can be used for video conferencing. SITs can be connected to several user PCs via a local area network (LAN). One of the main characteristics of these terminals is the low cost and small dish size. Forward Link (FL) allows data rates up to 45 Mbps.

EduSat is presently configured for 10 Mbps on the Forward Link considering satellite resources available and total traffic expected among all the SITs. Return link (RL) is responsible for carrying the return traffic using Multi-Frequency Time Division Multiple Access (MF-TDMA) based on ATM or MPEG standard. A single SIT allows data rates up to 2 Mbps. Presently, each SIT is configured in the Hub for a maximum 624/512 Kbps data. In MF-TDMA, each carrier is divided in logical time slots. The Hub assigns a particular time slot to a particular SIT for traffic to be sent to and from the Hub. The SIT transmits an ATM/MPEG cell in time slot in burst form. At present, each MPEG carrier is divided into 11 traffic time slots and each time slot supports a 56.75 kbps data rate. Each teaching end (classroom) is configured to support up to 624 Kbps RL traffic. Each ATM carrier is divided in 32 traffic time slots with single time slots supporting a 16 kbps data rate. Each classroom (CR) is configured in the Hub with request-based 24 time slots supporting up to 384 kbps RL traffic.

Receive Only Terminal (ROT)

The receive only terminal (ROT), as the name suggests, is a passive communication device making no provision for interactivity. In the EduSat context, such terminals are 0.75 meter dish antennas used for one-way TV and data reception.

Each user agency in EduSat can establish its own independent wide area network (WAN), but will be expected to use TCP/IP protocols for communication. The space-based satellite and the terrestrial Hubs are all the same. Users install their SITs or ROTs depending on the types of communication required. In each agency's network there will be one location that serves as the teaching end (TE), from where content related to teaching is generated and transmitted. The receiving end (RE) is defined as the classroom destination of information communicated. There will be at least one teaching end and several classroom ends in a user's network. The features of teaching end are a given below and Figure 4 shows the basic configuration required for a TE.

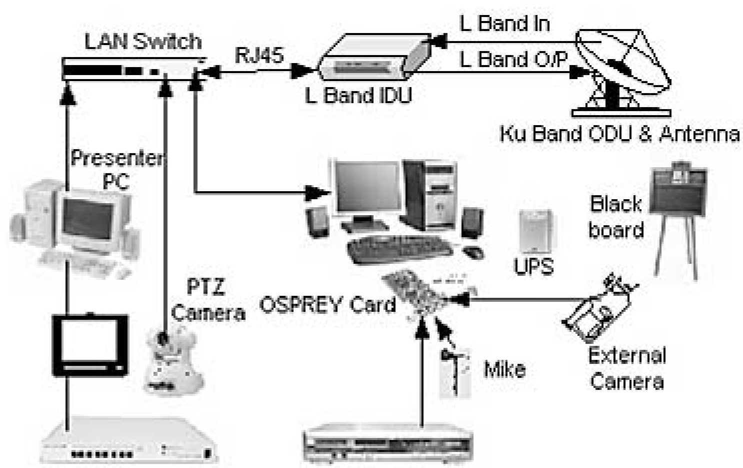


Fig. 4 - Configuration of a Teaching End

The live lecture of teacher using conventional blackboard with chalk and talk or using multimedia teaching aid for enhanced quality (using electronic board/touch screen, power-point presentation, VCD and DVD clippings) can be broadcasted from here.

EDUSAT session in progress
Source: http://www.smcte.ac.in/files/images/1.preview.JPG

These lectures can be recorded and archived so that these can be delivered on demand to the students. It can also maintain a digital library of all online books, journals, which can be accessed by the students.

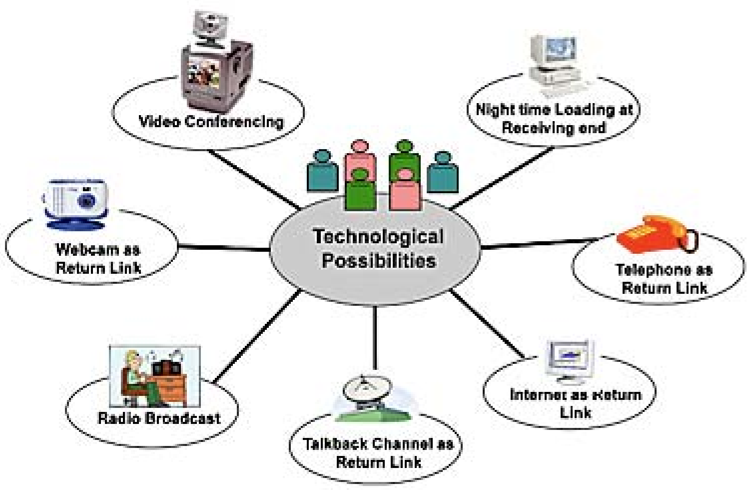


Fig. 5 - Potential uses of EDUSAT

Video conferencing can be initiated from the TE to achieve direct interactions between the teacher and students. The student database will be maintained there, as well as such administrative support as online registration, online examination, distribution of circulars and announcements. The TCP/IP network enables file transfer, chatting, application sharing, taking remote control of user's computer and access to Internet. Servers of different types can be installed at the teaching end which will provide video streaming facilities, digital repository services, access to databases and access to websites. Other potential uses of the EduSat network are shown in Figure 5. The centralised data bank accessible via the satellite can be used for storing radio and TV broadcasts, nighttime downloading/

recording at the receiving end and facilitating online education through the Internet.

