



Microsystems Technology Office  
Broad Agency Announcement  
Photonics in the Package for Extreme Scalability (PIPES)  
HR001119S0004  
October 31, 2018

**AMENDMENT 1**  
**As amended on November 16, 2018**

## Foreword

In June 2017, the Defense Advanced Research Projects Agency (DARPA) announced the Electronics Resurgence Initiative (ERI), a five-year, upwards of \$1.5B investment in the future of domestic, U.S. Government (USG), and Department of Defense (DoD) electronic systems. ERI recognizes and addresses long-foreseen obstacles to Moore's Law, the transistor scaling trend that has allowed for 50 years of rapid progress in electronics. These obstacles include economic, geopolitical, and physics-based complications that strain both the commercial and defense sectors. The cost of integrated circuit fabrication, design, and verification is skyrocketing and limiting innovation; the continued move towards generalization and abstraction is stifling potential gains in hardware; and foreign investments are distorting the market and shifting technology development outside of the United States. To address these issues, ERI kicked off a major investment that draws on the contributions of several ongoing DARPA programs and creates new, long-term technology investments. Through novel research and development (R&D) in semiconductor materials and integration, architectures, and designs, ERI programs will promote circuit specialization as a complement to transistor scaling. The success of these efforts will depend on constructively enmeshing the technology needs and capabilities of the defense enterprise with the commercial and manufacturing realities of the electronics industry.

DARPA publicly announced competitive awards for the first group of six new ERI programs at the first annual ERI Summit, held in July 2018. In addition to introducing the awarded ERI performers, the ERI Summit featured four workshops designed to generate ideas for future ERI programs. Three key issues emerged from the workshop discussions: the need to support domestic manufacturing options and enable them to develop differentiated capabilities for diverse needs; a demand to invest in chip security; and a desire to create new connections between the various ERI programs and to demonstrate the resulting technologies in defense applications. ERI Phase II will build on the existing ERI programs to address all of these challenges, with the goal of supporting a domestic semiconductor manufacturing industry that can implement specialized circuits, demonstrate that those circuits can be trusted through the supply chain and are built with security in mind, and are ultimately available to both DoD and commercial sector users.

To create unique and differentiated domestic manufacturing capabilities, potential areas of exploration in Phase II include the integration of photonics, microelectromechanical systems (MEMS), and radiofrequency (RF) components directly into advanced circuits and semiconductor manufacturing processes. This is important for the DoD because the Department's electronics manufacturing needs are numerous and diverse and its systems have unique requirements and specific functionality. Although traditional CMOS scaling for digital processing is still an important area of investment, many critical DoD-relevant electronics will likely derive from alternative and complementary vectors. Anticipated investments will seek to ensure that new capabilities support a strategy for the enduring availability of differentiated, high-performance electronics for the DoD and its commercial sector partners.

Over the fall of 2018, DARPA will announce additional investments relevant to issues highlighted at the ERI Summit. For instance, Summit participants discussed the need for traceability of electronics components, from design through to use, and for electronics that can enforce protections for security and privacy. Potential ERI Phase II programs under development

will therefore consider the need for assured electronics that incorporate protections from security risks. Summit participants also requested new opportunities for participating in the effort, to include possibilities for increasing the connections between the various ERI efforts – from fundamental research programs to technology application programs. ERI Phase II will therefore explore emerging and future applications of ERI technologies, developed across all sectors, to defense-specific systems. These connections between programs and end users will be key to ERI’s overall success, driving DARPA’s ability to deliver differentiated capabilities to the DoD and its partners. Programs under development should help ensure that the technological advances that derive from ERI will deliver significant impact for national security. Potential areas of exploration could include ERI applications in large-scale physical emulation, cognitive RF systems, next-generation satellites, cybersecurity, and beyond.

Together with the ongoing ERI programs, including the “ERI Page 3 Investments” announced in 2017, ERI Phase II is the next step in creating a more robust, secure, and heavily automated electronics industry that will provide a foundational contribution both to U.S. national security and to the needs and ambitions of the commercial sector, with new capabilities emerging in the 2025 to 2030 timeframe. DARPA is eager to receive proposals from entities that can help to achieve this goal.

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## PART I: OVERVIEW INFORMATION

- **Federal Agency Name:** Defense Advanced Research Projects Agency (DARPA), Microsystems Technology Office (MTO)
- **Funding Opportunity Title:** Photonics in the Package for Extreme Scalability (PIPES)
- **Announcement Type:** Initial Announcement
- **Funding Opportunity Number:** HR001119S0004
- **Catalog of Federal Domestic Assistance Numbers (CFDA):** 12.910 Research and Technology Development
- **Dates:** (All times listed herein are Eastern Time)
  - Posting Date: October 31, 2018
  - Proposers Day: November 1, 2018
  - **Abstract Due Date: November 27, 2018 at 1:00 PM**
  - FAQ Submission Deadline: January 3, 2019 at 1:00 PM
  - Proposal Due Date: January 17, 2019 at 1:00 PM
  - Estimated period of performance start: July 2019
- **Concise description of the funding opportunity:** The DARPA Microsystems Technology Office is soliciting research proposals for the development of package-level optical signaling technologies for advanced microelectronic systems to enable disruptive performance scaling through parallelism.
- **Anticipated Funding Available for Award:** Approximately \$65M of funding is anticipated for awards made against this BAA, with a distribution of:
  - \$35M for Technical Area 1 (TA1) including Technical Area 1B (TA1B)
  - \$20M for Technical Area 2 (TA2)
  - \$10M for Technical Area 3 (TA3)
- **Anticipated individual awards:**
  - Multiple awards are anticipated in each technical area.
  - DARPA anticipates individual awards in TA1B not to exceed \$600,000.
- **Anticipated funding type:**
  - 6.3 for TA1 and TA1B
  - 6.2 for TA2 and TA3
- **Types of instruments that may be awarded:**
  - TA1 and TA1B may award procurement contract or other transaction only.
  - TA2 and TA3 may award procurement contract, grant, cooperative agreement or other transaction.
- **Agency contact:**
  - Dr. Gordon Keeler, Program Manager  
BAA Coordinator: HR001119S0004@darpa.mil  
DARPA/MTO  
ATTN: HR001119S0004  
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 the procedures under Federal Acquisition Regulation (FAR) 6.102(d)(2) and 35.016 and 2 C.F.R. § 200.203. Any negotiations and/or awards will use procedures under FAR 15.4, Contract Pricing. 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 Federal Business Opportunities (FedBizOpps) website, <http://www.fbo.gov>, and, as applicable, the Grants.gov website at <http://www.grants.gov>. The following information is for those wishing to respond to the BAA.

The Microsystems Technology Office at DARPA seeks innovative research proposals to develop optical technologies for data movement in digital microelectronics to allow disruptive system scaling through parallelism. Proposed research should investigate 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.

