



Broad Agency Announcement
Data Protection in Virtual Environments (DPRIVE)
Microsystems Technology Office
HR001120S0032
February 27, 2020

FOREWORD

In June 2017, DARPA announced the Electronics Resurgence Initiative (ERI) as a bold response to several critical emerging trends. Among them, the cost and complexity of advanced microelectronics design and manufacture has increased rapidly, challenging Gordon Moore’s economic premise that future machines would require lower costs and shorter turnaround times. For the first time, the defense community faces few or no options for accessing leading-edge electronics, the result of cost-driven foundry consolidation. Meanwhile, non-market foreign forces are working to shift the electronics innovation engine overseas, challenging U.S. economic and security advantages. In addition, the nation is gaining a new appreciation for electronics security—a longtime defense concern—following publicized challenges to our digital backbone in sectors as diverse as automotive, cybersecurity, and voting. ERI envisioned a unified national response marked by research collaborations between DARPA, the defense community, academia, and the commercial sector.

There is significant historical precedent to suggest the viability of this approach; each wave of modern electronics development has benefitted from the combination of defense-funded academic research and commercial sector investment. In the 1980s, when geometric scaling started to make low-volume integrated circuit fabrication unaffordable, DARPA’s investment in the Metal Oxide Silicon Implementation Service (MOSIS) opened the door to rapid, low-cost chip manufacture, laying the foundation for the nation’s world-leading fabless design industry. In the 1990’s, a combination of defense, academic, and commercial partners pioneered 193 nm lithography, which became the industry-critical fabrication process. Then, as Dennard scaling ended in the 2000’s, the semiconductor industry adopted Fin Field Effect Transistors (FinFETs), another DARPA-funded innovation that drove to low power computing and led to the era of 3D devices.

The nation now stands ready to innovate a 4th wave of electronics progress. The state of the industry indicates that the 4th wave will be defined by three-dimensional heterogeneous integration. Through integration, innovators will add new materials and devices to the silicon foundation and enable intelligence and specialized functions precisely designed to meet the diversifying needs of the commercial and defense sectors. 3D heterogeneous integration will also demand new architectures and design tools, developed to manage the complexity of working in three dimensions while enabling rapid system upgrades and integrating security as a primary design concern. These areas—3D heterogeneous integration, new materials and devices, specialized functions, and design and security—have been central to ERI since its inception and will continue to guide the initiative as it enters its third year.

The 4th wave of electronics progress, however, is neither inevitable nor inevitably beneficial to the United States. As a community, the collective challenge faced by DARPA and its ERI partners will be to ensure that benefits differentially accrue to the U.S. commercial and defense base, which is aggressively investing in continued progress. To meet our national security needs, 4th wave technologies must enable more capable systems that process data locally, extract actionable information, and make decisions at “the edge”. To address new security concerns, 4th wave technologies must integrate security considerations into microsystem design in a way that

is both effective and easy to implement. To address the rapid rise of devices operating at the edge, the glut of information those devices will collect, and the growing cyber-driven threats those devices will encounter, 4th wave technologies must find ready adoption by the commercial and defense sectors. New and existing ERI programs will therefore increasingly address the challenge of transitioning 4th wave technologies to the domestic sectors that need them.

Together with the ongoing ERI programs, the program addressed in this Broad Agency Announcement (BAA) will continue to provide a foundational contribution both to U.S. national security and to the needs and ambitions of the domestic commercial sector. DARPA seeks to receive proposals from entities that can help to achieve this goal. For reference, an updated list of ERI programs, solicitations, and events is available via <https://www.darpa.mil/work-with-us/electronics-resurgence-initiative>.

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PART I: OVERVIEW INFORMATION

- **Federal Agency Name:** Defense Advanced Research Projects Agency (DARPA), Microsystems Technology Office (MTO)
- **Funding Opportunity Title:** Data Protection in Virtual Environments (DPRIVE)
- **Announcement Type:** Initial Announcement
- **Funding Opportunity Number:** HR001120S0032
- **Catalog of Federal Domestic Assistance Numbers (CFDA):** Not applicable
- **Dates:** (All times listed herein are Eastern Time)
 - Posting Date: February 27, 2020
 - Proposers Day: March 2, 2020
 - Abstract Due Date: March 23, 2020
 - FAQ Submission Deadline: May 16, 2020
 - Proposal Due Date: June 2, 2020
 - Estimated period of performance start: November 2020
- **Concise description of the funding opportunity:** DARPA is soliciting innovative research and development to reduce the computation run time of fully homomorphic encrypted computation through hardware acceleration. The goal of the DPRIVE program is to enable fully homomorphic encrypted computation to within one order of magnitude of the compute time of current unencrypted computation.
- **Anticipated Funding Available for Award:** Total award funding is expected to be \$33M.
- **Anticipated individual awards:** Multiple awards are anticipated.
- **Anticipated funding type:** 6.2
- **Types of instruments that may be awarded:** Procurement contract or other transaction
- **Agency contact:**
 - Dr. Tom Rondeau, Program Manager
BAA Coordinator: DPRIVE@darpa.mil
DARPA/MTO
ATTN: HR001120S0032
675 North Randolph Street
Arlington, VA 22203-2114

PART II: FULL TEXT OF ANNOUNCEMENT

I. Funding Opportunity Description

The Defense Advanced Research Projects Agency (DARPA) often selects its research efforts through the Broad Agency Announcement (BAA) process. This BAA is being issued, and any resultant selection will be made, using either the procedures under Federal Acquisition Regulation (FAR) 6.102(d)(2) and 35.016 and 2 C.F.R. § 200.203 or Other Transactions (OT). Any negotiations and/or awards will use procedures under FAR 15.4, Contract Pricing, or OT as applicable. Proposals received as a result of this BAA shall be evaluated in accordance with evaluation criteria specified herein through a scientific review process.

DARPA BAAs are posted on the Beta SAM website, under the Contract Opportunities (FBO) link, at <https://beta.sam.gov/>. The following information is for those wishing to respond to the BAA.

The Microsystems Technology Office at DARPA seeks innovative proposals in the research, design, and implementation of fully homomorphic encryption (FHE) processing hardware that enables FHE computation at time scales that are within an order of magnitude of unencrypted computation on conventional CPU-based computing platforms. DPRIVE will enable the use of fully homomorphic encryption to protect data during computation as well as during storage and transmission. The outcome of DPRIVE will be a fabricated chip and supporting hardware/software that realizes the goals of the program. The program will have a single technical area. BAA submissions must fully address all technical challenges discussed below. Proposals that do not address all technical challenges will be considered non-conforming. Proposed research should investigate innovative approaches that enable revolutionary advances in science, devices, or systems. Specifically excluded is research that primarily results in evolutionary improvements to the existing state of practice. Given the anticipated challenges of the DPRIVE program, multidisciplinary teams with grounded experience in the mathematics of FHE, embedded software systems, and unconventional VLSI hardware design are encouraged to submit proposals.

A. Background

Current art in cryptographic solutions, such as Advanced Encryption Standards (AES), provide security of data while it is in transit across a network or at rest while in storage. Computations that manipulate data in useful ways (i.e., transaction processing, analytics, machine learning, etc.) require the data to be decrypted. Such decryption exposes the data to local processes and other vulnerabilities, e.g., zero-day attacks. Current encryption therefore does not allow full data protection.

A known solution to this problem is fully homomorphic encryption, which enables computation on ciphertext (encrypted data) rather than plaintext (unencrypted data). The key enabling concept of FHE is lattice cryptography, which presents complex mathematical challenges to the adversary that, without knowledge of the secret structure (i.e., the key), are well beyond the capability of current technology including theoretical quantum computers to solve. Critically,

lattice encryption enables mathematical operations that work directly on the ciphertext; these same operations applied to the underlying plaintext produce the same numerical result, thereby enabling secure computation.

The FHE concept is illustrated in Figure 1, where it is compared to traditional encryption.

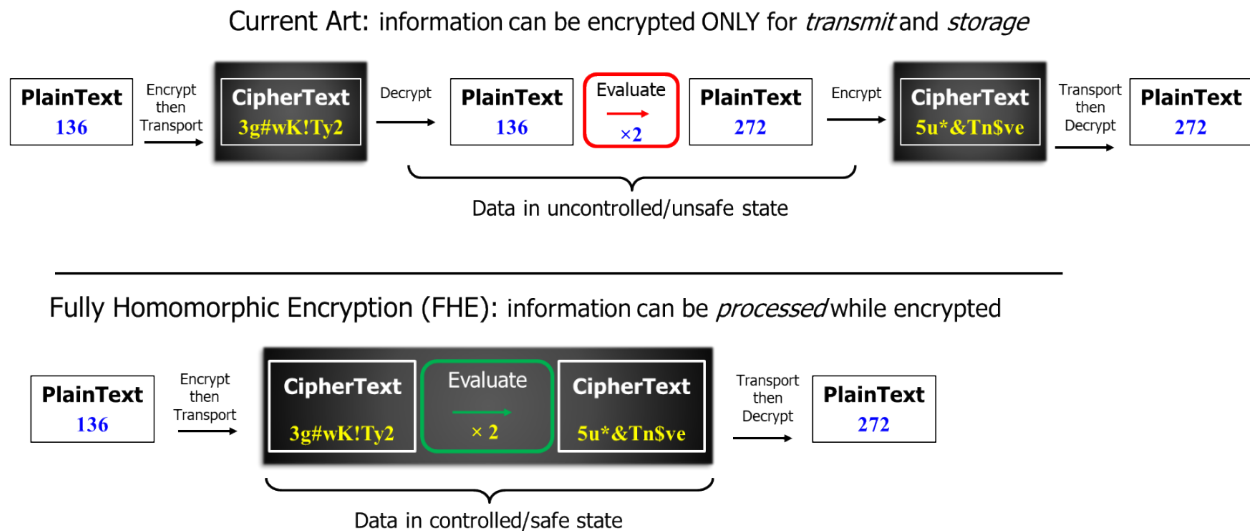


Figure 1: Current “secure” computation versus FHE computation

Intrinsic to lattice encryption is an unavoidable accumulation of noise with every computation. Noise accumulation rapidly rises above a threshold where recovery of the underlying plaintext becomes impossible. The “bootstrapping” innovation reduces accumulated noise down to a level comparable to the original ciphertext but produces orders of magnitude more overhead in the computations (bootstrapping is further discussed in the Program Description below).

The increase in FHE’s computation overhead arises from the explosion in the number of computations which must take place, the size of the data vectors used in each computation, and limitations in current processing hardware due to inherent restrictions in architecture and data representation. A single bootstrapping operation in FHE can require numerous multiply and modulo operations of data with word sizes of 1000s of bits.

Word size directly relates to the signal-to-noise ratio (SNR) of how a ciphertext is stored and manipulated in computation. Recent studies demonstrate that using large arithmetic word size (LAWS) increases SNR in the FHE computations. Larger SNR results in reduced accumulation of noise at each compute step and reduced overhead burden from costly operations such as bootstrapping. Figure 2 illustrates the potential reduction in FHE compute runtime by moving to a LAWS data representation.

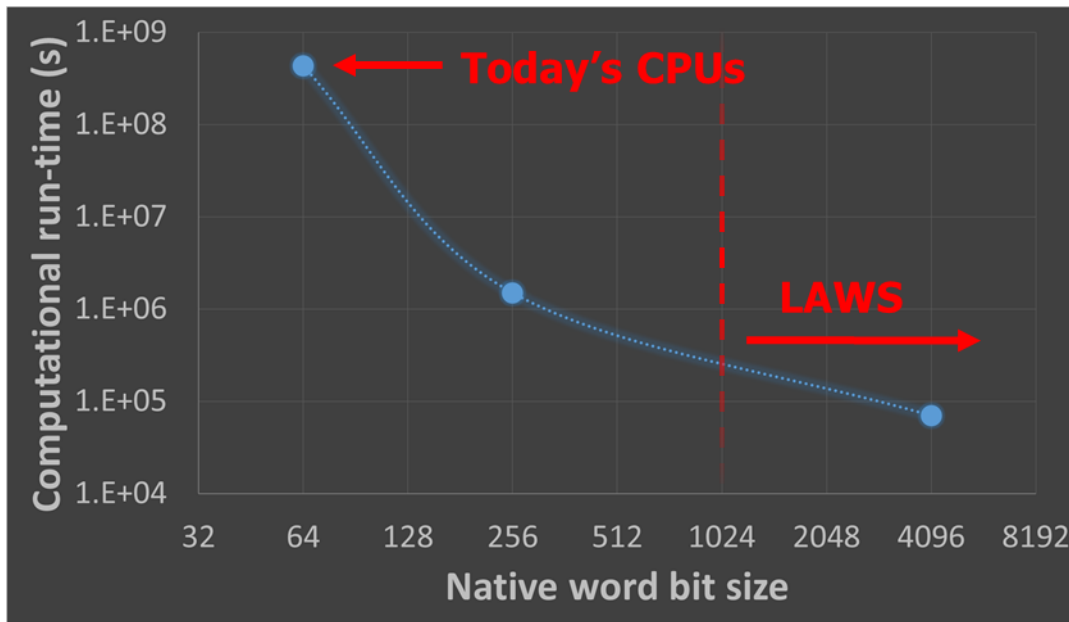


Figure 2: Word size directly relates to computational noise and how ciphertext is stored and manipulated.¹

Current processor architectures are based on data representation of 64 bits or less. Virtualization of larger bit word sizes are possible, but ultimately when processed through an arithmetic logic unit (ALU), the data is reduced to native architecture word size of 64 bits or less. The DPRIVE program seeks to build a hardware accelerator that can realize the potential reduction on compute time for FHE by natively processing on LAWS operands of 1024 bits or more. Developing a hardware accelerator to natively process LAWS operations introduces challenges and opportunities for additional gains in compute runtime through memory management and flexible data structure, as detailed below in the Program Description.

