

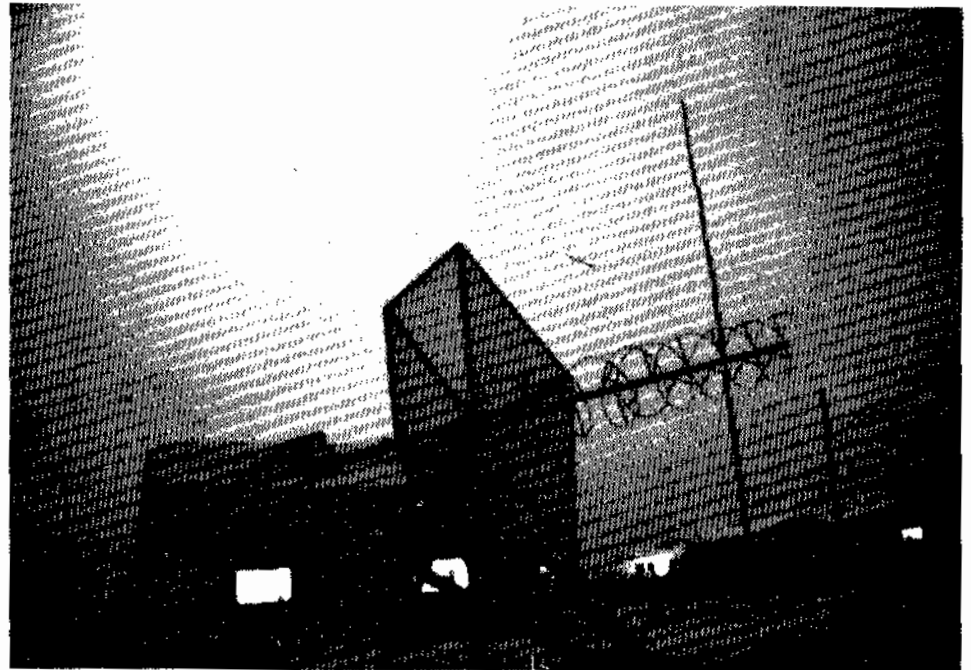
THE ALASKA TELECOMMUNICATION SYSTEM

INTRODUCTION

Almost half of Alaska's population lives in the vicinity of the largest city, Anchorage. Most of the remaining people live in the ten larger communities over 3000; the rest are scattered in 150 villages with populations between 25 and 3000. The average distance between one settlement and another is approximately 60 miles; some villages are more than 150 miles from their nearest neighbor. Given this isolation and the difficulties of climate and terrain, communications systems that have worked well elsewhere in the United States are useless here.

Historically, Alaska has on several occasions been in the forefront of innovative communications systems and yet has been unable to fill the basic needs of its citizens for adequate communication.¹ For example, after several attempts to lay a trans-Atlantic telegraph cable had failed in the early 1850s, some Americans attempted to establish a telegraph line to Europe by going west through Canada and Alaska, across the Bering Straits, connecting with the Russian telegraph line in the Amur River Basin. Surveys had already begun when the trans-Atlantic cable was finally completed and the Alaska project was abandoned. (An early supporter of the trans Alaska telegraph system was William H. Seward, who arranged the purchase of Alaska in 1867 when he was Secretary of State.)

Further progress in Alaska telecommunications had to wait until the early 1900s, when the United States Army Signal Corps began constructing a telegraph line through the territory. Shifting ice destroyed submarine cables in one section along the coastline. As a result, the Army developed a 100-mile radio-telegraph link in 1903—the first operational



ATS-1 VHF satellite antenna in an interior Alaska village.

application in the world of this type of communications link. Other than the development of high frequency (HF) radio circuits, very little then occurred in Alaska communications until the Second World War when open-wire telephone lines were strung along the Alaska Highway from Alaska through Canada to Seattle, Washington.

Following the War, major communication improvements in Alaska came with the installation of a microwave transmission system back through Canada to the contiguous 48 states, and the development of a tropospheric forward scatter system to transmit over long distances in Alaska. Most small villages, however, were still isolated from the integrated communication network. They relied on HF radio which, due to the highly disturbed ionosphere over Alaska, has a reliability between 12 and 15%.

