CREATING AN INEXPENSIVE, NARROW-BAND, MULTIFUNCTION S/L BAND EARTH STATION FOR THE REMOTE PACIFIC ISLANDS


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1. ABSTRACT

The University of Guam PEACESAT (UOG PEACESAT) station provides non profit public services to over a three million square mile area of the tropical north Pacific, generally referred to as Micronesia. Within this area, only 8 of over 200 significantly populated islands (with a teacher or dispensary) have any off island communication facilities, except for HF radio systems. The outer islands of Yap, Chuuk, Pohnpei, and Majuro are more populated, than the INTELSAT and PEACESAT (public service telecommunications) serviced main centers. In order to network remote Micronesian medical and educational facilities, small, robust, marine grade narrow-band earth stations need to be developed.

This paper presents a vision of rugged 3 meter S/L band earth stations strategically located over the outer Micronesian Islands that do not have INTELSAT or PEACESAT earth stations. These simple solar powered narrow-band links would serve remote educational and medical learning centers and would provide emergency communications during environmental and natural disasters in coordinating state relief workers. We hope that the industry could provide a narrow-band single three channel (2 simplex and one duplex) transceiver, hopefully digital, earth station that could provide wide band receive only and simple voice communications, 9.6 KHz data transmission, and G-3 two way facsimile capability for under US $15,000. The earth stations must be easy to maintain and cost efficient to operate (space segment being provided by PEACESAT at no cost to the qualified user). This network would provide basic communications for the remote islands until the LEO or "Spaceway" style GEO systems are launched and are affordable to thin route Pacific Island countries of the Federated States of Micronesia (FSM), the Republic of Palau, and the Republic of the
2. INTRODUCTION

The University of Guam (UOG) is the only four year post secondary educational institution located in Micronesia. UOG offers 26 baccalaureate degrees in four undergraduate colleges: the College of Arts and Sciences; the College of Agriculture and Life Science; the College of Business and Public Administration; and the College of Education. In addition, the UOG Graduate School oversees the offering of Master's degrees in the areas of art, biology, business, education, and public administration.

The student body is relatively diverse. It consists of students from Guam, Micronesia, the US mainland, the Philippines, and Asia. The present enrollment is approximately 5,500 students at the main campus. In addition, the University offers a variety of courses throughout Micronesia through its Center for Continuing Education and Outreach Programs (CCEOP).

Micronesia is about 3,000,000 square miles of ocean (more than 7 million square kilometers) and 1,045.3 square miles of land (2,707.2 square kilometers). It runs from 2.39 degrees south to 20.33 degrees north for a maximum north to south distance of 1,387.2 nautical miles (1,595.28 statute miles). The east to west distance is approximately 2,726 nautical miles (3,135 statute miles) lying between 131.10 degrees east and 176.54 degrees east. Thus it covers an area that is roughly equal to that of the continental United States (See Figure 1 (57 k)).

Within Micronesia, UOG has concentrated its efforts on the former American flag territories. Today, these territories are divided into five separate political jurisdictions: the Republic of the Marshall Islands and the Federated States of Micronesia, both of which are freely associated with the United States; the Commonwealth of the Northern Mariana Islands and the Unincorporated Territory of Guam, both U.S. Territories; and the Republic of Palau, the remnant of the Trust Territory of the Pacific Islands.

3. UOG PEACESAT

The primary role of the UOG PEACESAT is to provide public service telecommunications to support the Micronesian educational and medical communities.

As a regional telecommunications hub, UOG PEACESAT handles most of the emergency,
disaster and medical evacuation traffic in the region. UOG also delivers college courses and seminars over the PEACESAT network to the constituents within the three million square miles of Micronesia. Combining the use of the UOG PEACESAT SSB radio, satellite RF technology, and distance education program options, the UOG outreach program and the local community in general have been able to communicate with the Micronesian region more efficiently and effectively.

Some of the emergency management users of UOG PEACESAT include the Red Cross, Federal Emergency Management Agency, Centers for Disease Control, and the Coast Guard Search and Rescue.

