This document presents the **Statement of Work** (SOW) for the **SER** project. It is a bi-step document, consisting of:

1. Portions of the original customer's "need" obtained through both writing (written open SBIR solicitation), and various email and oral clarifications, and statements of desires (the latter being goals if technology permits); DURING THE FALL OF 2006.
2. The expanded SOW that includes the needs and desires of the original solicitation after several feasibility studies were conducted to ascertain the current "state-of-art" and components' capabilities enabling the expansion of the significant features and functions of the original SOW; DURING SPRING OF 2007.

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Original Need:

Objective:

"Develop a robust, integrated, g-hardened miniature "data recorder on a chip" to reliably record data from penetrating weapon tests."

Description:

(abstract version of problem)

"Data recorders are used to record the output of test sensors and/or the function of various … components at impact – these recorders provide the same digitizing functions as commercial data acquisition (DAQ) products in a miniaturized, hardened form. However, the duration of the test (several seconds) coupled with the severe impact loads makes it an extremely harsh environment for electronics to reliably trigger and function without loss/interruption of recorder power or data. Compounding the problem is that test article recovery takes many hours and sometimes several days."

"… the recorder must require less than 7 V supply with approximately 200 mAh of energy available. … is required to provide … power for up to 10 s should the primary power supply be damaged under test."

"The recorder, including both the back-up and primary power, will be required to have a miniaturized form factor with a volume of less than 0.7 in^3." "… must have the capability of digitizing 3 or more channels at 12-bit resolution at a minimum 50 kSa/s sampling rate per channel (200 kSa/s for Phase II)."

"Each channel must also have the following features:
1. a variable, 10 kHz (minimum) anti-aliasing filter,
2. differential input (i.e. instrument amplifiers)
3. programmable gain
4. programmable bias"

"The data recording will require two separate trigger inputs with … isolation."

"The recorder will be required to function in two representative impact environments:
1. an impulse load with peak acceleration of 100 kg for 20us,
2. and a longer duration impact profile of 40 kg for 1 ms."

(verbal desires)

As a result of several email and telephone conversations with the Technical Point of Contact for this solicitation, the following "desires" and clarifications are added to the "written" SOW to complete the big picture of the problem to be solved.

The sensors can vary, but all will be piezo-resistive four-arm bridge types (mainly strain gauges and accelerometers). We really want to be able to widen the bandwidth to 40kHz if possible, and preferably use 16-bit resolution. We need at least a gain of 1000, more if possible. Since the current (far less capable) technology has a case size of about 2 in^3, the new recorder can be larger than 0.7 in^3, but preferably no more than 1 in^3, and it doesn't really need to be a "data recorder on a chip." It is imperative that we have the ability to adjust the bias point for each channel since sensors' null-states vary so widely and the gains are so high. Post test analysis consists of "time domain" work, where linear phase response is far more important than absolute amplitude.

Expanded SOW:

The following is an expanded version of the original SOW that includes as a subset the technical features and functions of the original need, extended in scope, breadth, and depth as possible based upon current technological capabilities in order to provide a product that successfully targets more vertical markets than just the original one cited.

New Objective:

Develop a Thumb-Sized, Untethered/Self-Powered, High-Performance, Field-Adaptable, Automatic, Survivable, Multi-Channel, Extreme-Shock Event Recorder.

Why:

Many Data Acquisition tasks involve brief, violent, unconstrained events that preclude the use of "standard" DAS boards/modules; explosions, impacts, pyroshocks, manikin ejection seat & crash testing, to name a few. SER is an automatic, miniature, ruggedized Data Acquisition System that simul-samples 3 piezo-resistive-sensors with hard/soft triggering at up to 500,000s/s/c, featuring non-volatile data storage & latent (non-battery) sources for internal power. This project will include the standard product development phases, including features and functions, goals, a full prototype work breakdown structure, GANTT chart, specifications, research & component design tradeoffs, schematics, bills-of-materials, packaging, boards artwork, VHDL coding, etc.

