REMOTE DATA ACQUISTION USING

RANDOM MODE SUB-TELEMETRY SYSTEMS

BY

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INTRODUCTION

There are many applications for a simple wide area data collection system, Sheridan, 1981. The system described in this paper has been applied over the past six months to a number of remote measurement problems, including, temperature, pressure, relative humidity, soil moisture, snow pillows, precipitation, well depth and several other parameters of interest. The system is basically simple in its design and uses existing wide area communications networks to complete the data acquisition and processing loop. The basis of this concept uses an innovative solution to the wide area monitoring problem called the "POPCORN" Sub-Telemetry System (STS), Kleppe, 1979, 1982.

A key factor to the success of the STS was the development of the "POPCORN" concept combined with the "piggybacking" of data on existing data collection networks such as the SNOTEL or GOES systems, Carter and Paulson, 1979.

SYSTEM CONCEPTS

The STS system concept is shown outlined in Figure (1). The Data Collection Platform (DCP) is either a GOES or standard Meteor-Burst SNOTEL site. The SEI system has a receive-only unit (STS-R) located adjacent to the DCP. This receiver is so placed that it looks over many other data points of interest. Each desired data point uses an STS-TX remote transmitter. These remote transmitters are of a "throw-away" nature, i.e., small, low power, low cost, etc. These transmitters are programmed to transmit on a random interval, that is, no receiver is required or special clock needed to self time them. This means that one DCP site can cover an entire basin for measurements such as well depth, etc. As an example, refer again to Figure (1). Assume that the one (1) DCP overlooks over some thirty (30) test wells located in a basin of interest. Each well would have a depth or

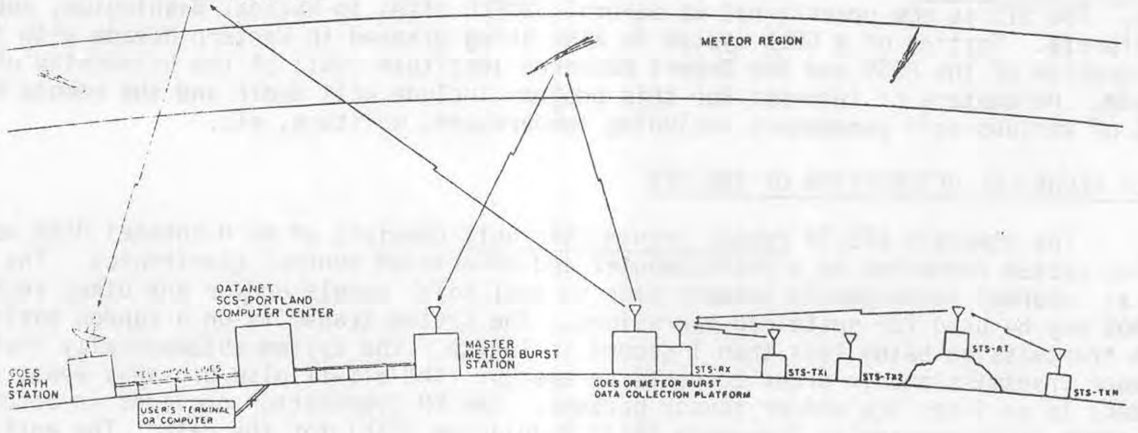

Figure (1) Block Diagram of Wide Area Computerized Data Collection System.

quality sensor (or any other parameter of interest). Each well would also have an STS transmitter. It is possible to calculate the data recovery from these thirty (30) sites using the following equation.

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$$P_s = 1 - (1 - e^{2tM/T})^n$$

where

P_s is the probability of successfully receiving a transmission in a given time,

n is the number of transmission tries in the observation time,

t is the length of each transmission,

T is the time interval between transmissions, and

M is the number of transmitters operating in the channel of interest.

For example, further assume that the transmissions from each site consists of a four (4) second data burst at a random interval of average value ten (10) minutes. Then in any given hour the probability of data recovery at the DCP (STS-R) site would be given as:

$$n = 6 \text{ transmissions/site/hour}$$

$$t = 4 \text{ sec/site}$$

$$T = \frac{3600}{n} = \frac{3600}{6} = 600 \text{ seconds}$$

$$M = 30 \text{ sites}$$

then

$$P_s = 1 - \left(1 - \exp\left(\frac{-2(4)(30)}{600}\right)\right)^6$$

$$= 1 - (0.0013) = 0.9987$$

This means that there would be a data recovery (in one hour) of 99.9% of the 30 sites reporting. This is quite interesting since all 30 transmitters can operate in a random transmit mode and do not require receivers or expensive self-timed clocks to trigger them. The STS is now operational at several SNOTEL sites in Nevada, Washington, and California. Testing of a GOES system is also being planned in Western Nevada with the cooperation of the USGS and the Desert Research Institute (DRI) of the University of Nevada. Parameters of interest for this program include well depth and the remote measurement of various soil parameters including temperature, moisture, etc.