B. Program Description

The DPRIVE program will develop a hardware accelerator for FHE that reduces computational run-time overhead by many orders of magnitude compared to software-based FHE computations on conventional CPUs. FHE enables operation on data in the encrypted state, providing a much higher degree of security as compared to conventional encryption methods where decryption is required to operate on the data. Implementation of FHE is currently impractical due to the enormous computation time required to perform even simple operations. Through new insights into computational structures that minimize the effects of an FHE processing procedure known as *bootstrapping*², DPRIVE will speed up FHE calculations to within one order of magnitude of the current CPU performance of computations on unencrypted data, making FHE practical and more widespread for many applications (Figure 3).

¹ Analysis performed by Kurt Rohloff (NJ Institute of Technology), DARPA Young Faculty Awardee.

² Craig Gentry. "Fully Homomorphic Encryption Using Ideal Lattices," *41st ACM Symposium on Theory of Computing (STOC)*, 2009.

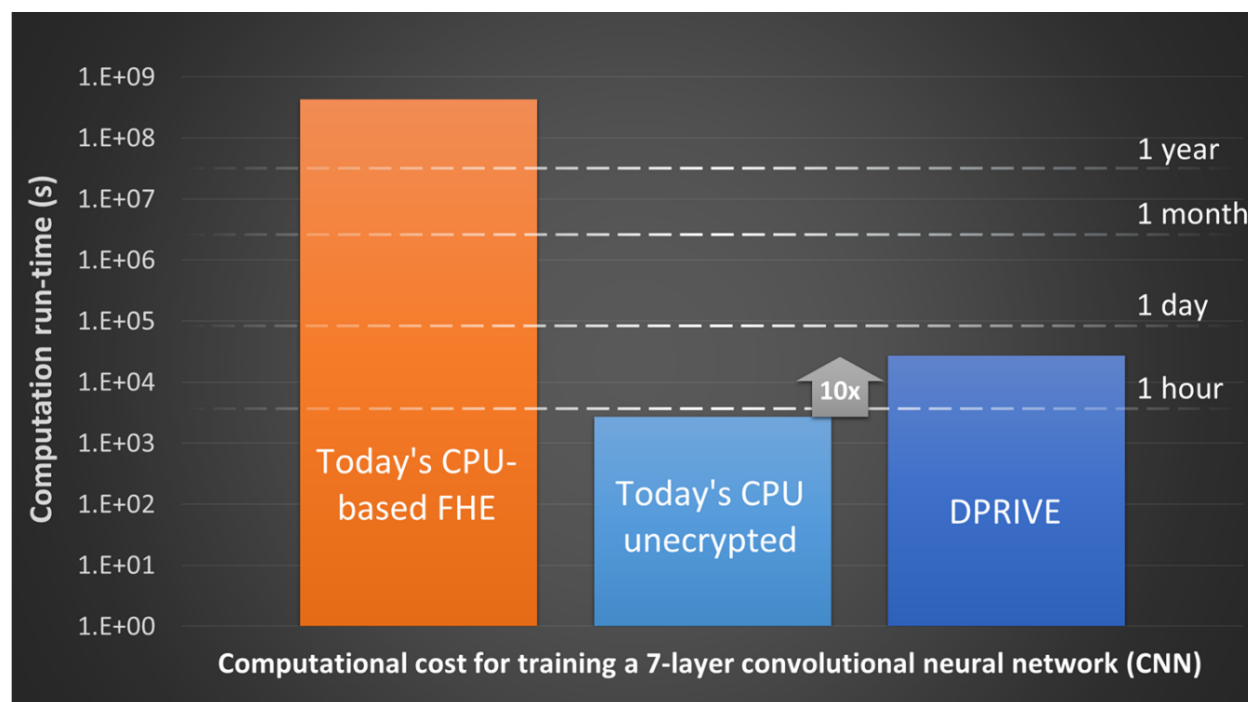


Figure 3: DPRIVE accelerators will establish the foundation for FHE computation with minimal run-time burden (10x over plaintext).

To improve FHE computation speeds, the DPRIVE program will address the debilitating overhead required for FHE computation. The key insight to the program is that *Large Arithmetic Word Size (LAWS)* logic will lead to enormous reduction in processing speed of FHE algorithms by reducing the accumulation of the computation noise in lattice encryption, which translates into improved computation runtime by reducing the frequency and computational penalty of bootstrapping. DPRIVE will develop a LAWS accelerator to process native word sizes expected to be thousands of bits long, in contrast to conventional computing systems, which operate with physical word lengths no longer than 64-bits. Initial analysis of processing with LAWS indicates an improvement of four orders of magnitude in FHE algorithm processing speeds.

Building a LAWS accelerator will stress most aspects of chip design. The key technical challenges that will be overcome in DPRIVE include:

1. *Design FHE hardware accelerator based on LAWS architecture that can be formally verified within minutes to hours.* While many challenges exist in the design of a LAWS accelerator (e.g., routing, physical area, power management), circuit verification is among the most difficult. Formal verification is essential for two reasons:
 - a. Cryptographic circuits have a high burden of proof for mathematical correctness that elevates the need for full circuit verification; and
 - b. LAWS circuits are large and lead to a combinatorial explosion of the circuit state space. Previous verification attempts of large-word size multipliers timeout at word sizes of 256 bits. In contrast, DPRIVE seeks innovations in using symbolic arithmetic representation of the gate logic to significantly cut down on verification time. Such representation should for example reduce execution time for the verification of LAWS multipliers down to minutes for a 256-bit multiplier

of reasonable sophistication and to only a few hours for full formal verification of multipliers in the thousands of bits.

2. *LAWS memory management that provides $\geq 10x$ run-time speed-up with tolerable circuit area.* Optimization efforts to parallelize data execution show 10 – 100x speed improvement. Implementing storage for parallel operations in LAWS processors has two big issues:
 - a. Moving large words around a processor to enable simultaneous execution on multiple words; and
 - b. Storing enough words in local caches on the processor to enable parallel data processing and efficient pipelining.

Today's processors use input and output (I/O) models for memory fetches for around 512 bits (64 bytes) at a time, which means added latency of eight fetches per word in a 4k LAWS architecture. Furthermore, storing large words leads to very large local caches. A common processor today can have a 16 MB cache with 64-bit words, which results in storing 256k words at a time. Such caching consumes approximately 40 mm² of the chip area in a 14 nm node size. An FHE processor with a cache that holds the same number of 4k words means a 1 GB cache and a chip size of 2,545 mm², which is well beyond the reticle limits of chip manufacturing processes at the 14-12nm node size (i.e., just over 800 mm²). The memory challenge of the DPRIVE program is to remove memory fetch penalties for LAWS through new I/O designs while also improving the computational speeds of execution on memory through parallelized operations, resulting in at least a factor of 10 reduction in computation time without breaking size limits of the chip production process. Size limits will be based on available DARPA/MTO shuttle runs of approximately 150 mm².

3. *Flexible data structures and programming models to enable parameterization of FHE algorithms.* FHE algorithms have parameters that affect security and execution times. Building an FHE accelerator should enable the parameterization of the FHE algorithm to support different user and application needs. Trying to attain optimal performance might lead to static implementations. By contrast, DPRIVE is looking for solutions that provide flexibility of the parameter space. DPRIVE will look at models of computation that provide mapping from the mathematical operations to the underlying hardware without excessively impacting the overall execution speed of an FHE algorithm. This is largely accomplished by taking advantage of vectorized computing models that affect much of the parameter space in question in order to provide at least a 10x improvement in speed over non-vectorized approaches, given the memory model designs of the second challenge. In addition, the data structures and programming models should support diversity of FHE scheme that are based on Ring Learning With Errors (RLWE) in the support of lattice encryption. Such could be implemented through programmable chaining of core mathematical operations common to most RLWE schemes.

DPRIVE focus areas are illustrated in Figure 4.

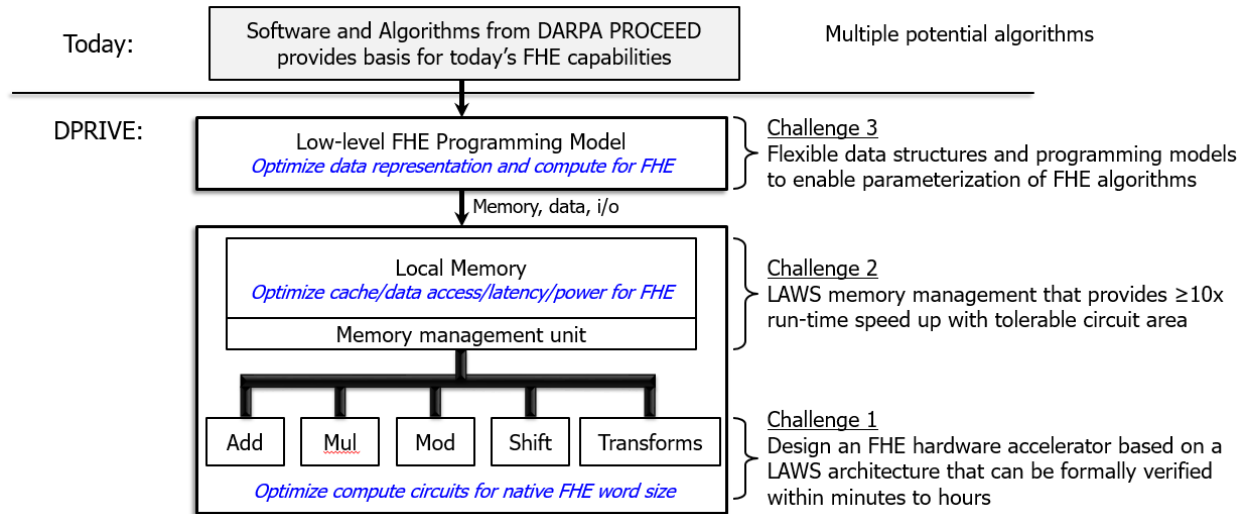


Figure 4: DPRIVE focus areas

In addition, DPRIVE must address challenges in the co-design of FHE algorithms, hardware, and software. The implementation of an FHE accelerator must bring together mathematical experts in FHE with designers of complex, unconventional circuits to implement an effective FHE accelerator. Software developers must be included in the co-design process to implement the supporting software and firmware. The coordinated strengths of the proposing teams in FHE algorithm design and in VLSI circuit design will be important factors towards team selection.

Software is critical to the use and viability of any accelerator implementation. Application programming interfaces (APIs) and associated software and hardware infrastructures to ingest the encrypted wide word size and interface with host processing are essential. Without software that enables a user to efficiently use the FHE accelerator within the domain of the host processor, a hardware solution, despite its potential, will never be used. There are a few existing and open source libraries for FHE processing. Proposers are strongly encouraged to adopt and use one of the existing libraries and provide a plan for interacting with the developers of such libraries to provide interfaces and other enhancements that are judged necessary to interoperate with the proposed FHE coprocessor. Note that the development of wholly new FHE software libraries is not within scope of the DPRIVE program.

The DPRIVE program and the resulting accelerators and supporting infrastructure will address the above described challenges and establish the foundation for and an implementation of FHE computation with minimal run-time burden. This will enable FHE to provide data security during data computation, storage, and transit – resulting in security for data in all states. Ease of use of the DPRIVE FHE accelerator hardware will be essential towards widespread uptake of the outcomes from DPRIVE and overall acceptance of FHE among diverse technology communities of interest.

C. Program Structure

The DPRIVE program will be a 42-month program composed of three phases, a base Phase 1 and optional Phases 2 and 3 described in this section. It is expected that fewer performers will be

funded to participate in Phases 2 and 3 of the program. Options may be exercised, at the Government's sole discretion, based on technical progress measured against the metrics and milestones defined in this BAA and funding availability.

Phase 1 of the three-phase program is a 15-month effort to produce the core logic of the FHE accelerator design. Teams must conduct the trade space analysis to determine optimal word size, design, and emulate all building block circuits required for FHE computation (e.g., multiply, add, modulo, shifts, and data transforms) and run on a circuit emulator a logistic regression analysis on a data set(s) to be provided by the government team on or before program kickoff. The designs must show:

- Formal verification of all logic blocks with $\geq 90\%$ coverage in less than 1 day.
- Execution of the logistic regression problem of 1024 data points in less than 10 ms.

Phase 2 is a 15-month effort to finish the design of the full FHE accelerator based off the Phase 1 building blocks along with the memory architecture. The Phase 2 exam is the execution of a 7-layer convolutional neural network (CNN) inference against the CIFAR-10 data set in less than 250 ms (within 100x of plaintext operation on a standard workstation). Other metrics of this phase are:

- Formal verification of all logic blocks with 100% coverage in less than 1 day.
- Chip area: $\leq 150 \text{ mm}^2$.

Phase 3 is the final 12-month effort to build out a working and fully-usable FHE accelerator with built-in I/O and appropriate hardware/firmware interfacing to a CPU to ensure full software and programming functionality. The final exam will measure the following metrics:

- Execution of 7-layer CNN inference against CIFAR-10 data set: $\leq 25 \text{ ms}$ (within 10x).
- Execution of 7-layer CNN training against CIFAR-10 data set: $\leq 10 \text{ hours}$ (within 10x).
- Demonstrate flexibility in the algorithm parameters:
 - Plaintext modulus: $2 - 1024$.
 - Ciphertext modulus: $2^{15} - 2^{500}$
 - Ring dimension: $512 - 16384$.

DARPA will provide the data sets used for Phase 1 evaluation, as well as the CNN structure to be used in Phases 2 and 3 for use with the standard CIFAR-10 data.

The DPRIVE program will not entertain alternative computing models outside of silicon. Fabrication is expected to be at leading node geometries and utilize DARPA/MTO managed shuttle runs with a designated foundry. Instructions detailing this process will be provided after contract award. Additional details about this process are provided in Section I.H below.

