ATS-3 Packet Experiments:
The Potential Impact of Packet Radio upon Pacific Basin Communications

Gerald A. Knezek - KB5EWV
Department of Computer Education and Cognitive Systems

Greg Jones - WD5IVD
Department of Computer Science

University of North Texas

Abstract.

Most amateurs do not realize the impact that packet radio is having upon communications outside the amateur community. This paper discusses current packet experiments taking place over NASA's ATS-3 satellite with respect to the system's potential for providing low cost data communications to remote Pacific Islands.

Introduction

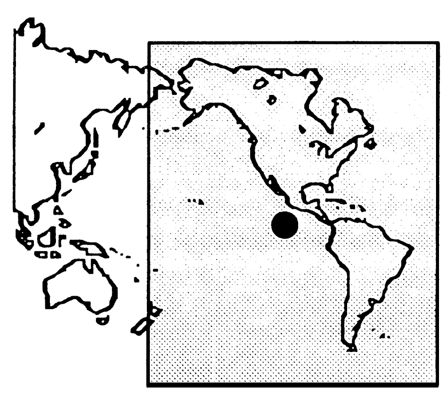
With the passing of each year, many Pacific Islanders fall further behind the technology curve [1]. Distance education is commonly viewed as the best means for providing these islanders with a way to maintain self-determination and self-sufficiency in the global community of the 21st century [2; 3]. A low-cost data network covering the Pacific Basin is very important for providing distance education [4] An integrated satellite-packet radio system offers one possible data communication solution [5].

ATS-3

The ATS-1 and ATS-3 satellites, launched by NASA in 1966 and 1967, are convenient platforms for working on wide area network connectivity. ATS-1 is now in an unstable orbit that will cause it to move out of its Pacific footprint (for the second time) during 1990-91. ATS-3 is maintained at 105 degrees (+/- 1 degree) west longitude, with an orbit inclination of 10.3 degrees as of January 1984 [6]. Figure 1 shows the Earth coverage for ATS-3.

The ATS VHF repeaters have a baseband bandwidth of approximately 90KHz. The repeater may be used for wide band data transmission using the entire repeater capability. Arbitrary channel assignments have been made so that the satellite can support multiple FM simplex voice channels [6].

Figure 1 : ATS-3 Footprint



The VHF communications transponder is an active frequency-translator limiting (Class C) repeater receiving at a frequency of 149.22 MHz and retransmitting the received signal at 135.6 MHz. Reception and transmission is through an eight-element phased array antenna. Because the IF amplifiers include automatic gain-control circuitry, and the final power-amplifier stages are operated in class C, the VHF transponder is best suited to relaying one or more frequency or phase modulated carriers. [6; 7]

PEACESAT

Pan Pacific Education and Communications Experiments by Satellite (PEACESAT) was conceived in 1969 by John Bystrom, Communications Professor at the University of Hawaii. Bystrom's primary goal was to have NASA allow Pacific islanders free experimental access to ATS-1 when the satellite completed its scheduled NASA activities [8]. PEACESAT was the first project in the world in which the delivery of instruction by satellite was attempted. This project produced the world's first satellite library network, the first international satellite network, and the first college credit course delivered by satellite [2; 9].