#### **A. Background**

Since the end of clock frequency scaling in the mid-2000s, the microelectronics industry has progressively embraced parallelism to sustain performance growth. Distributed and parallel architectures are now pervasive across all size scales, from multicore processing units to high-performance computing systems, and span application domains from consumer electronics to DoD systems. Increasingly, however, the benefits of parallelism are constrained not by the limits of computation at individual nodes, but by data movement between nodes. While short-reach connectivity between on-chip cores and within multi-chip modules (MCMs) can be achieved using electrical links with high density, bandwidth, and efficiency, interconnect performance rapidly degrades at the length scales of circuit boards and beyond due to unfavorable scaling with frequency and reach. The energy dissipated by Serializer/Deserializer (SerDes) functions used to move data between integrated circuit (IC) packages represents a large and increasing fraction of overall energy use, restricting off-chip I/O capacity, reducing system performance, and limiting scalability.

Conversely, photonic transceiver modules enable optical signaling with high bandwidth and minimal loss over long distances with optical fiber. However, optical I/O to date has taken the form of pluggable modules on circuit boards, connected to MCM packages with electrical links whose power dissipation and density limit overall performance. Improvements must be achieved through a reduction in signaling energy and latency, while overall signaling capacity and component density must be increased. To fully achieve the potential benefits of optical signaling, photonic solutions must move into the microelectronics package.

## **B. Program Description and Technical Overview**

The objective of PIPES is to enable disruptive system scalability by developing optical signaling technologies for digital microelectronics. The program will employ intimate integration of photonics with advanced ICs to yield system connectivity with an unprecedented combination of high aggregate bandwidth, power efficiency, channel density, and link reach.

Through the PIPES program, DARPA seeks to: 1) integrate photonic interconnect capabilities within state-of-the-art MCMs for system prototyping; 2) advance embedded optical signaling performance through the development of emerging component technologies, photonic-electronic integration techniques, and scalable architectures and multiplexing concepts; 3) develop and mature low-loss optical packaging and reconfigurable switching technologies; and, 4) establish a domestic ecosystem that facilitates enduring Department of Defense (DoD) access to differentiated capabilities for in-package photonic signaling.

The development of efficient, high bandwidth package-level photonic signaling is anticipated to impact a host of applications that can be categorized in two key areas. The first is the domain of big data, which includes machine learning, large scale emulation, and high performance computing. Recent trends towards massive parallelism and disaggregation have increased the demand for improved interconnect performance. Optical signaling is already common in such systems at the board and rack levels, but has not yet been directly integrated within the component switch chips, central processing units (CPUs), and graphical processing units (GPUs). Second is the area of advanced sensors and wireless interfaces. The DoD makes extensive use of application-specific integrated circuits (ASICs) and field-programmable gate arrays (FPGAs) that push the boundaries of socket power and I/O capacity in such domains. While big data applications have numerous commercial volume drivers, the market pull for many DoD-relevant specialty ASICs is insufficient to justify the early adoption of optical technologies. The PIPES program seeks impact in both key areas by aiding commercial advances through technology investment, and by aligning these commercial outcomes with system integrators to establish a path for national security impact.

In order to achieve these goals, PIPES is soliciting innovative research proposals in three main Technical Areas (TAs):

Technical Area 1 (TA1) – Photonically-Enabled MCMs will develop high-performance optical I/O technology for co-packaging with state-of-the-art packaged ICs, including FPGAs, CPUs, GPUs, and ASICs. Specific objectives of this TA include component development leading to 1 pJ/bit energy consumption for end-to-end links, delivery of multiple MCM prototypes containing optical I/O, and a scalability demonstration of 100 Tbps full-duplex I/O bandwidth from the package.

Successful proposals to TA1 must combine the necessary photonic component development, electronic integration, and robust packaging necessary to fulfill technical program metrics, but should also outline a framework within which I/O technology developed under PIPES could be accessed more broadly within a domestic ecosystem for differentiated DoD access to unique capabilities. Such availability may be achieved by: 1) making optical I/O chiplet products



available to system integrators, 2) developing open interface standards, 3) providing intellectual property (IP) blocks accessible in foundry design kits, and 4) offering a domestic optoelectronic packaging capability to enable third parties to add photonic I/O functionality to high-performance microelectronic ICs. Establishing a mechanism for DoD access to PIPES technologies is an essential element of the program and of ERI Phase II programs more generally; contributions to realizing this vision are expected from all Technical Areas.

Technical Area 1, Track B (TA1B) – Defense Applications and Demonstration will be a separate effort within TA1 that investigates the application of photonically-enabled MCMs for DoD-specific use cases. This TA will develop performance models with detailed hardware requirements. Pending the results of these studies and availability of funds, exceptional concepts may be advanced to hardware system demonstrations using TA1 prototypes and/or capabilities. Successful proposals to TA1B will identify the performance constraints imposed by data I/O in current or future DoD systems, and evaluate the improvement provided by TA1 technology. Ultimately, the goal of TA1B is to demonstrate the national security benefits of photonic I/O technologies, and collaboration with TA1 performers will be strongly encouraged and facilitated during the program.

Technical Area 2 (TA2) – Photonics for Massive Parallelism will develop revolutionary new approaches to in-package optical I/O scalable to 1 Pbps aggregate bandwidth for future microelectronic systems. This TA will investigate novel component technologies and advanced link concepts that target 0.1 pJ/bit energy consumption in end-to-end bidirectional links. Elements of TA2 are expected to be less mature than those used in TA1, but proposers should identify how the technology can be transitioned to high-volume manufacturing settings. Successful proposals to TA2 will combine photonic component development, electronic design and integration, and packaging concepts to fulfill technical program metrics, and will describe a path to maturation.

Technical Area 3 (TA3) – Interconnect Fabrics will develop key technologies to facilitate the use of package-level photonic I/O in future systems and amplify its impact. Two technical thrusts will be pursued, both seeking disruptive, innovative technology solutions to support optical connectivity with hundreds of individually routable high-bandwidth channels. The first thrust will develop low-loss optical packaging approaches to enable high channel densities and port counts, while the second thrust will develop reconfigurable, low-power optical switching technologies.

#### Preferred MCM Form Factors

The program vision for all TAs calls for consistency with IC packages that can be easily accepted and employed by the broader microelectronics industry. Therefore, the desired package should not present a significant departure from current IC packaging practice in terms of size, form factor, electrical interfaces, and thermal management. It is recommended that the size does not exceed 2 inches in any horizontal dimension. As in most IC packages, electrical connections should be constrained to the bottom surface, with solder or pin connectors compatible with printed circuit board solutions. Optical I/O may be interfaced through any of the package surfaces, as long as it does not interfere with standard circuit board layout or thermal

management requirements. While the use of optical fibers is anticipated, alternative waveguide technologies may be considered, provided they can meet program goals.