D. Technical Area

DPRIVE will have a single Technical Area. Each DPRIVE team will need to address all required DPRIVE development activities (hardware + software + algorithms). This will include: FHE design and requirements analysis, FHE accelerator design analysis and trade-offs, formal verification of the circuit design, algorithm-accelerator co-design development, building block and integrated accelerator design development, building block and full FHE accelerator design

and performance verification, host processing environment development, FHE supporting accelerator software development, user interface and tools, accelerator implementation, accelerator fabrication, accelerator supporting board and host CPU interface implementation, and accelerator evaluation and demonstration.

As discussed above, DPRIVE's single Technical Area will specifically include the identified key technical challenges:

- *Design FHE hardware accelerator based on LAWS architecture that can be formally verified within minutes to hours.*
- *LAWS memory management that provides $\geq 10x$ run-time speed up with tolerable circuit area.*
- *Flexible data structures and programming models to enable parameterization of FHE algorithms.*

Proposals must not address cryptanalysis approaches or research. The proposed effort must specifically address only the development of an FHE accelerator, as described in this solicitation.

E. Schedule/Milestones

The DPRIVE program will have three phases over a total program length of 42 months. The overall objective is the implementation of a working FHE accelerator and supporting software and hardware infrastructure that enables the performance of FHE computation at runtimes within an order of magnitude of that of conventional unencrypted computation. The DPRIVE program schedule is shown in Figure 5 and the detailed objectives/outcomes of each phase are given in Figure 6.

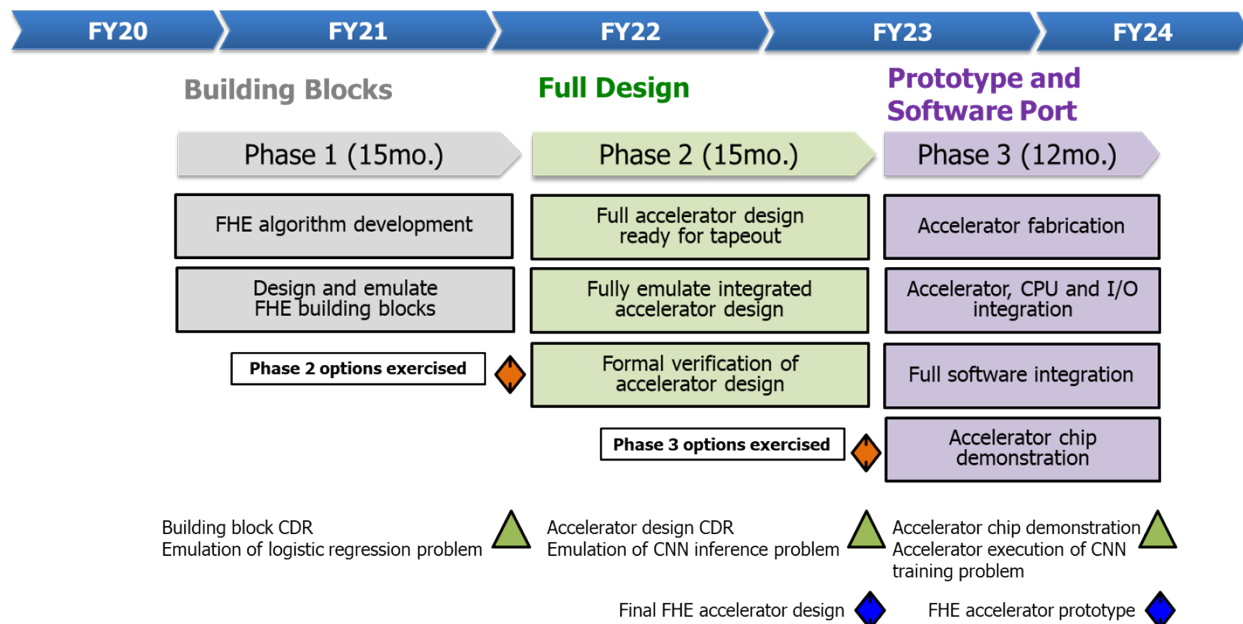


Figure 5: DPRIVE Program Schedule

The DPRIVE program metrics will address the design maturity, formal design verification, and performance in terms of power dissipation and speed evaluated against the same data sets and

CNN models for all performers. The data sets will be provided at program kickoff. The CNN model is described under Section H. Government Furnished Equipment/Property/Information.

Program Metrics by phase are given in Figure 6.

Challenge		Phase 1: Building Blocks in emulation	Phase 2: Full Design in emulation	Phase 3: Prototype and Software Port
1	Ability to build and emulate all blocks (add, sub, mul, mod, shifts, transforms)	Binary yes/no		
1	Verification coverage of logic circuits	$\geq 90\%$	100%	
1	Time to perform logic circuit verification	≤ 1 day	≤ 1 day	
2	Chip dimensions	$\leq 150 \text{ mm}^2$ (estimate)	$\leq 150 \text{ mm}^2$ (RTL)	$\leq 150 \text{ mm}^2$ (real chip)
3	FHE parameter range: Plaintext Modulus	2 – 1024	2 – 1024	2 – 1024
3	FHE parameter range: Ciphertext Modulus	$2^{15} - 2^{500}$	$2^{15} - 2^{500}$	$2^{15} - 2^{500}$
3	FHE parameter range: RingSize	512 – 16384	512 – 16384	512 – 16384
Overall	Execution of a 1024-point logistic regression model	$\leq 10 \text{ ms}$ (100x)	$\leq 1 \text{ ms}$ (10x)	$\leq 0.1 \text{ ms}$ (1x)
	Execution of 7-layer CNN inference w/ CIFAR-10 data set per image		$\leq 250 \text{ ms}$ (100x)	$\leq 25 \text{ ms}$ (10x)
	Execution of 7-layer CNN training w/ CIFAR-10 data set over 10 epochs			$\leq 10 \text{ hours}$ (10x)

Figure 6: DPRIVE program metrics. Specific details of the algorithms and datasets to be tested will be provided by the US Government once the DPRIVE program is underway. Metrics in parenthesis indicate expected runtime penalty vs. plaintext operations.

F. Deliverables

All performers shall deliver detailed plans at program kickoff and upon execution of subsequent option awards, quarterly technical reports, monthly financial reports including updated expenditures, and end of phase technical reports providing details on work and accomplishments performed during that program phase. Performers shall prepare and submit briefing materials and participate in quarterly progress reviews, either by teleconference or at the performer's site, at the discretion of the DARPA program manager. All performers shall travel to and support bi-annual program reviews scheduled at the DARPA program manager's discretion.

In addition to periodically scheduled deliverables, performers will deliver in-depth technical briefings as requested by DARPA. DARPA estimates that such requests will be made no more than once per quarter.

Upon the completion of each phase, the performer end-of-phase technical report must include:

- A documented description of the technical development and achievements accomplished.
- DPRIVE demonstrations and a documented description of capabilities developed and supported.
- Details and description of the work performed, and capabilities developed and how the capabilities meet, exceed, or fall short of program goals as established in this BAA.

- All design files corresponding to the deliverables, including high level descriptive language implementations of the circuit design, Verilog (or equivalent), GDSII layouts, etc.
- Plans and projections for the next program phase, with DoD and commercial transition opportunities specifically provided upon the completion of all phases.

The deliverables by program phase are as follows:

Phase 1:

- Initial design description and emulation of DPRIVE accelerator building blocks.
- Initial FHE algorithm implementations in the emulated accelerator blocks. Descriptions of the operation and implementation of the FHE algorithms must be thoroughly documented.
- Analysis of the emulated performance per subcomponent/design block.
- Formal verification of all building blocks, with results documented and providing details of the approach to formal verification. The formal verification will not only validate the circuit design for accuracy, but will also provide a scalable and automatable proof of correctness that the circuit performance is formally verifiable under all circumstances.
- Analysis of the proposed design, including performance/complexity trade-offs and detailed descriptions of proposed design decisions. This analysis should show where DPRIVE program metrics and goals were met. For situations where such goals were not met, provide compelling descriptions of alternative metrics.
- Software code and configurations for the accelerator emulation of a logistic operation (see Figure 5).
- A full Critical Design Review (CDR) of the proposed DPRIVE accelerator, providing the proposed accelerator design, anticipated performance (based on the accelerator emulation for a logistic regression problem), relevant implementation decisions, performance versus program metrics and goals, and supporting software environment. All high level design, register transfer logic (RTL) Verilog, netlist, design (e.g., computer aided design (CAD)) files, and code produced during Phase 1 shall be made available to the government.

Phase 2:

- Further enhancements and documentation of the DPRIVE accelerator design description.
- Complete DPRIVE accelerator tapeout ready for fabrication of the accelerator.
- Emulation of test chip comprised of core ALU building blocks developed in Phase 1.
- Full accelerator emulation based analysis of the accelerator design versus DPRIVE program metrics and goals, including performance speed and power consumption metrics. The emulation will include execution of FHE algorithms running an application on a full accelerator emulator (application as given in Figure 5).
- Formal verification of the entire FHE chip, with results documented. Provide details of the approach to formal verification that not only validates the circuit design for accuracy, but provides a scalable and automatable proof of correctness that the circuit performance is formally verifiable under all circumstances.
- DPRIVE accelerator package and supporting board design.

- Provide initial evaluation through emulation of full DPRIVE chip using government provided data set.
- Full chip DPRIVE accelerator design review, including review of the design tapeout, execution performance (including accelerator emulation results for a logistic regression and CNN inference), description of relevant implementation decisions, performance versus program metrics and goals, and supporting software environment. All high level design, RTL, Verilog, netlist, etc., CAD files, and code shall be made available to the government.

Phase 3:

- Implemented and packaged DPRIVE accelerator on functional FHE processing board. The functional DPRIVE FHE board will include I/O, interfaces, and firmware/software to support integration into a functional CPU computing system.
- Full demonstration, verification, testing, and analysis of DPRIVE accelerator with full software stack and environment.
- Documentation, user manuals, and example training material for using the FHE processing board.
- Analysis of the design versus DPRIVE program metrics and goals, including performance speed and power consumption metrics.
- Evaluate government provided data set through DPRIVE accelerator.
- Full software environment implementation, with execution on the DPRIVE accelerator system and porting to the hosting CPU, including software driver from CPU to load data and execute FHE algorithms (as per Figure 5).
- FHE algorithm demonstrations on the accelerator.
- Evaluate performance of and validate accelerator.
- Full chip DPRIVE accelerator design review, including review of DPRIVE accelerator implementation, performance of FHE accelerator system (including on the accelerator system for CNN training and inference), relevant implementation decisions, performance versus program metrics and goals, and supporting software environment. All high level design, RTL, Verilog, netlist, etc., CAD files, and code shall be made available to the government.

Prior to conclusion of Phase 3, the performer will deliver a minimum of three complete FHE prototype boards to one or more selected US Government agencies for their own internal evaluation and application exploration. Training material, engineering time, and documentation are expected as part of this deliverable.

Important Points:

1. DPRIVE calls for the implementation of fully homomorphic encryption in the accelerator to be delivered. “Somewhat homomorphic” (SHE), “partially homomorphic” (PHE), multi-party compute (MPC) and garbled circuit (GC), or other solutions/approaches to privacy protecting/preserving computation are not acceptable to the program in that they are mathematically incomplete in the underlying mathematical operations that must take place over the encrypted data, or otherwise do not address the goals of the program.

2. Field Programmable Gate Array (FPGA) or graphics processing unit (GPU) solutions are not of interest to the program. Multichip module approaches will be considered provided a clear path toward meeting program goals and objectives is proposed.
3. The underlying approach and algorithmic architectures will be based on lattice encryption. Proposers are recommended to follow FHE approaches as proposed by the HomomorphicEncryption.org standards consortium, in particular as described in the document:
 - <http://homomorphicensryption.org/wp-content/uploads/2018/11/HomomorphicEncryptionStandardv1.1.pdf>Equivalent approaches to FHE lattice encryption from other organizations will likewise be considered.
4. It is envisioned that a lambda value of 128 bits of security should be adequate for most applications, but that design flexibility should allow a range of values for lambda as provided by the plaintext modulus, ciphertext modulus, and ring size in the program metrics.
5. DPRIVE proposals should support FHE algorithms based on Ring Learning with Errors (RLWE). Flexible designs able to support two or three different FHE algorithms (e.g., BGV) based on the mathematics of RLWE through reprogramming the processor will be reviewed favorably.

G. Commercialization

Proposers must provide a plan for commercialization, promoting a vision and associated commercialization steps at each phase within this program, as well as upon program completion. To this end, proposers are also encouraged to leverage DARPA's Embedded Entrepreneur Initiative (EEI), which provides guidance and additional funding towards the implementation of a commercialization plan for technologies developed under DARPA Microsystems Technology Office sponsorship (see Section IV Application and Submission Information / Paragraph J under "Section II. Detailed Proposal Information"). Supporting activities towards commercialization may include participation in industry standards development, publications, conference demonstration, academic design challenge, and industry association engagement. It is anticipated that the DPRIVE program will influence Third Generation Partnership Project (3GPP) and Internet Engineering Task Force (IETF) standards. DPRIVE program members are encouraged to coordinate with the Office of the Undersecretary of Defense for Research and Engineering (USD(R&E)) and/or the Office of Science and Technology Policy (OSTP) on DoD standards, and initiate interactions with 3GPP, IETF, and other data communications standardization bodies.

H. Government Furnished Equipment/Property/Information

DPRIVE accelerator implementation is expected to use available DARPA/MTO device fabrication access. This will be accomplished by performers signing up for accounts/access to the government designated fabrication process. DPRIVE accelerator designs will be fabricated as riders on shared DARPA/MTO wafer fabrication runs. Details on shared fabrication runs will be

provided to proposers selected as performers. The fabrication costs for DARPA/MTO shared fabrication runs will be borne by the government.

