BAA04-35
Proposer Information Pamphlet (PIP)

for

Defense Advanced Research Projects Agency (DARPA)
Advanced Technology Office (ATO)

Advanced Speech Encoding Program Phase 2

Technical POC: Dr. Lisa Porter, DARPA/ATO

****

This BAA will be open for **one (1) year** from the date of its publication in www.fedbizopps.gov and www.fedgrants.gov.

NOTE: Although this BAA will be open for one (1) year from the date of its publication on www.fedbizopps.gov and www.fedgrants.gov, the Government anticipates that the majority of initial funding for this program will be committed during First Selections. To be considered for funding during First Selections, full proposals must be received no later than **4:00pm Local Time on local Arlington, Virginia time on 01 SEP 2004.**

****

TABLE OF CONTENTS

BAA04-35

1. INTRODUCTION

The Defense Advanced Research Projects Agency (DARPA) Advanced Technology Office (ATO) is soliciting proposals under this BAA for Phase 2 of its Advanced Speech Encoding Program. The Advanced Speech Encoding Program Phase 2 consists of two (2) program topic areas: 1) Ultra-Low Rate Speech Encoding in Harsh Noise Environments, and 2) Novel Sensor and Signal Processing for Inaudible Speech. The Government is soliciting proposals in both of these Phase 2 topic areas as specified herein.

1.1. APPROACH

This BAA affords proposers the choice of submitting proposals for the award of a Procurement Contract, Cooperative Agreement, Technology Investment Agreement, Grant, Other Transaction for Prototype Agreement, or other such appropriate award instrument. The Government reserves the right to negotiate the type of award instrument determined appropriate under the circumstances.

1.2. PROPOSERS

The Government encourages proposals from non-traditional defense contractors, nonprofit organizations, educational institutions, small businesses, small disadvantaged business concerns, Historically-Black Colleges and Universities (HBCU), Minority Institutions (MI), large businesses and Government laboratories. Teaming arrangements between and among these groups are encouraged. However, no portion of this BAA will be set aside for HBCU and MI participation due to the impracticality of preserving discrete or severable areas of research in the technologies sought. Government/National laboratory proposals may be subject to applicable direct competition limitations, though certain Federally Funded Research and Development Centers are excepted per P.L. 103-337 § 217 and P.L 05-261 § 3136. Any responsible and otherwise qualified proposer is encouraged to respond. Proposers may be foreign firms or may team with foreign firms as long as the firm meets the criteria in this BAA and the Government is otherwise permitted to conduct business with the firm, however, only unclassified proposals will be considered from foreign sources, or where any proposed teaming arrangement involves a foreign source. Proposers may include foreign personnel as part of their proposed resources as long as these personnel qualify technically, the proposed effort is unclassified, and such foreign personnel sign any and all appropriate non-disclosure agreements prior to participating in the research effort. For this BAA, proposers should note that the Government anticipates the proposed research will be unclassified.

1.3. PROGRAM SCOPE AND FUNDING

The Government anticipates multiple awards. DARPA reserves the right to fund some, all, or none of the proposals submitted under this BAA. Further, DARPA may choose to select for negotiation all of a given proposal, or selected portions thereof. Total program funding for this BAA is currently estimated at the following amounts: $0.8M for FY04, $7.5M for FY05, $7.0M for FY06, $3.25M for FY07 and $1.25M for FY08. Detailed information is provided in Section 2 below.

1.4. PERIOD OF PERFORMANCE

While the earliest anticipated award is planned to occur in 2004, the Government may select for funding any proposal or set of tasks in a proposal at any time. The period of performance for the base period is twelve (12) months. Proposed efforts beyond the initial funding period should be proposed as pre-priced options. The period of performance for the first option will be twelve (12) months. Periods of performance for options thereafter are dependent on the topic area as described in Section 2. The Government may incrementally fund any awards under this BAA. Any structure and period for exercise of options (if any) shall be negotiated as part of the award process.

1.5. TECHNICAL SUPPORT

It is the intent of this office to use contractor support personnel in the administration of all submittals to this BAA. The Government intends to use non-Government employees and subcontractors, to include, but not limited to Schafer Corporation of Arlington, Virginia, Multisensor Science, LLC of Columbia, MD, System Planning Corporation of Arlington, VA, and Lincoln Laboratory of Lexington, Massachusetts to assist in administering the evaluation of the proposals and to provide advice regarding the technical content of the proposals to the Government evaluators. These personnel will have signed and be subject to the terms and conditions of non-disclosure agreements. By submission of its proposal, a proposer agrees that its proposal information may be disclosed to employees of these organizations for the limited purpose stated above. If you do not send notice of objection to this arrangement, the Government will assume you consent to use the subject personnel in review of your submittal(s) under this BAA. Only Government evaluators will make technical evaluations and award determinations under this BAA.

1.6. INSTRUCTIONS AND POINTS OF CONTACT

Questions pertaining to this BAA may be submitted to DARPA at the following e-mail address: ase@darpa.mil. DARPA may post updates to questions/comments periodically to the Advanced Speech Encoding Program Phase 2 website: http://www.darpa.mil/ato/solicit/ASE/index.htm.

For Administrative/Contractual questions, please contact the following:
DARPA/CMO
Anthony E. Cicala, Contracting Officer
3701 North Fairfax Drive
Arlington, VA 22203-1714
Email: acicala@darpa.mil

2. OVERVIEW OF ADVANCED SPEECH ENCODING PROGRAM

2.1. PROGRAM OVERVIEW

The ultimate objective of the Defense Advanced Research Projects Agency (DARPA) Advanced Speech Encoding (ASE) Program is to achieve ultra-low-bit-rate (ULBR) voice encoding (300 bps) with acceptable intelligibility, quality, and aural speaker recognizability in acoustically harsh environments. It is believed that novel noise-immune sensors such as the Aliph Radio Vibrometer (ARV, formerly the General Electromagnetic Motion Sensor or GEMS), physiological microphones (p-mics), and bone-conduction devices will enable this capability.

During the Advanced Speech Encoding Program Phase 1, such novel sensors were married with traditional linear predictor-type coders (e.g., Mixed Linear Excitation Prediction, Enhanced MELPe at 2400 bps) to determine whether or not the information provided by those sensors could be used to greatly improve intelligibility in harsh military noise environments. The Phase 1 results, presented in detail in Appendix A, conclusively demonstrated the utility of a multi-sensor approach to voice encoding in harsh noise environments.

In order to achieve the ultra-low bit rate objectives of the program, the Advanced Speech Encoding Program Phase 2 will need to go beyond traditional MELP-like coding constructs and focus on how to incorporate the information from the novel sensors in an integrated manner as part of an ultra-low-rate coding paradigm.

2.1.1 Synopsis of Advanced Speech Encoding Program Phase 1 Efforts

Generally, existing military low-rate speech coders have only marginally acceptable intelligibility and quality in harsh noise environments. Measurements taken in 1998 (the Department of Defense Digital Voice Processor Consortium (DDVPC)) and again in 2002 (NATO AdHoc Working Group 3) showed that Diagnostic Rhyme Test (DRT) intelligibility test scores were more than fifteen points lower in harsh military noise environments than in a quiet environment. This result includes measurements taken for a coder that has noise mitigation features that were developed specifically to improve performance in these harsh environments, the Mixed Linear Excitation Prediction, Enhanced (MELPe).

