1989

Ku-band satellite telecommunications and its implications for education

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Abstract

The world of telecommunications is expanding at a fast rate. The word telecommunications comes from the Greek word "tele" which means "far off". Communications means "the act of imparting or exchanging information, knowledge, and ideas" (Carne, 1984, p.5). Together the word telecommunications means "communicating at a distance". How did telecommunications arise? Historically people have always had to come together face to face in order to communicate. This began to change with the advent of writing skills. Communication could then occur at greater distances by means of sending a letter or message from one person to the other. With increasingly better transportation, the organization of states and enterprises became possible because the regular flow of communication was made possible. The telegraph and telephone were the first inventions to truly make the limitations of time and distance all but disappear. In today's world electronic communications make it possible to send and receive messages instantly to all parts of the earth.

Ku-Band Satellite Telecommunications and Its Implications for Education

A Graduate Project
Submitted to the
Department of Curriculum and Instruction
In Partial Fulfillment
of the Requirement for the Degree
Masters of Arts
UNIVERSITY OF NORTHERN IOWA

by
Constance J. Miller
May 8, 1989

This Research Paper by: Constance J. Miller

Entitled: Ku-Band Satellite Telecommunications and Its Implications for Education

has been approved as meeting the research paper requirement for the Degree of Master of Arts.

May 8, 1989
Date Approved

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May 8, 1989
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Chapter 1

INTRODUCTION

The world of telecommunications is expanding at a fast rate. The word telecommunications comes from the Greek word "tele" which means "far off". Communications means "the act of imparting or exchanging information, knowledge, and ideas" (Carne, 1984, p.5). Together the word telecommunications means "communicating at a distance".

How did telecommunications arise? Historically people have always had to come together face to face in order to communicate. This began to change with the advent of writing skills. Communication could then occur at greater distances by means of sending a letter or message from one person to the other. With increasingly better transportation, the organization of states and enterprises became possible because the regular flow of communication was made possible. The telegraph and telephone were the first inventions to truly make the limitations of time and distance all but disappear. In today's world electronic communications make it possible to send and receive messages instantly to all parts of the earth.

Telecommunication technologies are delivered by several means: Instructional Television Fixed Service (ITFS), microwave, coaxial, fiber optic, or satellite systems. This paper focuses on the technology of satellite delivery.

A Brief History of Satellite Telecommunications

With satellite telecommunications, you can sent a message from earth to a satellite positioned more than 22,000 miles above the earth. The satellite receives and then retransmits the message down to another part of the earth, all within less than half a second. It is truly insensitive to distance. Satellite telecommunications gives us, as members of the world community, the ability to transmit data, images, and sounds from one part of the world to another part instantaneously.

Up until most recently, satellite transmission of television, data, telephone conversations used a frequency range referred to as C-Band. The definition of C-band is the frequency range from roughly 4 to 6 GHz. The transmission from earth to satellite (or the uplink) is sent at the higher frequency of 6 GHz. The transmission from satellite to earth (or the downlink) is sent at the lower frequency of 4 GHz (Dick, 1988).

Originally the 6-4 GHz frequency range was created for use by the telephone companies to transmit their services from point to point on the surface of the earth. Satellite TV was allocated a shared use of the C-band at the same time providing that the satellite systems didn't interfere with the telephone companies' terrestrial services. This was before the sudden and unforeseen growth of satellite television. What resulted was that the C-band frequency became heavily used both for telephone and satellite television transmission and became quite congested in some areas (Cooper, 1986). C-band remains the frequency range used most heavily in television communication.

In response to the need for more room on the frequency spectrum, the Ku-band of frequencies was created. In 1979 the Federal Communications Commission (FCC) organized around the 12.2- to 12.7-GHz portion (Cooper (1986). Now Ku-band usually uplinks at around 14 GHz and downlinks at around12 GHz.

A term encountered a great deal in the reviewed literature is direct broadcast satellite or DBS. According to Don Savereid (personal communication, April 20, 1989), the term refers to whenever a viewer receives a signal directly from a satellite rather than from a cable company or from a broadcast station. A direct broadcast satellite can send either a C-band or Ku-band signal. Most of the backyard satellite dishes seen in the United States today are C-band receiver dishes.

However, when the C-band frequencies became too congested, a move was made within the direct broadcast industry to go to a higher power satellite that can send to a smaller dish size. In 1982 the FCC authorized the construction of DBS-TV systems to serve the communication needs of the public whereby television signals could be broadcast from space for private use. The uplink for DBS will approach 18 GHz in one design. The broadcasting power will almost 200 watts per TV channel at frequencies near 12 GHz. The combination of high power and high frequency means that the receiving antenna can be about 3 ft. or 1 m in diameter (Carne, 1984). In these instances the characteristics strongly parallel those of Ku-band. Thus, the author used the term DBS rather advisedly in her survey of literature. Only when the characteristics of the particular DBS system being discussed closely approximated those of Ku-band, was that literature included in this review.