MEDICAL COMMUNICATIONS

Medical care in the villages of Alaska is provided by the U.S. Public Health

Service (PHS). In this program, a local person, usually a Native woman, receives a few weeks of training in emergency medical procedures and patient care. The health aide consults daily with a regional doctor by HF radio. This doctor-call program with the health aide and the regional physician has been in operation for many years; it always was very successful but had been limited by the unreliable HF radio communications.

In 1969 the University of Alaska started a research program to develop a communication system utilizing the NASA ATS 1 Satellite VHF transponder and a simplex (push-to-talk) voice circuit. The program began with three locations: two villages and the University Electrical Engineering Department. A doctor from the local PHS Clinic would come every evening to discuss medical problems with the village health aides over the ATS-1 transmitter-receiver facility. The system worked so well that the Public Health Service wanted the system extended to more villages. We were able to convince

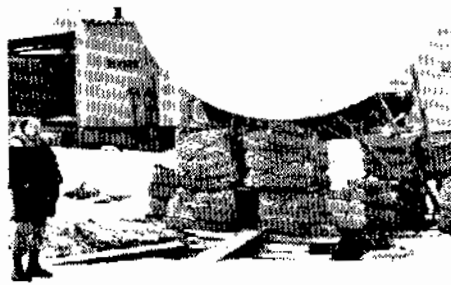
Robert P. Merritt, P.E., is a professor of electrical engineering at the University of Alaska, Fairbanks. He has had extensive experience in the field of satellite telecommunications in Alaska, and served on the Governor's Subcommittee on Telecommunications.

the National Library of Medicine, Communications Section, to provide funds to allow us to extend the program to 23 villages. Most of these villages were in the Tanana district, which includes about 200,000 square miles of interior Alaska.

In 1974 the Geophysical Institute staff secured a contract to analyze the communications problem in the Bethel district, in which about 50 villages communicate with Bethel Native Service Hospital (PHS) for their medical advice and consultation. After a careful study of the possibilities of VHF mountain-top repeaters and other communication options, it was decided that the most cost-effective and reliable method of providing this communication was by satellite. The conclusions, presented in a report to the Department of Health, Education and Welfare, specified that 10-foot diameter antennas operating into an appropriately configured satellite would provide communications to all 50 villages in the Bethel district. Our original design of the basic earth station was expanded to include a public access message telephone service in addition to the PHS doctor-call emergency medical capability.



Medical aide Florence Esmailka of Ruby conferring via satellite transmission.



Author Bob Merritt inspects 4.5-meter earth station at Gamble, Alaska, January 1978.

OPERATIONAL PROGRAM

In 1975 the Legislature provided funds to 120 small earth stations to ensure that all communities with a permanent population of 25 or more would receive adequate telephone service. The basic criterion was to provide a voice circuit for emergency medical communication plus a message telephone circuit (MTS) for public use.

The design of the system was largely determined by the characteristics of the communication satellites which were available. The existing satellite-earth station system was designed for more general use in the contiguous United States; the satellite transponder design was originally intended for use with high-sensitivity earth stations employing 10-meter and larger diameter antennas. The Alaska system uses smaller antennas in all but the largest communities in order to make it economically feasible to locate earth stations at each village. At the special request of the State of Alaska, RCA modified their satellites F-1 and F-2 to provide several transponders with more amplifier gain through the satellite and adjusted their antenna feed-horn to increase the radiated power directed toward Alaska for 6 of the 24 transponders on board each satellite. Using larger earth stations would have limited the number that could be constructed, making it necessary to link many villages via VHF or thin-route microwave circuits to the nearest earth station. The initial cost of

utilizing this "cluster concept" to provide basic service to all communities would have been greater; adding more circuits later would have been difficult or impossible. The cost of supplying television to small villages is much less with the small earth-station approach, whereas it would have been prohibitive if only large earth stations were constructed and the cluster concept used, because of the high cost of terrestrial video distribution.