The goal of Advanced Speech Encoding Program Phase 1 was to demonstrate that the introduction of novel, noise-immune sensors into the existing coding paradigm of current military coders could result in greatly enhanced performance in harsh military environments. This goal was achieved, and the results are described in greater detail in Appendix A.

2.1.2 Overview of Advanced Speech Encoding Program Phase 2

Phase 2 will consist of two thrust areas, which are described in detail below.

2.1.2.1 Ultra-Low-Bit-Rate Speech Encoding in Harsh Noise Environments

DARPA ATO is interested in proposals that offer a means of developing a prototype voice communications system (sensors and coder) capable of operation at ultra-low bit rates in harsh military noise environments. This capability will be achieved in a staged approach. In the first stage, a voice communication system (sensors plus coder) operating at ≤ 1000 bits per second (bps) that achieves specified quality and intelligibility metrics will be tested in the laboratory as part of a first program milestone (See Section 2.2). In the second stage of the program, a voice communication system capable of operating at 300 bps will be demonstrated in a laboratory setting. In the final stage of the program, the 300 bps technology will be packaged in a prototype suitable for a field demonstration. Each of the first two stages of Advanced Speech Encoding Program Phase 2 is expected to last twelve months. The final stage is anticipated to last 18 months.

As noted above, in contrast to Phase 1, which utilized standard linear-prediction coding at 2400 bps, Phase 2 will require a paradigm shift in the coding approach to achieve 300 bps. Possible approaches include, but are not limited to, segmental and phonemic-based coding algorithms. Super-framing approaches are also possible. Approaches that allow for variable bit-rates are acceptable, as long as 300 bps average bit rate is achievable. Approaches that incorporate some degree of speaker adaptation and/or environment adaptation are also acceptable; however, the proposer must address the required amount of training expected in such an approach. Proposers should note that they have the flexibility to trade coder delay for bit-rate. Proposers are advised to propose some feasible delay/rate tradeoffs as part of their approach to achieving the program milestones.

In addition, although significant progress was made in sensor characterization during Phase 1, DARPA believes that the information content of the signals measured by the noise-immune sensors has still not been fully explored. Hence, a two-pronged approach in Phase 2 is anticipated: one element is to better characterize the sensor outputs, to maximize the utility of the multiple sensors. The second element is the development of integrated noise suppression and coding algorithms that efficiently exploit all of the available information provided by the sensors.

The two-pronged approach of sensor output characterization and novel coder development will require a carefully planned measurement program that directly feeds into the algorithm work. Clear, detailed measurement plans will need to specify what will be measured, why it will be measured, how it will be measured, and when it will be measured. *Answers to these questions must tie clearly and directly into the algorithm/coding work that is proposed*. It should be noted that the focus of the Advanced Speech Encoding Program Phase 1 on a certain set of noise-immune sensors (ARV, p-mics, bone-mics) does not preclude a proposer from proposing the use of other noise-immune sensors, as long as a well-thought-out two-pronged approach (sensor output characterization coupled with coding development) is clearly articulated. However, this program is not interested in the design and development of new sensors; all

proposed measurement efforts must be for existing sensors.

Practical methods with acceptable delay and packaging requirements are preferred to methods that yield delays of more than 300 milliseconds or that have power/size requirements that would make incorporation into a man-portable radio difficult. Coding methods that minimize user impacts (special communication procedures, restrictive sensor positioning) are preferred.

Teaming is *strongly* encouraged. It is anticipated that teams will consist of experts in noise-immune sensors and ultra-low bit rate vocoders. It is also expected that teams will include expertise in the integration of hardware and software into a prototype that can be field-tested. Proposals that lack such a teaming structure will *not* be favorably reviewed. Proposals that address only constituent technologies as opposed to the development of a field-testable prototype will not be favorably reviewed.

Total funding for this topic area is expected not to exceed $0.5M in FY04, $5.5M in FY05, $5.0M in FY06, $3.25M in FY07, and $1.25M in FY08.

Proposals to this topic area should be structured for an initial period of performance of 12 months. The period of performance for the first option will also be 12 months. The period of performance for the final option will be 18 months.

2.1.2.2 Scientific Discovery - Novel Sensor and Signal Processing for Sub-Auditory Speech

DARPA ATO is also interested in exploring and characterizing the nature of subauditory (nonacoustic) speech and its potential utility as an alternative means of communication in acoustically harsh environments. Recent studies at NASA AMES have indicated that robust, repeatable features can be extracted from laryngeal and sublingual muscle signals that are produced when a speaker generates subvocal speech. Tests conducted by Ames researchers convincingly demonstrated that a classifier could be trained to recognize 6 words and 10 digits that were generated subvocally with an accuracy of 92%.

While these results are promising, there are several questions that must be addressed in order to assess the potential utility of sub-vocally generated signals for communication.

DARPA is soliciting proposals that offer a well-defined, scientific approach to answer these questions. Within the first twelve (12) months, the following questions must be answered, all of which are needed to characterize the nature of the sub-vocalic signal:

1) What is the physiological source of the subvocal signals?

2) How do the signals vary with speaker?

3) What are the sources of noise for this signal (e.g., swallowing, sensor placement), and how do they impact the signal-to-noise ratio (SNR)?

4) How does the signal vary with speaker state (e.g., stress, fatigue)?

5) What is the impact of acoustic noise on the signal? (presumably none, but this needs to be tested)

Within the second twelve (12) month period, the following questions must be answered in order to address the potential utility of the signal.

6) Are the signals distinguishable for words that are acoustically similar? (e.g., DRT word pairs)

7) Can the signals be differentiated at the phonemic level?

8) Can the signals be extracted from continuous speech?

9) What type of vocoding is most appropriate for these signals?

10) Do these signals contain sufficient information to encode continuous speech, or do they need to be augmented by other (nonvocal) signals?

Proposers should not interpret this parsing to mean that work on questions 6 –10 cannot be started during the first 12-month period. It is advisable that proposers think about how they will address all 10

questions, and lay out a detailed schedule that will allow them to achieve the answers to the first 5 questions within 12 months and the answers to the second 5 questions within 24 months.

Teaming is *strongly* encouraged. It is anticipated that teams will consist of experts in the physiology of laryngeal and sublingual myoelectric signals, novel sensors for the measurement of those signals, and algorithms for the extraction of robust, exploitable features from those signals. Proposals that lack such a teaming structure will *not* be favorably reviewed.

Total funding for this topic area is expected not to exceed $0.3M in FY04, $2.0M in FY05, and $2.0M in FY06.

Proposals to this topic area should be structured for an initial period of performance of 12 months. The period of performance for the first option will also be 12 months. If the answers to the above questions suggest that a sub-vocalic vocoder could be built, a separate program effort will begin.