The FSM Consulate routes medical referral communications to and from Guam Hospital and FSM Hospitals through the UOG PEACESAT. Telephone interconnections with SSB, HF radio, and the GOES satellite systems help the FSM states in their typhoon recovery efforts. The solar powered UOG PEACESAT was the primary source of information to the outer areas of Micronesia after the Great Quake on Guam (August 8, 1993). The GOES satellite and the SSB high frequency radio links connect the most remote reaches of Micronesia to the developed information centers around the Pacific Rim.

4. PEACESAT MICRONET -- DISTANCE EDUCATION MISSION, PROGRAMS, SERVICES, AND NEEDS.

The UOG PEACESAT provides public service, distance education and Internet via satellite to Palau, Majuro, and the four emerging island states of FSM and their respective outer islands of Micronesia. The UOG PEACESAT also established and continues to operate a HF/SSB network that reaches dozens of outer island schools and dispensaries within Micronesia. UOG services provided to the region include:

- MICRONET news and weather (international and regional) are broadcast daily from Guam, often directly into the local island's AM station.
- UOG provides UOG College of Education courses to Rota (Commonwealth of the Northern Mariana Islands, CNMI), the four states in the FSM, the Republic of the Marshall Islands, and the Republic of Palau. Most courses are live interactive voice or on-site video with PEACESAT interactive voice lectures.
- The UOG College of Nursing is currently providing interactive digitized compressed video, electronic whiteboard and digital voice over standard voice grade circuit to Palauan nurses. This exciting new distance education delivery technology is currently run over a Macintosh format and is interactive with Palau Community College. We would like to expand this service to other entities and organizations. Courses will use land line modem connections for color digital transfers combined with standard lectures that are delivered over PEACESAT voice circuits. The College of Nursing and the Palau nursing students produced short videos and exchange them via Continental pouch.
- All Distance Education services are supported by the UOG9 UNIX Internet Services combined with facsimile and modem connectivity provided through the PEACESAT system. R&D continues on Packet/duplex/ethernet extensions over to interface with the proposed PEACESAT Services Improvement Plan (SIP) that will provide enhanced digitized audio-video graphics for superior distance education programming. Also, Guam is currently seeking funds for training workshops and technical development upgrade projects that will support all of the Micronesian sites.

5. COMMUNICATIONS NEEDS IN THE REMOTE ISLANDS

UOG PEACESAT has been, and continues to be, committed to providing services to the Micronesian region. Unfortunately, the current communication environment does not allow UOG to provide support to the outer islands.
The remote islands, as stated earlier, are not served by the telecommunication carriers within the region. The majority of the population base in Chuuk, Pohnpei, Yap and the Marshall Islands are not in the centers and are generally without any communication links to the children and professionals in the schools and dispensary facilities.

There are no Intelsat or PEACESAT earth stations at these remote sites. The location of Intelsat earth stations on these islands have not yet been deemed cost effective by carriers. Further, the current PEACESAT earth stations are not configured to enable UOG PEACESAT to provide the kind of services that it is prepared to support in the remote islands of Micronesia.

The current PEACESAT earth stations support a single carrier that can be used for voice or for data, but are not designed for receiving compressed digital video at base speeds of 128 Kbps. The current PEACESAT stations are also more expensive ($35,000 with autotracker) than is possible for many of these small islands to purchase.

Consequently, these remote islands only have HF and SSB communications that are not fully reliable. There is a very strong need in Micronesia for the development of a small, robust, marine grade narrow-band earth station that works in conjunction with the PEACESAT system.

6. GENERAL APPROACH TO A LOW COST EDUCATION/MEDICAL SATELLITE DELIVERY SYSTEM IN MICRONESIA

The following vision is an effective, efficient, appropriate and cost effective scenario to provide distance education and teacher training curriculum communication links to the underserved population centers in the outer islands of the emerging island nations of Republic of Palau, FSM, and the Republic of the Marshall Islands.

The vision is based on the use of the PEACESAT GOES-2 satellite. The same scenario with proper hardware changes could use a commercial C-Band or Ku band space segment. However, PEACESAT is appropriate for distance education and medical conferencing as long as the traffic is limited to non profit communications.