The earth station design which evolved was described in the report to HEW; it incorporates 4.5 meter antennas, receivers employing gallium-arsenide field-effect transistor (GASFET) preamplifiers with equivalent noise temperature of less than 190 Kelvins (typically 150K), and transmitters using traveling-wave tubes of 40-watt power output. Voice transmission is accomplished by frequency modulating a specific carrier (SCPC) for each channel (Fig. 1). Earth stations in the smaller villages are usually equipped with two circuits: a conventional message telephone circuit, and a special circuit for emergency medical service. Expansion up to eight circuits can be accomplished easily by inserting additional circuit modules; this would supply enough trunks to serve a community of one thousand with a local telephone exchange. In villages with no existing telephone service, a single instrument was located in a central building which was accessible to the public. At this time over 100 small earth stations have been installed.

The carrier frequency for each circuit in every earth station is unique and pre-assigned. All circuits are routed through the satellite to a major earth station and then to a switching center in Anchorage. Thus, calls between villages must be transmitted through the satellite twice. This "double-hop" transmission is annoying due to the increased propagation delay (approximately 0.6 second); it also utilizes twice the satellite bandwidth, reducing the number of simultaneously available channels by a factor of two. If a channel is not being used by the station it is assigned to, it cannot be used by any other station. Traffic characteristics re-

