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Portable Broadband Instrument Center

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Project: Portable Broadband Instrument Center (PBIC)
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The PBIC took delivery of our first three Guralp CMG-40T sensors in early June. The PBIC was active in Web and software development, response calibration and outreach programs. The PBIC has also been looking at telemetry options for the portable recorders.

Equipment Usage

The CLC/SCEC UCSB Hazards Study and the Garner Valley Rock Site experiments were completed in preparation for deployment of Monica Kohler's Los Angeles Basin Passive Seismic Experiment (LABPSE). The LABPSE project used all of the PBIC equipment for the majority of the year, concluding in mid-November. Steve Day (SDSU), working in conjunction with UCSD is using the CMG-40Ts in an experiment in northern Baja.

Dates	Institution	PI(s)	Experiment
01/01/96-02/27/96	UCSB	Archuleta/Steidl	GVDA Rock site
10/17/96-02/27/97	UCSB	Archuleta/Nicholson	CLC/SCEC UCSB Hazard Study
03/04/97-11/21/97	UCLA	Kohler/Davis	LA Basin Passive Seismic Exp.
05/13/97-05/15/97	UCSB	Archuleta/Steidl	CLC Borehole
08/18/97-current	SDSU	Day/Astiz	Northern Baja Broadband depl.

Telemetry

One of the projects this year has been to look at using telemetry to minimize the cost of maintaining a portable deployment of Refteks. Digital radio telemetry and spread spectrum telemetry have both been used successfully with Refteks, but it involves a significant investment in time and hardware at startup to get this type of network hardened and running reliably. We must evaluate the practical telemetry needs of the PBIC user. First we will look at different levels of telemetry and the pros and cons of each.

At the lowest end of the telemetry spectrum, the DAS would broadcast its status to a central site. This one way communication allows the user to know the operating state of the site. This can be accomplished through use of the ARGOS satellite system. An on-site satellite transmitter broadcasts the DAS status at selected intervals to the polar orbiting ARGOS satellites. The transmitters have requirements similar to the GPS receivers. They need to point towards the sky. Interference should be minimal and typically will not matter since data integrity is not critical for this information. The on-site transmitter costs about $1500 per DAS. The access fee for the ARGOS system would be approx. $5-10/day. This fee gets the data sent to the user automatically at preselected intervals. If the fee has to be paid for each DAS, long-term deployments could become expensive. The benefits of this system are simplicity, flexibility and ease of access.

The next level would be two–way, low–speed communication with the DAS. This could be accomplished via spread spectrum technology or possibly by digital cellular modems. This level of telemetry allows the user to interrogate the DAS, check disk status, event status, and to change parameters. The bandwidth would probably not allow any significant transfer of data. The DAS would record in triggered or continuous mode normally. While the radio links may be somewhat susceptible to noise and interference, this shouldn't pose too much of a problem. For interrogation purposes, the transmission is not critical. If the user wants to send parameters, any interference becomes much more important. Costs of digital cellular phones have been dropping recently as availability has increased. The hardware cost of the major pieces of equipment should be less than that for the ARGOS system, but there may be connectivity issues that require specialized hardware to interface to the DAS.

Yet another level of telemetry would be a high speed one–way or two–way link to send continuous data directly to a central receiving system. The Reftek arrays in Anza and northern Colorado currently use this type of telemetry. Again, spread spectrum technology or digital FM radios could be used. The built-in IRIS/PASSCAL software wasn't originally designed for telemetry, doesn't perform adequate error checking, and has no retransmission ability. Therefore, the IRIS/PASSCAL EPROMs in the Refteks must be replaced with EPROMs that adequately support telemetry. The two existing arrays mentioned earlier use software developed by UCSD. Once this reprogramming is done, the Refteks can only be used in telemetry mode. Because of transmission bandwidth limitations, this mode is more suited to low sample rate data, such as arrays of long period seismometers. The two existing arrays maintain a total throughput of about 423 samples per second for all channels and data streams. In this telemetry only mode, any interference or transmission problems are critical since it means losing data. There is also the question of site locations. Certain sites may be unsuitable for radio transmission due to nearby interference, range or line-of-site limitations. Site location may then be driven by telemetry considerations rather than scientific objectives. This type of telemetry typically requires a longer "hardening" time and more preparation time. It may require radio surveys to be done prior to deployment to find suitable sites. Also range and line of site limitations may require that the signal be retransmitted. It is probably only appropriate for sites that will be deployed for a minimum of six months or so. The benefits of this type of system include complete access to data on-line.