Educational Uses of Satellite Telecommunications

Telecommunications is used in all areas of study. We will be looking at how they are used in the field of education, most particularly how they are used in distance education.

The concept of 'distance learning' is as simple as it sounds: "the learner in one location, the source of instruction in another" (Bruder, 1989, p. 36). The literature surveyed seem to discuss the use of distance education with regard to two main areas: (a) its use in smaller or rural schools and (b) its use with adult learners. First let us look at how satellite telecommunications is used in the smaller or rural school systems.

In today's world many smaller schools are being threatened with cutbacks in teaching staffs, reduction of course offerings or eventual consolidation with nearby school districts.

Barker wrote:

> Subscribers to interactive satellite instruction are chiefly rural and small schools which are hampered by low student enrollments which increase per pupil cost of programs, facilities, and certified personnel. Satellite technology is a viable approach to bringing educational opportunity to students, facilities, and staff in these schools. The technology is now here to reach out and teach thousands of students via 'long distance' where a certified teacher is not always available or in small schools where limited student enrollments make hiring teachers for low incident courses cost prohibitive, satellite instruction may be the 'next best thing to being there' (1987, p. 9).

According to Barker (1987) there are 6 benefits of instructional satellite television (ITV) to rural schools. ITV provides: (a) equity in the quality of educational opportunities, (b) the same access to subject matters that would not be available locally, (c) interactive and joint activities between schools and other students, (d) access to information and instructional resources not otherwise available to students, (e) opportunity for instructional development and training, and (f) more school and community links to one another.

The second main area of use with regard to distance learning is that of adult learning. To explain the need for adult learning, Juliet Miller (1983, p3) enumerated these statistics:

* From 1949 to 1965, about 3,000 occupations disappeared from the United States labor market while more than 6,000 new occupations were developed.
* Many workers will need to retrain three or four times during their careers because of rapid technological advance. (Abbott 1978).
*Microcircuitry, which can replace hundreds of moving parts, is redefining and reducing the number of jobs in many industries. Robots are altering the environment of the assembly line. Printing, textiles, metal and plastic fabrication, instrumental engineering, electronics, shipbuilding and aircraft fabrication are some of the industries that are being affected by this technology (Normen 1980).
*The work place will become a set of human/machine partnerships. The new "basics" required of workers will center on largely nontechnical skills that in many ways resemble those taught in a liberal arts, general education curriculum.
*Theobald (1979) suggest that the following skills will be required:skills to live happily and creatively with others, life-planning skills, decision-making skills, creative change skills, and skills in analyzing the need for stability versus change.

It should be noted that technology is not the answer in and of itself to the problems of remote school systems and the problems of the adult learner. As stated by Schneller (1983), satellite telecommunications should always be considered as only a tool for the use of education. It does not solve problems of thinking, research and teaching in education.

How available are satellites to be used in telecommunications? "At the end of 1982, there were about 500 earth stations providing 1,200 pathways or direct communications links via satellite among 170 countries, territories and areas of independent sovereignty, and more earth stations are being built" (Schneller, 1983, p.1).

In surveying the literature on the educational use of satellite communications, the author only used information that was published within the last two or three years. Only in this way could the author be assured that it would include the latest technologies of satellite telecommunications in education. Sometimes the article or source of information did not specifically mention the use of Ku-band. However, due to the prominence of this new technology with its accompanying cost effectiveness, the author assumed that Ku-band was either currently being used or was being planned for use in the future.

Research Topics

The questions addressed in this paper will be: what are the characteristics of Ku-band in satellite transmission? What are its strengths and limitations? How is it being used in education today? What are the factors that impede its progress in educational usage?

What are some major educational institutions using the Ku-band frequency to distribute education programs via satellite? Overall what are the educational implications for the use of the Ku-band of frequencies in education?

Definition of Terms

Bandwidth------------ The range of frequencies available for signals to be sent within. The range is the difference between the highest and lowest frequencies (Martin, 1977)

C-Band--------------- Covers the satellite frequencies from 4 GHz to 6 GHz. The lower frequency is used for the downlink signal and the higher frequency is used for the uplink (Dick, 1988).

Earth Station--------- Used to indicate the transmitting and/or receiving antennas for satellite communication transmission on earth.

GigaHertz------------- One billion cycles per second of electromagnetic energy.

Ku-Band-------------- Covers the satellite frequencies from 11 GHz to 14 GHz. Ku-band downlinks at frequencies around 12 GHZ and uplinks at frequencies around 14 GHz.

Rain Attenuation----- The loss of signal power to/from satellite transponder due to rain (Grimes, 1985).

Receive Gain---------- The effective gain in signal strength when transmitted from one point to another: often expressed in decibels.

Terrestrial Transmitter----- Transmitting and receiving antennas are both based on the earth. Usually refers to microwave transmission towers.

