Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

*Title*: New Paradigms in Sensing (Prof. Steven Glaser, glaser@ce.berkeley.edu)

*Potential Participants (to be updated during the formation of the collaboration)*:

University of California, Civil Engineering – Steven Glaser
Lawrence Berkeley National Laboratory, Geophysics Dept., Earth Sciences Division –
Seiji Nakagawa, Larry Myer, Joe Wang
South Dakota School of Mines and Technology – William Roggenthen
Fermi National Laboratory – Chris Laughton
Free University of Berlin – Serge Shapiro
GeoForschungsZentrum Potsdam – Georg Dresen, Sergei Stanchits
University of Wisconsin – Herbert Wang
Penn State University – Derek Ellsworth
All other experiments and construction

*Proposed Program*

Traditionally sensors have been viewed simply as transduction elements. We have gone from mechanical devices to electromechanical devices, but they have all been macroscale in size. New advances in microfabrication have provided us with micro electromechanical systems (MEMS). These are electromechanical devices constructed on a micron scale. Such integration of mechanisms and electronics is made possible by utilizing techniques mastered in integrated circuit fabrication. This allows for very small and inexpensive transduction elements, many with linearization, compensation, and digitization built in. We can make use of the many sensors developed by DARPA, the automotive and process industries, and they pay the steep development costs. A great many of these devices are directly applicable to variables we want to measure. Since these devices are small and inexpensive, we can imagine a very dense array of sensors providing us detailed measurements of rock mass properties that we have averaged into continuum approaches.

There has also been a revolution in information and communication technologies, allowing us to change how we view a “sensor.” There are now available cheap, powerful, and low power microcontrollers (MCU), such as the TI MSP430 which has an integral 12 bit digitizer. We can now se a seamless integration of transducer and computational elements. This allows a “smart” utilization of the transducer as well as local integration and computation. If we follow the new paradigm of a dense array of thousands of sensors, there will be too much data to rationally handled. Local computation will allow the conversion of data into information, cutting the transmitted volume immensely.

The new type of sensor can also integrate large amounts of on-board memory so the information can be downloaded at convenient intervals. What is more, advances in communications technology allows us to integrate two-way wireless communications between an array of sensors and a central collection point. The transceivers are small, low-cost, and use relatively little energy. Depending on the demand, the devices can communicate from a few meters to many hundreds of meters. Our experiments have shown that underground openings act as faraday cages, so transmission distance is enhanced as long as there is line of sight between stations.

We now have the new sensor paradigm – a seamless integration of transduction, computation, memory, and communication into a seamless embedded system – a Mote. The networks allow us to form the sensors as individual local information-gathering nodes, or integrate them into arrays to perform integrated tasks such as beam - forming and array processing. We also see that these sensor networks can be adapted to provide information from virtually every activity in DUSE at a relatively low additional cost. We therefore will not need additional space.

*Space Requirement*
The sensor networks described in this LOI can be seamlessly integrated into every activity in DUSEL, so no additional space will be required.

*TimeLine (to be coordinated with 4850 and DUSEL Development)*:

2006-2007 installation of measurement sites within 4850 laboratory
2008-2012 monitoring measurements at deep sites
2013- deep and large excavation monitoring

*Collaboration Strategy*:

We have mentioned a few collaboration partners in the opening segment of this LOI. This list is limited to the P.I.'s personal collaborations to date. In fact we would expect to work with all or most of the investigations to be made at DUSEL. The science of this proposal will be pushed by the many and diverse needs of the DUSEL community.

*Example Experiments:*

Integration of MEMS ionized radiation transducers into Motes

Measuring air velocity on multiple scales, including eddy behavior.

Development and proof-testing of MEMS-based strain measurement

Developing MEMS high-fidelity acoustic emissions sensors so as to install large arrays of microseismic monitors.

Smart convergence and tilt devices.

Miniature intelligent seismic stations

Etc.