### **C. Program Structure**

PIPES is a 42-month program divided into three Phases, summarized below:

- Phase 1 (base) – 18 months: Demonstration of concepts, components, and function
- Phase 2 (option) – 12 months: Integration and prototyping
- Phase 3 (option) – 12 months: Establishing scalability, complexity, and maturity

DARPA anticipates funding a variety of technical approaches within the PIPES program. 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.

TA1B represents an exception to the structure above. This effort has two phases (base 12 months, option 12 months), with a goal of transitioning the technologies developed under PIPES through demonstrations relevant to DoD needs. Further discussion of the TA1B timeline, structure, and expectations are detailed below.

### **D. Technical Area Details**

PIPES seeks proposals in three main Technical Areas. Entities may submit to more than one Technical Area, and multiple proposals per organization are permitted. Each proposal must address only a single TA. TA1B also requires a standalone proposal. TA3 proposers can address one or both TA3 thrust areas within a single proposal.

#### ***Technical Area 1 (TA1) - Photonically-Enabled MCMs***

The goal of TA1 is to develop and mature optical I/O for advanced MCMs, including the technology required to enable 100 Tbps aggregate escape bandwidth per IC package with an energy consumption of 1 pJ/bit. These goals meet anticipated I/O requirements for advanced microelectronics of the 2025 era while constraining the power reserved for communication to 100 Watts, thereby enabling the use of conventional cooling techniques. Key outcomes of this Technical Area include the demonstration of in-package photonic signaling technologies meeting prescribed metrics; prototypical, commercially-relevant photonically-enabled MCMs; and the creation of an ecosystem that makes package-level photonic interconnect technology accessible to the DoD.

The technologies, prototypes, and capabilities developed under TA1 funding have clear commercial applications, and performer cost share is highly encouraged.

The photonically-enabled multi-chip modules envisioned in TA1 will include one or more advanced integrated circuit cores that are anticipated to be fully electrical in nature, and may originate from one of many microelectronics foundries. The PIPES program considers signals to originate and terminate on these IC cores in the electrical domain, and seeks to transport these

bits with high efficiency in the optical domain. Inter-package optical signaling technology is anticipated to be enabled through in-package integration of additional ICs, photonic dies, chiplets, and/or interposer-like technologies that will be combined with the IC core.

The development of new IC cores lies outside the scope of this program. Proposers are encouraged to use existing IC cores or technology developed outside of the PIPES program for this effort. Proposers must present a test plan to verify all program metrics, including the proposed means to generate, transmit, detect, and validate data streams originating and terminating within the package. This testing is anticipated to be achieved using performer-provided MCM IC cores and proxy IC cores whose development does fall within the scope of PIPES.

PIPES TA1 proposals should clearly outline all elements of the proposed solution to enable the link metrics posed below. All in-package electrical circuits required for signaling, coding, multiplexing, clock and data recovery, error correction, etc. should be included in the analysis of the proposed link. Laser source(s) can be internal or external to the package, but all power consumption related to laser operation, including light generation and control, must be accounted for in energy calculations.

*Phase 1* – In the initial 18-month Phase 1, the TA1 goal is to demonstrate a packaged I/O prototype with intermediate performance of 10 Tbps aggregate bandwidth consuming 2.5 pJ/bit. Metrics in Table 1 apply to this “10T technology demonstrator,” which can be satisfied by co-packaging optical I/O with a proxy IC core to generate and receive data streams.

*Phase 2 (Option)* – In the 12-month Phase 2, the TA1 goal is to demonstrate a packaged I/O prototype with intermediate performance of 10 Tbps bandwidth consuming 1 pJ/bit. Again, the “10T technology demonstrator” can be satisfied by co-packaging optical I/O with a proxy IC core to generate and receive data streams. In addition, the same I/O technology at 1 pJ/bit should be packaged in an MCM with a performer-provided, fully-functional IC core. It is envisioned that this MCM demonstrator will be satisfied by an operational state-of-the-art IC (e.g., FPGA, GPU, CPU, ASIC, etc.) with potential to support a DoD-relevant system demonstration. The processing core(s) and one or more optical modules must be fully packaged in a multi-chip package, along with required electrical support components and optical fibers or other waveguides. The data output through the optical I/O may consist of any dataset approximating the intended application. For any MCM proposed, its function and relevance to a DoD application must be clearly specified. A satisfactory demonstration requires a pair of packaged MCMs communicating in full-duplex mode at the specified data rate over a >20 m optical channel. A pair consisting of an optically enabled ASIC and an optically enabled FPGA/GPU/CPU does satisfy the requirement.

Metrics in the Phase 2 column of Table 1 below apply to both the 10T technology demonstrator and the MCM demonstrator. Delivery of ten packaged and operational MCM units and two packaged 10T technology demonstration units is required at the conclusion of Phase 2. A Government agent will perform an independent test and evaluation of the delivered devices. Deliverable units will not be returned to the performer. Phase 2 MCMs may be made available to

TA1B performers as government-furnished equipment for use in a TA1B demonstration, should DARPA select to award such an activity.

*Phase 3 (Option)* – In a final 12-month Phase 3, the TA1 goal is a 100 Tbps prototype demonstration with a proxy core, and elements of the technology made available for third party use within a domestic ecosystem for differentiated DoD access to unique capabilities. Metrics in Table 1 below apply to the technology demonstrator. Any core capable of generating 100 Tbps can be used, and the use of a proxy core in lieu of an actual processing core is permitted.

Delivery of two fully packaged operational units is required at the end of Phase 3. A Government agent will perform an independent test and evaluation of the delivered devices. Deliverable units will not be returned to the performer.

Additional TA1 metrics are detailed in Table 1 below.

**Table 1. Technical Area 1 (TA1): Photonically-Enabled MCMs – Program Metrics**

	Phase 1	Phase 2	Phase 3
<b>Key outcomes</b>	<b>10T technology demonstration*</b>	<b>Enhanced 10T demo* AND Packaged MCM demo</b>	<b>100T technology demo* AND Differentiating Access</b>
Aggregate bandwidth	10 Tbps	10T demo: 10 Tbps MCM: proposer defined	100 Tbps
Energy per bit	2.5 pJ/bit	1 pJ/bit	1 pJ/bit
Edge bandwidth density	1 Tbps/mm	2 Tbps/mm	2 Tbps/mm
Link latency	200 ns + TOF	100 ns + TOF	100 ns + TOF
Link reach (between packages)	20 meters	20 meters	20 meters
Bit error ratio (BER)	$10^{-9}$	$10^{-12}$	$10^{-12}$
Link margin	0 dB	2 dB	4 dB
Packaged units delivered	--	2x 10T demo units 10x MCM units	2x 100T demo units
Operating temperature range	--	Room temperature to 80°C	Room temperature to 80°C
Solder reflow compatible	--	250°C, 5 min	250°C, 5 min
Integration and optical packaging technique	manual assembly	manual assembly	automated
Total port count	proposer defined	proposer defined	proposer defined

\* Technology demonstrators are satisfied by co-packaging optical I/O with a proxy IC core to generate and receive data streams.