The maximum size of fabrication rider designs is anticipated to be on the order of 150 mm². Proposers should consider this design limitation in DPRIVE proposals and plan to develop DPRIVE accelerator designs that utilize MTO fabrication access and are within 150 mm².

A design larger than 150 mm² can be proposed, but may not exceed the reticle limit of the designated fabrication process (typically around 800 mm²). If a proposer, for performance or functional reasons, submits a proposal with a design larger than 150 mm² they will need to include in their technical and cost proposals a full description of the rationale for the design size being proposed and the associated cost and funding approach. Specifically, this should include a detailed explanation of the performance improvement and impact to program metrics. In order to support a design greater than 150 mm², the proposer will not be able to utilize MTO fabrication access and will, therefore, have to include the full cost of fabrication for their DPRIVE accelerator in the cost proposal. When the full cost of fabrication is included in the cost proposal, the proposer offsetting the increased cost (the anticipated delta fabrication cost associated with a design greater than 150 mm²) by contributing cost share is encouraged.

All data sets used in the program for the logistic regression and CNN training and inferences stages will be based on publically available data sets. The intention is not to advance the state of the art in unencrypted regression and CNN operations but to demonstrate the feasibility of performing such operations at highly accelerated speeds on a FHE coprocessor. It is for this reason that the DPRIVE program has selected data sets that are frequently encountered as benchmarks for a variety of approaches instead of classification problems.

CNN Inference and Training

The CNN operations will make use of the CIFAR-10 data set³. This data set contains 60,000 32x32x3 color images assigned to 10 classes, with 6,000 images per class. A total of 50,000 training images and 10,000 test images are available in the set.

To assure consistency in the evaluation of the CNN performance across teams, it is required that the classification CNN of Figure 7 be implemented for unencrypted (baseline) operations and the FHE operations.

³ Learning Multiple Layers of Features from Tiny Images Alex Krizhevsky April 8, 2009
<https://www.cs.toronto.edu/~kriz/learning-features-2009-TR.pdf>

- 1) Convolution: input image $3 \times 32 \times 32$, window size 3×3 , stride (1, 1), pad (1, 1), number of output channels 64: $R_{64 \times 1024} \leftarrow R_{64 \times 27} \cdot R_{27 \times 1024}$.
- 2) ReLU Activation: calculates ReLU for each input.
- 3) Convolution: window size 3×3 , stride (1, 1), pad (1, 1), number of output channels 64: $R_{64 \times 1024} \leftarrow R_{64 \times 576} \cdot R_{576 \times 1024}$.
- 4) ReLU Activation: calculates ReLU for each input.
- 5) Mean Pooling: window size $1 \times 2 \times 2$, outputs $R_{64 \times 16 \times 16}$.
- 6) Convolution: window size 3×3 , stride (1, 1), pad (1, 1), number of output channels 64: $R_{64 \times 256} \leftarrow R_{64 \times 576} \cdot R_{576 \times 256}$.
- 7) ReLU Activation: calculates ReLU for each input.
- 8) Convolution: window size 3×3 , stride (1, 1), pad (1, 1), number of output channels 64: $R_{64 \times 256} \leftarrow R_{64 \times 576} \cdot R_{576 \times 256}$.
- 9) ReLU Activation: calculates ReLU for each input.
- 10) Mean Pooling: window size $1 \times 2 \times 2$, outputs $R_{64 \times 16 \times 16}$.
- 11) Convolution: window size 3×3 , stride (1, 1), pad (1, 1), number of output channels 64: $R_{64 \times 64} \leftarrow R_{64 \times 576} \cdot R_{576 \times 64}$.
- 12) ReLU Activation: calculates ReLU for each input.
- 13) Convolution: window size 1×1 , stride (1, 1), number of output channels of 64: $R_{64 \times 64} \leftarrow R_{64 \times 64} \cdot R_{64 \times 64}$.
- 14) ReLU Activation: calculates ReLU for each input.
- 15) Convolution: window size 1×1 , stride (1, 1), number of output channels of 16: $R_{16 \times 64} \leftarrow R_{16 \times 64} \cdot R_{64 \times 64}$.
- 16) ReLU Activation: calculates ReLU for each input.
- 17) Fully Connected Layer: fully connects the incoming 1024 nodes to the outgoing 10 nodes: $R_{10 \times 1} \leftarrow R_{10 \times 1024} \cdot R_{1024 \times 1}$.

Figure 7. Convolution Neural Network for CIFAR-10 dataset. The network comprises 6 inner convolution-activation layers with a final fully connected layer⁴. R means the space of real numbers.

I. Intellectual Property

Any proposed use of intellectual property (patents, proprietary information, etc.) should be clearly identified in the proposal. Identify all intellectual property claims to future results, prototypes, and deliverables. Explain how these claims may limit the Government use of the technology developed under the DPRIVE program or development of derivative technologies. For forms to be completed regarding intellectual property, see Section IV.B.10. If there are no intellectual proprietary claims, this should be stated.

DARPA expects application-level software and frameworks developed under the DPRIVE program to be licensed and executed as free and open source software (FOSS) using a standard model for open source licensing, management, and maintenance practices. FOSS for FHE will continue to foster the research and development of FHE practices for the wider adoption among network and mobile phone technology sectors.

⁴ Jian Liu, Mika Juuti, Yao Lu, and N. Asokan. Oblivious neural network predictions via minionn transformations. In Proceedings of the 2017 ACM SIGSAC Conference on Computer and Communications Security, CCS 2017, Dallas, TX, USA, October 30 - November 03, 2017, pages 619–631, 2017.

II. Award Information

A. General Award Information

Multiple awards are anticipated. The amount of resources made available under this BAA will depend on the quality of the proposals received and the availability of funds.

The Government reserves the right to select for negotiation all, some, one, or none of the proposals received in response to this solicitation, and to make awards without discussions with proposers. The Government also reserves the right to conduct discussions if it is later determined to be necessary. If warranted, portions of resulting awards may be segregated into pre-priced options. Additionally, DARPA reserves the right to accept proposals in their entirety or to select only portions of proposals for award. In the event that DARPA desires to award only portions of a proposal, negotiations may be opened with that proposer. The Government reserves the right to fund proposals in phases with options for continued work at the end of one or more of the phases, as applicable.

Awards under this BAA will be made to proposers on the basis of the evaluation criteria listed below (see section labeled “Application Review Information,” Sec. V.), and program balance to provide overall value to the Government. The Government reserves the right to request any additional, necessary documentation once it makes the award instrument determination. Such additional information may include but is not limited to Representations and Certifications (see Section VI.B.4., “Representations and Certifications”). The Government reserves the right to remove proposers from award consideration should the parties fail to reach agreement on award terms, conditions and cost/price within a reasonable time or the proposer fails to timely provide requested additional information. Proposals identified for negotiation may result in a procurement contract, grant, cooperative agreement, or other transaction, depending upon the nature of the work proposed, the required degree of interaction between parties, whether or not the research is classified as Fundamental Research, and other factors.

Proposers looking for innovative, commercial-like contractual arrangements are encouraged to consider requesting Other Transactions. To understand the flexibility and options associated with Other Transactions, consult <http://www.darpa.mil/work-with-us/contract-management#OtherTransactions>.

In accordance with 10 U.S.C. § 2371b(f), the Government may award a follow-on production contract or Other Transaction (OT) for any OT awarded under this BAA if: (1) that participant in the OT, or a recognized successor in interest to the OT, successfully completed the entire prototype project provided for in the OT, as modified; and (2) the OT provides for the award of a follow-on production contract or OT to the participant, or a recognized successor in interest to the OT.

In all cases, the Government contracting officer shall have sole discretion to select award instrument type, regardless of instrument type proposed, and to negotiate all instrument terms and conditions with selectees. DARPA will apply publication or other restrictions, as necessary, if it determines that the research resulting from the proposed effort will present a high likelihood

of disclosing performance characteristics of military systems or manufacturing technologies that are unique and critical to defense. Any award resulting from such a determination will include a requirement for DARPA permission before publishing any information or results on the program. For more information on publication restrictions, see the section below on Fundamental Research.

For the effort solicited under this BAA, OT agreements are encouraged for non-traditional teams and those proposing research with potential commercial application. As a resource, the Model OT Agreement for ERI programs has been provided on the DARPA Acquisition Innovation website, under the title “Microsystems Technology Office (MTO) Electronics Resurgence Initiative (ERI)” (see <https://acquisitioninnovation.darpa.mil/samples-and-resources/darpa-ot-programs>).

B. Fundamental Research

It is DoD policy that the publication of products of fundamental research will remain unrestricted to the maximum extent possible. National Security Decision Directive (NSDD) 189 defines fundamental research as follows:

‘Fundamental research’ means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.

As of the date of publication of this BAA, the Government expects that program goals as described herein may be met by proposed efforts for fundamental research and non-fundamental research. Some proposed research may present a high likelihood of disclosing performance characteristics of military systems or manufacturing technologies that are unique and critical to defense. Based on the anticipated type of proposer (e.g., university or industry) and the nature of the solicited work, the Government expects that some awards will include restrictions on the resultant research that will require the awardee to seek DARPA permission before publishing any information or results relative to the program.

Proposers should indicate in their proposal whether they believe the scope of the research included in their proposal is fundamental or not. While proposers should clearly explain the intended results of their research, the Government shall have sole discretion to determine whether the proposed research shall be considered fundamental and to select the award instrument type. Appropriate language will be included in resultant awards for non-fundamental research to prescribe publication requirements and other restrictions, as appropriate. This language can be found at <http://www.darpa.mil/work-with-us/additional-baa>.

For certain research projects, it may be possible that although the research to be performed by a potential awardee is non-fundamental research, its proposed subawardee’s effort may be fundamental research. It is also possible that the research performed by a potential awardee is fundamental research while its proposed subawardee’s effort may be non-fundamental research.

In all cases, it is the potential awardee's responsibility to explain in its proposal which proposed efforts are fundamental research and why the proposed efforts should be considered fundamental research.

III. Eligibility Information

A. Eligible Applicants

All responsible sources capable of satisfying the Government's needs may submit a proposal that shall be considered by DARPA.

1. Federally Funded Research and Development Centers (FFRDCs) and Government Entities

a) FFRDCs

FFRDCs are subject to applicable direct competition limitations and cannot propose to this BAA in any capacity unless they meet the following conditions. (1) FFRDCs must clearly demonstrate that the proposed work is not otherwise available from the private sector. (2) FFRDCs must provide a letter, on official letterhead from their sponsoring organization, that (a) cites the specific authority establishing their eligibility to propose to Government solicitations and compete with industry, and (b) certifies the FFRDC's compliance with the associated FFRDC sponsor agreement's terms and conditions. These conditions are a requirement for FFRDCs proposing to be awardees or subawardees.

b) Government Entities

Government Entities (e.g., Government/National laboratories, military educational institutions, etc.) are subject to applicable direct competition limitations. Government Entities must clearly demonstrate that the work is not otherwise available from the private sector and provide written documentation citing the specific statutory authority and contractual authority, if relevant, establishing their ability to propose to Government solicitations and compete with industry. This information is required for Government Entities proposing to be awardees or subawardees.

c) Authority and Eligibility

At the present time, DARPA does not consider 15 U.S.C. § 3710a to be sufficient legal authority to show eligibility. While 10 U.S.C. § 2539b may be the appropriate statutory starting point for some entities, specific supporting regulatory guidance, together with evidence of agency approval, will still be required to fully establish eligibility. DARPA will consider FFRDC and Government Entity eligibility submissions on a case-by-case basis; however, the burden to prove eligibility for all team members rests solely with the proposer.

(1) Non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements,

security regulations, export control laws, and other governing statutes applicable under the circumstances.

(2) For classified proposals, applicants will ensure all industrial, personnel, and information systems processing security requirements are in place and at the appropriate level (e.g., Facility Clearance Level (FCL), Automated Information Security (AIS), Certification and Accreditation (C&A), and any Foreign Ownership Control and Influence (FOCI) issues are mitigated prior to submission. Additional information on these subjects can be found at <http://www.dss.mil>.

B. Organizational Conflicts of Interest

FAR 9.5 Requirements

In accordance with FAR 9.5, proposers are required to identify and disclose all facts relevant to potential OCIs involving the proposer's organization and *any* proposed team member (subawardee, consultant). Under this Section, the proposer is responsible for providing this disclosure with each proposal submitted to the BAA. The disclosure must include the proposer's, and as applicable, proposed team member's OCI mitigation plan. The OCI mitigation plan must include a description of the actions the proposer has taken, or intends to take, to prevent the existence of conflicting roles that might bias the proposer's judgment and to prevent the proposer from having unfair competitive advantage. The OCI mitigation plan will specifically discuss the disclosed OCI in the context of each of the OCI limitations outlined in FAR 9.505-1 through FAR 9.505-4.

Agency Supplemental OCI Policy

In addition, DARPA has a supplemental OCI policy that prohibits contractors/performers from concurrently providing Scientific Engineering Technical Assistance (SETA), Advisory and Assistance Services (A&AS) or similar support services and being a technical performer. Therefore, as part of the FAR 9.5 disclosure requirement above, a proposer must affirm whether the proposer or *any* proposed team member (subawardee, consultant) is providing SETA, A&AS, or similar support to any DARPA office(s) under: (a) a current award or subaward; or (b) a past award or subaward that ended within one calendar year prior to the proposal's submission date.

If SETA, A&AS, or similar support is being or was provided to any DARPA office(s), the proposal must include:

- The name of the DARPA office receiving the support;
- The prime contract number;
- Identification of proposed team member (subawardee, consultant) providing the support; and
- An OCI mitigation plan in accordance with FAR 9.5.