Transponder---------- Made up of two words: (trans)mitter and re(sponder). Transponder receives the uplinked frequency and then shifts signal to downlink frequency. Then filters, amplifies, and re-transmits back to earth. Up to 24 channels on a transponder. All are on different frequencies.

Chapter 2

REVIEW OF LITERATURE

Strengths of Ku-Band

Low Cost

A primary strength of Ku-band is its low cost. The first reason for its low cost is the small size of its receiver antenna. The initial purchase price is therefore relatively inexpensive. Then there is the cost of assemblage. According to Brand (1988) it costs about $800 to assemble a 10 to 20 foot satellite dish needed for C-band reception. It costs about $500 to assemble a 4 foot dish used by Ku-band.

The second reason for its low cost is the cost of installing and mounting a satellite dish. A rooftop is often the most desirable place for a satellite dish because it provides a clear view to the south. This is necessary in order to track a satellite more than 22,000 miles above the earth. Obstructions such as steel buildings, trees, and even the hemisphere line can be eliminated this way.

A large dish as the one C-band uses creates tremendous windloads. Windload refers to the stress put upon a satellite dish's structure, mounting, and the rooftop whenever the wind is 'caught' by its concave structure. Special mounting precautions are thus needed when locating a large dish above the ground (Dick, 1988). The savings in cost come because the small Ku-band dish is easier to install. Secondly it does not need as much reinforcement in the mountings and roof to withstand higher windloads (Dick, 1988).

Mobility

Another major strength of Ku-band is the mobility that it offers. The news gathering industry aptly demonstrate this mobility. According to Long (1985, p. 39), "By 1987, Ku-band satellite links will be the dominant method of delivering video news coverage from the field to the studio control room." NBC has installed Ku-band receivers with all its affiliates and 50 or more affiliates are being equipped with Ku-band transmitters (Cooper, 1986). The smaller dish size used for uplinking by Ku-band is one of the major reasons for this development. Small dishes are easily mounted and transported on vans or trucks. They are also less expensive to transport. The cost of these mobile earth stations are affordable enough to allow local, regional and national news services to buy their own units (Long, 1985).

Small Dish Size

The small sized dish used by Ku-band has been repeatedly cited as a major strength. But why does Ku-band use a small dish or receiver antenna? First of all, the reason for the dish-like shape of an satellite receiver antenna is so that the dish can capture and amplify the signals as they are beamed from a satellite transponder stationed above. The signals are fed into the feedhorn appliance you see in the middle of the dish and from there become converted back into whatever the original message form was: video, data, sound. Since satellites transmitting with a Ku-band transponder are very powerful, the signal is stronger. Thus it needs less amplification or strengthening. The dish does not have to be as big as the one used to pick up C-Band frequencies (E. Pugh, personal communication, November 21, 1988).

An actual comparison in sizes using measurements can be a little confusing because dish size is given in both meter and feet measurements. The size given refers to the diameter of the dish. Authors of various periodical articles have cited a range in C-band receiver dish size which range from from 3 to 4.5 meters across or 10 ft to 15 feet across. According to Brand (1988) a C-band receiver antenna needs at least a 10 foot wide dish to pull in the signals properly.

A Ku-band receiver antenna can properly collect signals with a 4 foot wide dish (Brand 1988). Stated by other authors, home satellite TV reception is possible with antennas only 70 centimeters (2 feet) in diameter (Long, 1985).

A small dish is desirable from an appearance viewpoint. They are small, easier to hide, aesthetically more attractive (Chakraborty,1986). Other advantages are as mentioned above, low purchase price, easier installation, less stress on rooftops due to windloads, and good mobility.

Freedom from Terrestrial Interference

There is solid agreement among authors as to the strength of Ku-band in this area. The agreement is stated in different ways. Following are a few examples: "Ku band's chief advantage is that Ku-band assignments are not shared with terrestrial users (such as telephone companies), so the number of earth locations where terrestrial interference is likely to occur is far smaller than with C-band" (Cooper, 1986, p. 8). Carne (1984) makes the point that the absence of competition with terrestrial use of frequencies available in the higher frequencies makes site selection for earth stations much easier. Weber (1984) states that in congested areas, Ku-band is less affected by microwave traffic than C-band. Dick (1988, p. 169) approaches this problem from a different angle. His point is that to avoid interference "complex and sometimes costly measures must be taken to shield the receive dish from the interference." Chakraborty (1986) claims the C-band transponders are restricted to reduce terrestrial interference.

Poyser (1987) gives a more detailed explanation of the actual cause of interference. When satellite signals coming down to earth in C-band cross telephone microwave links, they will encounter interference. Dish owners in areas of heavy microwave traffic may receive a great deal of interference for certain stations.

The Ku-band of frequencies was the first band of frequencies to be created for the sole aim of satellite use. There is virtually no one on earth using the same frequency so the signals sent down by a Ku-transponder will come in loud and clear. In congested areas, Ku-band is almost unaffected by microwave traffic. This means there will be less trouble locating a Ku-band receiver dish in order to avoid interference from local microwave traffic (Weber, 1985).

