The PACSAT Communications Experiment (PCE)

DOE Grant # DE-FG01-90CE33017 (8/13/90 - 2/12/92)

Final Report

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Introduction

Volunteers in Technical Assistance (VITA) is pleased to submit this final report to the U.S. Department of Energy (DOE). VITA is appreciative of the timely and significant contribution made by the U.S. DOE towards the objective of bringing millions of people in developing countries into the information mainstream. While VITA is the recognized world leader in low earth orbiting satellite technology ("small" LEOs - below 1 GHz), VITA's chief goal is development; its involvement in communications technologies, therefore, is only to facilitate development. VITA has made the use of its communications system(s) to support renewable energy technology transfer a top priority.

VITA is grateful for the help and guidance offered by the DOE technical project officers: Roger Meyer, and Tom Hall.

Background

In 1981, VITA began a long, complicated journey towards developing a low earth orbiting (LEO) satellite communications system for development and humanitarian purposes. VITA's initial efforts were supported by the contributed work of volunteers from VITA and AMSAT (Radio Amateur Satellite Corporation), and by funds from the U.S. Agency for International Development, the Margaret W. & Herbert Hoover, Jr. Foundation, VITA, and several smaller donors.

Planning meetings in 1983 resulted in the design and construction of a communications payload, the Digital Communications Experiment (DCE). It was incorporated into the mission of the UoSAT 2 satellite under construction by the University of Surrey (Guildford, UK). The satellite was launched in March 1984, on a NASA flight; and the world's first use of a "store and forward" LEO for civilian data exchange began.¹

After this successful "proof of concept," the U.S. Congress recognized the potential value of a low-cost communications system to facilitate development, and recommended that DOE also provide financial support to continue the development of the communications system as a way to support renewable energy technology transfer to developing countries. This action was strong-

¹ This was noted by the U.S. Federal Communications Commission in its announcement of its selection of VITA for its first award of a "tentative" Pioneer's Preference in Jan 1992 (contingent on allocation of international frequencies by the World Administrative Radio Conference and the creation of LEO service rules by the FCC). The award was finalized on Jan 14, 1993, ensuring VITA of U.S. operational licenses.

ly endorsed by the U.S. Export Council for Renewable Energy (US/ECRE), and resulted in the first grant from DOE to VITA in 1987 (DE-FG01-87CE33007). The purpose of this grant was to design and initiate the second phase of the program, the PACSAT Communications Experiment (PCE). The purpose of the PCE phase is to demonstrate the system's value in a wide variety of applications in developing countries.

The prototype satellite (PCE) was launched in January 1990. In August of that same year, the U.S. Department of Energy awarded a second grant to VITA to design and test the prototype ground stations (command and field), install field ground stations in several developing country sites, pursue the operational licensing process, and transfer the results of the evaluation to the design of an operating system.²

This report covers activities of the ten principal tasks of Grant # DEFG01-90CE33017 (the second grant).

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Concomitant with the testing and evaluation of the prototype satellite and ground stations, VITA aggressively pursued the securing of construction and operational licenses from the U.S. Federal Communications Commission and international radio frequency allocation through the World Administrative Radio Conference of the International Telecommunications Union. The particular difficulty in this process was that LEOs were a technology that was ignored by most people other than the military, and no operational frequencies had ever been assigned for their civilian use. *VITA and the current users of the PCE have experimental licenses.* Until January 14, 1993 there were no rules anywhere in the world to regulate their use; the United States created the first set of rules to govern the use of the frequencies by the "little" LEOs.³

² This phase is on-going. For example, in Feb 1992, the U.S. Agency for International Development also provided funds to support the installation and use of the prototype LEO for 5 renewable energy project ground stations in developing countries, and, in Dec 1992 provided additional funds to add 3 new projects to the growing renewable energy users network. Following this grant period, ground stations were installed in Indonesia as the first station in a pilot disaster preparedness network that will also include stations in Thailand and the Philippines; Antarctica for the National Science Foundation for team communications and, eventually, for geomagnetic data acquisition; and, Somalia for disaster supply logistical support; and in Somalia for logistical management of critical supplies. In addition to DOE and AID, there are many other supporters of the PCE phase of the program, including: the Office of Foreign Disaster Assistance, the UN High Commissioner of Refugees, the Virginia Center for Innovative Technology, Sandia National Laboratories, the U.S. Export Council for Renewable Energy, Plan International, Christian Aid (UK), IBM, the Hoover Foundation, and others.

³ VITA submitted its applications to the FCC in 1990. In Jan 1993, the FCC created a LEO service, acknowledging that VITA was the catalyst for this new US service (Non-voice, Non-geostationary MSS Satellite Service). VITA's work was also important in getting the small LEO issue on the agenda of the World Radio Conference (WARC) of the 163 nation member International Telecommunications Union (ITU) in 1992, and securing international allocation of frequencies for the exclusive use of "little" LEOs (below 1 Ghz).

Task One: Establishing the Demonstration/Evaluation Standard Procedures

VITA developed standard operating procedures, and produced an extensive, illustrated users manual that must be periodically updated based on the actual experience of the ground station operators. The manual is used both to train operators and systems managers, and to serve as a maintenance tool. (VITA plans to convert the manual to a video format in the future.)

Task Two: Selecting Participants for the Demonstrations

VITA developed a standard Memorandum of Understanding (MOU) form. Before interested parties can become applicants, they must first demonstrate that their proposed use of the system is innovative in the sense that it relieves a communications traffic jam or makes communications available where it doesn't currently exist. VITA was also concerned about a variety of uses of the satellite system in a variety of sectors such as energy, health, environment, and so on. While there were many expressions of interest, there were fewer applicants, and only several of them secured MOUs. A major obstacle has been securing experimental licenses in the host country. (This burden is incumbent on the station user, and often requires many months in some developing countries.)