### *TA1 Metrics Definitions*

- *Aggregate bandwidth* – The full-duplex data rate of optical signaling. Demonstrations must transmit and receive data at this aggregate rate, but the number of independent channels, wavelengths, symbols, fibers, etc. is proposer defined (see ports).
- *Energy per bit* – The energy required to move electrical bits between IC cores of two packages, originating and terminating with digital signaling at standard clock rates and full swing voltage levels. Includes all in-package signaling energy, all required electrical circuits for modulation, SerDes, receiver amplification, coding, error correction, etc., electro-optical components and control overhead (e.g., thermal or other), and laser power consumption. All energy required to drive, control, and cool the laser must be included, and all optical coupling and insertion losses must be accounted for. The energy per bit

metric must be supported by a quantitative link power budget including all of the above elements. The link budget should be consistent with the receiver sensitivity and required margin for the modulation format proposed and BER metric given.

- *Edge bandwidth density* – Bi-directional (duplex) optical bit rate divided by the length of package edge required for optical I/O.
- *Bit error ratio (BER)* – Received bit error rate. Any required coding and error correction must be accounted for in signaling power and latency estimates.
- *Link latency* – All added signaling delays must be analyzed and discussed. The evaluation of latency must include delays from both the electrical interfaces and the optical link components, as well as any overhead introduced by signal processing. Time of flight (TOF) for optical signal propagation should not be included.
- *Operating temperature range* – Package temperature range through which the MCM operates and meets all other Table 1 metrics. If the operating temperature inside the MCM package is expected to exceed 80°C, it must be specified and the co-packaged optical I/O must be tested for reliable operation at that higher temperature. If an external laser module is proposed, the operation temperature of that module is proposer-defined and must be specified and evaluated in the context of a realistic usage scenario.
- *Total port count* – An optical port is defined as an indivisible I/O connection between two physically distinct locations. For example, 10 separate optical fibers on an MCM might be connected to 10 separate locations, and would represent 10 ports. As a counterexample, 10 wavelength-division multiplexed (WDM) optical channels routed through a common single fiber represent a single port. The number of ports and the number of wavelengths per port must be analyzed and discussed in the context of the intended application.

### ***TA1 Track B (TA1B) - Defense Applications and Demonstration***

The goal of the Defense Applications and Demonstration track is to apply the technology developed in TA1 to a high-value mission of interest to the DoD. The effort consists of two 12-month phases to develop a concept, and to clearly define a hardware demonstration, respectively. During these phases, TA1B performers are also expected to participate in defining a domestic ecosystem for differentiated DoD access to unique capabilities through discussions and collaboration with technology developers and providers.

At the end of the second phase, DARPA anticipates funding one or more efforts to demonstrate the impact of PIPES technologies in a compelling defense application. DARPA anticipates receiving proposals for such work from PIPES TA1B performers at that time, and may solicit proposals more broadly through a future BAA. A description of this 18-month “Demonstration Phase” is provided below for reference. TA1B proposers should not include Phase 3 activities in response to the current BAA.

*Phase 1* – In the initial 12-month Phase 1, the TA1B goal is to develop an integration concept that leverages PIPES technologies to enable a DoD-relevant system application. It is expected that TA1B DoD system integrators will work closely with one or more TA1 performers to co-develop the integration concept, and will identify additional requirements needed to implement

the concept. It is anticipated that Phase 2 options will be exercised only for the most promising concepts.

*Phase 2 (Option)* – In the optional 12-month Phase 2, the TA1B goal is to develop a full demonstration plan for the proposed defense application. The demonstration is expected to use photonically-enabled MCMs produced and delivered at the conclusion of TA1 – Phase 2, and/or custom hardware enabled by access to PIPES capabilities and technologies. At the end of Phase 2, TA1B performers are required to deliver a white paper detailing the integration and demonstration plan for the concept, which could be proposed as a follow-on activity in the Demonstration Phase.

*Phase 3 (For reference only. Not to be proposed)* – As a follow-on activity, and dependent on the successful development of technologies described above, DARPA anticipates funding one or more performers to participate in an 18-month Demonstration Phase. Technologies developed under TA1, TA2, and TA3 may be provided as government-furnished equipment (GFE) for the purposes of such demonstrations, particularly the photonically-enabled MCMs delivered under TA1 – Phase 2.

Alternatively, performer access to relevant technologies may be facilitated through the collaborations and the mechanisms for differentiated access to unique capabilities established under PIPES.

DARPA reserves the right to solicit and select proposals from performers other than those initially selected to participate in TA1B.

TA1B proposers are required to address the following proposal elements with sufficient detail:

- (1) Describe the DoD application targeted, the interconnect requirement in terms of architecture, bandwidth, power, reach, latency and any other relevant performance metrics. Describe how the problem is addressed today, the limitations of the current approach, and why a solution based on PIPES technology will be beneficial.
- (2) Clearly show the expected benefit to the DoD mission by projecting the differential advantage provided to the Warfighter. DARPA is interested in providing revolutionary advances in the respective field or enabling new missions not possible with today's technology. Specifically excluded are applications that primarily result in evolutionary improvements to the existing state of practice.
- (3) Outline the specific technical requirements for the photonically-enabled MCMs and/or optical I/O capabilities accessed through an emerging ecosystem and describe how these will be integrated into the proposed effort. Include a description of the required interfaces, operating conditions (e.g., temperature range, acceleration range, radiation environment, etc.), and physical footprint/form-factor requirements. Refinement of the requirements for a successful demonstration will continue through Phase 1 and must be finalized prior to Phase 2. Collaboration with a TA1 proposer at the proposal stage is encouraged but not required. If the proposed concept is selected for an award, it is

expected that a TA1 partner will be identified and an Associate Contractor Agreement (ACA) between the two performers will be signed no later than the conclusion of Phase 1.

### ***Technical Area 2 (TA2) - Photonics for Massive Parallelism***

The goal of TA2 is to develop revolutionary optical I/O technologies capable of 1 Pbps bandwidth from a microelectronics package at 0.1 pJ/bit. While challenging today, this bandwidth requirement is consistent with projected microelectronic I/O needs in the 2030 era based on historical scaling trends. This technical area will focus on component innovation, intimate electronic-photonics integration, optical packaging, and novel signaling approaches that enable disruptive improvements to bandwidth density, energy consumption, and complexity scaling. A key driver of this effort is to enable system scalability through distributed and massively parallel architectures, yet substantial impact may be realized by achieving only midterm metrics.