BRIEF TECHNICAL DESCRIPTION OF THE STS

The standard STS-TX remote transmitter unit consists of an 8 channel data acquisition system connected to a microcomputer and associated control electronics. The unit has an internal rechargeable battery pack so that solar panels and/or any other recharging method may be used for sustained operations. The system transmits on a random basis with each transmission being less than 1 second in length. The system automatically shuts down between transmissions in order to conserve energy. The STS-TX also provides power (if needed) to an interface and/or sensor package. The FM transmitter provides an output of 1.5 watts using subcarrier Frequency Shift Modulation (FSK) for the data. The entire system is packaged into a small NEMA type 4 enclosure (H = 10", W = 8", D = 4"). The internal battery pack allows for at least 60 days of operation without recharge for a transmission interval of average value ten minutes. The antenna can be a simple "whip" or any vertical polarized antenna depending upon local requirements. A standard interface box can also be provided for connection to any SNOTEL system. The STS-RX receiver system was designed around a microcomputer providing for maximum flexibility to the user. In the case of a SNOTEL system the STS-R unit can be directly connected to a standard SNOTEL transceiver without "cutting a wire". The STS-R connector will fit directly into a GOES or SNOTEL system. The STS-RT repeater system is used where "line-of-sight" radio paths do not exist between the "POPCORN" transmitters and the central receiver. The receiver antenna is also selected according to local requirements and can be a simple "whip" or any other type vertically polarized antenna. The STS system can also be programmed to operate on a random adaptive basis, Buckelew, 1980, Preble, 1979. This means that the data reporting cycle can be adjusted by data changes, hence, providing intensive sampling only when it is required. Time marking is accomplished by using "aging" parameters assigned by the STS-R receiver unit. Time resolution for a standard system is one minute.

DATANET, A STEP TOWARD A COMMERCIALLY OPERATED WIDE AREA DATA COLLECTION SYSTEM

The low cost of the SEI Sub-Telemetry System allows existing GOES and SNOTEL meteor-burst users to expand their data collection activities and also creates the potential for a large number of additional users to gather data without making a large investment in telemetry and data processing facilities. However, both the SNOTEL and GOES networks are operated by government agencies with specific missions in hydrological and environmental areas. Use of these networks, especially the ground receiving stations, is limited mainly to authorized SCS and USGS projects and a few select outside users conducting related water or environmental monitoring activities. Other potential users with monitoring applications not related to water and the environment would generally not be encouraged to use the networks. This does not imply a denial of access to the GOES satellite itself or of privately owned meteor-burst transmitters, but the use of government owned and operated data collection and distribution facilities is restrictive.

It is clear that the SEI Sub-Telemetry System creates a need for a private network to provide data reception and distribution services, independent of the various government programs. The SCS SNOTEL system and the USGS GOES receiving stations will simply not have the capacity or the resources to provide services to a large group of diversified users. SEI believes that the availability of its new line of sub-telemetry equipment will greatly enhance the need for such a service.

DATANET's immediate objective is to fill the void created by the gap between limited government sponsored service and a need enhanced by an innovative advancement in low-cost measurement and telemetry technologies.

SUMMARY AND CONCLUSIONS

There has been a growing need for an inexpensive, reliable and versatile system that can be applied to wide area data collection problems. Accurate and timely models usually require a data density that cannot be economically provided by expensive GOES or Meteor-Burst DCP's alone. The STS - "POPCORN" system does offer a cost effective solution to the problem.

Government manpower ceilings and an increasing demand for more data is forcing many government agencies to investigate automated data collection systems. The SEI "DATANET" concept will provide a wide area data collection system by maximizing joint use of both government and private facilities. The use of "POPCORN" and "DATANET" type of systems will also allow users to turn their attention to sensor development, data analysis and modeling, etc. In this way, user resources can be expended in areas more aligned with their assigned missions and less with technical support functions.

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REFERENCES

Buckelew, T.D., (1980), "Down to Earth Satellite Data Collection" ASCE Conference "Broadening Horizons - Transportation and Development Around the Pacific", Honolulu, Hawaii, July.

Carter, W.D. and R.W. Paulson, (1979), "Introduction to Monitoring Dynamic Environment Phenomena of the World Using Satellite Data Collection Systems, 1978" Geological Survey Circular #803.

Kleppe, J.A., (1979), "Investigation into the Use of Remote Sensing for Well Level Measurements" Report submitted by Scientific Engineering Systems to Nevada Division of Water Resources, June.

Kleppe, J.A., (1979), "The Use of Meteor Burst Communications for Well Monitoring by the State of Nevada and Washoe County" Report prepared by ERDC for Nevada Division of Water Resources and Washoe County, July.

Kleppe, J.A., (1982), "POPCORN - - A Simple Answer to Wide Area Data Collection," EXPOSURE, Oceanography, Oregon State University, Vol. 9, No. 6, pp. 4-8.

Preble, D.M., (1979), "Demonstration of Adaptive Random Reporting GOES Data Collection System," U.S. Army Report SCR-333-78-006, Army Engineers, Waltham, Mass, January.

Sheridan, D., (1981), "The Underwatered West, Overdrawn at the Well", Environment, Vol. 20, No. 2, pp. 6-33.