2.2. PROGRAM METRICS DECISION CRITERIA

In order for the Government to evaluate the effectiveness of a proposed solution in achieving the stated program objectives, proposers should note that the Government hereby promulgates the following program metrics that may serve as the basis for determining whether satisfactory progress is being made to warrant continued funding of the program. Although the following program metrics are specified, proposers should note that the Government has identified these goals with the intention of bounding the scope of effort, while affording the maximum flexibility, creativity, and innovation in proposing solutions to the stated problem.

Milestone	Months After Program Kick-off	Ultra-Low Bit-Rate Coder	Sub-Auditory Speech Encoding
1	12	Demonstrate ≤ 1000 bps vocoder with intelligibility and quality in harsh noise environments that is at least as good as that of today's MELPe 2400 in harsh (> 110 dBC) military noise environments.	Characterize the signal: Answer questions 1 – 5 above
2	24	Demonstrate ≤ 300 bps vocoder with intelligibility, quality and aural speaker recognizability in harsh (> 110 dBC) military noise environments that is at least as good as that of today's MELPe 2400. Aural speaker recognition must achieve an equal error rate of < 5%.	Evaluate the utility of the signal: Answer questions 6-10 above
3	42	Demonstrate the capability for ultra-low-rate coding in a field demonstration of a prototype communications system.	N/A

2.2.1 Ultra-low-bit-rate Coder Thrust Area

Progress against the above milestones for the ultra-low-bit-rate coder will be assessed by Government-sponsored independent testing conducted by ARCON, Incorporated. The results of these tests will provide information for decisions on the exercise of options after the 12-month base period. The first test will be conducted approximately 12 months after award, and will measure quality and intelligibility of sub-kilobit coders in harsh military noise. It is anticipated that this test will be similar to that described for Advanced Speech Encoding Program Phase 1 in Appendix A. The second test will be conducted

approximately 24 months after award and will be similar to the 12-month test in that quality and intelligibility will be measured in harsh noise environments, but there will also be a subjective measurement of aural speaker recognizability at the output of the vocoder, also in harsh military noise environments. Aural speaker recognizability will be measured by a subjective test using listening panels[1]. The field tests will demonstrate the capability for ultra-low-bit-rate coding in the field and will address issues in field usage both in terms of algorithms and deployment. By submission of its proposal, a proposer agrees that information necessary to conduct these tests may be disclosed to employees of ARCON, Incorporated for the limited purpose stated above. ARCON will have signed and be subject to the terms and conditions of non-disclosure agreements.

At the end of 24 months, in addition to the program milestone, performers will be expected to have developed a prototype design and to have fully costed the prototype for Milestone 3 testing (see Sections 4.2.3.4 and 4.2.4.3 below).

In order to increase the likelihood that the above milestones will be met, three Progress Waypoints are outlined below. The intent of these waypoints is to provide a measure of progress toward meeting the program milestones so that the Program Manager can provide more effective guidance and assistance to performers. The Program Manager will use these waypoints to assess whether the program as a whole is on the right path or whether course correction is needed to ensure program success. Another benefit of the waypoints is to provide supporting data that can be used to demonstrate the coder improvements that are attributable to Advanced Speech Encoding Program technology.

It is anticipated that Government-sponsored waypoint testing at 6 mos and 18 mos will also be conducted at ARCON, Incorporated, but proposers are strongly encouraged to consider conducting their own subjective testing (e.g., DRT intelligibility tests, forced-choice paired comparison quality tests, speaker recognizability tests)[2,3,4] as part of their development process. Proposers are free to use these waypoints as a guide to constructing their own schedule and deliverables as discussed in Section 4.2 of this solicitation, but proposers should not feel limited by these waypoints. The intent is to provide guidance, not to inhibit innovation.

Advanced Speech Encoding Phase 2 Progress Waypoints for the Ultra-Low-Bit-rate Coder

Waypoint	Test/Data	Intent
6 month	Measure intelligibility and quality in quiet and in harsh noise environments for a small speaker set at ≤1000 bps	- Strike a development baseline - Determine development emphasis - Provide input on potential data collection requirements
12 month (in addition to the Program milestone)	In addition to intelligibility and quality (the 12-month milestone), coder delay and aural speaker recognizability will be measured at ≤1000 bps	- Strike a development baseline for 300 bps coder - Identify potential trades between bit-rate and coder delay - Identify potential trades between bit-rate and aural speaker recognizability
18 month	Measure intelligibility, quality, coder delay, and aural speaker recognizability in quiet and in harsh noise environments for a small speaker set at 600 bps	- Assess risk in scaling to 300 bps - Identify specific weaknesses

2.2.2 Sub-Auditory Speech Encoding Thrust Area

While Progress Waypoints are not being specified in this solicitation for this thrust area, proposers are

strongly encouraged to propose waypoints in concert with their required 6-month deliverables (See Sections 4.2.3.4 and 4.2.4.3 below).

3. GENERAL INFORMATION

3.1. ELIGIBILITY

To be eligible for award of a contract, a proposer must meet certain minimum standards pertaining to: financial resources, ability to comply with the performance schedule, prior record of performance, integrity, organization, experience, operational controls, technical skills, facilities, and equipment. (See FAR 9.104). Additionally, proposers proposing contracts must be registered in the Central Contractor Registration database IAW DFARS 204.73. Proposals from non-U.S. organizations will only be considered for those proposals that are unclassified. Non-U.S. citizens may only perform under proposals involving only unclassified work.

3.2. LIMITATIONS ON OTHER TRANSACTION AUTHORITY

Proposers are advised that an Other Transaction for Prototype Agreement will only be awarded if there is:

1. At least one nontraditional defense contractor participating to a significant extent in the prototype project, or
2. No nontraditional defense contractor is participating to a significant extent in the prototype project, but at least one of the following circumstances exists:
    a. At least one third of the total cost of the prototype project is to be paid out of funds provided by the parties to the transaction other than the federal Government. The cost share should generally consist of labor, materials, equipment, and facilities costs (including allocable indirect costs).
    b. Exceptional circumstances justify the use of a transaction that provides for innovative business arrangements or structures that would not be feasible or appropriate under a procurement contract.

Although use of one of these options is required to use an Other Transaction for Prototype agreement as the procurement vehicle, no single option is encouraged or desired over the others.

NOTE: For purposes of determining whether or not a participant may be classified as a nontraditional defense contractor and whether or not such participation is determined to be participating to a significant extent in the prototype project, the following definitions are applicable:

"Nontraditional defense contractor" means a business unit that has not, for a period of at least one year prior to the date of the OT agreement, entered into or performed on:

1. any contract that is subject to full coverage under the cost accounting standards prescribed pursuant to section 26 of the Office of Federal Procurement Policy Act (41 U.S.C. 422) and the regulations implementing such section; or

2. any other contract in excess of $500,000 to carry out prototype projects or to perform basic, applied, or advanced research projects for a Federal agency that is subject to the Federal Acquisition Regulation

"Participating to a significant extent in the prototype project" means that the nontraditional defense contractor is supplying a new key technology or product, is accomplishing a significant amount of the effort wherein the role played is more than a nominal or token role in the research effort, or in some other

way plays a significant part in causing a material reduction in the cost or schedule of the effort or an increase in performance of the prototype in question.