Currently, the PEACESAT Services Improvement Plan proposes to upgrade specific sites to 6 meter digital earth stations (Okamura and Mukaida, 1995, 1994) with wide bandwidth capability. This scenario is fine for government centers such as Kolonia, Pohnpei, Koror, Palau, Kwajalein/Ebeye area of the Republic of the Marshall Islands, Garapan, Commonwealth of the Northern Mariana Islands, and the University of Guam where a high volume traffic conduit is needed.

However, the large earth stations will cost upwards of U.S. $250,000 each and will commit the hosting government agency to a recurring maintenance and personnel cost. For the outer islands of the FSM and the Republic of the Marshall Islands, we hope that smaller, more appropriate systems can be installed for 1/10th of the cost of a 6m earth station and serve as a complement to the PEACESAT Hub Site network.

Commercial links will not be cost effective in these outer islands until LEO's or super GEO wide area satellite phone exchanges are launched and implemented sometime after the turn of the century. With over 3 million square miles of ocean, only SSB/HF radio and satellite networks may be cost effective within the region in the near future. However, we are still not sure that the final cost of these new LEOs and GEOs will be cost effective for the outer islands in the region.

7. FUNCTIONAL CONCEPT OF A DIGITAL VIDEO RECEIVE WITH VOICE OR DATA RETURN

The basic concept is to install and maintain a small learning resource center in the more populated outer islands. Each class room would be supplied with solar powered circuits with generator back up for the audio-video computer integrated earth station. All equipment would be DC input (12VDC VCR/ Monitors and computers are currently available), and simple to operate and maintain.

The earth stations would be small, digital and capable of up & down linking of 9.6 Kbps with 128 Kbps digital video receive capability. The concept assumes that power required for wide bandwidth transmit capability would not be cost effective and therefore not sustainable. The wider bandwidth receive link would allow the remote site to receive compressed color video
from the originating up link facility in Guam, Saipan, Pohnpei, Hawaii, etc. A PC based, low speed video codec system would be used for receiving programs.

Full G-3 fax and phone links will be available along with Internet access and basically any communication device that is compatible with a phone system that can be hung on the earth station. The earth stations need not have more than 2 simplex (multiple site teleconferencing) channels and one duplex channel. The VCR system can show the prerecorded class tapes, and the remote classroom can interact via the satellite link. The earth stations can be installed for under U.S. $20,000 each and with local support can be operated inexpensively thanks to the U.S. supported GOES space segment.

In addition to the educational services a grant would fund, emergency links will utilize the 'earth alert' hand held triggered from UOG via satellite. When islanders receive an alert from UOG, they will check the SSB for details from Guam. UOG can design low powered FM broadcast stations that can be used for distance education, cultural programs, primary health care workshops, and would be available for emergency information dissemination for Tsunami/typhoon locations, search and rescue, etc. This scenario allows small $10 transistor radios to be at the homes for monitoring the local atoll’s solar powered FM broadcast station, which can be fed to UOG PEACESAT Communications Hub during emergencies or distance education programming.

Figures 2 and 3 contains a general pictorial representation of this vision. Figure 2 (55 k) shows how the system would be interfaced to existing HF and AM systems, as well as to emergency notification system such as Earth Alert, currently being tested by NASA.

Figure 3 (58 k) shows an inexpensive 6m mesh antenna to receive digital video and have a data or voice return based on digital compression technologies. The figure illustrates the conceptual application needs of UOG PEACESAT, but does not need to be implemented with this specific technology. Figure 3 also shows the existing PEACESAT 3m sites as participating in network through 64 Kbps digital modems. The key is not the technology that is identified but the ability to meet requirements that are generally outlined below.
8. SYSTEM REQUIREMENTS

The following are some of the requirements and parameters of the system.

7.1. GOES-2 Satellite Environment

PEACESAT uses the second of a series of Geostationary Observation Environmental Satellite or GOES-2. The GOES-2 satellite is in an inclined orbit to save fuel and located at 175°W. This inclined orbit requires any system accessing the satellite to constantly track its movement through a figure eight. The nominal satellite position dimensions in the Year 2000 consist of:
- North-South +/- 15.0°
- East-West +/- 2.0°
- 8.1.1. The satellite link budget, based on the best available information, is:
  - Beam center EIRP 54.4 dBm
  - Downlink beamwidth 19.6°
  - Earth edge 2.4 dBm
  - Earth edge EIRP 52.0 dBm
  - Multicarrier EIRP 52.0 dBm
  - Transmit EIRP 35.4 dBm
  - Transmit EIRP Stability +/- 1 dBm

8.1.2. The system has a hard limited repeater and operates in multicarrier mode. There must not be any interference or intermodulation impacts to the existing carriers.