Limitations of Ku-band

Rain Attenuation

Rain attenuation refers to the loss of signal strength due to atmospheric conditions mostly rain. The non-spherical shape of raindrops causing the break-up of the signal (Dick,1988).
This drawback affects the higher level of frequencies more than the

lower levels although the lower levels are not immune. As stated by Grimes (1985, p.290), "It is well known that for an earth station operating at Ku-band frequencies, the power level received from/to the satellite is directly dependent on weather and atmospheric conditions."

·Many mathematical models exist to predict rain attenuation according to each transmitting/receiving site. Each model "predicts attenuation as a function of site-specific data (rain rate and elevation angle to the satellite (Grimes, 1985, p. 290). There is voluminous literature based on research work directed toward predicting weather vagaries affecting Ku-band signal transmission (Chakraborty, 1988).

Chakraborty (1986) recommends the Crane global model because of its better overall prediction methods for locations in the United States. The model divides the continental United States into seven regions based upon annual rain rates. Then it calculates rain attenuation based on this data to determine the amount of energy absorption possible in any one time of satellite transmission. He also offers a mathematical model used to calculate how much an increase in noise will accompany the loss of signal strength due to rain attenuation.

Chakraborty's recommendation to combat rain attenuation is to install a slightly larger high-power amplifier in the uplink transmitter. Thus while you can't stop attenuation of the signal due to atmospheric conditions, you can boast the signal strength in the first place to counteract it according to the model you use.

Battery Reliability in Ku Transponders

Ku-band transponders use higher levels of power. Ku transponders are operating higher frequencies which require greater wattage of power to transmit. Also more energy is required to overcome the atmospheric losses which accompany transmission of higher frequencies. As stated by Eugene F. Murphy, chairman of RCA Communications, "These satellites will be the most powerful domestic communications satellites in service. Each satellite carries 16 transponders with 45 watts of power, which means that they can deliver a superior quality television signal into antennas as small as three feet in diameter" (Long, 1985, p. 40).

However there has been trouble with Ku-transponders being tested in space. Satellites use solar energy when in view of the sun. During the time they move out of the sight of the sun, they need to use reserve batteries (Martin,1981). The problems arise during this solar eclipse period. Because the Ku transponders are so much bigger, there is more demand for battery power. There the technical problems are still to be worked out (TV Services, personal correspondence, November 21, 1988).

Cooper (1986, p. 93) states:

> Unfortunately, reliable 250-watt transmitters have yet to be operated in space; they are something of a curiosity, even in the laboratory sense, the unavailability of 250-watt satellite transmitters has placed Ku-band DBS on indefinite hold.

He goes on to say (1986, p. 94):

> The 100-watt satellite transmitters launched into space so far have failed at a brisk rate. The most recent of those failures

> was a Japanese unit put into service early in 1985; two of its three 200-watt transmitters quit within months of turn-on. At best, the results thus far have not been encouraging, even at the 100 watt-power level.

However Joseph Sivo, chief of the Lewis Space Communications Division, offers this prediction: "Technologies to be tested could lead to at least a five-fold increase in satellite communications capabilities in the 1990's (to 180,000 circuits). These capacity increases will be necessary to meet the rapid expansion of telephone, television, teleconferencing, electronic mail, data communications, and other communications satellite traffic for the rest of this century-growing at roughly 20 percent per year" (Wedemeyer, 1986, p.7).

Educational Applications of Ku-Band

Many systems are using satellite technology today. On the international level is Intelsat, numerous domestic systems (RCA, Western Union, At&T, etc..) and private system (Satellite Business Systems) as well as a host of educationally-based satellite networks (Wedemeyer, 1986).

Our efforts in this portion of the paper are to take a look at some of the educationally-based satellite networks using Ku-band and only the most recent technologies of DBS which are related to Ku-band. The author only used sources in this section that were published within the last two or three years to insure the premise that, although Ku-band may not have been expressly mentioned, it would either be a part of the system or being looked at for the future.

Public School Level

Satellite technology has been proven especially useful for the national and regional distribution of instructional television (ITV). ITV is distributed by satellite to public broadcasting stations at a fraction of the cost of mail and in much less time. ITV can either be pre-programmed or broadcast live (Bond, 1987). The following are examples where instructional television is being broadcast in the pre-programmed form.

From 1980--1986 the Alaska State Department of Education and the University of Alaska at Anchorage formed a Learn Alaska Network. Two hundred and fifty communities of Alaska are served which included public schools and university students. It operated 24 hours and seven days a week. In this case satellite delivery was selected as the most efficient way to delivery instructional television to remote places (Bond, 1987).

A second example program is Kentucky. Beginning in the fall of 1988, the Kentucky Educational Television (KET) hopes in begin Ku-band broadcasting of ITV programs to all Kentucky public schools. KET has a strong commitment to ITV. KET will offer a General Equivalency Diploma series, a dropout prevention program, other adult learner programs in addition to regular instructional programming for adults and children.