While a full hardware demonstration of 1 Pbps I/O is not required within the program, TA2 efforts are expected to develop fully-functional I/O links with sufficient performance and demonstrated scalability such that the ability to reach that goal is clearly established. In a similar spirit to TA1, the energy consumption metric of 0.1 pJ/bit is required to constrain the future 1 Pbps solution to a communication power envelope of 100 Watts, thereby enabling the use of conventional cooling techniques. Note that the TA2 areal bandwidth density metric of 5 Tbps/mm<sup>2</sup> corresponds to 100 Tbps I/O occupying an area of less than 5 mm x 5 mm. These efficiency and density targets lie far beyond the state-of-practice for optical interconnect, and success will likely entail the incorporation of novel components and concepts.

While DARPA remains agnostic to the specific technologies proposed as solutions, it is envisioned that some of the following innovations may appear in TA2 links: dense wavelength-division multiplexing (DWDM), comb laser sources, efficient directly-modulated lasers integrated on-chip, coherent signaling, advanced modulation formats, compact/high-efficiency modulators and detectors using plasmonics, nanophotonics, or low-dimensional materials, receiverless photodetection, and the elimination of other circuitry for coding, error correction, clock and data recovery (CDR), SerDes, etc. Further, intimate photonic-electronic integration will be essential to eliminate most in-package electrical signaling power, and integration methods beyond conventional 2.5D approaches may be required.

As described previously, signals are considered to originate and terminate on advanced integrated circuits in the electrical domain. While the extensive development of application-specific ICs lies outside the scope of PIPES, proposers must present a test plan to verify all program metrics. This will require a means to generate, transmit, detect, and validate large data streams originating and terminating within the package. This testing may be performed using proxy IC cores, whose development does fall within the scope of PIPES. Note that TA2 efforts must develop full-duplex bidirectional links and proposals to develop standalone individual components or partial solutions will not be considered for funding.

PIPES TA2 proposals should clearly outline all elements of the proposed solution to enable the link metrics posed below. All in-package electrical circuits required for signaling, coding, multiplexing, clock and data recovery, error correction, etc. should be included in the analysis of the proposed link. Optical source(s) can be internal or external to the package, but all power consumption related to their operation, including light generation and control, must be accounted for in energy calculations.

*Phase 1* – In the initial 18-month Phase 1, the TA2 goal is to develop and demonstrate benchtop prototype link concepts consistent with the goals of 5 Tbps/mm<sup>2</sup> areal bandwidth density and 0.5 pJ/bit energy consumption. This Phase will be used to demonstrate feasibility of the proposed approach and to validate component performance. Measurements should demonstrate performance aligned with integrated link targets, although photonic-electronic integration processes may require further development before all required integrated circuits are incorporated in Phase 2.

*Phase 2 (Option)* – In the 12-month Phase 2, the TA2 goal is to demonstrate integrated prototype links with 10 Tbps aggregate bandwidth consuming only 0.2 pJ/bit. Links prototyped and measured should demonstrate performance consistent with a scaled Phase 3 platform to meet the final program goals.

Delivery of two operational demo units satisfying a complete link (i.e., 1 or more ports) is required at the conclusion of Phase 2. A Government agent will perform an independent test and evaluation of the delivered hardware. Deliverable units will not be returned to the performer.

*Phase 3 (Option)* – In the 12-month Phase 3, the TA2 goal is to demonstrate a fully integrated and packaged system with a 100 Tbps aggregate bandwidth consuming only 0.1 pJ/bit, delivered through 10 or more independent I/O ports, and in a form factor that is scalable to 1 Pbps in the dimensions of typical MCM packages.

Delivery of two operational demo units satisfying a complete link (i.e., 10 or more ports) is required at the conclusion of Phase 3. Deliverable units will not be returned to the performer.

Additional TA2 metrics are detailed in Table 2 below.

**Table 2. Technical Area 2 (TA2): Photonics for Massive Parallelism – Program Metrics**

	Phase 1	Phase 2	Phase 3
<b>Key outcomes</b>	<b>Benchtop component demonstration</b> performance traceable to link prototype	<b>Integrated link demonstration</b> performance traceable to scaled system	<b>Scaled multi-port I/O demonstration</b> performance consistent with 1 Pbps capability
Energy per bit	0.5 pJ/bit	0.2 pJ/bit	0.1 pJ/bit
Areal bandwidth density	5 Tbps/mm <sup>2</sup>	5 Tbps/mm <sup>2</sup>	5 Tbps/mm <sup>2</sup>
Aggregate bandwidth	proposer defined	10 Tbps	100 Tbps
Total port count	--	≥ 1	≥ 10
Link latency	--	100 ns + TOF	50 ns + TOF
Link reach (between packages)	1 meters	10 meters	100 meters
Bit error ratio (BER)	10 <sup>-9</sup>	10 <sup>-12</sup>	10 <sup>-12</sup>
Hardware delivered	--	2 demo units	2 demo units



Operating temperature range	--	Room temperature to 80°C	Room temperature to 80°C
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### *TA2 Metrics Definitions*

- *Energy per bit* – The energy required to move electrical bits between IC cores of two packages, assuming digital signaling at standard clock rates and full swing voltage levels. Includes all in-package signaling energy, all required electrical circuits (modulation, SerDes, receiver amplification, coding, error correction, etc.), electro-optical signal manipulation (thermal or other), and laser/source power consumption. All energy required to drive, control and, cool the laser/source must be included, and all optical coupling and insertion losses must be accounted for. The energy per bit metric must be supported by a quantitative link power budget including all of the above elements.
- *Areal bandwidth density* – Bi-directional (duplex) optical bit rate divided by the area required to implement optical I/O.
- *Aggregate bandwidth* – The full-duplex data rate of optical signaling. Demonstrations must transmit and receive data at this aggregate rate, but the number of independent channels, wavelengths, symbols, fibers, etc. is not prescribed (see total port count).
- *Total port count* – An optical port is defined as an indivisible I/O connection between two physically distinct locations. For example, 10 separate optical fibers on an MCM might be connected to 10 separate locations, and would represent 10 ports. As a counterexample, 10 wavelength-division multiplexed (WDM) optical channels routed through a common single fiber represent a single port.
- *Link latency* – All added signaling delays must be analyzed and discussed. The evaluation of latency must include delays from both the electrical interfaces and the optical link components, as well as any overhead introduced by signal processing. Time of flight (TOF) for signal propagation in fiber should not be included.
- *Bit error ratio (BER)* – Received bit error rate. Any required coding and error correction must be accounted for in signaling power and latency estimates.
- *Operating temperature range* – Package temperature range through which the MCM operates and meets all other Table 1 metrics. If the operating temperature inside the MCM package is expected to exceed 80°C, it must be specified and the co-packaged optical I/O must be tested for reliable operation at that higher temperature. If an external laser module is proposed, the operation temperature of that module is proposer-defined and must be specified and evaluated in the context of a realistic usage scenario.