NOTE: Proposers are cautioned that if they are classified as a traditional defense contractor, and propose the use of an OT for Prototype Agreement, the Government will require submittal of both a cost proposal under the guidelines of the FAR/DFARS, and a cost proposal under the proposed OT for Prototype Agreement, so that an evaluation may be made with respect to the cost tradeoffs applicable under both situations. The Government reserves the right to negotiate either a FAR based procurement contract, or Other Transaction for Prototype Agreement as it deems is warranted under the circumstances.

3.3. PROCUREMENT INTEGRITY, STANDARDS OF CONDUCT, ETHICAL CONSIDERATIONS

Certain post-employment restrictions on former federal officers and employees may exist, including special Government employees (Section 207 of Title 18, United States Code). If a prospective proposer believes that a conflict of interest exists, the situation should be raised to the DARPA Contracting Officer specified in Section 1.6 (Instructions and Points of Contact) before time and effort is expended in preparing a proposal. All proposers and proposed sub-contractors must therefore affirm whether they are providing scientific, engineering, and technical assistance (SETA) or similar support to any DARPA technical office(s) through an active contract or subcontract. All affirmations must state which office(s) the proposer supports and identify the prime contract numbers. Affirmations shall be furnished at the time of proposal submission. All facts relevant to the existence or potential existence of organizational conflicts of interest (FAR 9.5.) must be disclosed. The disclosure shall include a description of the action the proposer has taken or proposes to take to avoid, neutralize, or mitigate such conflict.

3.4. INTELLECTUAL PROPERTY

3.4.1. Noncommercial Items: (Technical Data and Computer Software)

Proposers responding to this BAA shall identify all noncommercial technical data, and noncommercial computer software that it plans to generate, develop, and/or deliver under any proposed award instrument in which the Government will acquire less than unlimited rights, and to assert specific restrictions on those deliverables. Proposers shall follow the format under DFARS 252.227-7017 for this stated purpose. In the event that proposers do not submit the list, the Government will assume that it automatically has “government purposes rights” for a period of five (5) years from the date of award, to all noncommercial technical data and noncommercial computer software generated, developed, and/or delivered under any award instrument, unless otherwise agreed to by the parties. Additionally it is understood that such rights will convert automatically to “unlimited rights” after such five (5) year period, notwithstanding any period of performance extensions that may result after the award instrument is executed, unless otherwise agreed to by the parties. The Government may use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer’s assertions. If no restrictions are intended, then the proposer should state “NONE.”

A sample list for complying with this request is as follows:

NONCOMMERCIAL			
Technical Data Computer Software To be Furnished With Restrictions	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(LIST)	(LIST)	(LIST)

3.4.2. Commercial Items: (Technical Data and Computer Software)

Proposers responding to this BAA shall identify all commercial technical data, and commercial computer software that may be embedded in any noncommercial deliverables contemplated under the research effort, along with any applicable restrictions on the Government's use of such commercial technical data and/or commercial computer software. In the event that proposers do not submit the list, the Government will assume that there are no restrictions on the Government's use of such commercial items. The Government may use the list during the source selection evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer's assertions. If no restrictions are intended, then the proposer should state "NONE."

A sample list for complying with this request is as follows:

COMMERCIAL			
Technical Data Computer Software To be Furnished With Restrictions	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(LIST)	(LIST)	(LIST)

3.4.3. Proposal Marking and Handling/Freedom of Information Act Requests

The Government intends to comply with procurement integrity statutes and regulation and DFARS 252.227-7016 in its treatment of information submitted in response to this BAA solicitation and marked with the individual or company's legend. The proposer is cautioned, however, that portions of the proposal may be subject to release under terms of the Freedom of Information Act (FOIA), 5 U.S.C. 552, as amended. In accordance with FOIA regulations, the proposer will be afforded the opportunity to comment on, or object to, the release of proposal information.

3.5. REPORT REQUIREMENTS

The number and types of reports will be specified in the award document. The reports shall be prepared and submitted in accordance with the procedures contained in the award document and mutually agreed on before award. A Final Report that summarizes the project and tasks will be required at the conclusion of the performance period for the award, notwithstanding the fact that the research may be continued under a follow-on vehicle.

3.6. REQUIRED REVIEW AND INTERCHANGE MEETINGS

Awardees under this BAA will be required to present an overview of their proposed work at a Program Kick-off Meeting. In addition, attendance at biannual Principal Investigator Meetings will be required. It is expected that all key personnel will attend the Principal Investigator meetings. The purpose of these meetings is to facilitate an open exchange among the research teams. DARPA believes that this open interchange will result in a higher probability of success in achieving the overall program objectives. For costing purposes anticipate the first year to include a program kick off meeting to be held in Arlington, VA and a Program Review to be held on the west coast. Thereafter, anticipate one Program Review on the west coast and one Program Review on the east coast. It is anticipated that the duration of each meeting shall be approximately 2 days.

3.7. SUBCONTRACTING

Pursuant to Section 8(d) of the Small Business Act (15 U.S.C. 637(d)), it is the policy of the Government to enable small business and small disadvantaged business concerns to be considered fairly as subcontractors to contractors performing work or rendering services as prime contractors or subcontractors under Government contracts, and to assure that prime contractors and subcontractors carry out this policy. Each proposer who submits a contract proposal and includes subcontractors is required to submit a subcontracting plan IAW FAR 19.702(a)(1) and (2) should do so with their proposal. The plan format is outlined in FAR 19.704. Proposals including non-U.S. organizations will only be considered those proposals that are unclassified.

3.8. USE OF HUMAN SUBJECTS

Awardees under this BAA must comply with applicable provisions of national policies concerning research involving the use human subjects. The provisions include the Common Federal Policy for the Protection of Human Subjects codified by the Department of Health and Human Services at 45 CFR part 46 and implemented by the Department of Defense at 32 CFR part 219, as well as DoD Directive 3216.2.

4. PROPOSAL PREPARATION

This section is intended to provide information needed by the scientist/engineer preparing the proposal to prepare research proposals for submission. Both prospective principal investigators and business office personnel will find it useful. Organizations or individuals interested in submitting research proposals are encouraged to make preliminary inquiries on the general need for the type of research effort contemplated before expending extensive time and effort in preparing a detailed research proposal.

4.1. GENERAL GUIDANCE

All proposals submitted must follow the instructions in this Proposer Information Pamphlet (PIP) and include only the information requested to avoid delays in evaluation or disqualification. It is anticipated that within 30 days of completing the evaluation, proposers will be notified that: 1) its proposal has been accepted for negotiation, or 2) its proposal has not been accepted. Proposals not accepted will be destroyed; however, the original copy of non-accepted proposals will be retained and filed.

4.1.1. Restrictive Markings on Proposals

All proposals should clearly indicate limitations on the disclosure of their contents. Further, proposers should mark the specific information that requires limited disclosure, vice marking the entire document for limited disclosures. They may be marked as "Proprietary" or words to that effect. Markings like "Company Confidential" or other phrases that may be confused with national security classifications shall be avoided. Typical phrases used to indicate the proprietary nature of submitted documentation includes the following: “SOURCE SELECTION INFORMATION – See FAR 3.104”.

