LOW-NOISE BOREHOLE TRIAXIAL SEISMOMETER—PHASE II

James D. Kerr and David W. McClung

Geotech Instruments, LLC

Contract No: DE-FG02-03ER83667

Sponsored by National Nuclear Security Administration
Office of Nonproliferation Research and Development
Office of Defense Nuclear Nonproliferation

ABSTRACT

This paper describes the preliminary design of a low-noise borehole triaxial seismometer for use in networks of seismic stations for monitoring underground nuclear explosions. The design assumes the use of the latest technology of broadband seismic instrumentation. Each parameter of the seismometer is defined in terms of the known physical limits of the parameter. These limits are defined by the commercially available components and the physical size constraints. A prototype has been built along with accessory equipment and successfully installed in a borehole. Noise testing is to be completed by the end of 2006.

OBJECTIVES

The goal of this Small Business Innovative Research (SBIR) Phase II contract is to design a low-noise borehole triaxial seismometer for use in networks of seismic stations for monitoring underground nuclear explosions. The design assumes the use of the latest technology of broadband seismic instrumentation. Each parameter of the seismometer is defined in terms of the known physical limits of the parameter. These limits are defined by the commercially available components and the physical size constraints. A prototype design has been built that meets the size requirements.

The design goals set out for the SBIR are for a triaxial seismometer that can be deployed in 7-in. boreholes at a depth of 100 m. The instrument must operate over a bandwidth of 0.2 to 16 Hz, with a response flat to velocity or acceleration. Two instruments may be used to meet the requirements. The self-noise of the instrument(s) must be 6 dB below the U.S. Geological Survey (USGS) low-noise model over the full bandwidth and have a dynamic range of 120 dB. Self-calibration within 5% of amplitude and within 5º for phase over the bandwidth is a requirement. The instrument must have low power requirements and a high reliability when operated unattended in harsh environments.

RESEARCH ACCOMPLISHED

For Phase II, a prototype seismometer has been built, including all accessory equipment required for installation in a borehole. The seismometer uses the modules similar to the KS2000 surface modules with redesigned electronics.

Hole locks strain relief and stabilizers have also been designed and built along with the hole lock installation tool. These tools have been used to successfully install the seismometer in a borehole.

Figure 1 shows the seismometer and accessories ready for lowering into a borehole.

Figure 1. Prototype seismometer and accessories.

The seismometer is 3.5 in. in diameter and approximately 96 in. in length. It can fit into a 4.15 in. minimum diameter casing.

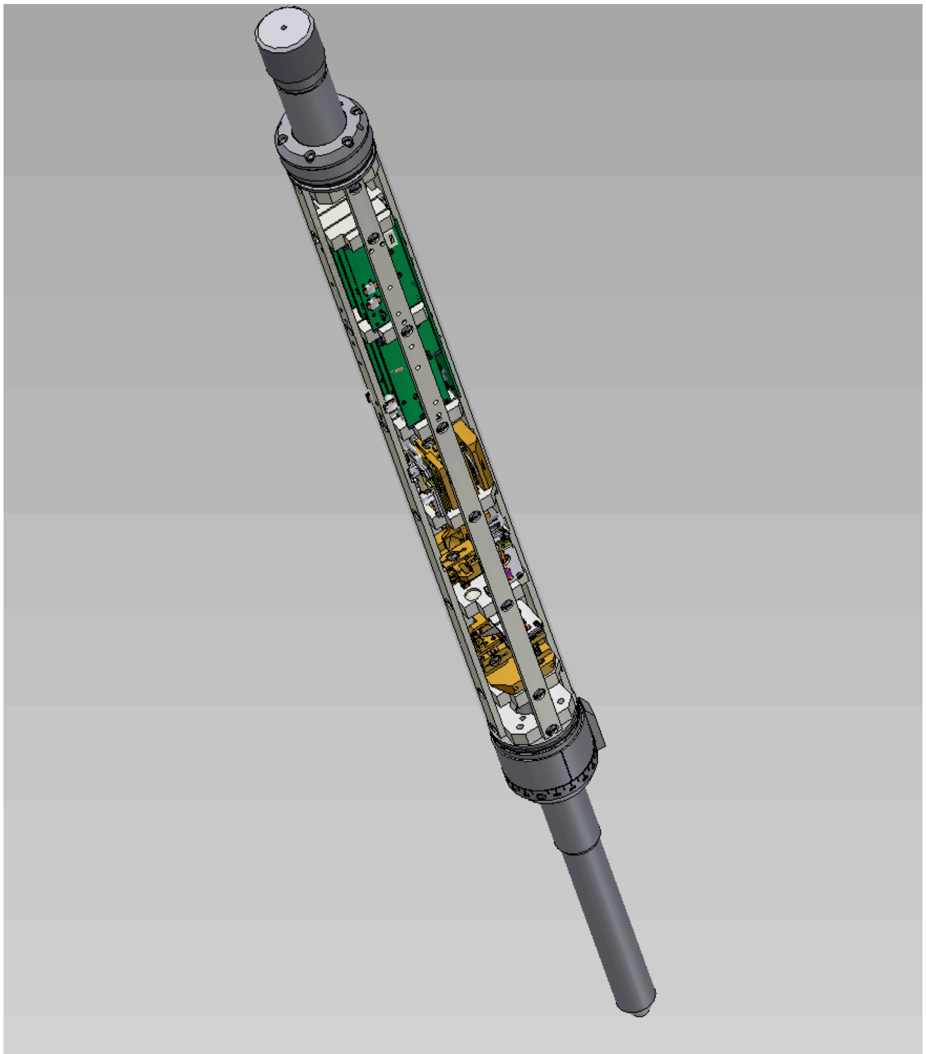

Figure 2. Internal seismometer.

Figure 2 is a CAD drawing of the internal seismometer.

Figure 3 shows the hole lock installation tool, and Figure 4 shows the hole lock.

Figure 3. Hole lock installation tool.

Figure 4. Hole lock.

The next step in this development is to install two or more verticals in the package and install the seismometer in a quiet site to verify the noise characteristics of the seismometer. This testing is scheduled for the latter part of 2006.

CONCLUSIONS AND RECOMMENDATIONS

One of the questions to be considered in this preliminary study was to determine if it was feasible to achieve a seismometer self-noise level at least 6 dB below the USGS low-noise model over the frequency range of 0.2 to 16 Hz. A second question was, could it be done with one instrument, or would two instruments be required. Based on the preliminary theoretical study of Phase I, only one instrument will be required. The requirements for the electronics, suspension, and basic sensors can be achieved with current technology based on the experience with and the history of the KS36000, KS54000 and similar designs.

It is recommended that Phase II continue with the development and testing of prototypes.