Description:

The SER system is a part of a new generation of compact, technologically advanced, high performance, "unconstrained" Data Acquisition System Modules designed to provide wide bandwidth, high speed digitization and non-volatile data storage from an assortment of sensors during extremely quick, and often environmentally violent test events, including those involving ultra-extreme mechanical impulse shock events and wide bandwidth random vibration conditions.

It is self-powered for untethered (unconstrained) testing scenarios using the latest in Electrochemical Double Layer Capacitor technology. The analog and digital circuits use high-accuracy, extremely tiny components for minimum mass and maximum performance. The circuitry is protected by both the packaging and the signal line conditioning circuits against large EMI, RFI, and ESD events, which are common phenomenon in many pyro-based testing scenarios.

All user-adjustable parameters are saved on-board in non-volatile memory, including: sensor excitation voltages, RCAL resistance values, mid-scale bias-offsets, gains, cutoff frequencies and sampling rates, and the "save-data" pointer value. Test sequence (mode) profiles are also field-selectable.

Design Desires:

- All modifiable circuit parameters stored on-board as Non-Volatile-Programmed (NVP) data
- Programmable simul-Sampling Rates up to 500,000 samples per second per channel (less than 50nS channel-to-channel jitter/separation)
- 16-bit digitizers for maximum dynamic range (and efficient usage of memory)
- Tunable sensor sampling bandwidth up to 40 kHz (locked to sampling rate to ensure anti-aliasing protection), using Linear Phase response filters
- Quad isolated external "hard" triggers for event recording and sampling profile modifications
- Data derived internal "soft" triggers (data greater than, equal to, or less than parameters) for event recording and sampling profile modifications
- Timer delays available for each of the "hard" and "soft" triggers for postponement of changes to sampling profiles and other system "actions"
- Per channel non-volatile-programmable excitation sources
- Per channel non-volatile-programmable shunt calibrators
- Per channel non-volatile-programmable gain blocks (up to 4,000 V/v, if possible)
- Per channel non-volatile-programmable mid-scale adjustment circuits
- Per channel EMI-RFI-ESD protection
- Per channel differential inputs for 4-arm piezo-resistive sensors
- Non-volatile-programmable Save-Data "anywhere" pointer
- Run all systems for at least 10 seconds without external power present

Typical Applications:

The broader Statement of Work enables targeting additional (beyond the original "penetrating weapons tests") vertical markets, including (but not limited to):

- Mil-STDs: 167, 202F, 331, and 810F testing for gunfire, explosions, random drop, pyroshocks, high impact shock, and extreme accelerations, not achievable using "standard products"
- Untethered, free-flight article testing, like ejection seat testing, parachute deployments, and/or their respective crash landings
- Manikin tests including passenger injuries, safety equipment studies, vehicle-pedestrian collisions, 3-axes g-loading tolerance and protection tests, vertical and horizontal (including rocket-powered) sled testing, and biomechanical testing
- Sudden-stop failure mechanism studies: *think* fast moving hard object hitting a brick wall
- Free-fall packaging durability studies: *think* crated material falling out of the back of a moving truck or airplane
- Pyro-blast survivability testing
- Works well where telemetry fails due to antenna misalignments and/or large RFI and EMI fields (like those surrounding live rockets)
- Automated Seismic "pulse" recording
- Size is ideal for integrated MEMs-based velocity, acceleration, jerk, and rotation testing
- Vehicle Armor protection testing
- Personal body armor (flack vest, etc.) testing
- Any testing scenario where a tether/cable system is either impractical, or affects the collected data due to the test vehicle's motion

Critical Goals:

There are a few design goals that need to be evaluated at every applicable juncture:

- For maximum survivability: minimum size and mass for all components
- For maximum survivability: minimum rigidity, maximum flexibility
- For maximum survivability: no caustic chemicals (no batteries) on rupture
- For minimum volume/size: minimum size and mass for all components
- For minimum volume/size: minimum necessary connections only
- For minimum volume/size and power requirements: ALL data massaging and formatting and analysis activities are performed post-test outside the SER
- For minimum power requirements: ALL circuitry is essential and low power (yet high performance enough to meet all other design goals)

END OF DOCUMENT, FOR NOW.