The classroom end is used to receive live lectures. With receive only facilities, interactions cannot be done through satellite, so telephone lines are usually the alternative solution. When interactive terminals are used, both audio and video content can be present using video conferencing. Offline accessing of content can be done via the Internet. Basic configuration of a classroom end is shown in Figure 6.

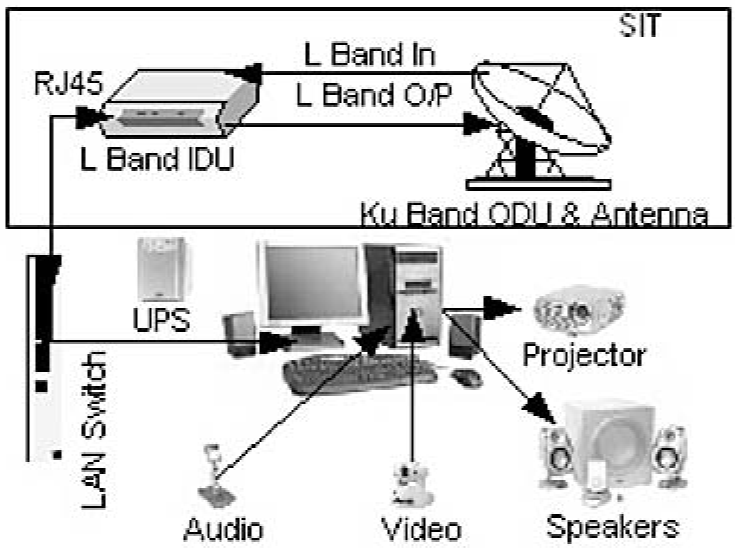


Fig. 6 - Configuration of a Classroom End

5. ICT Enabled Education

Education in India has always been regarded as one of the basic inputs in human resource development. In the ancient days, the Gurukul system of education was prevalent. The teacher was the Guru and the disciple was the Sishya. The teacher there observed the children's attitude, aptitude and ability, and educated them accordingly. Guru chanted the shloks (verses) that Shisya were expected to memorise. Ancient records of the Indian tradition testify to the search of the Rishis and sages for higher knowledge (para vidya), and their discoveries have been continuously transmitted to posterity and kept alive through its long history, marked by periods of expansion, specialization, decline and renewal. Despite serious handicaps of means and resources, the country has built up during the last 50 years a very large system of education and has created a vast body of men and women equipped with a high order of scientific and technological capabilities, robust humanist and philosophical thought, and creativity. Though challenged by an explosion in the growth of is population, a large illiterate population and problems of economic poverty affecting one-third of the people, modern India is still set to forge a bright future.

Concepts of access, equity, relevance and quality can be operationalized only if the system is both effective and efficient. Hence, the management of education and the total networking of the system for effective management has become an important issue. This shift can occur only through a systemic approach to change, the development of its human resource, and networking of its education system through technology. Technology has been the driving force to bring paradigm shifts in education. Big changes are not possible unless tools are available.

Technology has great impact on what we can do. The printing press is an example. People were reading and writing even before the invention of the press but it was not that wide spread. The sharing of accumulated knowledge was possible due to the accessibility and affordability of books. In earlier days, students had to rely on memory to remember everything that teacher delivered, but now books are available. More recently, there has been a more universal use of radio, television, and computers in education. The past few years have produced an explosion of electronic information resources available to students, teachers, library patrons, and anyone with a computer. Millions of pages of graphics and text-based information can be accessed directly on-line through hundreds of public, private, and commercial networks via the Internet.

With the advent of IP technology and the tremendous growth in data traffic, satellite communication has adapted to and embraced IP technologies. The advances in information and communication technology provide great opportunities for enhancing teaching and learning both on-campus and via distance education. Even disabled students who are denied access to traditional institutions, and all those who require updating of their knowledge and need life-long education, can now be benefited by the modern facilities of communication. Advanced satellite technologies now can provide increased access to information sources and facilitate communication among researchers and teachers and assist in the building of networks of institutions and scholars.

As a very small proportion of the relevant age group, around 6 per cent of young people of college age in India are enrolled in higher education, compared to about 40 per cent of the developed countries. The increased use of information and communications technologies (ICTs) is beginning to make an impact in the provision of distance/open/flexible learning programs. As an outcome, myriad approaches are being used to either to enhance the quality of the overall student learning experience or to better accommodate for students' specific learning needs and requirements. The present evolution of virtual institutions is a further indication of the potential of ICTs for education and training (Jasola, 2004).