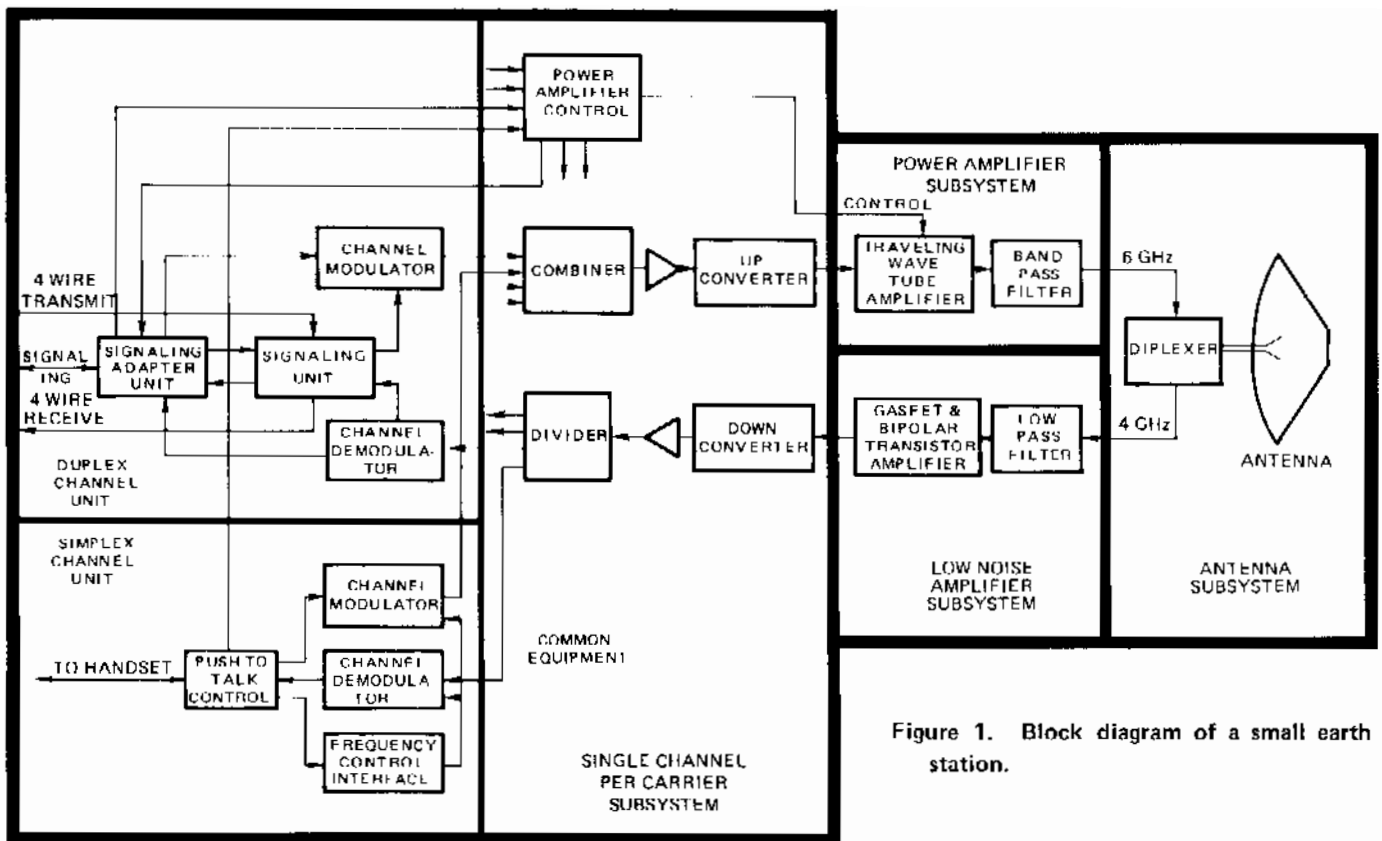


Figure 1. Block diagram of a small earth station.

quire that, in a preassigned system, a large fraction of channels will generally be unused. Demand Assigned Multiple Access (DAMA) techniques will be utilized in the future to reduce these problems greatly. In the DAMA system no frequencies are assigned to any earth station on a permanent basis. Instead, frequencies are automatically assigned to channel units only when necessary to establish a circuit to meet a specific need. Digitally-controlled frequency synthesizers are programmed by channel selection logic to allow single hop transmission directly between any two stations. Traffic statistics indicate that using DAMA gives five to 15 times the effective circuit capacity of fixed assignment.²

The emergency/medical service does not utilize conventional full-duplex circuits. Instead, all stations in a medical district network employ a single frequency for transmitting and receiving. This requires simplex (push-to-talk) operation, a mode shown to be preferred for this service from experience with HF radio and the ATS-1 satellite. It was learned that when the medical aides listened to consultations between a doctor and other medical aides, they acquired much valuable knowledge. Further, group participation helps reduce the

sense of isolation in these remote communities. The telephone desk sets used in this service can select one of five channels; different channel frequencies can be assigned in various geographical regions to allow specialized networks to be established and to limit the participants on any one channel to a manageable number.

Establishing the basic services for medical communications was an answer only to the most urgent rural communication problem. Because of the extreme isolation and lack of adequate transportation in most locations, telecommunications support many activities in rural Alaska to a greater-than-usual extent.

TELEVISION DEMONSTRATION PROGRAM

A program to demonstrate the capability of the small earth stations to supply quality color television programming via satellite for entertainment and education was conducted for several years. The alternative to supplying television programming by satellite is to mail pre-recorded videotapes to the village television transmitter sites. Satellite distribution is favored for increasing numbers of sites and greater numbers of programming hours as the cost per site-hour decreases; this cost is essentially con-

stant in a tape distribution system. Forty-seven rural villages presently have earth stations equipped to receive frequency-modulated video signals from a satellite transponder dedicated to television transmission. When the FCC licensing is forthcoming, 100 more villages may be added.

To obtain the best compromise between signal quality and margin above fm threshold at the small earth stations, a frequency deviation less than optimum for more sensitive earth stations is used (7.5 MHz vs. 11.7 MHz).³ The quality of the received signals exceeds that required for excellent viewing. Ten-watt "mini-TV" transmitters broadcast programming in the villages. These low power transmitters have a range of three miles or greater, more than adequate for the typical village.

The entertainment programming for rural Alaska is selected by representatives from the villages receiving television. They meet periodically to choose programming best suited for their villages. These programs are transmitted on the state-leased transponder for six hours each evening after transmission to the urban areas has ended.

The same satellite transponder used for transmitting television to the small

earth stations is used earlier in the day to bring signals into Alaska from the lower 48. This programming is intended only for the urban areas which are served by large earth stations. The increased sensitivity of these stations allows two channels of programming to be transmitted through the transponder at the same time.

The Alaska Time Zone, where most of the state's citizens live, is two hours behind the Pacific Time Zone and five hours behind the Eastern Zone. Earth stations are located in each of these time zones, allowing a specific program to be accessed at two different times. Because two programs can be transmitted simultaneously, it is possible to import as many as four national programs which are scheduled for the same local time. The commercial programming brought into Alaska is selected by the managers of the three television network stations here; any scheduling conflicts are resolved through negotiation.

The morning hours are utilized by the Department of Education and the University of Alaska to transmit instructional programming for pre-school through college-level students; in addition there are courses in basic educational skills for adults. Access to instructional programming libraries in other parts of the country is technically possible and is being investigated. Beginning in September 1981, a second satellite transponder will be leased by the State of Alaska to increase instructional programming to classrooms statewide.