An uplink operating facility will be used to broadcast these programs to about 1,700 buildings statewide, all of which will be equipped with downlink dishes. The buildings are comprised of all

Kentucky public school, public libraries, and county courthouses (Bond, 1987).

The Utah State Department of Education broadcasts the Accelerated Learning of Spanish Program. It operates with financial support from IBM and the Bonneville International Corporation. It broadcasts pre-taped instruction to subscriber schools. There are over 800 students covering six states that are a part of this network. The course work is designed for junior high to high school levels. Lessons are sent in on alternate days of the week. On the other days of the week, students work on microcomputers with voice synthesis capabilities doing individualized instruction. So far the Spanish language is the only course offered through this system but newer additions of English as a second language is being planned.

The fee for subscription for a school district to the above system is $1,600. This includes 80 pre-recorded programs and permission to video-tape any of them off-air. It also includes 80 computer programs, teacher materials, enrichment activities for students, and inservice training (Barker, 1986).

When a school system cannot operate or attract a qualified teacher, live instruction by satellite is an option. Satellite technology makes live communication possible between people on opposite sides of the country or of the world. Teaching courses live by satellite is practical as long as there is enough students to justify the cost. The cost of the television instructor can then be shared by the participating schools (Bond,1987).

Only audio interaction is possible during a live satellite telecourse. Students response to instructors are by microphones that are linked to the satellite's audio-response channels or by long-distance phone lines.

Video interaction is not possible. Students can see the instructor but the instructor cannot see them. Therefore classroom supervisors are desirable for purposes of maintaining classroom discipline, administering homework assignments, and monitoring during the testing periods. Course materials can be sent by mail or faxed to the school systems.

Satellite technology is further flexible in that it can be used for other purposes besides classroom instruction. Live teleconferences by satellite links make it possible to bring people together across great distances without the time and expense of travel (Bond, 1987).

There are currently several major interactive instructional television satellite systems beaming instruction to high school students throughout the United States (Barker, 1987). We'll begin with a look at the largest one.

The nation's largest satellite system is the TI-IN Network, Inc. in Texas. It is a private, for profit, satellite network that was developed to correct problems of teacher shortages and uneven preparation for college due to differing local school course offerings.

TI-IN provides Ku-band satellite capability transponder time and administrative coordination of the curriculum. Instructional accreditation and training are provided by the Texas state agencies, universities, school districts, and professional associations.

TI-IN offers live instruction in the widest array of subjects of all the instructional satellite television networks. Courses include algebra, trigonometry, computer math, physics, French, German, and Spanish. Instruction was first beamed in August, 1985 and was broadcast just to students in remote Texas schools.. Today it broadcasts classes to two Arkansas schools, 18 California schools and 81 Texas schools. These classes are accredited by the state of Texas (Bond, 1987).

Herein arises one of the problems encountered with telecourses being beamed across state lines. Problems arise in relation to accreditation. Since courses cannot be altered to meet special requirements of each state that subscribes to them, a class being beamed into a particular state or district may not meet with the local accreditation requirements for courses or instructors. (Bond,1987).

The second largest satellite network is the schools subscribing to Oklahoma State University's (OSU) Art and Sciences Teleconferencing Service. OSU began broadcasting a single semester of German in January, 1985. During the 1986-87 school year, broadcasts were received by 101 districts in six states and offerings had been expanded to two full years of German and a full year of high school physics.

The OSU satellite courses are broadcast on intermittent days of the week, either 2 or 3 days a week. On non-broadcasting days, students work on computer-assisted instruction designed by university instructors.

The base cost of subscription for schools is $1,750. In order to subscribe, school systems must also buy their own dish, micro-computers which are equipped with accompanying voice recognition software packages, and tape recorders. This layout for equipment comes to about $5,000 to $10,000 as of 1986 (Barker, 1986).

The Easter Washington University's Telecommunication Project is locafed outside Spokane, It was formed in conjunction with the Education Service District #102 and began broadcast of four high school courses to 15 schools in Washington State in the fall of 1986. Live instruction is beamed to subscribing high schools for four days a week. In-service training is also provided to teachers (Barker, 1987).

Another example of a statewide use of interactive instructional television satellite system is in Missouri. In 1987 the Board of Directors of the Missouri State School Boards Association (MSSBA) approved establishment of the Educational Satellite Network. Two hundred downlink dishes will be installed in the public secondary and elementary districts across Missouri. By the end of 1989, the MSSBA plans to have installed downlinks at most of the state's 545 elementary and secondary districts.

Uplinking will be from a Ku-band mobile unit, thereby allowing programing to originate from virtually any desired location within the state. The base price for districts to participate in the network is about $3,500. The range of programming include high school courses, student enrichment, staff development, and college credit classes. The network is on a non-profit basis (Barker, 1987).