### ***Technical Area 3 (TA3) - Interconnect Fabrics***

The successful development of package-level photonic I/O in TA1 and TA2 will impose new and unprecedented challenges to system architectures employing these technologies. Many applications favor all-to-all network connectivity or dynamic reconfiguration of resources and functions. For massively interconnected networks with distributed parallelism, potentially consisting of hundreds to thousands of nodes with PIPES I/O, management of ports becomes critically important. The goal of TA3 is to develop foundational technologies that will facilitate the use of package-level photonic I/O in such systems. TA3 considers two technical thrusts, each seeking disruptive, innovative solutions to the challenges imposed by successful developments in

TA1 and TA2. These include high-density, high-efficiency optical packaging and signal routing, and the development and maturation of high port count, reconfigurable optical switching technology.

The Packaging Thrust Area looks to further the technologies used for optoelectronic packaging, fiber-to-chip coupling, optical connectorization, and/or system-level signal breakout and routing. Concepts proposed in this thrust should target the development and demonstration of methods for low-loss fiber attach and high-port-count optical packaging compatible with preferred MCM form factors (as described in Section B. Program Description and Technical Overview) and moderate-scale, automated volume manufacturing. While optical packaging solutions of varying levels of maturity will also be developed within TA1 and TA2 efforts, TA3 seeks high-risk, high-payoff approaches to enable future scaling beyond what will be developed elsewhere within the program. Additionally, in combination with the Reconfigurable Switching Thrust Area described below, the Packaging Thrust will provide the necessary elements of high-bandwidth, high-efficiency port management modules for massively interconnected systems.

While DARPA remains agnostic to the specific technologies proposed as solutions in this Thrust, it is envisioned that approaches related to some of the following innovations may appear in proposals: additive manufacturing of waveguides or micro-optics, polymer waveguides, nanophotonic couplers, high-density optical fanout, multi-core fiber solutions, and package-level connectorization for pigtail-free modules.

Beyond technology innovation, another envisioned outcome of the Packaging Thrust Area is the creation of a domestic photonic-electronic packaging capability consistent with one element of the model, described earlier, for a domestic ecosystem for differentiated access to unique capabilities. The DoD's ability to leverage state-of-the-art technologies for critical systems is essential, and proposers in this area are encouraged to describe how their capabilities could further this goal. In particular, DARPA seeks a path to perform packaging of advanced ASICs together with the photonic I/O solutions created under PIPES, in a controlled, domestic setting. Required capabilities include fabrication of electronic interposers, 2.5D assembly, and optical fiber attach consistent with the metrics described above.

The Reconfigurable Switching Thrust Area seeks to develop and mature low power optical switching technologies in chip-scale formats. As optical I/O becomes more pervasive in microelectronic systems, the ability to perform switching and bandwidth steering in the optical domain offers clear advantages to electrical network switching. This thrust looks to enable high port count reconfigurable NxN optical switches (i.e.,  $N > 1,000$ ) with low insertion loss, low power consumption, fast reconfigurability, and wide spectral bandwidth. Solutions that are transparent to signaling rates and formats are preferred. Hardware control through electrical drive signals is anticipated.

While DARPA remains agnostic to the specific approaches proposed as solutions in this Thrust, it is envisioned that some of the following technologies may appear in proposals: micro-electro-mechanical systems (MEMS), optical phase change materials, thermo-optic switching, and electro-optic switches and materials.

Although limited quantitative metrics are provided below as targets for Technical Area 3, additional performance targets may be proposed specific to the technologies under development consistent with the goals outlined above. Clear, quantifiable milestones should be outlined for each Phase to establish technology progress and demonstrate a methodical reduction of risk towards the goals of the effort. Proposers to TA3 are anticipated to target the goals of a single technical thrust with their approach, but may propose to both thrusts.

*Phase 1* – In the initial 18-month Phase 1, the TA3 goal is to demonstrate the feasibility of the technical approach through modeling, simulation, and benchtop experimentation of components and concepts.

*Phase 2 (Option)* – In the 12-month Phase 2, the TA3 goal is to demonstrate, through an integrated prototype, the scalability of the technology towards the goal of achieving high port count functionality with low optical losses and consistent with the final program goals.

*Phase 3 (Option)* – In the final 12-month Phase 3, the TA3 goal is to demonstrate fully-integrated devices and capabilities to meet the program goals of low loss, high port count optical signal connectivity, routing, and switching.

Delivery of two operational demo units is required at the conclusion of Phase 3. Deliverable units will not be returned to the performer.

Additional metrics are detailed in Table 3 below.

**Table 3. Technical Area 3 (TA3): Interconnect Fabrics – Program Metrics**

Thrust	Phase 1	Phase 2	Phase 3
<b>High-density optical packaging and routing</b>	Concept demonstration*	Integration demonstration**	Volume-compatible optical packaging capability
			1,000+ ports out of the package***
			Target insertion loss < 0.25 dB
			Insertion loss not to exceed 1 dB over 100 nm spectral bandwidth
			Automated alignment/attach
<b>Reconfigurable optical switching technologies</b>	Concept demonstration*	Integration demonstration**	Integrated switch meeting performance targets
			1,000 x 1,000 or greater switch matrix***
			Fiber-to-fiber insertion loss below 3 dB
			Switch reconfiguration time below 10 $\mu$ s
			Spectral bandwidth > 100 nm
			Switch power < 100 W

\* Phase 1 metrics are user-defined and must establish the feasibility of the technical approach, highlighting the ability of the concept to meet the ultimate metrics of the thrust.

\*\* Phase 2 metrics are user-defined and must establish confidence in the technical approach, while demonstrating that the technology is capable of scaling to high port counts with low optical losses, and consistent with the ultimate metrics of the thrust.

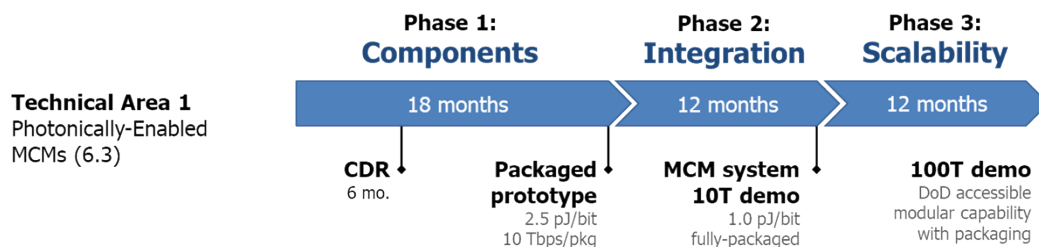
\*\*\* The package dimensions should be compatible with preferred MCM form factors, as defined above. Proposers are not constrained to edge attach, and the optical I/O may be interfaced through any of the package surfaces as long

as it does not interfere with common circuit board layouts, including electrical connections and thermal solutions. An optical port is defined as an indivisible I/O connection between two physically distinct locations. For example, 10 separate optical fibers on an MCM might be connected to 10 separate locations, and would represent 10 ports.