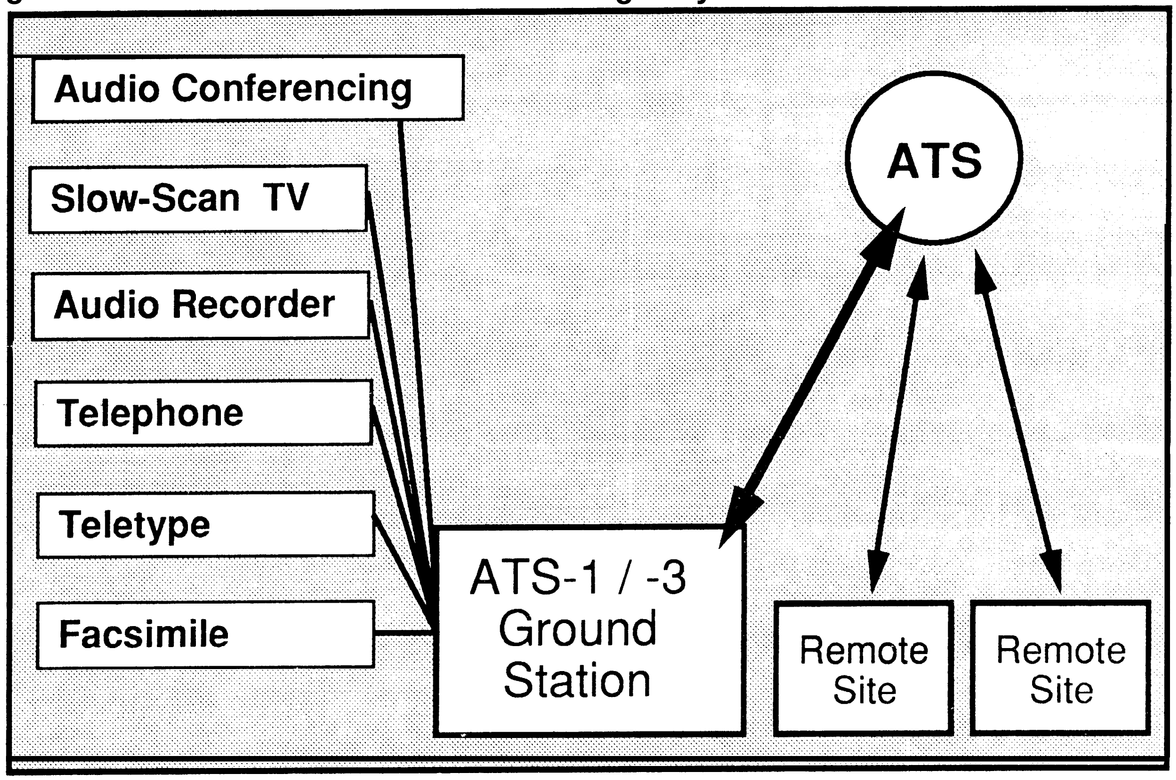
PEACESAT became an international organization with the participation of Wellington Polytechnic (New Zealand) in 1971. A cooperative satellite project between the University of Hawaii and the University of the South Pacific, with its main campus on Fiji, yielded a credit course in comparative Pacific education in 1973. Several other institutions in the South Pacific area later joined the network. These schools included New Zealand's Victoria University, the Papua and New Guinea Institute 'of Technology, and Hawaii Community College. PEACESAT is still active, and currently interconnects institutions in about 20 nations in the Pacific Basin and Rim with two-way communications [2; 9].

PEACESAT Data Communications

The dissemination of machine readable data to Pacific Islanders has been a PEACESAT goal for more than 25 years. The initial ground station designed and constructed by Professors Paul Yuen and Katashi Nose (KH6IJ) of the University of Hawaii were used to demonstrate facsimile as well as voice communications as early as 1971 [10]. Teletype transmission via ATS-1 was demonstrated in 1973 [9]. However, comparatively high costs for data communications equipment, a lack of technical sophistication on the part of typical ground station operators, and the inaccuracy of noise-saturated data all contributed to the failure of the data communications side of the intended applications shown in Figure 2 to fully materialize [1].

The early 1980's saw a resurgence of interest in low-cost PEACESAT/ATS data communications. Knezek in Honolulu first successfully captured a file transmitted from Suva, Fiji through a modified Hayes Micromodem (Bell 103 standard), Kenwood phone patch unit, and ATS-1 satellite to a similar system attached to a Texas Instruments portable bubble memory terminal in May of 1980. Measured error rates of less than .4 percent for early transmissions were sufficiently encouraging to continue development of a messaging system based upon Apple II-Micromodem technology [11]. This messaging system remained in use in Micronesia and the South Pacific until ATS-1 first drifted over the horizon in 1985 [12].

Figure 2 : Mediums of Communication Originally Planned for ATS



PEACESAT Project Report One : Early Experience. Honolulu: University of Hawaii, 1975, p. 13.