University Level

The National Technical University (NTU) is a satellite university (Salamone, 1987). This is composed of several major universities and corporations who have gone together to create the first "electronic university". It is situated in Fort Collins, Colorado, and from there broadcasts via Ku-band on the GStar I transponder. Making up the curriculum are 12 graduate-level classes sent via satellite to more than 80 corporate sites. It is a private, nonprofit organization which has been in existence since 1984. The purpose is to bring "high-quality education to working engineers" according to president Lionel V. Baldwin (Salamone, 1987, p. 63). Accreditation by the North Central Association of Colleges and Schools was expected by August of1987. By the fall of 1985, more than 600 students from major corporations enrolled in courses such as computer engineering, computer science, electrical engineering, engineering management and so on (Long, 1985).

NTU classes are broadcast over two channels for 14-16 hours a day. Twenty-two member universities contribute classes including Boston University, Georgia Tech, and Purdue. Seven universities uplink or directly transmit directly to a satellite (Salamone, 1987).

A subscription fee of $65,000-$260,000 to companies is charged on a one-time only basis. The difference in price depends on the number of employees of the corporation. Corporate subscribers include AT&T, DEC, GE, IBM, DuPont, Honeywell, and Kodak.

A third of the classes are broadcast live and are interactive. Others are delayed broadcasts of live classes. Or students can view videotapes at their convenience. If they still have questions, they can call the professor. Tests and homework are exchanged through the mail for grading (Salamone, 1987).

An educational institution with a Ku-uplink at present is Iowa State University (ISU). ISU has a Ku-band uplink in the final completion stages now and soon will be operational. ISU added the Ku uplink in order to contribute classes to NTU. It is also used for extension services. The Engineering Department built the Ku uplink and will market it. The excess capacity not used for educational needs will be used for commercial purposes. It will be managed by WOI-TV with the expense being born by ISU. Existing extension services are all on C-band capacity but will have Ku-band downlinks in the future (E. Powers, personal communication, November 10, 1988).

Sharing satellite capacity with NTU is the Association for Media-Based Continuing Education for Engineers or AMCEE. It provides courses of interest to engineers and technicians for several hours a day. Unlike the NTU program, these courses are unaccredited (Long, 1985).

Also on the GStar satellite is the Campus Satellite Network. This provides a variety of entertainment programming to college and university campuses nationwide. Concerts in stereo and other programs of interest to students are regularly presented (Long, 1985).

The Hospital Satellite Network (HSB) and the Vanderbilt University Medical School offer another example of the education use of the Ku-band on a university level. These services bring education to the work site and have done so successfully for a number of years. Over 450 hospitals subscribe to HSN. "Between 2.5 and 7 percent of a hospital's budget is spent on continuing education, says Gene Nichols, a spokesman for HSN, and HSN helps bring down those costs by bringing the classes to more staff members at once" (Satellite Orbit, 1985, p. 33).

The Virginia Cooperative Extension Service plans the addition of a Ku-band satellite transmission/receiving station for the fall of 1987 (Murphy, 1987). There are two broadcast-quality video signal channels transmitted from Blacksburg which originate from one studio or one of twp electronic classrooms on campus. In addition, 41 downlink sites are planned for local extension offices, 4-H continuing education centers, district offices and research stations. These sites will receive teleconferencing aimed at extension staff development.

Starting in the fall of 1989, is the nationally broadcast of a Master of Business Administration program. It will be broadcast by cable TV and originates from Colorado State University. The program as been available in Colorado for 20 years and now is the first time it will be televised nationally. Colorado State is working with national cable services of Mind Extension University, in Englewood, Colorado, which has been broadcasting educational courses from nine universities since 1987. Prospective students must meet the same requirements as in-class students. Each course gives three credits. Students will be provided access by telephone to their professors for questioning and messages. Each course will cost approximately $900 (Sunday Register TV and Cable Guide, 1989).

Public Broadcasting

The Public Broadcasting System began a trial program in February of 1986 to deliver professional training to workers via the Nation' Narrowcast Service or NNS (Satellite Orbit, 1986). An application fo Ku-band is pending as of May, 1988 according to Business TV (1988). It will broadcast four hours of programming per day. This includes two hours of college-credit classes per day. Examples of classes offered will be "Performance Appraisals for Managers, Accounting and Finance for Non-Financial Managers, The Effective Negotiator, High Performance Leadership, and Communications That Work" (Satellite Orbit, 1986, p. 33).

Satellite Orbit reported this remark:

> "NNS is a response to the increasing demands by American corporations for their employees to have greater opportunities to learn, whether in a formal training program or in pursuit of a higher degree," says Monica Morgan, associate director of marketing for NNS. "As time becomes more precious at the desk and away from the desk, we've created an opportunity to bring services to the work site" (1986, p.33).

International Level

An important study was released after the UNISPACE 82 Conference. The study (A/AC.105/341) is entitled "The Feasibility of Using Direct Broadcasting Satellites for Educational Purposes and of Internationally or Regionally Owned Space Segments" and was prepared by people from all around the world. Their conclusions were that direct broadcasting satellites are a part of the future in the educational field. It also states, "The technology is expected to improve fairly rapidly in the near future, particularly in the 12 GHz band, resulting in lower costs for satellites and small receiving stations and making direct broadcasting economically attractive" ("Using Space", 1985, p. 24).

