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# EVALUATION OF A PROTOTYPE INFRASOUND SYSTEM RECEIVED

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## ABSTRACT

Under Department of Energy sponsorship, Sandia National Laboratories and Los Alamos National Laboratory cooperated to develop a prototype infrasonic array, with associated documentation, that could be used as part of the International Monitoring System. The United States Government or foreign countries could procure commercially available systems based on this prototype to fulfill their Comprehensive Test Ban Treaty (CTBT) obligations. The prototype is a four-element array in a triangular layout as recommended in CD/NTB/WP.224 with an element at each corner and one in the center. The prototype test configuration utilize an array spacing of 1 km.

The prototype infrasound system has the following objectives:

- Provide a prototype that reliably acquires and transmits near real-time infrasonic data to facilitate the rapid location and identification of atmospheric events.
- Provide documentation that could be used by the United States and foreign countries to procure infrasound systems commercially to fulfill their CTBT responsibilities.

Infrasonic monitoring is an effective, low cost technology for detecting atmospheric explosions. The low frequency components of explosion signals propagate to long ranges (few thousand kilometers) where they can be detected with an array of sensors.

Los Alamos National Laboratory's expertise in infrasound systems and phenomenology when combined with Sandia's expertise in providing verification quality systems for treaty monitoring make an excellent team to provide the prototype infrasound sensor system.

By September 1997, the prototype infrasound system will have been procured, integrated, evaluated and documented. Final documentation will include a system requirements document, an evaluation report and a hardware design document. The hardware design document will describe the various hardware components used in the infrasound prototype and their interrelationships. Final versions of all documents should be available from the bibliography on the CTBT R&D web site, URL: <http://www.ctbt.rnd.doe.gov/>

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## OBJECTIVE:

The prototype infrasound system has the following objectives:

- Provide a prototype that reliably acquires and transmits near real-time infrasonic data to facilitate the rapid location and identification of atmospheric events.
- Provide documentation that could be used by the United States and foreign countries to procure infrasound systems commercially to fulfill their CTBT responsibilities.

## RESEARCH ACCOMPLISHED

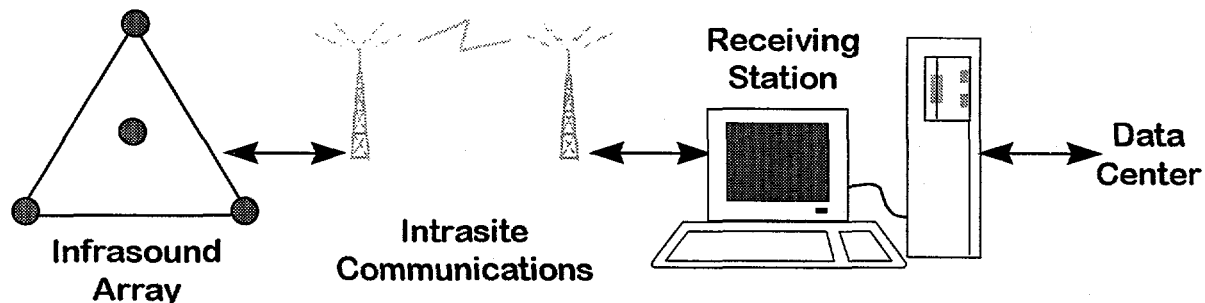
### Background

Sandia and Los Alamos initially held several technical interchange meetings to define programmatic responsibilities for the development of the prototype infrasound system. They jointly developed the "Program Plan for the Infrasound Prototype Development" and "System Requirements for the Infrasound Prototype," and received comments on the plan and requirements at a technical interchange meeting with Air Force Technical Applications Center on April 12, 1996.

Several hardware options were developed that could satisfy the requirements. The Department of Energy held a design review May 22, 1996 to discuss the hardware options for the prototype. Based on discussions during and after the review, the decision was made to bid the data acquisition system. A request for proposals was distributed to potential suppliers in July. After reviewing the two bids received, a contract was awarded for the data acquisition system in September 1996. The data acquisition system was delivered in early May.