## E. Schedule/Milestones

PIPES is a 42-month program with an anticipated start in July 2019. Program kickoff and periodic review sessions are mandatory and represent an opportunity to interact with the Government on planned work, specifics of the technical approach, and any technical or programmatic items of concern. Regular technical and financial reporting is required by all performers.

### *Technical Area 1 Schedule and Milestones*

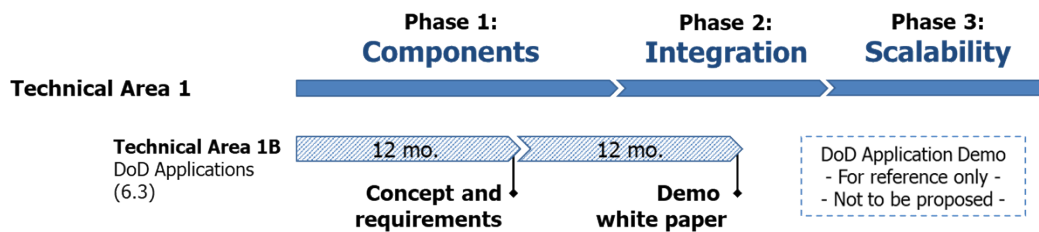


The following program milestones are applicable to Technical Area 1:

- A Program kickoff meeting will be held at the program start.
- A Critical Design Review (CDR), approximately 6 months after program kickoff – A detailed review of the proposer’s PIPES approach and discussion of any potential risks to meeting program metrics going forward. To this end, it is expected that the Performer will have completed necessary diligence in validating the considered approach, such as simulations, assumptions, and risks/mitigation strategies for successfully completing all three phases of the program. Detailed specification of components, integration approach, packaging approach and finalized system layout should be delivered at the CDR. Any plans for collaboration and support of TA1B demonstration(s) should be presented.
- Ongoing reporting and meetings – Monthly financial reports and quarterly technical reports via teleconference are due throughout the program. End-of phase reviews will be scheduled within the last two months of the corresponding program phase.
- Phase 1 milestones include:
  - o Demonstration of a packaged I/O prototype with 10 Tbps bandwidth at 2.5 pJ/bit, meeting all Phase 1 metrics included in Table 1.
  - o A detailed integration plan to meet Phase 2 and 3 goals.
  - o Execution of Associate Contractor Agreements (ACAs) with TA1B performers to allow free exchange of information and unimpeded close collaboration.
  - o A detailed plan for enabling a domestic, differentiated capability that includes photonics-electronics manufacturing, IP access, and optoelectronics packaging accessible to the DoD and its performers.
- Phase 2 milestones include:
  - o Demonstration of a packaged I/O prototype with 10 Tbps bandwidth at 1 pJ/bit, meeting all Phase 2 metrics included in Table 1.

- Demonstration of a packaged MCM with a performer provided, fully-functional IC core (e.g., FPGA, GPU, CPU, or ASIC), meeting all Phase 2 metrics included in Table 1 except for aggregate bandwidth. This demonstration will serve as an in-house test case for exercising the Differentiated Access capability.
- Phase 3 milestones include:
  - Demonstration of a packaged I/O prototype with 100 Tbps bandwidth at 1 pJ/bit, meeting all Phase 3 metrics included in Table 1.
  - Specification of offerings in the domestic ecosystem for differentiated DoD access to unique capabilities including PIPES technology, ideally enabling a DoD-relevant demonstration in the TA1B track of the program.

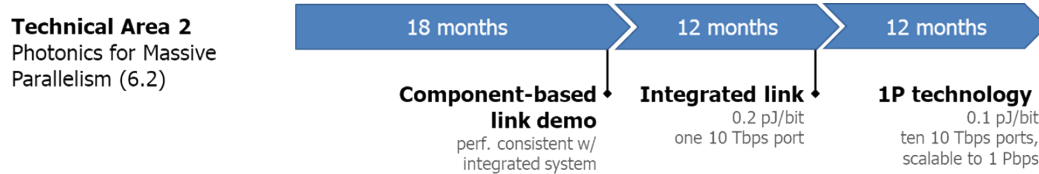
### **Technical Area 1B Schedule and Milestones**



The schedule to TA1B is shown above in relation to TA1. The following program milestones are applicable to Technical Area 1B:

- A Program kickoff will be held at the program start.
- Ongoing reporting and meetings – Monthly financial reports and quarterly technical reports via teleconference are due throughout the program. End-of phase reviews will be scheduled within the last two months of the corresponding program phase. TA1B performers will also attend and present at TA1 performer meetings.
- Phase 1 technical milestones include:
  - A refined integration concept for a DoD-relevant application using technology developed under TA1. It is expected that TA1B performers will identify one or more TA1 partner performers and enter into Associate Contractor Agreements (ACAs) over the course of Phase 1, allowing free exchange of information and unimpeded close collaboration.
  - Specification of the technical and integration requirements for performer use of TA1 components.
- Phase 2 technical milestones include:
  - An integration and demonstration plan for the proposed concept, based on photonically-enabled components produced and delivered at the conclusion of TA1 - Phase 2 or through access to the Differentiating Access Ecosystem.

### Technical Area 2 Schedule and Milestones



The following program milestones are applicable to Technical Area 2:

- A Program kickoff will be held at the program start.
- Ongoing reporting and meetings – Monthly financial reports and quarterly technical reports via teleconference are due throughout the program. End-of phase reviews will be scheduled within the last two months of the corresponding program phase.
- Phase 1 technical milestones include:
  - o Demonstration of a benchtop I/O prototype with 0.5 pJ/bit efficiency and 5 Tbps/mm<sup>2</sup> density meeting all Phase 1 metrics included in Table 2.
- Phase 2 technical milestones include:
  - o Demonstration of an integrated I/O prototype with 0.2 pJ/bit efficiency and 10 Tbps aggregate bandwidth delivered through one or more independent I/O ports meeting all Phase 2 metrics included in Table 2.
- Phase 3 technical milestones include:
  - o Demonstration of an integrated platform with 100 Tbps aggregate bandwidth at 0.1 pJ/bit delivered through 10 or more independent I/O ports meeting all Phase 3 metrics included in Table 2, and in a form factor that is scalable to 1 Pbps in the dimensions of typical MCM packages.
- End-of-program manufacturing assessment – A scaling and manufacturability assessment detailing a path for the developed technology to high-volume manufacturing of components and compatibility with a domestic photonics-electronics manufacturing and packaging capability.