4.1.2. Proposal Format

Proposals must be in English. Five sets of the full proposal plus one set in electronic format shall be submitted to DARPA. Each submittal shall reference BAA04-35. These proposals shall be on single-sided pages, font no smaller than 12 point, and 1-inch margins left/right/top/bottom. A page is defined as being no larger than 8.5” x 11.0”; accordion-style fold-outs will be counted as multiple pages equivalent to the expanded size. Proposals shall be stapled or submitted in loose-leaf binder, not bound. Electronic copies shall be in a MS-Word, MS-Excel, or .pdf readable format either on a single 3.5 inch High Density MS-DOS formatted 1.44 Megabyte (MB) diskette, a single 100 or 250 MB Iomega Zip disk, or a CD-ROM.

4.1.3. Confidentiality

It is the policy of DARPA to treat all proposals as competitive information and to disclose their contents only for the purpose of evaluation. No proposals will be returned. The original of each proposal received will be retained at DARPA and all other copies destroyed.

4.1.4. Proposal Submission

This BAA shall remain open for one year from the date of publication on www.fedbizopps.gov and www.fedgrants.gov. Although the Government may select proposals for award at any time during this period, *it is anticipated that the funds that are currently available will be awarded during the first selection phase.* Proposers may submit a full proposal in accordance with the instruction provided herein at any time up to the proposal due date.

Proposals must be received by DARPA/ATO no later than **4:00pm Local Time, 01 SEP 2004** to be considered in the first selection phase. Proposals must be submitted to the DARPA/ATO mailing address identified in this BAA. Proposals must be submitted in hard copy, with one signed original and four copies, plus one electronic copy. Facsimile or electronic submissions will not be accepted.

Proposals submitted under this BAA may either be mailed or hand-delivered.

Mailing address: DARPA/ATO
ATTN: BAA04-35
3701 North Fairfax Drive
Arlington, VA 22203-1714

For hand deliveries, the courier shall deliver the package to the DARPA Visitor Control Center at the address specified above. The outer package, as well as the cover page of the proposal, must be marked "Advanced Speech Encoding Program Phase 2 BAA04-35."

Proposals received after the deadline will be handled in accordance with the provisions detailed in Appendix A.

4.2. VOLUME I - TECHNICAL AND MANAGEMENT PROPOSAL

The technical portion shall include an Executive Summary, a technical approach, description of relevant prior work, a program plan (including a statement of work), a facilities and equipment description, list of documentation and reports, and management plans. The statement of work should indicate the effort intended for the period of performance. All paragraphs containing proprietary information must be clearly marked.

4.2.1. Format

Volume I, Technical and Management Proposal, may include an attached bibliography of relevant technical papers or research notes (published and unpublished), which document the technical ideas and approach(s) upon which the proposal is based. Copies of not more than three (3) relevant papers can be included with the submission. The bibliography and attached papers are not included in the page counts given below. The submission of other supporting materials along with the proposal is strongly discouraged, and they will not be considered for review. Except for the attached bibliography and Table of Contents, Volume I shall not exceed fifty-two (52) pages if one work area is addressed in the proposal, and eighty-two (82) pages if both work areas are addressed in the proposal. Maximum page lengths for Sections A, B, C and D are shown in braces {} below. Maximum page limits for each subsection are also indicated in braces. Section A includes a Table of Contents, which has no page limit. Both work areas may be included within a proposal, but must be described in separate and clearly identified sections, as described below. Proposers must submit a signed original and four (4) hard copies of the proposals and

an electronic copy. All pages in excess of the specified page limit for each subsection may not be considered in the evaluation.

4.2.2. Section A – Administrative

Cover sheet to include: {1 page}

(1) BAA number.

(2) Lead Organization Submitting proposal.

(3) Type of business, selected among the following categories: "Large Business," "Small Disadvantaged Business," "Other Small Business," "HBCU," "MI," "Other Educational," or "Other Nonprofit."

(4) Contractor's reference number (if any).

(5) Other team members (if applicable) and type of business for each;

(6) Proposal title.

(7) Technical point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available).

(8) Administrative point of contact to include: salutation, last name, first name, street address, city, state, zip code, telephone, fax (if available), electronic mail (if available).

Official transmittal letter with original signature {1 page}

Table of Contents {no page limit}

4.2.3. Section B – Summary of the Proposal {5}

This section provides a brief overview of the proposed work. Further elaboration will be provided in Section C.

4.2.3.1. Executive Summary {1}

A title and an abstract that includes a concise statement of work and basic approaches to be used. This should be on a separate page and in a form suitable for release under the Freedom of Information Act, 5 U.S.C. 552, as amended.

4.2.3.2. Summary Of Innovative Claims For The Proposed Research {1}

This subsection should succinctly describe the uniqueness and benefits of the proposed approach relative to the current state-of-art and alternative approaches.

4.2.3.3. Summary of Technical Approach {1}

The technical rationale, technical approach, and constructive plan for accomplishments of technical goals in support of innovative claims and deliverable production should be summarized.

4.2.3.4. Summary of Deliverables {1}

Products, transferable technology, and deliverables associated with the proposed research should be summarized. Deliverables should be defined that show progress toward achieving the stated Program Metrics Decision Criteria. Deliverables should be specified at 6-month intervals.

For the Ultra-low-bit-rate speech encoding thrust area, a Milestone 3 prototype design and a fully developed cost proposal for this prototype is a required deliverable, to be delivered no later than 24 months after contract award.

4.2.3.5. Summary of Cost, Schedule, and Milestones {1}

Summarize, in table form, cost, schedule, and milestones for the proposed research, including estimates

of cost for each deliverable and total cost.

4.2.4. Section C — Detailed Technical Summary {30}

This section provides the detailed discussion of the proposed work necessary to enable an in-depth review of the specific technical and managerial issues. Specific attention must be given to addressing both risk and benefit of the proposed work that make it desirable to DARPA.

Each Topic Area (as listed in section 2.1.2) that is being addressed in the proposal is provided a separate Section C with the following required subsections and page counts.

4.2.4.1. Statement of Work {3}

Statement of Work (SOW) written in plain English, outlining the scope of the effort and citing specific tasks to be performed and specific proposer requirements.

4.2.4.2. Summary of Technical Approach {12}

The description of the technical approach should describe the objectives, scientific relevance, technical approach, and expected significance of the work. The key elements of the project should be clearly identified and related to each other. The methods or approaches to be used should be described in detail. The anticipated results should be identified and their relation to the proposal's stated objectives and the objectives of the Advanced Speech Encoding Program Phase 2 should be discussed.

4.2.4.3. Detailed Description of Deliverables {4}

Products, transferable technology, and deliverables associated with the proposed research should be described. Well thought-out deliverables that define a clear path toward program milestones are strongly encouraged as the Government anticipates that this will be a very important element of the proposal. Deliverables will be specified at 6-month intervals. As noted above, for the ultra-low-bit-rate speech encoding thrust area, a Milestone 3 prototype design and a fully developed cost proposal for this prototype is a required deliverable, to be delivered no later than 24 months after contract award.