In the past the PBIC has worked with principal investigators on balancing the frequency of site maintenance with data loss from failed sites. Having a method of checking the site remotely will be a huge benefit for the PI's, since they will have a way of seeing if the site is running as expected or not. The PBIC sees the most benefit in an intermediate form of telemetry at this time. One that allows the user to interrogate the DAS about its status. The user can then judge when the site needs to be visited. Future technological advances should allow us even more capability for reducing the cost of operating an experiment while maximizing the uptime of the equipment.

Sensor Calibration

The PBIC is currently working with PASSCAL personnel at Lamont in another round of calibration box construction. The response calibration method is being used regularly by the Stanford PASSCAL group.

The LABPSE project demonstrated the need for the frequent checking of sensor leveling. Calibration pulses were used to check centering of the sensors about six months into the experiment. Several sites had enough tilt that even small signal inputs were affected by the tilt. The PBIC is experimenting with different approaches to sensor installation in intermediate term installations such as the LABPSE. One of the projects for the holiday season is to get a quantitative idea of exactly what tilts produce what levels of distortion.

Hardware: Management, Development, Repair and Quality Control

The PBIC has been upgrading the disk subsystems for the DASs by purchasing new, higher capacity drives. The increase in disk capacity allows users more data collection options. In environmentally noisy areas, such as Los Angeles, some users prefer to record continuously and perform filtering during processing. This use of continuous recording results in large quantities of data being recorded which makes transferring the data to tapes in the field impractical (i.e.: a 1Gb transfer would take ≈166 minutes or over 2.5 hours). The PBIC now has more field disks than DASs. This allows users to swap disks in the field, speeding up field data collection for high capacity recording sites. New field disks were fabricated in–house at a substantial cost savings. Field tests of the new disk subsystems during the LABPSE project were very positive.

Overall, the equipment had very few problems or failures. Most of the problems were minor in nature and field repairable. This can probably be attributed to the maintenance performed last year on the equipment. The PBIC had to replace a DSP card for one of the older 72A-02s, which failed during the LABPSE experiment and could not be repaired. Two palmtops were stolen and are being replaced.

The PBIC upgraded 3 disk subsystems for UCLA and performed some maintenance on the DASs. The PBIC also assisted CSUN in getting their DAS up and running again after a long gap in field operations.

An inventory of PBIC equipment is shown in Table 1.

Computational Support: Web and Software Development

The PBIC web page access has doubled in the last year, being accessed 4121 times by 876 users in the last 12 months. The PBIC web page now has listings of vendor information as well as technical tables on the status of the equipment. The beginnings of a reference manual are on-line as well. Documentation and technical drawings of the response calibration hardware are now available on-line.

Software development this past year was minimal. There was some further development done on the logfile association program in conjunction with the LABPSE project. There was some porting development in cooperation with PASSCAL stanford to upgrade the response tcl/tk scripts to the new version of tcl/tk included in the PASSCAL software distribution.

Publications

The following publications reference data collected using the PBIC equipment. Most of these were listed as in press last year.

Bonilla, L.F., J. Steidl, G. Lindley, A. Tumarkin, R. Archuleta. Site Amplification in the San Fernando Valley, CA: Variability of Site-Effect Estimation Using the S-wave, Coda and H/V methods. *Bulletin of the Seismological Society of America.* **87**. 710-730.

Kohler, M.D, B. Kerr, P.M. Davis, A. Martin, and A. Rigor, "Amplification observations from the ongoing Los Angeles Basin Passive Seismic Experiment (LABPSE) Dense Array", SCEC Annual Meeting

Li, Y.-G., F. Vernon, K. Aki. San Jacinto Fault-Zone Guided Waves: A discrimination for recently active fault strands near Anza, CA. *J Geophys. Res.* **102**, 11689-11701.

Li, Y.-G., W. Ellsworth, C. Thurber, P. Malin, K. Aki. "Fault-Zone Guided Waves from Explosions in the San Andreas Fault at Parkfield and Cienega Valley, California" *Bulletin of the Seismological Society of America.* **87**, 210-221.

Table 1:

Equipment Inventory

The following table outlines the PBICs current major equipment inventory. Various subsystems, such as AC power and solar power, are not listed.

Curren	Model	Description
9	72A-02	16 bit data acquisition system (DAS)
9	72A-08	16/24 bit data acquisition system (DAS)
24	72A-05/PBIC	External hard disk subsystems (200Mb-1Gb)
18	111A	GPS units
18	L4C3D	1Hz velocity transducer
16	FBA23	Force Balance Accelerometer
3	CMG40T	Intermediate period 3 component sensor
1		CMG40T interface/calibration unit
2	72A-03	Portable exabyte tape system
1		Portable DAT tape system
2		2Gb Portable Data transfer disk
4		Zeos style palmtop computer
2		HP style palmtop computer