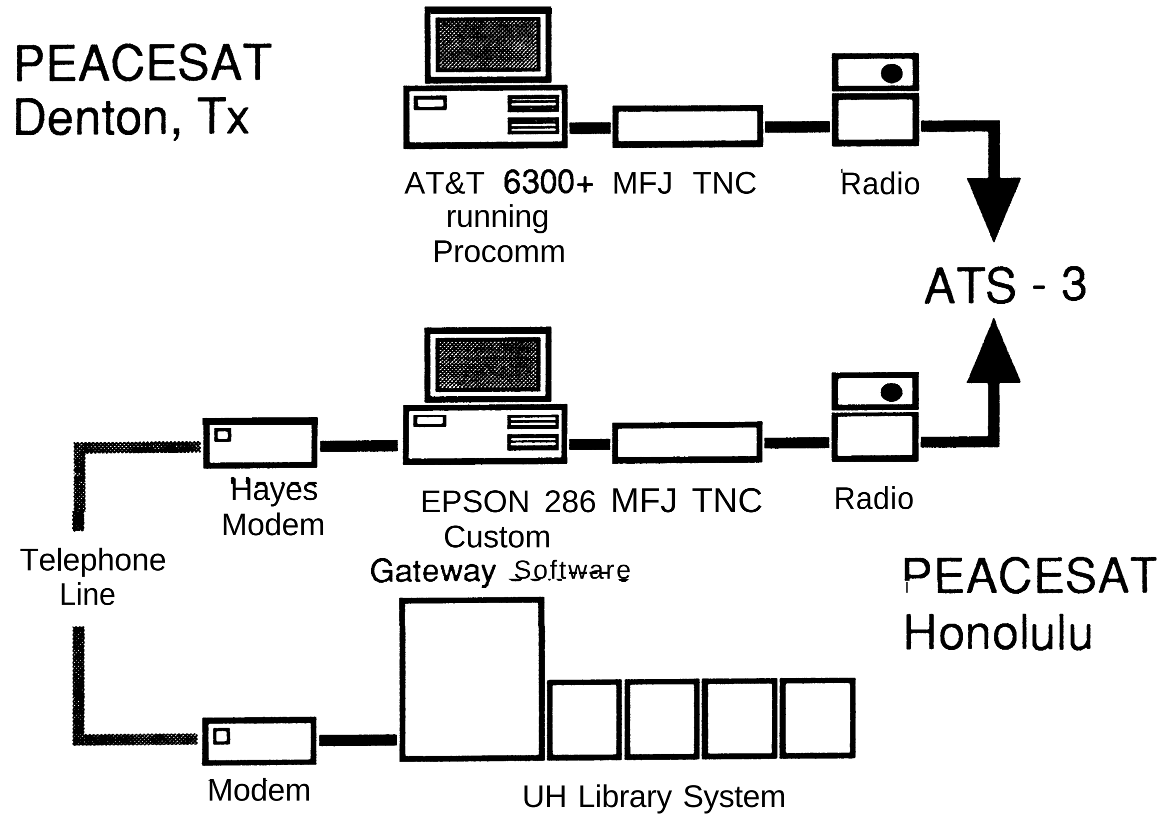
Also during the early 1980's, common carrier (Telenet, Tymnet) domestic telephone access from Hawaii to new information services such as The Source, CompuServe, and the Dialog Bibliographic Retrieval System caused an explosion of interest in computer-based information retrieval services among PEACESAT members. Unfortunately, international telephone rates prohibited even those Pacific Islanders (other than Hawaii residents) with reliable telephone access from being able to take advantage of such services [l]. Empirical data gathered during 1984-85 showed that micro-to-micro communications via PEACESAT could be 2-4 times more economical for Pacific Islanders than direct telephone or Telex connection, 5-1 0 times more economical than one-day air service delivery of printed material or a diskette, and 30-70 times more economical than telegraph transmission. [13]

Jones' suggestion to try packet radio was submitted as a proposal to PEACESAT in 1987. PEACESAT management endorsed the concept and determined the initial pilot project goal should be remote interactive access to the University of Hawaii computerized card catalog via ATS-3. As shown in Figure 3, the University of North Texas worked with the University of Hawaii to assemble a prototype hardware/software packet radio system which was used to demonstrate searches of Hawaii's card catalog, via ATS-3 from Texas, and vice-versa, by late 1988 [14].

Activities in Progress

The current phase of North Texas packet activities commenced in January of 1989 with modifications to ground station design. The basic premise was to design a modular low-cost station, from

Figure 3 : ATS-3 Library Access



would provide voice as well as data and be able to include other features as needed.

Figure 4 shows a block diagram of the modular station design. A modular design is important since in normal installations these stations would not have the equipment necessary for on-site service in case of problems. If a problem occurs with a modular station, then the ground station operator can remove the problem part and replace it with a backup. The problem part can then be sent out to be repaired and a new replacement sent. Figure 5 details the cost breakdown of such a station.