4.2.4.4. Summary of Approach to Intellectual Property {2}

Describe proposed approach to intellectual property rights, together with supporting rationale of why this approach offers the best value to the Government. This section should list technical data, computer software, or computer software documentation associated with this research effort in which the Government will acquire less than unlimited rights. See Sections 3.4.1, 3.4.2, and 3.4.3 for additional information and specific instructions.

4.2.4.5. Related Research {3}

Compare the proposed effort with other ongoing research in this area. Describe the advantages and disadvantages of the proposed effort in comparison with other relevant research.

4.2.4.6. Previous Accomplishments {3}

Discuss the proposer's previous accomplishments and work in this or closely related research areas.

4.2.4.7. Facilities {3}

Describe the facilities that would be used for the proposed effort for the work area (including experimental resources). Facilities and equipment that are available for conducting experiments in harsh military noise environments (Sound Pressure Level > 113 dBC) are of interest.

4.2.5. Section D — Other Proposal Common Information {15}

This section contains information common to the proposal as a whole. There should be one Section D per proposal.

4.2.5.1. Management Plan {12}

The Management Plan should define both the organizations and the individuals within those organizations that make up the team, including expected duties, relevant capabilities and task responsibilities of team members, and expected relationships among members. Expected levels of effort (percentage time or fraction of an FTE) for all key personnel should be clearly noted. A description of the technical, administrative, and business structure of the team and the internal communications plan should be included. Project/function/subcontractor relationships, Government research interfaces, and planning, scheduling, and control practices should be described. The team leadership structure should be clearly defined.

Provide a brief biography of the key personnel (including alternates, if desired) who will be involved in the research along with the amount of effort to be expended by each person during the year. Documentation of previous work or experience in the field of the proposer is especially important.

Indicate if the team organization has had prior Governmental contracting experience, and the extent of that experience.

Detailed support enhancing this section including formal teaming arrangements required to execute this program should be provided.

4.2.5.2. Resource Share {1}

The type of support, if any, the proposer might request from the Government, such as facilities, equipment, or materials, or any such resources the proposer is willing to provide at no additional cost to the Government to support the research effort. Cost sharing is not required from proposers and is not an evaluation criterion, but is encouraged where there is a reasonable probability of a potential commercial application related to the proposed research and development effort.

4.2.5.3. Agency Involvement {1}

The names of other federal, state, or local agencies or other parties receiving the proposal and/or funding the proposed effort. If none, so state.

4.2.5.4. Environmental {1}

A statement regarding possible impact, if any, of the proposal's affect on the environment IAW applicable statutory and regulatory guidance.

4.2.6. Section E – Additional Information

A brief bibliography of relevant technical papers and research notes (published or unpublished) which documents the technical ideas upon which the proposal is based. Copies of not more than three (3) relevant papers may be included in the submission.

4.3. VOLUME II – FINANCIAL/CONTRACTUAL {NO PAGE LIMIT}

4.3.1. Cover sheet

A cover sheet to include:

(1) Name and address of proposer (*include zip code).*

(2) Name, title, telephone number, fax number, email of proposer’s point of contact.

(3) Award instrument desired – grant, cooperative agreement, procurement contract and type (i.e. Firm Fixed Price, Cost-Plus-Fixed-Fee (CPFF) contract, or other contract type), technology investment agreement, other transaction for prototype, or other (*specify)*.

(4) Place(s) and period(s) of performance.

(5) Total proposed cost separated by basic award and option(s) (if any).

(6) Name, address, telephone number, fax number, email of the proposer's cognizant Defense Contract Management Agency (DCMA) or other administration office (i.e. Office of Naval Research) *(if known)*.

(7) Name, address, telephone number, fax number, email of the proposer's cognizant Defense Contract Audit Agency (DCAA) or other audit office (i.e. Dept of Health and Human Services) *(if known)*.

(8) Contractor and Government Entity (Cage) Code *(if known)*.

(10) Dun and Bradstreet (DUN) number *(if known)*.

(11) North American Industrial Classification System (NAICS) Number *(if known)*.

(12) Taxpayer Identification Number (TIN) *(if known)*.

(13) Verification that the proposer is registered in the Central Contractor Registration (CCR) System in order to do business with the federal Government *(as required)*

4.3.2. Detailed Cost Breakdown

A detailed cost breakdown to include:

1) Total program cost broken down by Government fiscal year (GFY) [Note: Government Fiscal Year runs from October 1st to September 30th] and program cost broken down by the Base Effort and proposed Options. These costs should be further broken down by major cost element (i.e. direct labor, subcontracts, materials, travel, other direct costs, overhead charges, etc.).
2) Costs of major program tasks by year and month;
3) An itemization of major subcontracts (labor, travel, materials and other direct costs) and equipment purchases;
4) A summary of projected funding requirements by month; and
5) The source, nature, and amount of any industry cost sharing, if applicable. Where the effort consists of multiple phases that could reasonably be partitioned for purposes of funding, these should be identified as options with separate cost estimates for each.

Supporting cost and pricing information in sufficient detail to substantiate the summary cost estimates above. Include a description of the method used to estimate costs and supporting documentation. Provide the basis of estimate for all proposed labor rates, indirect costs, overhead costs, other direct costs and materials, and escalation charges as applicable. *Key personnel must be listed by name for the prime and all subcontractors and/or consultants proposed*.

5. PROPOSAL EVALUATION

5.1. EVALUATION CRITERIA

The criteria to be used to evaluate and select proposals for this project are described in the following paragraphs. Each proposal will be evaluated on the merit and relevance of the specific proposal as it relates to the program rather than against other proposals for research in the same general area as no common work statement exists. Agency evaluators will evaluate proposals submitted against this BAA in accordance with the following six (6) criteria: 1) Proposer's Understanding of the Problem and Scope of Technical Effort, 2) Relevance to DARPA Mission, 3) Soundness of Proposer's Technical and Management Approach, Including Teaming, 4) Relevant Experience, 5) Schedule, and 6) Cost Realism. Agency evaluators will consider criteria 1, 2, and 3 (Proposer's Understanding of the Problem and Scope

of the Technical Effort, Relevance to DARPA Mission, and Soundness of Proposer's Technical and Management Approach, Including Teaming) as more important than the remaining criteria, 4, 5, and 6 (Relevant Experience, Schedule, and Cost Realism). Criteria 1, 2, and 3 are weighted in descending order of importance. Criteria 4, 5, and 6 are equally weighted. In accordance with FAR 35.016(e) the primary basis for selecting proposals for award shall be technical, importance to agency programs, and funds availability.

5.1.1. Proposer's Understanding of the Problem and Scope of Technical Effort

Problem Understanding and Scope of Technical Effort. The proposed technical approach is feasible, achievable, complete and supported by a proposed technical team that has the expertise and experience to accomplish the proposed tasks. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed deliverables clearly defined such that a final product that achieves the goal can be expected as a result of award. The proposal identifies major technical risks and planned mitigation efforts are clearly defined and feasible.