### Prototype Features

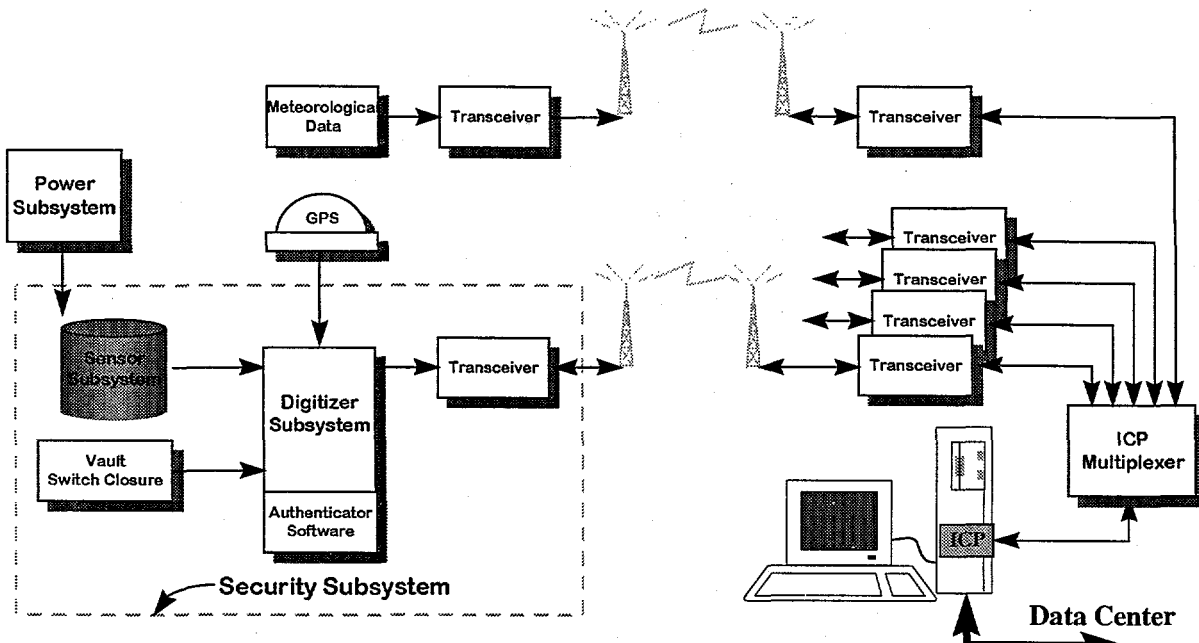
A block diagram of the infrasound prototype is shown in Figure 1.



**FIGURE 1. BLOCK DIAGRAM OF THE INFRASOUND PROTOTYPE**

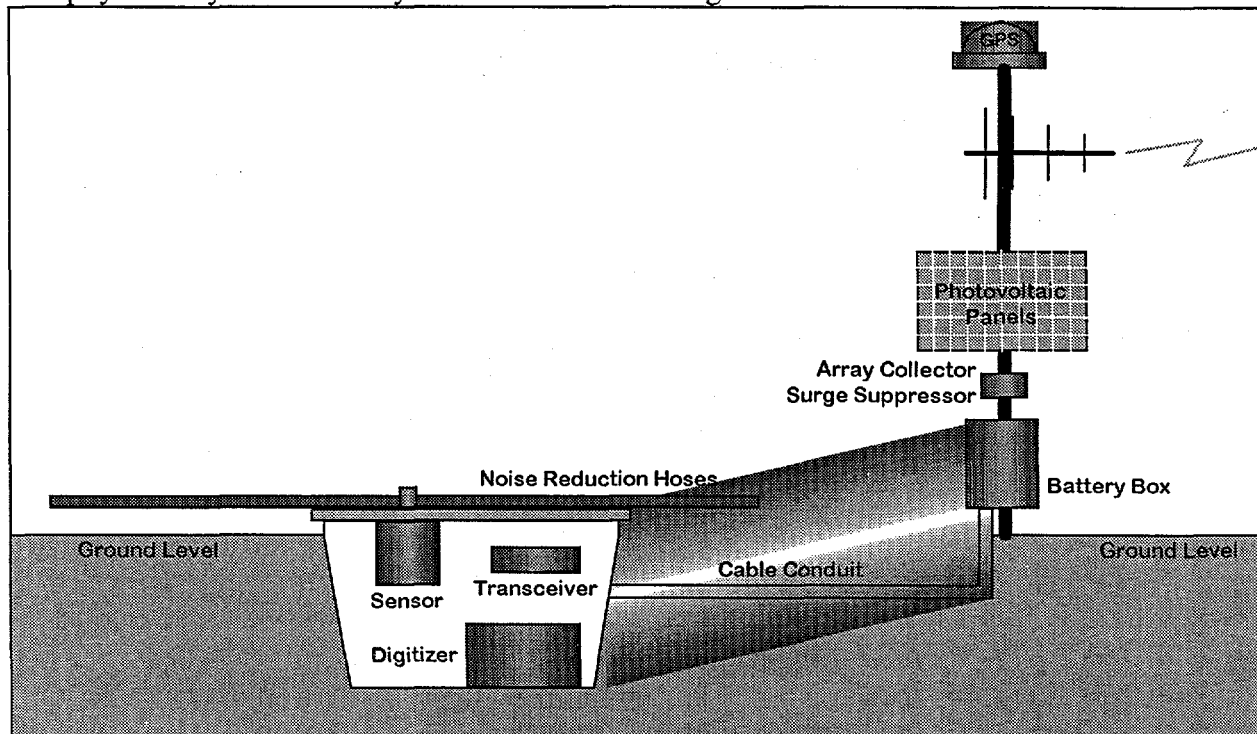
The triangular array layout was recommended in the Conference on Disarmament/Ad Hoc Committee on a Nuclear Test Ban/Working Paper 224 and 283. The infrasound array elements are located in a triangle (one at each corner and one in the center). The prototype spacing will be 1 km on a side, however, the Conference on Disarmament working papers provide for an optional spacing up to 3 km.