8.1.3. All performance measures must conform with the existing PEACESAT frequency and carrier plan.

8.1.4. The azimuth of the earth station must be plus or minus 25 degrees. The GOES-2 has...
a global footprint. Earth stations are located in Palau, Papua New Guinea, Australia, and Oregon. All must be able to see the GOES-2 in its current location.

8.1.5. The earth station must have a dual axis auto tracker to optimize on performance and minimize the level of operator intervention.

8.1.6. The tracking system must be compatible with the existing beacon receiver signal.

8.1.7. The operational frequencies for the GOES-2 satellite are as follows:

Transmit: 2025-2034 MHz
Receive: 1683-1695 MHz

8.2. Cost

The proposed system should cost about $15,000. This does not include the cost of the digital video receive only codec, microcomputer, or other peripheral equipment.

8.3. Environmental Requirements

The Pacific island countries present several problems that must be accounted for in the design. The earth station requirements include design consideration of the following environmental conditions or restraints.

8.3.1. The system must be able to operate with heat and humidity.

8.3.2. The system must be resistant to salt water that corrodes metal.

8.3.3. The system must minimize the electronic components that would be outside of a building.

8.3.4. Outdoor components must be protected and replaceable in the field.

8.3.5. The antenna must have a survival wind speed of 125 miles per hour.

8.3.6. The antenna must be capable of operating in winds gusting to 60 miles per hour.

8.3.7. The tracking system must have memory and renewals, and the use of a single step tracking capability.

8.4. Appropriate Technology

8.4.1. The system must be designed to use as much off the shelf low technology as possible that can be installed, operated, and repaired by electronics technicians.

8.4.2. The design must be based on field replaceable components to minimize the repair and maintenance problems created by the vast distances in the Pacific and the high costs of transportation and time.

8.4.3. The design of the earth stations must enable technicians in the field to diagnose problems without expensive test equipment.

8.4.4. Direct power must be used to interface with solar power batteries.

8.5. Functional System

8.5.1. The system must be able to transmit voice or data and receive digital video signals.

8.5.2. The system must be able to transmit data through multiple access channels.

8.5.3. The system must have the teleconferencing capabilities of a simplex channel.

8.5.4. The system must be able to interface with the existing PEACESAT analog simplex channels.

8.5.5. The system must be able to receive a compressed digital video receive only signal through the QPSK digital modulation that PEACESAT uses.

8.5.6. The system must be able to support phone patching through the PSTN.
8.5.7 The system must have standard audio interfaces for microphones and for speakers.

8.6. Technology

8.6.1. The system must support widely used component parts that will not be discontinued.

8.6.2. The system must have a high reliability under the conditions specified above.

9. SUMMARY

The outer islands of Micronesia are not well served despite similar needs for medical and educational uses of telecommunications as the main islands. Today, the outer islands are only served via HF or SSB radio links. These links are unreliable.

We are hoping that it might be possible for industry or an international funding organization to assist in the development of a system that would enable these outer islands to receive some of the programming that will be provided by the UOG and other PEACESAT Hub Sites in the Pacific Islands region. The programming would consist of voice teleconferencing, data and other information access, and the ability to receive compressed digital video at 128 Kbps.

In doing so, we will take a step toward ensuring that small island communities will be able to participate in the benefits of the revolution in telecommunications and information technology, services, and programs.

BIBLIOGRAPHY


ENDNOTES

● The opinions and the interpretations in this paper are those of the authors and do not necessarily represent, nor do they purport to represent, the views, opinions, or the work programs of PEACESAT - Headquarters.

● The idea of a digital video receive system was developed by PEACESAT as part of its "Services Improvement Plan." Unfortunately, it has not been developed given funding limitations.

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