The first several years of the television demonstration program have shown that there is extremely high interest for both entertainment and instructional programming, in rural and also urban parts of Alaska. Additional funds for extending the State of Alaska satellite project have been granted for determining better means for including all communities and developing acceptable financing methods for continuing operation.

In addition to the small earth stations discussed, the 30-meter station at Talkeetna and 15 installations with 10-meter antennas are now in service. Approximately ten more 10-meter stations will be constructed to handle high-density commercial and military traffic. Over 120 small earth stations are currently

in operation; this number could grow to nearly 200 before all needs are met.

Satellite communication is meeting needs in Alaska that would be prohibitively expensive if met by any other means at this time. The work done here may have ramifications elsewhere; a number of the larger developing nations have similar communications problems which can be solved most effectively through satellite telecommunications systems of this type. Advances in technology since the Alaska system was designed (especially in digital techniques) make it likely that other systems would differ in detailed parameters, but would still employ many small earth stations.

TELECONFERENCING

Juneau, the capital of Alaska, is almost 1500 miles from the northern reaches of Alaska and 2000 miles from the western areas of the state. These great distances and the fact that Juneau is not connected by road to the other parts of Alaska have led to the citizens' having a feeling of isolation from the processes of government. As the television demonstration program developed and other telecommunications facilities became available, several individuals and groups began looking at the possibility of using teleconferencing to cut down on the long distance constituents must travel to attend meetings in Juneau and the extent to which the general public feels isolated from the legislative process.

The Legislature was acutely aware of the public's concern over its inability to participate in the legislative process because of the remote, inaccessible location of the capital. In an effort to alleviate this, they began disseminating information from Juneau in several ways. In 1975, the Legislative Council created permanent legislative information offices in Anchorage and Fairbanks to provide facts relating to pending legislation to the public and press. The Legislative Information Office, staffed by employees of the Legislative Affairs Agency, set up teletypes, voice circuits, and a CRT computer terminal connected with Juneau. The computer terminal was connected with the central legislative computer and was capable of displaying the status of any bill in the legislative process when queried by typing in the number of the bill, the

title, or name of the sponsoring legislator. This public information program has been continued, and now has expanded to 15 communities.

A bill was proposed in the Senate to establish a telephone hot line to the Juneau legislative center telephone system, enabling constituents all over the state to speak with their legislators free of charge. A similar bill introduced in the House extended the original concept to include the Juneau offices of the Executive and Judicial branches. Neither of these bills passed in their original form, but they were incorporated into a Senate concurrent resolution which called for the creation of a legislative teleconferencing network. That legislation was passed in May of 1977.

In a teleconference, several people in different locations use a form of electronic communications to converse for the purpose of sharing information and making decisions. The mainstay of the legislative teleconference network is a dedicated private line circuit with the following characteristics:

(1) It links the Capitol in Juneau with network stations in Nome, Bethel, Fairbanks, Anchorage and Ketchikan. The network circuit simultaneously links all sites with one another like a high-quality telephone party line.

(2) It is a private line identified for easy maintenance by its own circuit number, and dedicated to the exclusive use of the conference centers.

(3) It is leased at a flat monthly rate for permanent, 24-hour availability so that charges are not a measurement of use.

(4) It uses both satellite and terrestrial carriers. Microwave terrestrial circuits connect Juneau and Ketchikan, Anchorage and Fairbanks. Single-hop satellite transmission links Juneau with the Talkeetna earth station serving Anchorage and Fairbanks, and likewise links Nome and Bethel with the same ground station. Double-hop transmission, two complete transmissions from the earth to the satellite and back, is necessary to carry audio from Nome and Bethel (in northwestern and west central Alaska) to Juneau and Ketchikan in Southeastern.

(5) It is a four-wire, rather than a standard two-wire, telephone circuit. The

additional two wires enable the circuit to provide exclusive paths for transmission and reception, i.e., one pair for each direction. This is the standard circuit used on a conference network because it is least prone to line degradation and lends itself to easy expansion.

(6) Finally, it is a voice-plus-data circuit, which means that it may be used to telecopy documents with no additional toll charges.