A block diagram of the components that make up the infrasound prototype is shown in Figure 2.



**FIGURE 2. DETAILED BLOCK DIAGRAM OF THE INFRASOUND PROTOTYPE**

The physical layout at an array element is shown in Figure 3.

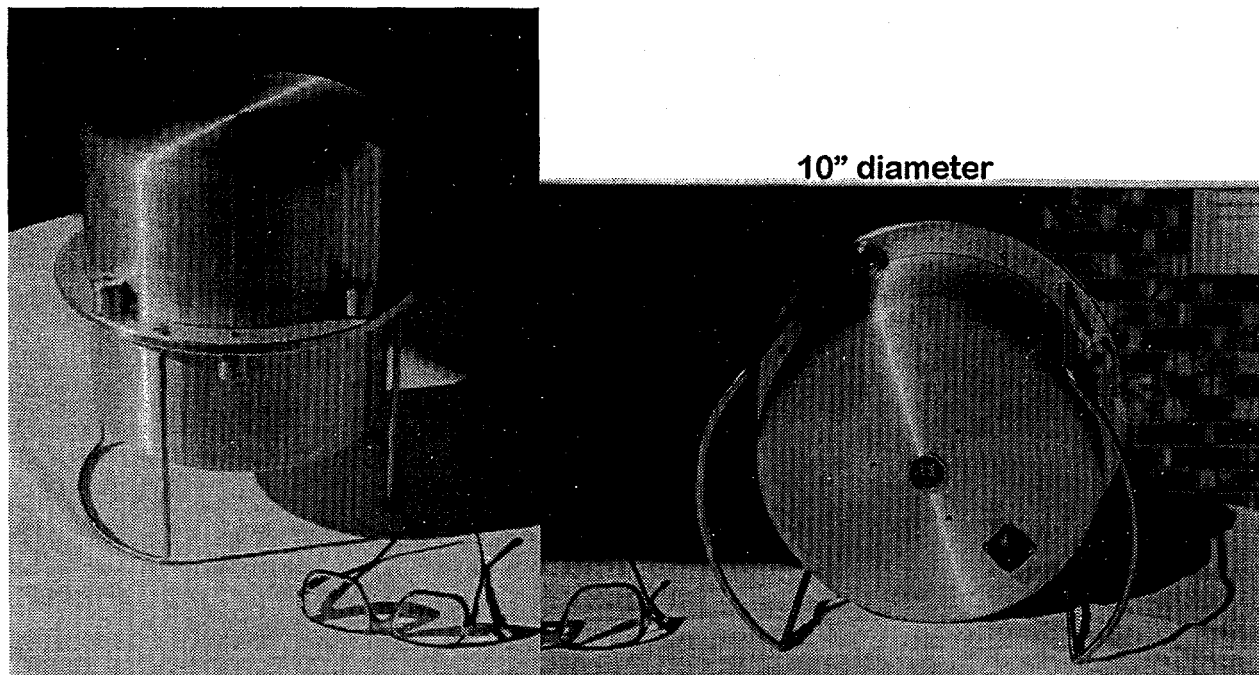


**FIGURE 3. LAYOUT OF AN ARRAY ELEMENT**

**Sensors**

The prototype infrasound sensor (Figure 4) is a microbarograph model 4.11 from Chaparral Physics Inc., Albuquerque, NM. Chaparral Physics re-packaged the sensor to accommodate the

infrasound prototype data surety features. The microbarograph can be calibrated remotely with a step function to verify the sensor electronics response and to confirm system operation.