Government Procedures

In accordance with FAR 9.503, 9.504 and 9.506, the Government will evaluate OCI mitigation plans to avoid, neutralize or mitigate potential OCI issues before award and to determine whether it is in the Government's interest to grant a waiver. The Government will only evaluate OCI

mitigation plans for proposals that are determined selectable under the BAA evaluation criteria and funding availability.

The Government may require proposers to provide additional information to assist the Government in evaluating the proposer's OCI mitigation plan.

If the Government determines that a proposer failed to fully disclose an OCI; or failed to provide the affirmation of DARPA support as described above; or failed to reasonably provide additional information requested by the Government to assist in evaluating the proposer's OCI mitigation plan, the Government may reject the proposal and withdraw it from consideration for award.

C. Cost Sharing/Matching

Cost sharing is not required; however, it will be carefully considered where there is an applicable statutory condition relating to the selected funding instrument. Cost sharing is encouraged where there is a reasonable probability of a potential commercial application related to the proposed research and development effort.

For more information on potential cost sharing requirements for Other Transactions for Prototype, see <http://www.darpa.mil/work-with-us/contract-management>.

D. Other Eligibility Criteria

1. Collaborative Efforts

Collaborative efforts/teaming are highly encouraged as deemed appropriate to be able to fully address all areas and challenges covered by this BAA. It is required that proposers address all technical areas of the BAA within their proposal and proposal team. Addressing individual tasks or subtasks of a technical challenge or of the BAA will render the proposal non-conforming.

IV. Application and Submission Information

PROPOSERS ARE CAUTIONED THAT EVALUATION RATINGS MAY BE LOWERED AND/OR PROPOSALS REJECTED IF PROPOSAL PREPARATION (PROPOSAL FORMAT, CONTENT, ETC.) AND/OR SUBMITTAL INSTRUCTIONS ARE NOT FOLLOWED.

A. Address to Request Application Package

This announcement, any attachments, and any references to external websites herein constitute the total solicitation. If proposers cannot access the referenced material posted in the announcement found at www.darpa.mil, contact the administrative contact listed herein.

B. Content and Form of Application Submission

All submissions, including abstracts and proposals must be written in English with type not smaller than 12 point font. Smaller font may be used for figures, tables, and charts. Copies of all

documents submitted must be clearly labeled with the DARPA BAA number, proposer organization, and proposal title/proposal short title.

1. Abstract Format

Proposers are strongly encouraged to submit an abstract in advance of a full proposal. Abstracts should follow the format described below in this section. The cover sheet should be clearly marked “ABSTRACT” and the total length of Section II should not exceed 5 pages, with the exception of Section II.E, Team Composition and Experience, which may be up to an additional 5 pages.

Section I. Administrative

A. Cover sheet to include:

- (1) BAA number (HR001120S0032);
- (2) Technical area(s);
- (3) Lead Organization submitting abstract;
- (4) Type of organization, selected among the following categories:
Large Organization, Small Disadvantaged Organization, Other Small Organization, HBCU, MI, Other Educational, Other Nonprofit;
- (5) Proposer’s internal reference number (if any);
- (6) Other team members (if applicable) and type of organization for each;
- (7) Proposal title;
- (8) Technical point of contact to include:
Salutation, last name, first name, street address, city, state, zip code (+4), telephone, fax (if available), electronic mail;
- (9) Administrative point of contact to include:
Salutation, last name, first name, street address, city, state, zip code (+4), telephone, fax (if available), electronic mail;
- (10) Total funds requested from DARPA, and the amount of cost share (if any); AND
- (11) Date proposal abstract was submitted.

(Note: An official transmittal letter is not required when submitting a Proposal Abstract.)

Section II. Abstract Details

A. Innovative Claims

Summary of innovative claims for the proposed research. This section is the centerpiece of the abstract and should succinctly describe the uniqueness and benefits of the proposed approach relative to the goals and metrics of the DPRIVE program as described above and anticipated performance versus current state-of-art FHE computation alternate approaches.

B. Technical Approach

Technical rationale, technical approach, and constructive plan for accomplishment of technical goals in support of innovative claims and deliverable production.

C. Deliverables

Deliverables associated with the proposed research and the plans and capability to accomplish technology transition and commercialization.

D. Cost and Schedule

Provide a cost estimate for resources (e.g., labor, materials) and any subcontractors over the proposed timeline of the project, broken down by Government fiscal year.

E. Team Composition and Experience (May be up to five additional pages beyond five-page abstract page limit)

Provide a description of the proposed team, applicable experience, relevant team facilities, and how the proposed team has the experience and capability to address all areas described in this BAA. Provide biographies for key team members highlighting their relevance to BAA technical areas and DPRIVE goals.

2. Full Proposal Format

All full proposals must be in the format given below. Proposals shall consist of two volumes: Volume I – Technical and Management Proposal (3 sections), and Volume II – Cost Proposal (4 sections). The submission of other supporting materials along with the proposals is strongly discouraged and will not be considered for review. Section II of Volume I, Technical and Management Proposal, shall not exceed 20 pages. The page limitation for full proposals includes all figures, tables, and charts. There is no page limit for Volume II, Cost Proposal.

A summary slide of the proposed effort, in PowerPoint format, should be submitted with the proposal. A template slide is provided as Attachment 2 to the BAA. Submit this PowerPoint file in addition to Volumes I and II of your full proposal. This summary slide does not count towards the total page count.

a. Volume I, Technical and Management Proposal**Section I. Administrative****A. Cover sheet to include:**

- (1) BAA number (HR001120S0032);
- (2) Technical area(s);
- (3) Lead Organization submitting proposal;
- (4) Type of organization, selected among the following categories:
Large Organization, Small Disadvantaged Organization, Other Small Organization, HBCU, MI, Other Educational, Other Nonprofit;
- (5) Proposer's internal reference number (if any);
- (6) Other team members (if applicable) and type of organization for each;
- (7) Proposal title;
- (8) Technical point of contact to include:
Salutation, last name, first name, street address, city, state, zip code (+4), telephone, fax (if available), electronic mail;

(9) Administrative point of contact to include:

Salutation, last name, first name, street address, city, state, zip code (+4), telephone, fax (if available), electronic mail;

(10) Total funds requested from DARPA, and the amount of cost share (if any); AND

(11) Date proposal was submitted.

B. Official transmittal letter.

The transmittal letter should identify the BAA number, the proposal by name, and the proposal reference number (if any), and should be signed by an individual who is authorized to submit proposals to the Government.

Section II. Detailed Proposal Information

A. Executive Summary

Summarize the technical approach, anticipated performance, and expected outcomes of the proposed effort. The executive summary should be concise and to the point. Tables, graphs, and diagrams can be used as supplemental material along with narrative to convey the information.

B. Technical Approach

This section is the centerpiece of the proposal and should succinctly summarize the innovative claims for the proposed research and clearly describe the proposed approach without using any jargon. This section should demonstrate that the proposer has a clear understanding of the DPRIVE program goals and metrics and a well-defined approach to provide programs goals, metrics and deliverable. The primary goal of providing FHE computation within a factor of 10 versus current unencrypted computation shall specifically be addressed. A comparison versus the state-of-the-art should be provided and should provide sufficient justification for the feasibility of the proposed approach(es). This section should include a detailed technical rationale, technical approach, and constructive plan for accomplishment of technical goals in support of innovative claims and deliverable creation.

C. Statement of Work (SOW)

In plain English, clearly define the technical tasks/subtasks to be performed, their durations, and dependencies among them. The page length for the SOW will be dependent on the amount of the effort. The SOW must not include proprietary information. For each task/subtask, provide:

1. A general description of the objective (for each defined task/activity);
2. A detailed description of the approach to be taken to accomplish each defined task/activity;
3. Identification of the primary organization responsible for task execution (prime, sub, team member, by name, etc.);
4. The completion criteria for each task/activity - a product, event or milestone that defines its completion.
5. Define all deliverables (reporting, data, reports, software, etc.) to be provided to the Government in support of the proposed research tasks/activities; AND

6. Clearly identify any tasks/subtasks (prime or subcontracted) that will be accomplished on-campus at a university, if applicable...

*Note: Each Phase of the program must be separately defined in the SOW. Include a SOW for each subcontractor and/or consultant in the **Cost Proposal Volume**. Do not include any proprietary information in the SOW(s).*

D. Schedules and measurable milestones

Schedules and measurable milestones for the proposed research. (Note: Measurable milestones should capture key development points in tasks and should be clearly articulated and defined in time relative to start of effort.) Where the effort consists of multiple portions which could reasonably be partitioned for purposes of funding, these should be identified as options. Additionally, proposals should clearly explain the technical approach(es) that will be employed to meet or exceed each program metric and provide ample justification as to why the approach(es) is/are feasible. The milestones must not include proprietary information.

Milestones for OTs should be carefully developed to provide clear development, completion criteria, and deliverables across the program phase leading to BAA defined deliverables and metrics. Please refer to Section III. Other Transaction Request below for further details on OT milestones and milestones plan.

E. Results and Technology Transfer

Description of the results, products, transferable technology, and expected technology transfer. This should also address mitigation of life-cycle and sustainment risks associated with transitioning intellectual property for U.S. military applications, if applicable. See also Section IV.B.10, "Intellectual Property." If there are no proprietary claims, this should be stated.

F. Risk Analysis and Mitigation Plan

Identify the major technical and programmatic risks in the program. Include a risk matrix. For each risk, assign a probability of occurrence on a scale of 1-10, where 10 indicates a high likelihood that the risk will impact program success, as well as an assessment of impact, also on a scale of 1-10, where 10 indicates that this risk would maximally limit the program from delivering prototypes on schedule or meeting performance objectives. For each item with total risk (likelihood × impact) exceeding 40, include a plan for mitigating the risk and assessing risk reduction.

G. Ongoing Research

Comparison with other ongoing research indicating advantages and disadvantages of the proposed effort.

H. National Security Impact Statement

To reduce the potential for unintended foreign access to critical U.S. national security technologies developed under this effort, proposals shall describe:

- How the proposed work contributes to U.S. national security and U.S. technological capabilities. The proposer may also summarize previous work that contributed to U.S. national security and U.S. technological capabilities.
- Plans and capabilities to transition technologies developed under this effort to U.S. national security applications and/or to U.S. industry. The proposer may also discuss previous technology transitions to the benefit of U.S. interests.
- Any plans to transition technologies developed under this effort to foreign governments or to companies that are foreign owned, controlled or influenced. The proposer may also discuss previous technology transition to these groups.
- How the proposer will assist its employees and agents performing work under this effort to be eligible to participate in the U.S. national security environment.

I. Proposer Team Composition, Experience, Accomplishments, and Facilities (Not included in page limit)

Describe the formal teaming arrangements which will be used to execute this effort. Describe the programmatic relationship between investigators and the rationale for choosing this teaming strategy. Present a coherent organization chart and integrated management strategy for the program team. For each person, indicate: (1) name, (2) affiliation, (3) abbreviated listing of all technical area tasks they will work on with roles, responsibilities, and percent time indicated, (4) discussion of the proposers' previous accomplishments, relevant expertise and/or unique capabilities.

For the proposed team, provide details on applicable experience, relevant accomplishments, and supporting team facilities. This section should address the proposed team's experience and capability to address the BAA technical area, DPRIVE goals, and the need for multi-disciplinary expertise in hardware, software, algorithms, and FHE. Provide a discussion of the proposed team's previous accomplishments and work in closely related research areas. Provide biographies for key team members highlighting their relevance to BAA technical areas and goals. Provide a description of the facilities and equipment that would be used for the proposed effort and how they will support meeting program metrics.

J. DARPA Embedded Entrepreneur Initiative (optional sub-section; does not count toward page count)

To catalyze the conversion of scientific discovery to impact, the Microsystems Technology Office offers applicants the opportunity for additional funding and transition assistance through participation in the Embedded Entrepreneur Initiative. The DARPA Embedded Entrepreneur Initiative will provide additional funding, up to \$250,000, to employ one entrepreneur-in-residence or one corporate business development lead. The entrepreneurial lead's ultimate goal is to develop a robust go to market strategy for entering into defense and commercial markets. All commercialization and transition activities will be timed to suit the Performer's stage of maturity. Often, the Embedded Entrepreneurial work is most useful in year two or three of a Program. Activities conducted can include, but are not limited to; cost modeling, end user engagement, market analysis and mapping, competitive analysis, techno-economic analysis, manufacturing and scale-up strategy, IP securement strategy, and financial plan creation. Embedded Entrepreneur participants will work closely with

DARPA's Commercial Strategy team and their extensive network of U.S. investors, strategic partners, and mentors.

Proposers wishing to participate in the Embedded Entrepreneur Initiative must:

- Include an initial hypothesis describing how the proposed technology will transition from its current state to future integration into a product or capability.
- Include separately costed tasks describing plans to build and refine a viable Go to Market Strategy over the course of the DARPA program. Tasks contributing to the build of a robust Go to Market Strategy can include, but are not limited to; cost modeling, end user engagement, market analysis and mapping, competitive analysis, techno-economic analysis, manufacturing and scale-up strategy, IP securement strategy, and financial plan creation.

Participation in the Embedded Entrepreneur Initiative is voluntary but highly recommended. Participants are not expected to form a new company or leave their current research positions to pursue transition, but are expected to, throughout the lifecycle of the proposed effort, identify appropriate partners for enabling transition. Embedded Entrepreneur Initiative funding requests should be consistent with the proposed work scope and proposed timeline, but are anticipated to be in the range of \$250,000 per Performer.