Proposals included simple applications like sending program and financial reports to headquarters from project sites in developing countries, using a station to respond to inquiries from developing countries about renewable energy technologies, coordination of refugee traffic, monitoring relief supply distribution, establishing a disaster preparedness system, remote data acquisition, and remote control of renewable energy mechanical systems.

During the period of this grant, VITA developed and implemented MOUs with several organizations, and has already installed ground stations in several sites with funds from the sponsors and AID. (*See Task Four*)

Task Three: Operating and Evaluating the Command Ground Station.

The command ground station is located at VITA headquarters in Arlington, VA. (The location was changed from 1815 N. Lynn Street to 1600 Wilson Blvd. in early 1992 to secure better access to the satellite.)

The prototype ground station was designed by Virginia Tech with financial support from the Virginia Center for Innovative Technology (CIT) and VITA. Following tests, adjustments and corrections, and on-going modifications, the ground station has been operating effectively since June of 1991.

This ground station has been the site for hundreds of demonstrations for government, development bank, development and relief organizations, multinational corporations and others.

Task Four: Designing and Evaluating Field Ground Stations.

There are two types of ground stations: desktop (personal computer, radio, directional antenna, and terminal node controller - modem), and portable (lap top computer, et al). The prototype field ground stations are essentially the same as the command ground station. Virginia's CIT delivered a prototype portable ground station (suitcase sized, with non-directional antenna, powered by solar or batteries), that VITA tested in the South Pacific; it was not able to be released in that form; VITA is continuing to improve this station, which it now refers to as a "transportable node." the Photovoltaic Design Center of Sandia National Laboratories continues to work with VITA on the development of the solar photovoltaic power system it requires.

There have also been several software upgrades for the field stations.

During this grant period, VITA installed the following ground stations:

- Sierra Leone, Plan International (administrative communications with its US headquarters)
- Djibouti, Institute of Higher Scientific and Technical Research in Djibouti (support its projects in hydropower and solar, and daily administrative traffic with VITA - manager of project)
- New Mexico, Sandia National Laboratories (to provide responses to technical questions about renewable energy technologies from developing countries)
- Ireland, Donough O'Malley Technical Regional College in Letterkenny (to demonstrate the value of the system in distance learning in a UNESCO-UNDP distance learning seminar for African universities)
- Ireland, Trinity College in Dublin (to provide technical information exchange with engineering schools in African universities)
- Pakistan, the United Nations High Commissioner of Refugees in Peshawar (for monitoring traffic of refugees returning to Afghanistan)

Task Five: Designing and Evaluating the Photovoltaic Systems

Sandia National Laboratories designed a preliminary evaluation procedure that remains to be applied because none of the systems is yet powered by photovoltaics. This task, therefore, remains on-going. Sandia National Laboratories remains involved in this activity, and is currently helping to design pv support for a system in Somalia.

Task Six: Trouble Shooting

This task remains on-going. VITA has had to revisit ground stations in Sierra Leone, Djibouti and Pakistan, to correct operator error, as well as hardware and software problems.

Task Seven: Establishing and Managing the Messaging System

This task remains on-going. While there is daily traffic that VITA monitors at its command ground station, there remains the need to periodically revise and develop new software; e.g. VITA designed "gateway" software between ground stations and VITANet (VITA's bulletin board) and international electronic mail networks (Internet, Bitnet, Fidonet); VITA is also working to more fully automate the system in connecting terrestrial and satellite networks.

It must be kept in mind that the PCE is an experimental system; VITA as well as other users continue to learn more and more about its use and applications.

Task Eight: Management and Evaluation of the PCE and UoSat 3

This is an on-going task. Both the satellite, and the PCE payload are managed in orbit by Surrey Satellite, Ltd., of Guildford, England.

Task Nine: Evaluating the Technical Quality of System Communications.

This is an on-going task. The system continues to work as planned.

In addition to the on-going technical evaluation, VITA asked George Mason University to conduct a preliminary economic assessment of the system in May, 1991 - to investigate the costs of VITASAT, other small satellites, and existing and planned telecommunications. The study concluded that: small satellites are emerging viable communications systems; VITASAT space segment costs are reasonable; per user capital costs of VITASAT range from \$2,000 to \$6,000 - better than any satellite system today; the VITASAT fixed station costs are fair, and superior to any rural access infrastructures; and, the VITASAT portable stations are superior in all cost comparisons (they represent the leading edge of a new wave in personal telecommunications).

Task Ten: Applying the PCE Test Results to VITASAT A.

The design of the first operational satellite, VITASAT A, is essentially completed; constructing it, however, is contingent on exactly when the FCC grants authorization to construct the satellite. U.S. law prohibits actual construction until licenses are granted. However, VITA has solicited proposals from several satellite and launch companies, and is ready to move quickly in this regard. VITA anticipates that the launch of its first operational satellite will be in 1994.

Note:

In February, 1992, the first AID grant (FY '91 appropriations) to VITA to demonstrate the special value of this system to renewable energy technology transfer began to be implemented. In December of 1992, a second AID grant (FY '92 appropriations) was awarded to VITA to expand the renewable energy users network commenced. Both of these grants came to VITA through the cooperative agreement between U.S. ECRE and AID.

**Prepared by: Joseph F. Sedlak, VITA
February 12, 1993**

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