The cost of operating a direct broadcasting satellite of its own would be prohibitive for most nations. The study estimates it to be a "minimum of $200 million to cover three satellites, two launches and the ground control and transmission facilities." ("Using Space", 1985, p. 25). Therefore the concept of time-sharing was introduced.

Time-sharing entails using a channel part-time along with other countries. Canada/United States Communications Technology Satellite (CTS-Hermes) is one example. The France/Federal Republic of Germany Symphonie satellite system is financed and shared equally by both countries. As for the third world, the Arab League countries use the Arabsat system. This is an example where sharing programming is done on the basis of an already existing organization.

Another way of reducing costs is to exchange educational programs between countries. A major drawback is that programming must be compatible to both countries with regard to accents, idioms and provide commonality with regard to cultures, values, etc.

Resistance to integrating television into the traditional education system was predicted by the study. However "Where broadcast television has been used to introduce new forms of education outside of the traditional classroom system, there has been less resistance to the new technology" ("Using Space", 1985, p. 25). The Open University of the United Kingdom and the Radio and Television Universities of China are examples. Similar programs exist in Canada, Australia, Indonesia, and the USSR.

In his article subtitled,"Conclusions and Recommendations for a South African Satellite for Distance Education", Ural (1987) encouraged new venture by private enterprise for distance education in South Africa.. In November 1987, private enterprise will launch a R360 million satellite over South Africa. It is presumed the South African satellite will be a third generation Hughes satellite. The third generation satellites are the most powerful satellites which can broadcast directly to relatively inexpensive and small receivers. Given the geographical terrain of the country and insufficient development of a microwave relay system, the use of a powerful satellite is the most appropriate for South Africa. It is assumed the satellite will be used to broadcast health, education and training programs.

The European Space Agency will launch a satellite known as Olympus in February, 1989. It will transmit at higher power than earlier satellites. The signals from Olympus will be received by dishes as small as 45 centimeters across and will sell for as little as $400. The project is financed by a consortium of 13 European countries and Canada. The "footprint" or "geographical area within which any satellite signal can be received" (Bruce, 1988, p.76) will cover Belgium, England, Wales, Denmark, France, Luxembourg, the Netherlands and most of West Germany and Spain.

This is an experimental satellite. The European Space Agency is providing transmission free of charge in order to investigate the uses of education broadcast by satellite throughout Europe.

It is felt satellite transmission is integral to the European integration process. As European unite to form a "Europe without frontiers" (Bruce, 1988, p. 76), it was felt this would overcome the limitations of national broadcasting systems. Although the footprint spans five or six major language groups, it is both "practically and symbolically right that academic communities, cultural communities and professional communities throughout Europe be served by a *European* network" (Bruce, 1988, p. 76).

Set to begin in February, 1990 is an experimental use of the classroom on an international level. It began last February when Jean Mayer, President of Tufts University, wrote the Soviet leader Mikhail Gorbachev with a proposal that would include both countries working together in an education capacity. The proposal was to teach two courses, concurrently, in both countries and then provide a satellite link-up so that students in both classrooms in the Soviet Union and the United States could have spontaneous discussions. As of next February, the class being offered is entitled; "The United States, the Soviet Union, and the Nuclear Arms Race in Historical Perspective". It will be taught with the same curriculum and similar readings. On Saturdays, the hook-up will be operated starting at 8 am in Boston and 4 pm in Moscow for spontaneously discussions by the students of the classroom subjects. This will occur once a month. Provided at both ends will be translators so students can discuss such topics as the history of the nuclear age, the decision to drop the first atomic bomb in Japan, the Cuban crisis, how students view the future of our world in the nuclear age. The cost to Tufts University for this project will be $150,00 to $200,000.

Mager also projects plans to set aside three satellites which would cover the entire world, and dedicate the satellites to only academic subjects thereby connecting the entire world to one another. His dream is summed up as "if students learn the same things about war, as adults they will do better than their parents at waging peace" (Newsweek, 1987, p. 103).

A brief look at other countries of the world include Canada. Canada plans a domestic communication satellite network that dedicates a part of its capacity for continuing education. India has in the works plans for a system where remote parts of India will be hooked up via direct broadcast television for education. Japan, Australia, Columbia, Saudi Arabia, Argentina, France, and Brazil all are planning launches of satellites in the 1980's than will extend their ability to unite the country by beaming educational and training programs (Zucher,1986).

Chapter 3

Conclusion and Summary

To summarize, there are many strengths the Ku-band of freqnencies has to offer in the field of educational telecommunications. The first strength discussed is its low cost. Because of its small dish size, the initial purchase price is low, it is cheaper to assemble. Mounting the dish upon a roof or in any place is less expensive. Because of it's small size, it creates less windload and therefore reduces stress on its mountings and on any rooftop.