The modular approach also enables the systematic upgrade of selected station components. For example, current testing is focused on the performance differences

Figure 4 : Modular ATS Station

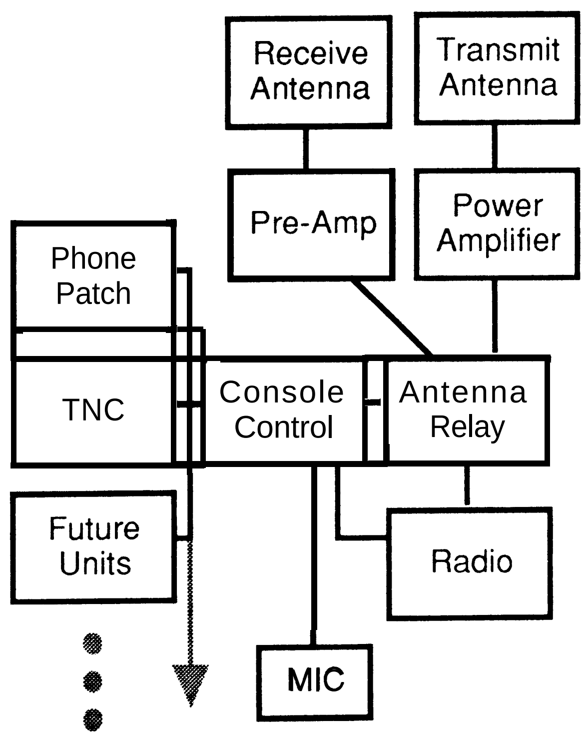


Figure 5 : Satellite (ATS) Packet Radio System Components and Costs

Satellite Ground Station Components	
Transmit Antenna (Circular Yagi, 13 db, 149 Mhz)	$200.00
Receive Antenna (Circular Yagi, 13 db, 135 Mhz)	$200.00
Antenna Stand	$100.00
Coaxial Cable & Connectors	$100.00
Coaxial Relay	$50.00
Transmit Amplifier (40 Watt in, 150 out)	$150.00
Receive Pre-Amplifier (GaAsFet 144-148 Mhz)	$90.00
Radio Transceiver (134-150 Mhz)	$750.00
Terminal Node Controller	$200.00
TOTAL	**$1840.00**

between the Kantronics KPC 2400 TNC and the MFJ Model 1270B. The next round of tests are scheduled to evaluate the effects of using 22 element (13db) antennas vs. the 14 element (10db) antennas commonly installed. Substitutions in any (or all) modular stations can be easily achieved, should either of these theoretical enhancements prove to be worthwhile in practice.

Recent Results

Results published by Lorente, LU4DXT, in the 6th ARRL Computer Networking Conference [15] indicate that the AMD 7910 demodulator used in the KPC 2400 should be superior to the EXAR 2211 demodulator used in the MFJ 1270B, at least in the noisy FM environment often encountered on ATS-3. Tests to date indicate that (once properly configured) the KPC TNC indeed improves performance to the point where 300 baud transmission can proceed without major concerns. It also appears that 2400 bps transmission on the KPC (using QAM) results in: 1) fewer retries than 1200 bps transmission on the MFJ, and 2) about the same ratio of successful packets to retries as does 300 baud transmission with an MFJ Model 1270B. These small improvements are important since SSB transmissions, which should greatly improve performance, have not been possible.

It is hoped that combining higher gain antennas (M2 Model C22s) with KPC 2400 TNCs will achieve dependable data communications at 2400 bps.

Future Plans

We believe the next major enhancement to an ATS-3 packet radio system will take the form of digital (FSK) radios substituted for the current voice (AFSK) units commonly employed. The goal is to achieve a message forwarding system that can operate reliably, in an unattended mode, by using late-night (continental U.S.) hours which are currently little utilized on the ATS-3 satellite. Units such as the TAPR packetRADIO described in a separate paper of these proceedings appear to hold promise for 9600bps communication.

Funding is being sought to conduct basic Pacific Basin local area network research. This research would outline potential LAN strategies and bring 2 or 3 technicians from Tonga, Western Samoa, or American Samoa to North Texas for cooperative ATS-3 packet radio development. The Pacific International

Center for High Technology Research (PICHTR) has agreed to send North Texas personnel to the South Pacific for packet radio training during the summer of 1990, and is working with UNT to secure external funds for the cooperative development activities.