Section III. Additional Information

Information in this section may include a brief bibliography of relevant technical papers and research notes (published and unpublished) which document the technical ideas upon which the proposal is based. Copies of not more than three (3) relevant prior papers may be included in the submission.

b. Volume II, Cost Proposal – {No Page Limit}

All proposers, including FFRDCs, must submit the following:

Section I. Administrative

Cover sheet to include:

- (1) BAA number HR001120S0032);
- (2) Technical area(s);
- (3) Lead Organization submitting proposal;
- (4) Type of organization, selected among the following categories:
Large Organization, Small Disadvantaged Organization, Other Small Organization, HBCU, MI, Other Educational, Other Nonprofit;
- (5) Proposer's internal reference number (if any);
- (6) Other team members (if applicable) and type of organization for each;
- (7) Proposal title;
- (8) Technical point of contact to include:
Salutation, last name, first name, street address, city, state, zip code (+4), telephone, fax (if available), electronic mail (if available);
- (9) Administrative point of contact to include:

Salutation, last name, first name, street address, city, state, zip code (+4), telephone, fax (if available), and electronic mail (if available);

(10) Award instrument requested:

Cost-Plus-Fixed Fee (CPFF), Cost-contract—no fee, cost sharing contract—no fee, or other type of procurement contract (*specify*), Grant, Cooperative Agreement, or Other Transaction;

(11) Place(s) and period(s) of performance;

(12) Total proposed cost separated by basic award and option(s), if any, by calendar year and by government fiscal year;

(13) Name, address, and telephone number of the proposer's cognizant Defense Contract Management Agency (DCMA) administration office (*if known*);

(14) Name, address, and telephone number of the proposer's cognizant Defense Contract Audit Agency (DCAA) audit office (*if known*);

(15) Date proposal was prepared;

(16) DUNS number;

(17) TIN number;

(18) CAGE Code;

(19) Subcontractor Information;

(20) Proposal validity period (120 days is recommended); AND

(21) Any Forward Pricing Rate Agreement, other such approved rate information, or such documentation that may assist in expediting negotiations (if available).

Attachment 1, the Cost Volume Proposer Checklist, must be included with the coversheet of the Cost Proposal.

Section II. Detailed Cost Information (Prime and Subcontractors)

The proposers', to include eligible FFRDCs', cost volume shall provide cost and pricing information (See Note 1), or other than cost or pricing information if the total price is under the referenced threshold, in sufficient detail to substantiate the program price proposed (e.g., realism and reasonableness). In doing so, the proposer shall provide, for **both the prime and each subcontractor**, a "Summary Cost Breakdown" by phase and performer fiscal year, and a "Detailed Cost Breakdown" by phase, technical task/sub-task, and month. The breakdown/s shall include, at a minimum, the following major cost items along with associated backup documentation:

Total program cost broken down by major cost items:

A. Direct Labor

A breakout clearly identifying the individual labor categories with associated labor hours and direct labor rates, as well as a detailed Basis-of-Estimate (BOE) narrative description of the methods used to estimate labor costs;

B. Indirect Costs

Including Fringe Benefits, Overhead, General and Administrative Expense, Cost of Money, Fee, etc. (must show base amount and rate);

C. Travel

Provide the purpose of the trip, number of trips, number of days per trip, departure and arrival destinations, number of people, etc.;

D. Other Direct Costs

Itemized with costs; back-up documentation is to be submitted to support proposed costs;

E. Material/Equipment

(i) For IT and equipment purchases, include a letter stating why the proposer cannot provide the requested resources from its own funding.

(ii) A priced Bill-of-Material (BOM) clearly identifying, for each item proposed, the quantity, unit price, the source of the unit price (i.e., vendor quote, engineering estimate, etc.), the type of property (i.e., material, equipment, special test equipment, information technology, etc.), and a cross-reference to the Statement of Work (SOW) task/s that require the item/s. At time of proposal submission, any item that exceeds \$2,000 must be supported with basis-of-estimate (BOE) documentation such as a copy of catalog price lists, vendor quotes or a written engineering estimate (additional documentation may be required during negotiations, if selected).

(iii) If seeking a procurement contract and items of Contractor Acquired Property are proposed, exclusive of material, the proposer shall clearly demonstrate that the inclusion of such items as Government Property is in keeping with the requirements of FAR Part 45.102. In accordance with FAR 35.014, "Government property and title," it is the Government's intent that title to all equipment purchased with funds available for research under any resulting contract will vest in the acquiring nonprofit institution (e.g., Nonprofit Institutions of Higher Education and Nonprofit Organizations whose primary purpose is the conduct of scientific research) upon acquisition without further obligation to the Government. Any such equipment shall be used for the conduct of basic and applied scientific research. The above transfer of title to all equipment purchased with funds available for research under any resulting contract is not allowable when the acquiring entity is a for-profit organization; however, such organizations can, in accordance with FAR 52.245-1(j), be given priority to acquire such property at its full acquisition cost.

F. Consultants

If consultants are to be used, proposer must provide a copy of the consultant's proposed SOW as well as a signed consultant agreement or other document which verifies the proposed loaded daily / hourly rate and any other proposed consultant costs (e.g. travel);

G. Subcontracts

Itemization of all subcontracts. Additionally, the prime contractor is responsible for compiling and providing, as part of its proposal submission to the Government, subcontractor proposals prepared at the same level of detail as that required by the prime. Subcontractor proposals include Interdivisional Work Transfer Agreements (ITWA) or similar arrangements. If seeking a procurement contract, the prime contractor shall provide a cost reasonableness analysis of all proposed subcontractor costs/prices. Such analysis shall

indicate the extent to which the prime contractor has negotiated subcontract costs/prices and whether any such subcontracts are to be placed on a sole-source basis.

All proprietary subcontractor proposal documentation, prepared at the same level of detail as that required of the prime, which cannot be uploaded to the DARPA BAA website (<https://baa.darpa.mil>, BAAT) or Grants.gov as part of the proposer's submission, shall be made immediately available to the Government, upon request, under separate cover (i.e., mail, electronic/email, etc.), either by the proposer or by the subcontractor organization. This does not relieve the proposer from the requirement to include, as part of their submission (via BAAT or Grants.gov, as applicable), subcontract proposals that do not include proprietary pricing information (rates, factors, etc.).

A Rough Order of Magnitude (ROM), or similar budgetary estimate, is not considered a fully qualified subcontract cost proposal submission. Inclusion of a ROM, or similar budgetary estimate, may result in the full proposal being deemed non-conforming or evaluation ratings may be lowered;

H. Cost-Sharing

The amount of any industry cost-sharing (the source and nature of any proposed cost-sharing should be discussed in the narrative portion of the cost volume). Cost sharing should be carefully considered and fully defined, particularly for OTs and efforts with clear commercial application. As noted in Section I.F. proposals that incorporate fabrication of chips sizes larger than supported by fabrication access available to this program, currently the anticipated fabrication limit is 150 mm², are expected to include the fabrication costs in the proposed cost share.

I. Fundamental Research

Written justification required per Section II.B, "Fundamental Research," pertaining to prime and/or subcontracted effort being considered Contracted Fundamental Research.

Note 1:

(a) "Cost or Pricing Data" as defined in FAR 15.403-4 shall be required if the proposer is seeking a procurement contract per the referenced threshold, unless the proposer requests and is granted an exception from the requirement to submit cost or pricing data. Per DoD Class Deviation 2018-O0012, dated 13 April 2018, the threshold for obtaining certified cost and pricing data is \$2,000,000. Per DFARS 215.408(5), DFARS 252.215-7009, Proposal Adequacy Checklist, applies to all proposers/proposals seeking a FAR-based award (contract).

(b) In accordance with DFARS 215.403-1(4)(D), DoD has waived cost or pricing data requirements for nonprofit organizations (including educational institutions) on cost-reimbursement-no-fee contracts. In such instances where the waiver stipulated at DFARS 215.403-1(4)(D) applies, proposers shall submit information other than cost or pricing data to the extent necessary for the Government to determine price reasonableness and cost realism; and cost or pricing data from subcontractors that are not nonprofit organizations when the subcontractor's proposal exceeds the cost and pricing data threshold at FAR 15.403-4(a)(1).

(c) Per Section 873 of the FY2016 National Defense Authorization Act (Pub L. 114-92), "Pilot Program For Streamlining Awards For Innovative Technology Projects," small businesses and

nontraditional defense contractors (as defined therein) are alleviated from submission of certified cost and pricing data for new contract awards valued at less than \$7,500,000. In such instances where this “waiver” applies, proposers seeking a FAR-based contract shall submit information other than certified cost or pricing data to the extent necessary for the Government to determine price reasonableness and cost realism; and certified cost or pricing data from subcontractors that are not small businesses or nontraditional defense contractors when such subcontract proposals exceed the cost and pricing data threshold at FAR 15.403-4(a)(1).

(d) “Cost or pricing data” are not required if the proposer proposes an award instrument other than a procurement contract (i.e., cooperative agreement, grant, or other transaction).

Note 2:

Proposers are required to provide the aforementioned cost breakdown as an editable MS Excel spreadsheet, inclusive of calculations formulae, with tabs (material, travel, ODC’s) provided as necessary. The Government also requests and recommends that the Cost Proposal include MS Excel file(s) that provide traceability between the Bases of Estimate (BOEs) and the proposed costs across all elements and phases. This includes the calculations and adjustments that are utilized to generate the Summary Costs from the source labor hours, labor costs, material costs, etc. input data. It is requested that the costs and Subcontractor proposals be readily traceable to the Prime Cost Proposal in the provided MS Excel file(s) – although this is not a requirement, providing information in this manner will assist the Government in understanding what is being proposed both technically and in terms of cost realism. NOTE: If the PDF submission differs from the Excel submission, the PDF will take precedence.

Section III. Other Transaction Request, if applicable

All proposers requesting an Other Transaction (OT) must include a detailed list of payment milestones (Milestone Plan). Each milestone must include the following:

- Milestone description
- Completion/Exit criteria (to include identifying all associated data deliverables excluding those specifically providing project status)
- Due date
- Payment/funding schedule (to include, if cost share is proposed, awardee and Government share amounts)
- For each data deliverable, identify the proposed Government data rights (keeping in mind how each data deliverable will need to be used by the Government given the goals and objectives of the proposed project)

It is noted that, at a minimum, milestones should relate directly to accomplishment of program technical metrics as defined in the BAA and/or the proposer’s proposal. Agreement type, expenditure or fixed-price based, will be subject to negotiation by the Agreements Officer. Do not include proprietary data.

As a resource, the Model OT Agreement for ERI programs has been provided on the DARPA Acquisition Innovation website, under the title “Microsystems Technology Office (MTO) Electronics Resurgence Initiative (ERI)” (see <https://acquisitioninnovation.darpa.mil/samples-and-resources/darpa-ot-programs>).

Section IV. Other Cost Information

Where the effort consists of multiple portions which could reasonably be partitioned for purposes of funding, these should be identified as options with separate cost estimates.

The cost proposal should include identification of pricing assumptions of which may require incorporation into the resulting award instrument (i.e., use of Government Furnished Property/Facilities/Information, access to Government Subject Matter Experts, etc.).

The proposer should include supporting cost and pricing information in sufficient detail to substantiate the summary cost estimates and should include a description of the method used to estimate costs and supporting documentation.

Cost proposals submitted by FFRDC's (prime or subcontractor) will be forwarded, if selected for negotiation, to their sponsoring organization contracting officer for review to confirm that all required forward pricing rates and factors have been used.

3. Proprietary Information

Proposers are responsible for clearly identifying proprietary information. Submissions containing proprietary information must have the cover page and each page containing such information clearly marked with a label such as "Proprietary" or "Company Proprietary." Note, "Confidential" is a classification marking used to control the dissemination of U.S. Government National Security Information as dictated in Executive Order 13526 and should not be used to identify proprietary business information.

4. Security Information

a. Program Security Information

Proposers should include with their proposal any proposed solution(s) to program security requirements unique to this program. Common program security requirements include but are not limited to: operational security (OPSEC) contracting/sub-contracting plans; foreign participation or materials utilization plans; program protection plans (which may entail the following) manufacturing and integration plans; range utilization and support plans (air, sea, land, space, and cyber); data dissemination plans; asset transportation plans; classified test activity plans; disaster recovery plans; classified material / asset disposition plans and public affairs / communications plans.

b. Unclassified Submissions

DARPA anticipates that submissions received under this BAA will be unclassified. However, should a proposer wish to submit classified information, an *unclassified* email must be sent to the BAA mailbox notifying the Technical Office PSO of the submission and the below guidance must be followed.

Security classification guidance and direction via a Security Classification Guide (SCG) and/or DD Form 254, “DoD Contract Security Classification Specification,” will not be provided at this time. If a determination is made that the award instrument may result in access to classified information, a SCG and/or DD Form 254 will be issued by DARPA and attached as part of the award.

c. Classified Submissions

Note: Proposals for the DPRIVE solicitation should not be classified.

Classified submissions shall be transmitted in accordance with the following guidance. Additional information on the subjects discussed in this section may be found at <http://www.dss.mil/>.

If a submission contains Classified National Security Information as defined by Executive Order 13526, the information must be appropriately and conspicuously marked with the proposed classification level and declassification date. Similarly, when the classification of a submission is in question, the submission must be appropriately and conspicuously marked with the proposed classification level and declassification date. Submissions requiring DARPA to make a final classification determination shall be marked as follows:

“CLASSIFICATION DETERMINATION PENDING. Protect as though classified _____ (insert the recommended classification level, e.g., Top Secret, Secret or Confidential).”

NOTE: Classified submissions must indicate the classification level of not only the submitted materials, but also the classification level of the anticipated award.

Proposers submitting classified information must have, or be able to obtain prior to contract award, cognizant security agency approved facilities, information systems, and appropriately cleared/eligible personnel to perform at the classification level proposed. All proposer personnel performing Information Assurance (IA)/Cybersecurity related duties on classified Information Systems shall meet the requirements set forth in DoD Manual 8570.01-M (Information Assurance Workforce Improvement Program).