The network implemented by the Legislative Affairs Agency connected the coordinator's office and various committee rooms in the Capitol with six primary and three secondary centers. Primary locations are usually medium-size rooms adjacent to the moderator's offices; they are used for teleconference administrative communications and for the great majority of audio-only teleconferences. Secondary centers have a seating capacity of 20 to 50, are equipped for video reception and live video production. In Nome and Bethel, the same centers served both purposes.

The audio terminal chosen for network use was a 50A-1 conference set manufactured by Western Electric. Capable of operating in a two- or four-wire mode, the conference set assembly utilizes voice-activated omnidirectional microphones. They are acoustically isolated from the conference set loudspeaker to avoid echo and feedback.

The facsimile or document transmission system mentioned above uses Xerox Model 400 telecopiers operating on the same voice-plus-data circuit as the conference terminals. A newer model is now being considered for upgrade of service next year. Reference documents or copies of legislative bills needed during a teleconference can be telecopied to all locations simultaneously in four or six minutes, depending on the desired reproduction quality, several hours prior to the meeting.

Cost alone made a dedicated video conference circuit impractical. However, the Task Force created by the May 1977 bill set aside funding for a limited number of videoconferences during the 1978 session, to give legislators a few experiments in the effectiveness and desirability of such a forum. Between February and April, the Legislative Affairs Agency

conducted three two-way and two one-way videoconferences.

A two-way videoconference is simply a teleconference in which live pictures of the participants accompany their voices. Those occurring on the Legislative Teleconference Network involved the Juneau committee hearing room and two remote teleconference centers. During each of these, two channels of video created continuous video transmission from Juneau, successive video transmission from each of the two remote sites, and continuous video reception at all sites, both participating and observing. During the one-way videoconferences there was only one video channel in operation, enabling participants at conference sites to see the legislative committee, but not the reverse.

The primary goal of the network was to improve access to the Legislature and legislators from persons living in, or traveling to, the participating communities. Secondly, the full-time availability of the audio circuit makes it possible to accommodate other non-legislative users on a limited and preemptible basis. Agencies of the executive and judicial branches of state government and instruments of local government, e.g., boroughs, municipalities, school districts, would be eligible.

Unfortunately, as legislative interest in teleconferencing grows, opportunity for other agency use will decline. It is also possible that should non-legislative use continue and become regularized, the Legislative Affairs Agency may institute a reimbursible costs arrangement for network time.

The network interprets its purpose as providing a forum for discussing any public issue. Therefore, network policy allows any person to monitor any teleconference. The audio circuit is designed in such a way as to make confidential, exclusive use impossible without major reconfiguration.

On the other hand, although there is no restriction on the public's right to observe, active public participation in a teleconferenced hearing is at the pleasure of the presiding chairman, as it is in any hearing which is not teleconferenced.

The Legislative Teleconference Network may be used by any legislator for any legislative-related matter, or by any group for the discussion of public or

agency business. No other group or subject matter is permissible.

The Task Force also discussed possible network abuse, drawing two conclusions. First, there is nothing about a teleconference hearing which makes it uniquely susceptible to misuse. All the opportunities for "grandstanding," "electioneering" or "witness manipulation" present in any committee hearing are present in a teleconference. The other point was that the self-policing effects of bipartisan committee membership, the presence of the news media, and a common sense of fair play typify most committee hearings irrespective of the medium in use. Furthermore, it was believed that the knowledge that conversation between any two locations can be heard system-wide would significantly deter exploitation. The first year's experience with legislative teleconferencing upheld these conclusions.

In an effort to learn who was using the network, and to define better the public market for legislative teleconferencing, the moderators were asked to distribute brief evaluation forms during the entire period of trial operation in 1978. Approximately 400 of a total of 491 users received questionnaires, of which 262 were completed and returned. An examination of the surveys and attendance records produced the data in Table 1.

A comparison of costs⁴ for the teleconference network demonstrates the relative economy of audio-only conferencing and the considerable capital investment required by video (Table 2). Measurement of the relative utility of each medium, however, is difficult because they achieve different things.

Audio-only conferencing has proved an effective and popular committee tool, admirably suited to an item-by-item consideration of even the most complex bills. Legislators and the public soon learn to use the system with confidence. As an inexpensive way to hear extensive testimony, audioconferencing is probably unequaled.