5.1.2. Relevance to DARPA Mission

The proposed solution meets the letter and intent of the stated goals and all elements within the proposal exhibit a comprehensive understanding of the problem. The proposer clearly addresses how the proposed effort will meet and progressively demonstrate the goals of the Advanced Speech Program. The proposed solution meets multiple DARPA or user needs and is conclusive with compliance and justification of required elements in the solicitation.

5.1.3. Soundness of Proposer's Technical and Management Approach, Including Teaming

The roles of the prime and other participants required are clearly distinguished and pre-coordination with all participants (including Government facilities) fully documented. Management plans must demonstrate: superior Government visibility into and interaction with key technical activities and personnel; and, single point of responsibility for contract performances. The requirement for and the anticipated use or integration of Government Furnished Property (GFP) including all equipment, facilities, information, etc. is fully described including dates when such GFP, GFE, GFI or other such Government provided resources will be required. Intellectual property ownership and the planned transition to production are adequately addressed, including a support concept for product described.

5.1.4. Relevant Experience

The proposer's prior experience in similar efforts must clearly demonstrate an ability to deliver products that meet the proposed technical performance within the proposed budget and schedule. The proposed team has the expertise to manage the cost and schedule. Similar efforts completed/ongoing by the proposer in this area are fully described including identification of other Government sponsors.

5.1.5. Schedule

The respondent clearly addresses how the proposed effort will meet and progressively demonstrate the goals of the Advanced Speech Encoding Program. The proposed schedule is complete and achievable. The proposal indicates that the proposer has fully analyzed the project's critical path and has addressed the resulting schedule risks.

5.1.6. Cost Realism

The proposed costs are reasonable, realistic, and affordable for the work proposed. Estimates are

"realistic" when they are neither excessive nor insufficient for the effort to be accomplished. The proposal documents all anticipated costs including those of associate, participating organizations. The proposal demonstrates that the respondent has fully analyzed budget requirements and addressed resulting cost risks. All cost-sharing and leveraging opportunities have been explored and identified. Other sponsors who have funded or are funding this proposer for the same or similar efforts are identified. The Government shall evaluate how well all cost data is traceable and reconcilable.

6.0 SECURITY INFORMATION

NOTE: As previously specified, the Government anticipates that proposals submitted under this BAA will be unclassified. In the event that a proposer chooses to submit a classified proposal, however, or submit any documentation that may be classified, the following information is applicable.

For guidance, questions, or other related matters related to Security, contract Mr. Gene McGoldrick, Email: emcgoldrick@darpa.mil

If you choose to submit a classified proposal you must first receive permission of the Original Classification Authority (OCA) to use their information in replying to this BAA and submit the applicable OCA classification guide(s) to ensure that the proposal is protected appropriately.

Classified submissions shall be in accordance with the following guidance:

Collateral Classified Data: Use classification and marking guidance provided by previously issued security classification guides, the Information Security Regulation (DoD 5200.1-R), and the National Industrial Security Program Operating Manual (DoD 5220.22-M) when marking and transmitting information previously classified by another original classification authority. Classified information at the Confidential and Secret level may only be mailed via U.S. Postal Service (USPS) Registered Mail or U.S. Postal Service Express Mail (USPS only; not DHL, UPS or FedEx). All classified information will be enclosed in opaque inner and outer covers and double wrapped. The inner envelope shall be sealed and plainly marked with the assigned classification and addresses of both sender and addressee. The inner envelope shall be addressed to:

Defense Advanced Research Projects Agency (DARPA)

ATTN: BAA04-35, DARPA/ATO, Program Manager's Name

3701 North Fairfax Drive, Suite 832

Arlington, VA 22203-1714

The outer envelope shall be sealed with no identification as to the classification of its contents and addressed to:

Defense Advanced Research Projects Agency (DARPA)

Security & Intelligence Directorate, Attn: CDR

3701 North Fairfax Drive, Suite 832

Arlington, VA 22203-1714

All Top Secret materials should be hand carried via an authorized, two-person courier team to the DARPA CDR.

Special Access Program (SAP) Information: Contact the DARPA Program Security Support Center (PSSC) at 703-812-1962/1970 for further guidance and instructions prior to transmitting to DARPA. All Top Secret SAP, must be transmitted via approved methods for such material. Consult the DoD Overprint to the National Industrial Security Program Operating Manual for further guidance. It is strongly recommended that you coordinate the transmission of SAP material and information with the DARPA PSSC prior to transmission.

Sensitive Compartmented Information (SCI) Data: Contact the DARPA Special Security Contact Office

(SSCO) at 703-812-1993/1994 for the correct SCI courier address and instructions. All SCI should be transmitted through your servicing Special Security Officer (SSO) / Special Security Contact Officer (SSCO). All SCI data must be transmitted through your servicing Special Security Officer (SSO) / Special Security Contact Officer (SSCO). All SCI data must be transmitted through SCI channels only (i.e., approved SCI Facility to SCI facility via secure fax).

Proposers must have existing and in-place prior to execution of an award, approved capabilities (personnel and facilities) to perform research and development at the classification level they propose.

APPENDIX A: ASE PHASE 1 DETAILS

The Advanced Speech Encoding Program Phase 1 focused on both novel sensor development and algorithm development. A summary is provided below, followed by a detailed description of the key results.

Novel sensors:

In the late 1990's, Lawrence Livermore National Laboratory (LLNL) demonstrated that a very low-power homodyne RF sensor (vibrometer) is capable of measuring physical phenomena directly related to the glottal excitation associated with speech production. LLNL recognized that this technology could play a critical role in coding speech. A series of papers describing the initial work done in speech coding using the vibrometer are available at the Universal Resource Locator http://speech.llnl.gov. The exact physiological phenomenon measured by this vibrometer is still a matter of some debate, but the evidence indicates that the signal is due either to the motion of the vocal folds or the motion of the tracheal wall. What is known is that this sensor is capable of precisely estimating both voicing activity (for voiced speech) and pitch. A commercialized variant of this sensor, the Aliph Radio Vibrometer (ARV, formerly the General Electromagnetic Motion Sensor or GEMS, www.aliph.com) was a focus of the Advanced Speech Encoding Program Phase 1 effort.

Additional noise-immune sensors – bone conduction microphones and physiological microphones – also provide noise immunity. Both of these sensor types were studied as part of multi-sensor packages that included the ARV. The physiological microphone is a Commercial-Off-The-Shelf product that has medical applications. Devices for this application were originally developed to monitor the physiology of soldiers in the field (http://www.arl.army.mil/sedd/acoustics//michael_scanlon.htm). Commercially available devices (http://www.biopac.com/AppNotes/app153promicr/promicr.html) use a piezo-electric sensor and have a useful frequency response of 35-3500 Hertz, making them suitable for speech applications. Bone conduction devices have been in use for some time. The bone conduction sensor studied in the Advanced Speech Encoding Program Phase 1 is a resident sensor in the Modular Integrated Communications Helmet (MICH) used by Operations Special Forces.