Proposers choosing to submit classified information from other collateral classified sources (i.e., sources other than DARPA) must ensure (1) they have permission from an authorized individual at the cognizant Government agency (e.g., Contracting Officer, Program Manager); (2) the proposal is marked in accordance with the source Security Classification Guide (SCG) from which the material is derived; and (3) the source SCG is submitted along with the proposal.

When a proposal includes a classified portion, and when able according to security guidelines, we ask that proposers send an e-mail to DPRIVE@darpa.mil as notification that there is a classified portion to the proposal. When sending the classified portion via mail according to the instructions, proposers should submit six (6) hard copies of the classified portion of their

proposal and two (2) CD-ROMs containing the classified portion of the proposal as a single searchable Adobe PDF file. Please ensure that all CDs are well-marked. Each copy of the classified portion must be clearly labeled with HR001120S0032, proposer organization, proposal title (short title recommended), and Copy _ of _.

Confidential and Secret Information

Use transmission, classification, handling, and marking guidance provided by previously issued SCGs, the DoD Information Security Manual (DoDM 5200.01, Volumes 1 - 4), and the National Industrial Security Program Operating Manual, including the Supplement Revision 1, (DoD 5220.22-M and DoD 5200.22-M Sup. 1) when submitting Confidential and/or Secret classified information.

Confidential and Secret classified information may be submitted via ONE of the two following methods:

- Hand-carried by an appropriately cleared and authorized courier to the DARPA CDR. Prior to traveling, the courier shall contact the DARPA Classified Document Registry (CDR) at 703-526-4052 to coordinate arrival and delivery.

OR

- Mailed via U.S. Postal Service (USPS) Registered Mail or USPS Express Mail. 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
ATTN: Program Security Officer, MTO
Reference: HR001120S0032
675 North Randolph Street
Arlington, VA 22203-2114

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

Defense Advanced Research Projects Agency
Security & Intelligence Directorate, Attn: CDR
675 North Randolph Street
Arlington, VA 22203-2114

Top Secret Information

Use classification, handling, and marking guidance provided by previously issued SCGs, the DoD Information Security Manual (DoDM 5200.01, Volumes 1 - 4), and the National Industrial Security Program Operating Manual, including the Supplement Revision 1, (DoD

5220.22-M and DoD 5200.22-M Sup. 1). Top Secret information must be hand-carried by an appropriately cleared and authorized courier to the DARPA CDR. Prior to traveling, the courier shall contact the DARPA CDR at 703-526-4052 to coordinate arrival and delivery.

Sensitive Compartmented Information (SCI)

SCI must be marked, managed and transmitted in accordance with DoDM 5105.21 Volumes 1 - 3. Questions regarding the transmission of SCI may be sent to the DARPA Technical Office PSO via the BAA mailbox or by contacting the DARPA Special Security Officer (SSO) at 703-812-1970.

Successful proposers may be sponsored by DARPA for access to SCI. Sponsorship must be aligned to an existing DD Form 254 where SCI has been authorized. Questions regarding SCI sponsorship should be directed to the DARPA Personnel Security Office at 703-526-4543.

Special Access Program (SAP) Information

SAP information must be marked in accordance with DoDM 5205.07 Volume 4 and transmitted by specifically approved methods which will be provided by the Technical Office PSO or their staff.

Proposers choosing to submit SAP information from an agency other than DARPA are required to provide the DARPA Technical Office Program Security Officer (PSO) written permission from the source material's cognizant Special Access Program Control Officer (SAPCO) or designated representative. For clarification regarding this process, contact the DARPA Technical Office PSO via the BAA mailbox or the DARPA SAPCO at 703-526-4102.

Additional SAP security requirements regarding facility accreditations, information security, personnel security, physical security, operations security, test security, classified transportation plans, and program protection planning may be specified in the DD Form 254.

NOTE: prior to drafting the submission, if use of SAP Information Systems is to be proposed, proposers must first obtain an Authorization-to-Operate from the DARPA Technical Office PSO (or other applicable DARPA Authorization Official) using the Risk Management Framework (RMF) process outlined in the Joint Special Access Program (SAP) Implementation Guide (JSIG), Revision 3, dated October 9, 2013 (or successor document).

5. Disclosure of Information and Compliance with Safeguarding Covered Defense Information Controls

The following provisions and clause apply to all solicitations and contracts; however, the definition of "controlled technical information" clearly exempts work considered fundamental research and therefore, even though included in the contract, will not apply if the work is fundamental research.

DFARS 252.204-7000, "Disclosure of Information"

DFARS 252.204-7008, "Compliance with Safeguarding Covered Defense Information Controls"

DFARS 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting” (A similar article will be included in all Other Transactions)

The full text of the above solicitation provision and contract clauses can be found at <http://www.darpa.mil/work-with-us/additional-baa#NPRPAC>. See the Model OT Agreement for ERI programs provided on the DARPA Acquisition Innovation website at <https://acquisitioninnovation.darpa.mil/samples-and-resources/darpa-ot-programs>, under the title “Microsystems Technology Office (MTO) Electronics Resurgence Initiative (ERI).”

Compliance with the above requirements includes the mandate for proposers to implement the security requirements specified by National Institute of Standards and Technology (NIST) Special Publication (SP) 800-171, “Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations” (see <https://doi.org/10.6028/NIST.SP.800-171r1>) that are in effect at the time the BAA is issued.

For awards where the work is considered fundamental research, the contractor will not have to implement the aforementioned requirements and safeguards. However, should the nature of the work change during performance of the award, work not considered fundamental research will be subject to these requirements.

6. Human Subjects Research (HSR)/Animal Use

Proposers that anticipate involving human subjects or animals in the proposed research must comply with the approval procedures detailed at <http://www.darpa.mil/work-with-us/additional-baa>, to include providing the information specified therein as required for proposal submission.

7. Approved Cost Accounting System Documentation

Proposers that do not have a Cost Accounting Standards (CAS) compliant accounting system considered adequate for determining accurate costs that are negotiating a cost-type procurement contract must complete an SF 1408. For more information on CAS compliance, see <http://www.dcaa.mil/cas.html>. To facilitate this process, proposers should complete the SF 1408 found at <http://www.gsa.gov/portal/forms/download/115778> and submit the completed form with the proposal. To complete the form, check the boxes on the second page, then provide a narrative explanation of your accounting system to supplement the checklist on page one. For more information, see (http://www.dcaa.mil/preaward_accounting_system_adequacy_checklist.html).

8. Section 508 of the Rehabilitation Act (29 U.S.C. § 749d)/FAR 39.2

All electronic and information technology acquired or created through this BAA must satisfy the accessibility requirements of Section 508 of the Rehabilitation Act (29 U.S.C § 794d)/FAR 39.2.

9. Small Business Subcontracting Plan

Pursuant to Section 8(d) of the Small Business Act (15 U.S.C. § 637(d)) and FAR 19.702(a)(1), each proposer who is a small business concern and seeking a procurement contract that has

subcontracting possibilities is required to submit a subcontracting plan with their proposal. The plan format is outlined in FAR 19.704. As of the date of publication of this BAA, per FAR 19.702, the threshold for submission of a small business subcontracting plan is \$700,000 (total contract amount including options).

10. Intellectual Property

All proposers must provide a good faith representation that the proposer either owns or possesses the appropriate licensing rights to all intellectual property that will be utilized under the proposed effort.

a. For Procurement Contracts

Proposers responding to this BAA requesting procurement contracts will need to complete the certifications at DFARS 252.227-7017. See www.darpa.mil/work-with-us/additional-baa for further information. If no restrictions are intended, the proposer should state “none.” The table below captures the requested information:

Technical Data Computer Software To be Furnished With Restrictions	Summary of Intended Use in the Conduct of the Research	Basis for Assertion	Asserted Rights Category	Name of Person Asserting Restrictions
(LIST)	(NARRATIVE)	(LIST)	(LIST)	(LIST)

b. For All Non-Procurement Contracts

Proposers responding to this BAA requesting a Technology Investment Agreement, or Other Transaction for Prototypes shall follow the applicable rules and regulations governing these various award instruments, but, in all cases, should appropriately identify any potential restrictions on the Government’s use of any Intellectual Property contemplated under the award instrument in question. This includes both Noncommercial Items and Commercial Items. Proposers are encouraged use a format similar to that described in Paragraph a. above. If no restrictions are intended, then the proposer should state “NONE.”

11. Patents

Include documentation proving your ownership of or possession of appropriate licensing rights to all patented inventions (or inventions for which a patent application has been filed) that will be utilized under your proposal for the DARPA program. If a patent application has been filed for an invention that your proposal utilizes, but the application has not yet been made publicly available and contains proprietary information, you may provide only the patent number, inventor name(s), assignee names (if any), filing date, filing date of any related provisional application, and a summary of the patent title, together with either: (1) a representation that you own the invention, or (2) proof of possession of appropriate licensing rights in the invention.

12. System for Award Management (SAM) and Universal Identifier Requirements

All proposers must be registered in SAM unless exempt per FAR 4.1102. FAR 52.204-7, “System for Award Management” and FAR 52.204-13, “System for Award Management Maintenance” are incorporated into this BAA. See <http://www.darpa.mil/work-with-us/additional-baa> for further information.

International entities can register in SAM by following the instructions in this link: https://www.fsd.gov/fsd-gov/answer.do?sysparm_kbid=dbf8053adb119344d71272131f961946&sysparm_search=KB0013221.

13. Funding Restrictions

Pre-award costs will not be reimbursed unless a preaward cost agreement is negotiated prior to award.

C. Submission Information

DARPA will acknowledge receipt of all submissions and assign an identifying control number that should be used in all further correspondence regarding the submission. DARPA intends to use electronic mail correspondence regarding HR001120S0032. Submissions may not be submitted by fax or e-mail; any so sent will be disregarded.

Submissions will not be returned. An electronic copy of each submission received will be retained at DARPA and all other non-required copies destroyed. A certification of destruction may be requested, provided the formal request is received by DARPA within 5 days after notification that a proposal was not selected.

All administrative correspondence and questions on this solicitation, including requests for clarifying information on how to submit an abstract or full proposal to this BAA should be directed to DPRIVE@darpa.mil. DARPA intends to use electronic mail for correspondence regarding HR001120S0032. Proposals and abstracts may not be submitted by fax or e-mail; any so sent will be disregarded. DARPA encourages use of the Internet for retrieving the BAA and any other related information that may subsequently be provided.

1. Submission Dates and Times

a. Abstract Due Date

Abstracts must be submitted to DARPA/MTO on or before 1:00 PM, Eastern Time, March 23, 2020. Abstracts received after this time and date may not be reviewed.

b. Full Proposal Date

Full proposals must be submitted to DARPA/MTO on or before 1:00 PM, Eastern Time, June 2, 2020, in order to be considered during the single round of selections. Proposals received after this deadline will not be reviewed. If deemed conforming, the Government will evaluate all received proposals

c. Frequently Asked Questions (FAQ)

DARPA will post a consolidated Question and Answer (FAQ) document on a regular basis. To access the posting go to: <http://www.darpa.mil/work-with-us/opportunities>. Under the HR001120S0032 summary will be a link to the FAQ. Submit your question/s by e-mail to DPRIVE@darpa.mil. In order to receive a response sufficiently in advance of the proposal due date, send your question/s on or before 1:00 PM, Eastern Time, May 16, 2020.

2. Abstract Submission Information

Proposers are strongly encouraged to submit an abstract in advance of a full proposal in order to provide potential proposers with a rapid response and to minimize unnecessary effort in proposal preparation and review. DARPA will acknowledge receipt of the submission and assign a control number that should be used in all further correspondence regarding the abstract.

All abstracts sent in response to HR001120S0032 shall be submitted via DARPA's BAA Website (<https://baa.darpa.mil>). Visit the website to complete the two-step registration process. Submitters will need to register for an Extranet account (via the form at the URL listed above) and wait for two separate e-mails containing a username and temporary password. After accessing the Extranet, submitters may then create an account for the DARPA BAA website (via the "Register your Organization" link along the left side of the homepage), view submission instructions, and upload/finalize the abstract. Proposers using the DARPA BAA Website may encounter heavy traffic on the submission deadline date; it is highly advised that submission process be started as early as possible.

All abstracts submitted electronically through the DARPA BAA Submission website must be uploaded as zip files (.zip or .zipx extension). The final zip file should only contain the document(s) requested herein and must not exceed 50 MB in size. Only one zip file will be accepted per abstract; abstracts not uploaded as zip files will be rejected by DARPA.

NOTE: YOU MUST CLICK THE 'FINALIZE PROPOSAL ABSTRACT' BUTTON AT THE BOTTOM OF THE CREATE PROPOSAL ABSTRACT PAGE. FAILURE TO DO SO WILL RESULT IN YOUR ABSTRACT NOT BEING OFFICIALLY SUBMITTED TO THIS BAA AND THEREFORE NOT BEING REVIEWED.

Please note that the DoD-issued certificate associated with the BAA website is not recognized by all commercial certificate authorities, resulting in untrusted connection errors/messages. You can either bypass the warning (possibly by adding <https://baa.darpa.mil> to your listed of trusted sites, or arpa.mil as a trusted domain), or visit DISA's site to download the Root Certificate

Authority (CA): <https://public.cyber.mil/from-iase/>.

Technical support for DARPA's BAA Website may be reached at BAAT_Support@darpa.mil, and is typically available during regular business hours, (9:00 AM - 5:00 PM EST Monday - Friday).

Note: DO NOT SUBMIT ABSTRACTS TO GRANTS.GOV.