The three videoconferences conducted in 1978 concerned a resolution relating to the voluntary withdrawal of life-support devices; a bill relating to the creation of closed primaries; and a series of bills relating to the regulation of subsistence hunting and fishing. The dispute under-

TABLE 1
Teleconference Statistics

- (1) Number of conferences — February 22-June 15, 1978
47 audio and 5 video: 52 total
- (2) Number of conferences per category:
- | | |
|---------|----|
| House | 25 |
| Senate | 5 |
| Joint* | 18 |
| Other** | 4 |
| TOTAL | 52 |
- (3) Number of witnesses — audio vs. video:
Audio: 414 total, 9 average
Video: 77 total, 15 average

(4) Number of witnesses — February 22-June 15

	Participants		Population	
Ketchikan	27	5.6%	18,770	6.7%
Juneau***	43	8.7%	19,193	6.8%
Anchorage	174	35.4%	175,603	62.8%
Bethel	26	5.4%	3,004	1.0%
Fairbanks	160	32.5%	60,227	21.5%
Nome	61	12.4%	2,585	0.9%
TOTAL	491	100%	379,382	99.7%

* Teleconferences involving both houses were round-table, or open-forum type, not joint committee hearings.

** Agencies or groups affiliated with the Executive Branch using the teleconference network were: The Educational Telecommunications Consortium; The Board of Fish and Game; the Division of Public Health, HSS; and The Governor's Council on the Gifted and the Handicapped.

*** This refers to Executive agency users stationed in Juneau, or to committee hearing witnesses (not legislators) invited to testify during a teleconference.

lying each issue was philosophic, fundamental, and emotionally charged. For first hearings on legislation that holds an exceptionally high level of popular interest, the ability to place names with faces and voices creates a level of intimacy which makes videoconferences attractive to many legislators.

The number of audio teleconferences is now near 500 per legislative session. Video teleconferences are still limited to three or four per year by cost and the conviction by almost everyone that audio is more than adequate for almost all public testimony and committee hearings.

CONCLUSIONS

The Alaska telecommunications system has grown tremendously and has produced a significant reduction in Alas-

TABLE 2
Comparison of Costs (1978)

- (1) Audioconference system as a whole: \$ 8,107 per month
(2) Videoconference (two one-way): \$ 2,430 total
(3) Videoconference (three two-way): \$24,500 total
(4) Estimated savings in travel & per diem costs to witnesses:
- | | |
|-----------|----------|
| Ketchikan | \$ 727 |
| Anchorage | 6,634 |
| Bethel | 2,095 |
| Fairbanks | 7,548 |
| Nome | 4,617 |
| TOTAL | \$21,621 |
- (5) Estimated savings in committee travel & per diem: \$12,053

kans' feeling isolated and separated from the mainstream of American life. The ability to get high quality, rapid telephone connection throughout the state and around the world has contributed to the growing economy of Alaska. There is an equally dramatic potential for growth in such areas as audio and video teleconferencing, digital communication, expanded use of telecommunication in classroom instruction from kindergarten through the university level, and

to all Alaskans. State and local governments must work together in cooperation with the telecommunication industry to improve further the quality of communication services, particularly in the rural areas. The reliability of the equipment used needs further study, and unreliable components must be replaced. Redundant subsystems installed in critical areas will greatly improve reliability. The development of a program to improve local power generation in the smaller villages is essential to maintain the operation of the communication system.

We look forward to continued involvement in developing telecommunication systems in Alaska and anticipate improved services, increased reliability and innovative new programs becoming available.

REFERENCES

- Walp, R.M. 1977. Evolution, Design and Use of a Telecommunication System in a Lightly Populated Region. Paper presented at the World Electro-technical Congress, Moscow, U.S.S.R. 22 June.
- Dill, G.D. 1972. Comparison of circuit call capacity of demand-assignment and preassignment operation. *COMSAT Technical Review* 2:1 (Spring).
- Dowling, R. 1977. Minimum Earth Station Size for Cable Television Program Reception in Alaska. Report presented to the 1977 Alaska Cable Television Convention in Juneau, AK.
- Fromuth, P. 1978. Final Report on Teleconferencing. Report presented to the Legislative Affairs Agency, July 1978, Juneau, AK. ♦