A second strength is the mobility that Ku-band communication offers. As is being demonstrated in the news industry, the dish can be mounted on top of any van and transported around to any location where it can be used as an uplink transmitter or as a receiver.

A third strength of Ku-band is the small dish it requires. Because Ku-band transponders transmit at a higher power of wattage, a smaller dish is needed in which to capture and amplify the signals. The signal coming in is already a stronger one, so less dish is needed to send the signals along to their final destination. It is predicted a Ku-band dish will soon be as small as a dinner plate and will be able to be mounted on top of your TV set and will cost about $500 (Zucher, 1986).

The Ku-band signal being transmitted down from the satellite in orbit is a strong enough one that terrestrial use of microwave frequencies do not interfere with the signal. This is a significant advantage in heavily metropolitan area where the microwave traffic can become quite congested in the lower frequencies.

There are limitations to the strength of Ku-band. One is atmospheric condition or rain. The higher frequencies are most susceptible to break-up due to the spherical shape of rain-drops. One way to counteract this phenomenon is to transmit at the higher power necessary to compensate for any signal loss.

A second limitation to the use of Ku-band is that the testing of the higher powered transponders in space have not proven conclusively successful. Higher wattage powers of 100, 200, and 250 have proven to be less than reliable in space. Therefore more research needs to be conducted in this area.

There are many examples of the educational application of Ku-band transmission. The first division discussed in the paper was the public school systems who have taken advantage of Ku-band. Public schools systems such as the Alaska State Department of Education have used satellite telecommunications for their widespread school systems. The Kentucky Educational Television, the Utah State Department of Education are examples given where the broadcast of educational classes are pre-programmed. The large TI-IN, Inc. system in Texas, Oklahoma State University Arts and Sciences Teleconferencing Services are examples of public school systems that broadcast educational classes live and are interactive. The state of Missouri, in1991, plans to have uplinking from a Ku-band mobile unit available to its state public school system.

Discussed next was the use of Ku-band technology by universities, some on a nation-wide basis. The National Technical University transmits solely by Ku-band. Iowa State University recently added a Ku-band uplink in order to contribute classes to this electronic university. The Hospital Satellite Network with the Vanderbilt University Medical School use Ku-band to serve over 450 hospitals with educational programing. The Association for Media-Based Continuing Education for Engineers and the Campus Satellite Network uses national Ku-band technology for delivery. Starting in the fall of 1989, Colorado State University will broadcast by cable TV on a nationwide network the courses necessary to attain a Master of Business Administration degree.

A Ku-band application is pending submitted by the Public Broadcasting System. PBS began a trial program in 1986 to deliver professional training to workers and wish to use the latest technology for means of delivery.

The paper discussed the international use of Ku-band technology in education. Direct Broadcast Satellites that transmit at higher powers and to smaller receiving stations are being cited as an important development for education by the UNISPACE 82 Conference. As important as it is, it is also too costly for one country to develop, launch and maintain their own direct broadcast satellite. Therefore several alternative plans were offered at this conference whereby sharing a satellite transponder with the above attributes would be possible among countries.

The writer, Ural (1987), proposes a powerful satellite with broadcast capabilities to inexpensive and small receivers for his country of South Africa. He feels it is the most appropriate means for his country for distribution of health, education and training programs.

The European Space Agency will launch a satellite known as Olympus in February, 1989. It will be used to investigate the uses of education by broadcast satellite throughout Europe, where several countries are included in the "footprint" of the satellite.

Beginning in February of 1990, the Soviet Union and the United States will conduct concurrent classes studying current issues in the nuclear arms race. Once a month a live hook-up will be provided so that students in the participating universities may have a spontaneous discussion of the issues.

In summary the author feels the chief advantage of Ku-band technology to education is its small dish size. This creates savings in terms of initial purchase, assembling, and mounting. It is easier to place because of its small size and because it is impervious to local microwave traffic.

Ku-band technology affords great mobility. The implications for education here is that several educational institutions could form a consortium and buy a Ku-band uplink together. It could be mounted on a movable piece of transportation and shared among member institutions. Scheduling would be conducted for overall usage of the uplink whenever and whereever it was needed. It could afford a great deal of flexibility within an institution. Possibly a sports program could be directly uplinked one day, a cultural program uplinked on another part of the campus another day and so on.

For these reasons the author feels the higher range of frequencies for broadcast satellite hold a secure future in education.

Another consideration is, as the Clarke belt, the belt that defines the geostationary orbit a little over 22,000 miles above the earth, begins to fill up with satellites, the trend to higher frequencies will only be accelerated. Therefore the space available in orbit space can be more efficiently used by going to higher frequencies.

The trend continues to higher powered satellites beaming signals to smaller and more inexpensive dishes. That can only help telecommunications in all areas of education but most especially in distance education, where distance is effectively and efficiently cut to a minimum.

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