3. Proposal Submission Information

The typical proposal should express a consolidated effort that addresses all challenges, deliverables, and metrics discussed above. Partial approaches or independent technology developments will not be considered. Disjointed efforts should not be included into a single proposal. Proposals not meeting the format described in the BAA may not be reviewed.

a. For Proposers Requesting Technology Investment Agreements

Proposers requesting Technology Investment Agreements (TIA) awarded under 10 U.S.C. 2371 must include the completed form indicated below. This requirement only applies only to those who expect to receive a TIA as their ultimate award instrument.

The National Defense Authorization Act (NDAA) for FY 2019, Section 1286, directs the Secretary of Defense to protect intellectual property, controlled information, key personnel, and information about critical technologies relevant to national security and limit undue influence, including foreign talent programs by countries that desire to exploit United States' technology within the DoD research, science and technology, and innovation enterprise. This requirement is necessary for all research and research-related educational activities. The DoD is using the form below to collect the necessary information to satisfy these requirements.

The Research and Related Senior/Key Person Profile (Expanded) form, available on the Grants.gov website at https://apply07.grants.gov/apply/forms/sample/RR_KeyPersonExpanded_2_0-V2.0.pdf, will be used to collect the following information for all senior/key personnel, including Project Director/Principal Investigator and Co-Project Director/Co-Principal Investigator, whether or not the individuals' efforts under the project are funded by the DoD:

- Degree Type and Degree Year.
- Current and Pending Support, including:
 - A list of all current projects the individual is working on, in addition to any future support the individual has applied to receive, regardless of the source.
 - Title and objectives of the other research projects.
 - The percentage per year to be devoted to the other projects.
 - The total amount of support the individual is receiving in connection to each of the other research projects or will receive if other proposals are awarded.
 - Name and address of the agencies and/or other parties supporting the other research projects
 - Period of performance for the other research projects.

Additional senior/key persons can be added by selecting the “Next Person” button at the bottom of the form. Note that, although applications without this information completed may pass Grants.gov edit checks, if DARPA receives an application without the required information, DARPA may determine that the application is incomplete and may cause your submission to be rejected and eliminated from further review and consideration under the BAA. DARPA reserves the right to request further details from the applicant before making a final determination on funding the effort.

b. For Proposers Requesting Contracts or Other Transaction Agreements

Proposers requesting contracts or other transaction agreements must submit proposals via DARPA's BAA Website (<https://baa.darpa.mil>). Note: If an account has already been created for the DARPA BAA Website, this account may be reused. If no account currently exists for the DARPA BAA Website, visit the website to complete the two-step registration process. Submitters will need to register for an Extranet account (via the form at the URL listed above) and wait for two separate e-mails containing a username and temporary password. After accessing the Extranet, submitters may then create an account for the DARPA BAA website (via the "Register your Organization" link along the left side of the homepage), view submission instructions, and upload/finalize the proposal. Proposers using the DARPA BAA Website may encounter heavy traffic on the submission deadline date; it is highly advised that submission process be started as early as possible.

All unclassified full proposals submitted electronically through the DARPA BAA website must be uploaded as zip files (.zip or .zipx extension). The final zip file should not exceed 50 MB in size. Only one zip file will be accepted per submission and submissions not uploaded as zip files will be rejected by DARPA.

NOTE: YOU MUST CLICK THE ‘FINALIZE FULL PROPOSAL’ BUTTON AT THE BOTTOM OF THE CREATE FULL PROPOSAL PAGE. FAILURE TO DO SO WILL RESULT IN YOUR PROPOSAL NOT BEING OFFICIALLY SUBMITTED TO THIS BAA AND THEREFORE NOT BEING REVIEWED.

Classified submissions and proposals requesting assistance instruments (grants or cooperative agreements) should NOT be submitted through DARPA's BAA Website (<https://baa.darpa.mil>), though proposers will likely still need to visit <https://baa.darpa.mil> to register their organization (or verify an existing registration) to ensure the BAA office can verify and finalize their submission.

Please note that the DoD-issued certificate associated with the BAA website is not recognized by all commercial certificate authorities, resulting in untrusted connection errors/messages. You can either bypass the warning (possibly by adding <https://baa.darpa.mil> to your listed of trusted sites, or arpa.mil as a trusted domain), or visit DISA's site to download the Root Certificate Authority (CA): <https://public.cyber.mil/from-iase/>.

Technical support for DARPA's BAA Website may be reached at BAAT_Support@darpa.mil, and is typically available during regular business hours (9:00 AM - 5:00 PM EST, Monday - Friday).

c. Classified Submission Information

See Section IV.B.4, "Security Information," for guidance on submitting classified abstracts and proposals.

4. Other Submission Requirements

Not applicable.

V. Application Review Information

A. Evaluation Criteria

Proposals will be evaluated using the following criteria, listed in descending order of importance:

1. Overall Scientific and Technical Merit

The proposed technical approach is innovative, feasible, achievable, and complete. The proposed technical team 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 outcome 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.

The proposed technical approach must establish the technical approach to reach the overall DPRIVE goals, deliverables, and metrics described above and for each of the three defined program phases. An understanding of the impact and challenges of LAWS as an enabler to reach the FHE computations goals of the program must be established as well as the knowledge and design capability, hardware and software, must be provided. An overall sequential plan to obtain the program goals must be defined and described.

The proposer's prior experience in similar efforts clearly demonstrates 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.

Appropriate knowledge of FHE is essential. Proven design, hardware and software must be established. As described above, the ability to provide system verification in a timely manner is critical and the background and capability to provide such verification is critical.

2. Potential Contribution and Relevance to the DARPA Mission and Technology Transition

The potential contributions of the proposed effort are relevant to the national technology base. Specifically, DARPA's mission is to make pivotal early technology investments that create or prevent strategic surprise for U.S. National Security.

The proposer clearly demonstrates its plans and capabilities to contribute to U.S. national security and U.S. technological capabilities. The evaluation will consider the proposer's plans and capabilities to transition proposed technologies to U.S. national security applications and to U.S. industry. The evaluation may consider the proposer's history of transitioning or plans to transition technologies to foreign governments or to companies that are foreign owned, controlled, or influenced. The evaluation will also consider the proposer's plans and capabilities to assist its employees and agents to be eligible to participate in the U.S. national security environment.

The proposer clearly demonstrates the capability to transition the technology to the research, industrial, and/or operational military communities in such a way as to enhance U.S. defense. In addition, the evaluation will take into consideration the extent to which the proposed intellectual property (IP) rights structure will potentially impact the Government's ability to transition the technology.

The impact of the FHE accelerator and the approaches to obtain those capabilities should be provided and described. Planned approaches to transition the FHE capabilities developed and impact current approaches should be addressed. Plans to impact standards and current implementations should be included. The implementation areas, FHE calculation and transmission, discussed above should specifically be addressed and the anticipated impact for DoD FHE encryption capabilities provided.

3. Cost and Schedule Realism

The proposed costs are realistic for the technical and management approach and accurately reflect the technical goals and objectives of the solicitation. The proposed costs are consistent with the proposer's Statement of Work and reflect a sufficient understanding of the costs and level of effort needed to successfully accomplish the proposed technical approach. The costs for the prime proposer and proposed subawardees are substantiated by the details provided in the proposal (e.g., the type and number of labor hours proposed per task, the types and quantities of materials, equipment and fabrication costs, travel and any other applicable costs and the basis for the estimates).

It is expected that the effort will leverage all available relevant prior research in order to obtain the maximum benefit from the available funding. For efforts with a likelihood of commercial application, appropriate direct cost sharing may be a positive factor in the evaluation. DARPA recognizes that undue emphasis on cost may motivate proposers to offer low-risk ideas with minimum uncertainty and to staff the effort with junior personnel in order to be in a more competitive posture. DARPA discourages such cost strategies.

The proposed schedule aggressively pursues performance metrics in the shortest timeframe and accurately accounts for that timeframe. The proposed schedule identifies and mitigates any potential schedule risk.

B. Review and Selection Process

1. Review Process

It is the policy of DARPA to ensure impartial, equitable, comprehensive proposal evaluations based on the evaluation criteria listed in Section V.A, and to select the source (or sources) whose offer meets the Government's technical, policy, and programmatic goals.

DARPA will conduct a scientific/technical review of each conforming proposal. Conforming proposals comply with all requirements detailed in this BAA; proposals that fail to do so may be deemed non-conforming and may be removed from consideration. Proposals will not be evaluated against each other since they are not submitted in accordance with a common work statement. DARPA's intent is to review proposals as soon as possible after they arrive; however, proposals may be reviewed periodically for administrative reasons.

Award(s) will be made to proposers whose proposals are determined to be the most advantageous to the Government, all factors considered, including the potential contributions of the proposed work to the overall research program and the availability of funding for the effort.

It is the policy of DARPA to ensure impartial, equitable, comprehensive proposal evaluations based on the evaluation criteria listed above and to select the source (or sources) whose offer meets the Government's technical, policy, and programmatic goals. Pursuant to FAR 35.016, the primary basis for selecting proposals for acceptance shall be technical, importance to agency programs, and fund availability. In order to provide the desired evaluation, qualified Government personnel will conduct reviews and (if necessary) convene panels of experts in the appropriate areas.

2. Handling of Source Selection Information

DARPA policy is to treat all submissions as source selection information (see FAR 2.101 and 3.104), and to disclose their contents only for the purpose of evaluation. Restrictive notices notwithstanding, during the evaluation process, submissions may be handled by support contractors for administrative purposes and/or to assist with technical evaluation. All DARPA support contractors performing this role are expressly prohibited from performing DARPA-sponsored technical research and are bound by appropriate nondisclosure agreements.

Subject to the restrictions set forth in FAR 37.203(d), input on technical aspects of the proposals may be solicited by DARPA from non-Government consultants/experts who are strictly bound by the appropriate non-disclosure requirements.

3. Federal Awardee Performance and Integrity Information (FAPIIS)

Per 41 U.S.C. 2313, as implemented by FAR 9.103 and 2 CFR § 200.205, prior to making an award above the simplified acquisition threshold, DARPA is required to review and consider any information available through the designated integrity and performance system (currently FAPIIS). Awardees have the opportunity to comment on any information about themselves entered in the database, and DARPA will consider any comments, along with other information in FAPIIS or other systems prior to making an award.

VI. Award Administration Information

A. Selection Notices

1. Abstracts

DARPA will respond to abstracts with a statement as to whether DARPA is interested in the idea. If DARPA does not recommend the proposer submit a full proposal, DARPA will provide feedback to the proposer regarding the rationale for this decision. Regardless of DARPA's response to an abstract, proposers may submit a full proposal. DARPA will review all conforming full proposals using the published evaluation criteria and without regard to any comments resulting from the review of an abstract.

2. Proposals

As soon as the evaluation of a proposal is complete, the proposer will be notified that (1) the proposal has been selected for funding pending contract negotiations, in whole or in part, or (2) the proposal has not been selected. These official notifications will be sent via email to the Technical POC identified on the proposal coversheet.

B. Administrative and National Policy Requirements

1. Meeting and Travel Requirements

All key participants are required to attend the program kickoff meeting. Performers should also anticipate regular program-wide PI Meetings and periodic site visits at the Program Manager's discretion. It is anticipated that PI meetings would be held at six month intervals with individual performer reviews held between PI meetings. For costing purposes, the PI meetings would be anticipated to be held on alternating coasts.

2. FAR and DFARS Clauses

Solicitation clauses in the FAR and DFARS relevant to procurement contracts and FAR and DFARS clauses that may be included in any resultant procurement contracts are incorporated herein and can be found at www.darpa.mil/work-with-us/additional-baa.

3. Controlled Unclassified Information (CUI) on Non-DoD Information Systems

Further information on Controlled Unclassified Information on Non-DoD Information Systems is incorporated herein can be found at www.darpa.mil/work-with-us/additional-baa.

4. Representations and Certifications

In accordance with FAR 4.1102 and 4.1201, proposers requesting a procurement contract must complete electronic annual representations and certifications at <https://www.sam.gov/>. In addition, resultant procurement contracts will require supplementary DARPA-specific representations and certifications. See <http://www.darpa.mil/work-with-us/additional-baa> for further information.

C. Reporting

The number and types of reports will be specified in the award document, but will include as a minimum quarterly technical and financial status reports. The reports shall be prepared and submitted in accordance with the procedures contained in the award document and mutually agreed on before award. Reports and briefing material will also be required as appropriate to document progress in accomplishing program metrics. 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.

D. Electronic Systems

1. Wide Area Work Flow (WAWF)

Unless using another means of invoicing, performers will be required to submit invoices for payment directly via to <https://wawf.eb.mil>. Registration in WAWF will be required prior to any award under this BAA.

2. i-Edison

The award document for each proposal selected for funding will contain a mandatory requirement for invention disclosures (and associated elections, confirmatory instruments, etc.) and patent reports to be submitted electronically through i-Edison (<https://public.era.nih.gov/iedison>).

3. TFIMS

The award document for each proposal selected for funding will contain a mandatory requirement for technical and status reports to be submitted electronically through DARPA's TFIMS (or similar) web-based tool.

VII. Agency Contacts

Administrative, technical or contractual questions should be sent via e-mail to DPRIVE@darpa.mil. All requests must include the name, email address, and phone number of a point of contact.

The technical POC for this effort is:

Dr. Tom Rondeau
DARPA/MTO
ATTN: HR001120S0032
675 North Randolph Street
Arlington, VA 22203-2114
Email: DPRIVE@darpa.mil

VIII. Other Information

A. Proposers Day

The DPRIVE Proposers Day will be held on March 2, 2020 in Cupertino, CA. Advance registration is required for the meeting. See DARPA-SN-20-28 posted at <https://beta.sam.gov> for all details. Attendance at the DPRIVE Proposers Day is not required to propose to this solicitation.

B. Protesting

For information concerning agency level protests see <http://www.darpa.mil/work-with-us/additional-baa#NPRPAC>.