Conclusion

It is important to bring the ATS-1 & -3 data communications work of the past 10 years into perspective. Just as many new developments from the amateur ranks have functionally equivalent counterparts in the commercial sector where large budgets are more common, so it is for ATS-3 packet radio developments. During recent years, NASA's ATS-3 control station at Malabar, Florida, has exchanged data with oceanographic research vessels and Antarctic research expeditions, via ATS-3, using Phase Shift Keyed (PSK) modems and minicomputers running DecNet communication protocols in full duplex, split channel operations. The cost of these ground stations is at least an order of magnitude (x10) higher than the amount paid for an ATS installation at a typical educational institution in a Pacific Island nation. Even if massive foreign aid could bring a NASA-type installation to every needy Pacific Island location, it is our opinion that it should not, because the resulting system would require even more massive amounts of external support to maintain. Just as foreign-subsidized automobiles often run for a year or two on a Pacific Island with a few miles of road, then rot after the first requirement for a major repair, so might sophisticated telecommunications facilities quickly become non-functional in environments where access to running water and electric power cannot be taken for granted. Perhaps we should be teaching Pacific Islanders how to ride bicycles, rather than how to drive cars, because bicycles are affordable, maintainable, and just as efficient transportation as automobiles for most Pacific Islander needs. Likewise, packet radio should be seriously considered as an alternative to more expensive, less maintainable data communication systems.

Bibliography

[1] Lange, James, Ray Casey, Bennit Dunqua, Colin Dunnet, Gerald Knezek, John Flanigan, Elsa Flavel, Ed Houlton, Kevin Livingston, Steven Seumahu, Peter Scannell and Peter Spooner. ATS-1: Social Service Satellite Networks in the Pacific. Proceedinas of the Sixth Pacific Telecommunications Conference Honolulu: Pacific Telecommunications Council, 1984, pp. 109-118.

[2] Tate, Pamela J. and Kressel, Marilyn, Editors. The Expandina Role of Telecommunications in Hiaher Education. San Francisco: Josey-Bass, 1983.

[3] Albright, Michael "The Past, Present, and Future of University-Level Instruction by Satellite," Tech Trends, November/December 1988, 23-28.

[4] Utsumi, Takeshi, Parker Rossman, and Steven Rosen. Global Education for the 21st Century : The GU Consortium. T.H.E. Journal Vol 16 (7), March 1989, pp. 75-77.

[5] Jones, Greg, Masa Hata, and Gerald Knezek. Packet Radio Prospects for Pacific Data Communications. Proceedinas of the Eleventh Pacific Telecommunications Conference, Honolulu, Hawaii : Pacific Telecommunications Council, 1989.

[6] ATS-1 & -3 Experimenter's Guide. NASA. Revision 5, March 1984.

[7] Davidoff, Martin R. The Satellite Exnerimenter's Handbook. Newington, CT: American Radio Relay League, 1985, pp. 3-2, 3-3, & 11-8.

[8] Bystrom, John and Paul Yuen, "Report and Request to the National Aeronautics and Space Administration". Honolulu: University of Hawaii, 1971.

[9] Peacesat Project Report One: Early Experience. Honolulu: University of Hawaii,

1975.

[10] Nose, Katashi - KH6IJ. "Using the ATS-1 Weather Satellite for Communications," QST, Vol. 55, no. 12, Dec. 1971, pp. 48-51.

[11] Southworth, John H., John M. Flanigan, and Gerald A. Knezek. Computers in Education: International Multi-Mode Node Electronic Conferencing. The Printout, Vol. 3 (3). March 15, 1981, pp. 8-13.

[12] Lange, James, Gerald Knezek, and others. '"Microcomputer Communication on Simplex Systems: Examples from ATS-1 ", unpublished manuscript, 1984.

[13] Knezek, Gerald A., Peter Scannell, and John M. Flanigan. Personal Computer-Based Communication Systems. Proceedings of the Sixth Pacific Telecommunications Conference, Honolulu: Pacific Telecommunications Council, 1985.

[14] Mukaida, Lori, Gerald Knezek, Peter Scannell, Greg Jones, Tusi Avegalio, Anne Freese, and John Haak. Pacific Island Interactive Data Base Network Access: A Peacesat, PICHTR, University of Hawaii Library Pilot Project. Proceedings of the 11 th Pacific Telecommunications Conference. Honolulu: Pacific Telecommunications Council, 1989, pp. 494-501.

[15] Lorente, Hugo. The Noise Performance of several Data Demodulators. Proceedings of the ARRL 6th Computer Networking Conference. Newington CT : ARRL, 1987, pp. 110-114.