Some of forces driving increased use of ICTs include:

- an increased capacity, flexibility and suitability of ICTs for education and training programs to meet student needs and demands;
- the provision of a more cost effective education;

- a means of providing courses to students that extend beyond an education provider's traditional catchment area for potential students; and
- as a perceived means "to keep up with the competition."

For the provision of courses to students who are unable to attend a campus for extended periods of time, particularly students who reside in remote or rural regions, there is a growing concern that too little is still known about the best ways to use ICTs for effective teaching and learning. How can students be provided with a greater range of teaching/learning environments? How can print (textbooks and programmed texts), CD-ROM delivered materials, interactive courseware, Internet-based audio and video, teleconferencing, chat sessions, database inquiries, and transactions be delivered to learners when and where they need them?

6. Satellite Supported Distace Education

EduSat has demonstrated that it can provide two-way videoconferencing, on-line multimedia, and video programming on demand. Virtual communities of learners and educators are already sharing those information resources that are growing exponentially over the Internet and will grow even faster with a more extended international information infrastructure. Global "virtual libraries" are now emerging through connections between university research libraries. These shared on-line public databases suggest the beginning of a comprehensive worldwide knowledge resource that is becoming available to anyone with access to a network gateway (Jasola & Sharma, 2005). As knowledge in all fields increases exponentially, our present day situation demands that we develop motivated, skillful, lifelong learners. We cannot hope to fill up students as if they were passive, empty vessels. During formal schooling, aspiring professionals can only begin to take in the amount of information that they will need during their career life times. We must define the goals in such a way that students become lifelong learners by helping them locate the resources they need to continue learning.

When learners interact with one another, with an instructor, and with ideas, new information is acquired, interpreted, and made meaningful. If students feel that they are part of a community of learners, they are more apt to be motivated to seek solutions to their problems and to succeed. There can be different types of interaction possible through the EduSat based network.

According to the predominant communication paradigm, these can include one-alone, one-to-one, one-to-many, and many-to-many. One-alone applications are those that utilize online resources: information (online databases and online journals), software (online applications and software libraries), and people (online interest groups and individual experts). Online information about any topic may be obtained through many sources and is available in many forms. Scholarly discussion groups distributed via LISTSERVs, for example, focus on issues of concern to educators and learners. Archives of papers, conference announcements, calls for papers, electronic journals, literature reviews, software, books, guides, library catalogues and resource databases are all accessible with a few keystrokes.

One-to-one interactions can include learning contracts, mentorships, apprenticeships, and correspondence study. These applications are characterized by one-to-one relationships and by individualized learning. One-to-many applications, such as lectures and skits, are differentiated from other forms of interaction by their use of presentation techniques in which learners are not usually invited to interact. With many-to-many applications, all participants have the opportunity to take part in the kind of interaction that can be facilitated in computer conferencing systems.

The Bulletin Board System (BBS) networks can be used as an educational resource. BBS networks are distributed group conferencing systems that allow teachers and students from around the world to interact with each other electronically in "virtual classrooms," sharing information and collaborating on learning projects. The bulletin board can be used to stimulate interaction among students and the instructors. A variety of different strategies can be used to encourage interaction on the BBS, including assignments, discussion questions, and team activities.

The courses offered via EduSat network are based on a learner-centered approach to education in which teachers and students share responsibility and participation in learning and teaching. Such courses help to alleviate learners' feelings of remoteness and isolation. To initiate such a process, teachers must make sure that they and their students have adequate training and support on the electronic system. Teachers must devise plans to make maximum use of the new medium. By initiating a variety of activities, both on and off-line, teachers can facilitate an active, challenging learning environment. Strategies are necessary to keep energy high. Because the courses are delivered via a satellite-based network, students are able to take considerable control over their learning in terms of how they schedule both personal study and group-interaction time, how much personal contact they have with the teacher and fellow learners, and how they can contribute to the class.

Courses delivered via EduSat can meet immediate learning needs as well as help learners become more self-directed in their ongoing learning. Using the Web as an instructional medium is possible as more learners gain access to the Internet. EduSat incorporates a technology base that is appropriate for the widest range of students within a program's target audience. Learners bring varied social and cultural backgrounds and diverse experiences to a distance-learning situation. The unique contexts in which learners live and work influences the way they think about and use EduSat network.

7. Concluding Thoughts

The advent of digital technology has brought radical changes in the means of creating, recording, processing and distributing video. Multiple delivery systems have emerged, including the DVB-RCS via satellite made possible by the convergence of computers and telecommunications. Due to its interactive capabilities, DVB-RCS and streaming audio-video have opened new horizons for distance education. Building on the strengths of DVB-RCS technology, the EduSat network sponsored by the Indira Gandhi National Open University and other institutions of learning are striving to offer a distributed learning system reaching students in the remote corners of the nation.

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