Algorithm Development:

Research in algorithm development focused primarily on noise suppression and had three main thrusts:

1. Improve coding by providing better parametric information such as pitch and voicing information to a standard linear-predictor coder

2. Improve performance by using the sensors in combination with various noise-suppression algorithms to remove the noise from the waveform before it is encoded, and

3. Merge the output of the sensors at the time series or spectral level and code the merged signal.

All three strategies were shown to provide enhanced quality and intelligibility when coupled to a MELPe or improved MELP (MELP-I) coder.

Relatively little coding work was performed. One of the coders tested was the MELP-I coder, a research coder developed at the Georgia Institute of Technology. The MELP-I coder is compatible with MELPe, but may improve performance because it uses a variable (pitch-synchronous) analysis window. A second approach attempted to achieve some bit-rate reduction by compressing line spectral pair temporal trajectories over a coder "super-frame". The hypothesis is that a low-order parametric model for these trajectories can be used, resulting in significant data compression at the cost of some delay. This was demonstrated in the concluding test, as shown below.

Advanced Speech Encoding Program Phase 1 Test Results

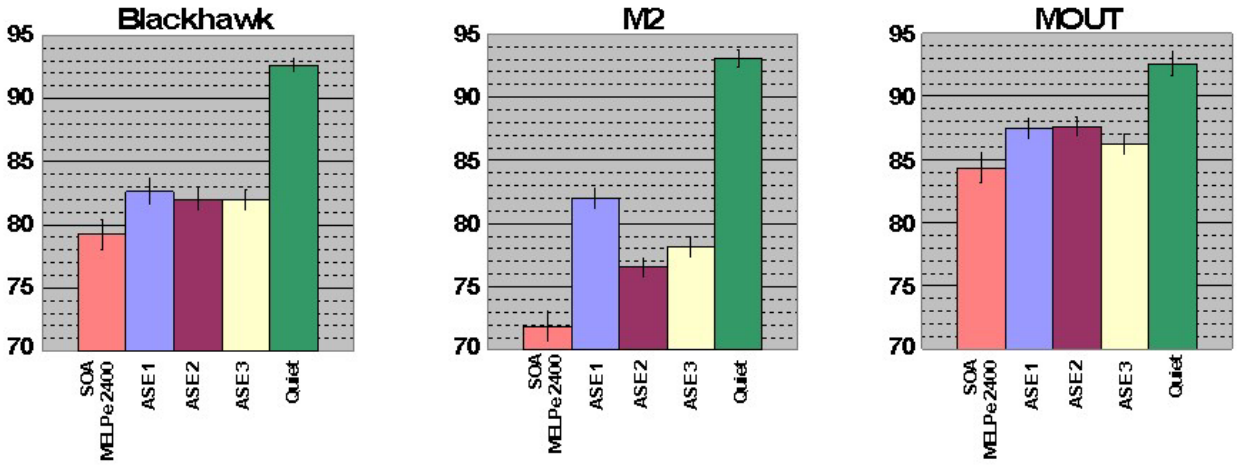
The first phase of the Advanced Speech Encoding Program was configured to provide test data using perceptual metrics that are meaningful for speech applications. Therefore, all testing was done using the most generally accepted and valid perceptual measures. Intelligibility was measured using the

Diagnostic Rhyme Test (DRT), which has been used by the DDVPC for more than a decade and is currently a NATO test for intelligibility. Speech quality was measured using a forced-choice test to compare quality with the DoD standard Code Excited Linear Prediction (CELP) 4800 bits per second (bps) vocoder.

The intelligibility results for the Advanced Speech Encoding Program Phase 1 are summarized in the figure below. The noise environments were Blackhawk helicopter noise at 110 dBC, M2 Bradley fighting vehicle noise at 114 dBC and Military Operations in Urban Terrain (MOUT) noise at 113 dBC (during impulse noise segments only).

We denote different approaches by different performers as ASE 1, ASE 2, and ASE 3. The ASE 1 system used a sensor suite consisting of dual microphones and the ARV vibrometer. The microphone system was used for noise suppression and signal enhancement. The ARV signal was used both for voice activity detection (used in noise suppression and in coding) and for improved pitch estimation in the MELPe coder. For the ASE 2 system, the microphone signal was adaptively filtered based on the output of a phonemic segmentation. Then, for the very low frequencies, a filtered and time aligned version of the p-mic output was substituted for the microphone output. The resulting composite output, up to a mid frequency cutoff, was filtered using an adaptive filter that correlated ARV output with the composite output. The ARV filtered signal and the filtered microphone signal were then adaptively combined to provide the best restoration of harmonic signal content. The higher frequencies were filtered using phonemic segmentation and a phoneme-adaptive filter bank. The ASE 2 coder was an improved version of the MELP coder, incorporating pitch synchronous enhancements including circular linear prediction (CLP) and the constant pitch transform (CPT). The ASE 3 system used spectral substitution (fusion) - a noisy sub-band of the speech signal was replaced by an equivalent output from a physiological microphone (p-mic) or bone conduction device. In addition, some bit-rate reduction was achieved by coding the time evolution of line spectral pairs, pitch and gain parameters using low-order polynomials in a “super-frame” coding scheme. The ASE 3 coder operated at 1533 bps.

Improvements in all three environments were demonstrated; most notable are the improvements in the M2 environment, where ASE 1 showed a ten point DRT score improvement over MELPe 2400. These are significant intelligibility enhancements, and validate the Advanced Speech Encoding Program approach. The results below are the first test of the ASE-developed systems (conducted in March 2004); subsequent work strongly suggests that more intelligibility improvement is available.



The results of the forced-choice testing are given below. The values presented are the percent preference of the participant vocoder over CELP for binary forced choice decisions averaged over multiple talkers and listeners. For the ASE 1 system, significant improvement in quality of over the CELP 4800 bps coder was demonstrated at 2400 bps, and moderate improvement was demonstrated at 1200 bps. The ASE3 system, at 1500 bps, also showed moderate improvement over the CELP 4800 bps coder.

Pair Comparison Results Percent Preference for Participant over CELP			
Environment	ASE 1 (2400 bps)	ASE 1 (1200 bps)	ASE 3 (1500 bps)
M2	74.31%	70.49%	62.85%
Blackhawk	70.83%	60.76%	65.63%
MOUT	62.33%	54.86%	51.91%

These results provide the technical basis for proceeding to the second phase of the program.

---

[1] Schmidt-Neilsen, A., and Crystal, T., *Human Vs. Machine Speaker Identification with Telephone Speech,* The 5th International Conference on Spoken Language Processsing, ICSLP-98, Australian Speech Science and Technology Association Incorporated, Sydney, Australia, Dec, 1998.

[2] Schmidt-Nielsen, A. and Brock, D., *Speaker Recognizability Testing for Voice Coders* IEEE Proc. ICASSP'96, V2 pp 1149-1152, 1996.

[3] *IEEE Recommended Practice for Speech Quality Measurements*, IEEE Trans. on Audio and Electro-acoustics, Volume 17, Issue 3, pp 225-246, 1969.; ANSI S3.2-1989 (R1999), Method for Measuring the Intelligibility of Speech over Communications Systems

[4] http://www.meyersound.com/support/papers/speech/section3.htm