**FIGURE 4. PHOTOGRAPHS OF THE MICROBAROGRAPH**

Los Alamos calibrates the microbarograph utilizing a piston phone calibration chamber to:

- Set the calibration constant to 0.04 volts per  $\mu$ Bars (0.004 volts/Pa) at the low gain setting.
- Verify a flat response over the frequency range from 0.16 to 4.0 Hz.

In addition, Sandia has performed side-by-side sensor coherence testing to determine the broadband sensor noise, sensor dynamic range, and relative amplitude & phase between sensors. Testing shows that the sensor self noise is down better than 80 dB from clip @ 1.0 Hz.

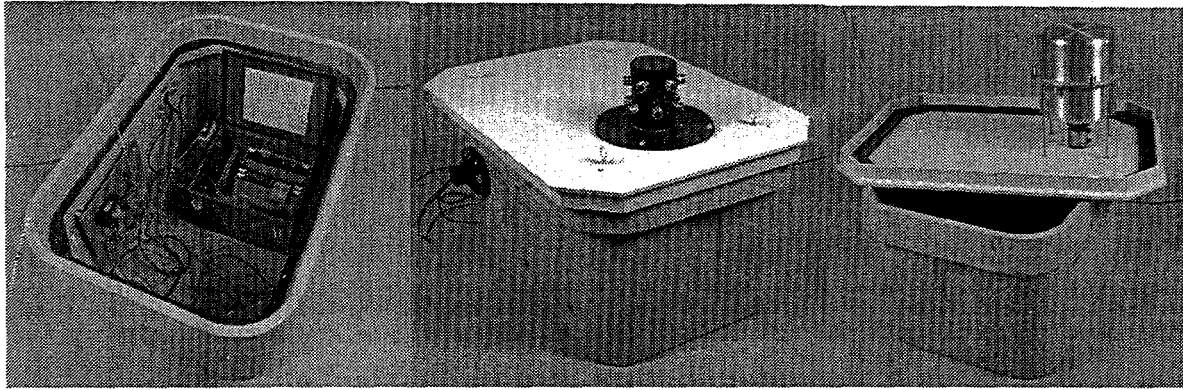
Complete results of the sensor testing will be presented at the symposium.

#### ***System and Data Surety***

The prototype data surety features are provided by a two fold thrust: authentication and tamper protection.

- Data authentication is performed in software in the digitizer utilizing a Digital Signature Algorithm furnished by Sandia. Sandia obtained data from the vendor and has validated the signature.
- Tamper protection is provided by both active and passive indicators on the enclosure housing the sensor and digitizer. An active switch closure signal is transmitted with the data to the National Data Center. The passive indicator is a seal on the enclosure. During maintenance, personnel can determine whether the enclosure seal has been broken.

Complete results of the system and data surety testing will be presented at the symposium.

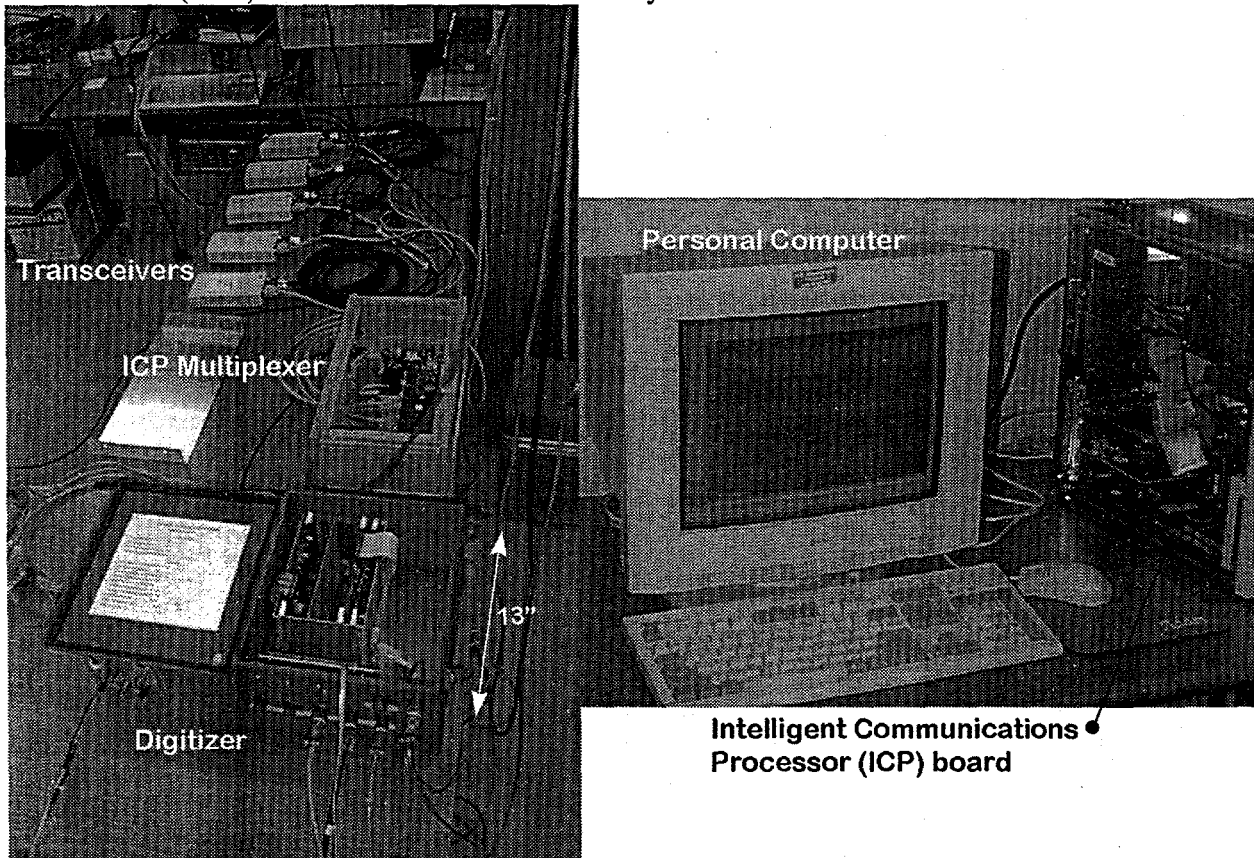


**FIGURE 5. THREE VIEWS OF THE ARRAY ELEMENT ENCLOSURE**

Figure 5 shows three views of the array element enclosure. Once buried (as in Figure 3) the enclosure (center, above) accommodates both active and passive tamper protection. The noise reduction hoses connect to the manifold shown on the top. The sensor (right) mounts to the bottom of the cover. The enclosure with the top removed is shown on left.

### *Data Acquisition System*

The Data Acquisition System (Figure 6) consists of the digitizer, intrasite communications, and a host processing system. These components are commercially available from Geophysical Services and Products (GSP). Their subcontractor is Teledyne Brown/Geotech Instruments.



**FIGURE 6. PHOTOGRAPHS OF THE DATA ACQUISITION SYSTEM**

Testing indicates that the digitizer meets or exceeds requirements. Some salient features include a:

- Dynamic range measured at better than 120 dB.
- Resolution measured at better than 20 bits.
- Bandpass measured from DC to 4 Hz at 10 sps.
- Accuracy measured to better than 1%.
- GPS timing accuracy measured to better than 1 ms.

Complete results of the data acquisition system will be presented at the symposium.

The primary features of the infrasound prototype data processing system have been demonstrated. These include:

- Storing data in the CSS 3.0 flat file format as verified by Los Alamos.
- Authenticating the Alpha protocol as verified by Sandia.
- Transmitting the infrasound data in the Alpha protocol as verified by the National Data Center.

## CONCLUSIONS AND RECCOMENDATIONS

Test and evaluation of the prototype infrasound system should be completed by the end of July 1997. Final versions of all prototype documentation will be available on the DOE CTBT R&D web site, URL: <http://www.ctbt.rnd.doe.gov/>.

### Technical Reports

- LANL, SNL, *Program Plan for the Infrasound Prototype Development*, SNL-CTBT-0001, dated 8/12/96
- LANL, SNL, *System Requirements Document for the Infrasound Prototype*, SNL-CTBT-0002, dated 8/16/96
- LANL, SNL, *System Test Plan for the Infrasound Prototype*, dated 7/31/97
- LANL, SNL, *Test Procedures for the Infrasound Prototype*, dated 7/31/97
- LANL, SNL, *Evaluation of the Infrasound Prototype*, dated 8/15/97
- LANL, SNL, *Hardware Design Document for the Infrasound Prototype*, dated 8/15/97

The Hardware Design Document identifies all hardware components in the prototype. Commercial components are listed by quantity, manufacturer, and part number. Modifications to commercial components are also included in the listing. If alternate components are recommended, they are also identified in the listing. Non-commercial components (cables, etc.), manufactured locally, are identified with drawing number. All drawings are included in the document.

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