### Technical Area 3 Schedule and Milestones



The following program milestones are applicable to Technical Area 3:

- A Program kickoff will be held at the program start.
- Ongoing reporting and meetings – Monthly financial reports and quarterly technical reports via teleconference are due throughout the program. End-of phase reviews will be scheduled within the last two months of the corresponding program phase.
- Phase 1 technical milestones include:
  - o Validation of the technical approach through modeling, simulation and benchtop experiments. Demonstration of the ability for the concept to scale to meet final

program goals. Clear, quantifiable milestones specific to their approach shall be defined by the proposer.

- Phase 2 technical milestones include:
  - o Demonstration through an integrated prototype that the technology can achieve the required scaling of port count with low optical losses and is consistent with the final program goals. Clear, quantifiable milestones specific to their approach shall be defined by the proposer.
- Phase 3 technical milestones include:
  - o Demonstration of approaches and devices meeting the program goals, as defined in Table 3 (e.g., low-loss packaging amenable to volume-manufacturing and automated system assembly methods, or reconfigurable high port count optical switches).
- End-of-program manufacturing assessment – A scaling and manufacturability assessment detailing a path for the developed technology to high-volume manufacturing of components and compatibility with the domestic photonics-electronics manufacturing and packaging ecosystem created under the program.

## **F. Deliverables**

All Performers shall deliver detailed spend plans at program kickoff and execution of subsequent option awards, quarterly technical reports, and monthly financial reports including updated expenditures. Performers shall prepare and submit briefing materials and participate in quarterly progress reviews, either via telecon or at the Performer's site at the discretion of DARPA. All Performers shall travel to and support annual program-wide reviews scheduled at the Program Manager's discretion.

Upon the completion of each phase, Performers in all Technical Areas must provide to the Government a technical progress report that includes:

- a) A description of the technical development and achievements in each area
- b) Component and system test results
- c) Charts and explanations of how well the system meets, exceeds, or falls short of specified program goals (as described in this BAA)
- d) Plans and projections for the following program phase with an updated risk assessment in each of the critical program areas

In addition, the following deliverables are expected by Technical Area and by program phase:

**Table 4. Program Deliverables.**

	Phase 1	Phase 2	Phase 3
TA1	- Report documenting plans to provide access to differentiated capabilities for DoD performers	- Two packaged 10T, 1 pJ/bit demonstrator units* - Ten packaged, fully operational MCMs*	- Two packaged 100T, 1 pJ/bit demonstrator units* - Detailed plan to implement PIPES technology ecosystem for DoD system integrators
TA1B	- Report detailing DoD integration concept - Report specifying TA1 hardware and IP requirements	- White paper detailing fully-developed plan for DoD relevant demonstration	- N/A
TA2	- Report outlining path to technology manufacturability	- Two packaged demonstrator units*	- Two packaged demonstrator units* - Detailed transition plan to mature the technology for broader use
TA3	- Report documenting concept performance and scaling feasibility - Report documenting plans to provide access to differentiated capabilities for DoD performers (packaging thrust)	- Report documenting performance of integrated devices - Commercialization strategy white paper	- Two packaged demonstrator units* (switching thrust) - Detailed transition plan to implement technology in PIPES ecosystem (packaging thrust)

\*All Phase 2 and Phase 3 packaged MCM and demonstrator units should be provided with adequate instructions to support government testing and evaluation using standard laboratory equipment. Additionally, performer-internal protocols and results for testing and characterization should be included.

### **G. Government Furnished Equipment/Property/Information**

No Government Furnished Equipment, Property, or Information will be provided for the effort solicited in this BAA.

### **H. Intellectual Property**

Any use of proposer-defined intellectual property (patents, proprietary information, etc.) should be clearly marked as such within the proposal. Include all proprietary claims to the results, prototypes, intellectual property, or systems supporting the effort and/or necessary for the use of the research, results, and/or prototype. If there are no proprietary claims, this should be stated. For forms to be completed regarding intellectual property, see Section IV.B.11.



## **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, cooperative agreement, or other transaction, depending upon the proposed Technical Area, 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.

## **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 proposers intending to perform fundamental research and proposers not intending to perform fundamental research or the 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 nature of the performer and the nature of the work, the Government anticipates 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 select award instrument type and to negotiate all instrument terms and conditions with selectees. Appropriate clauses will be included in resultant awards for non-fundamental research to prescribe publication requirements and other restrictions, as appropriate. This clause 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 being performed by the awardee is restricted research, a subawardee may be conducting fundamental research. In those cases, it is the awardee’s responsibility to explain in their proposal why its subawardee’s effort is 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 citing the specific authority establishing their eligibility to propose to Government solicitations and compete with industry, and their compliance with the associated FFRDC sponsor agreement's terms and conditions. This information is required 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.

### **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. In particular, cost sharing is strongly encouraged in Technical Area 1 (TA1), where the anticipated outcome of the program may include technologies, IP, and capabilities with clear potential for commercial applications.

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

### **D. Associate Contractor Agreement Clause**

This same or similar clause will be included in all TA1 and TA1B awards against HR001119S0004:

- (a) It is recognized that success of the PIPES research effort depends in part upon the open exchange of information between the various Associate Contractors involved in the effort. This clause is intended to ensure that there will be appropriate coordination and integration of work by the Associate Contractors to achieve complete compatibility and to prevent unnecessary duplication of effort. By executing this contract, the Contractor assumes the responsibilities of an Associate Contractor. For the purpose of this clause, the term Contractor includes subsidiaries, affiliates, and organizations under the control of the contractor (e.g., subcontractors).
- (b) Work under this contract may involve access to proprietary or confidential data from an Associate Contractor. To the extent that such data is received by the Contractor from any Associate Contractor for the performance of this contract, the Contractor hereby agrees that any proprietary information received shall remain the property of the Associate Contractor and shall be used solely for the purpose of the PIPES research effort. Only that information which is received from another contractor in writing and which is clearly identified as proprietary or confidential shall be protected in accordance with this provision. The obligation to retain such information in confidence will be satisfied if the Contractor receiving such information utilizes the same controls as it employs to avoid disclosure, publication, or dissemination of its own proprietary information. The receiving Contractor agrees to hold such information in confidence as provided herein so long as such information is of a proprietary/confidential or limited rights nature.
- (c) The Contractor hereby agrees to closely cooperate as an Associate Contractor with the other Associate Contractors on this research effort. This involves as a minimum:
  - (1) Maintenance of a close liaison and working relationship;
  - (2) Maintenance of a free and open information network with all Government identified Associate Contractors;
  - (3) Delineation of detailed interface responsibilities;

- (4) Entering into a written agreement with the other Associate Contractors setting forth the substance and procedures relating to the foregoing, and promptly providing the Agreements Officer/Procuring Contracting Officer with a copy of same; and,
- (5) Receipt of proprietary information from the Associate Contractor and transmittal of Contractor proprietary information to the Associate Contractors subject to any applicable proprietary information exchange agreements between associate contractors when, in either case, those actions are necessary for the performance of either.
- (d) In the event that the Contractor and the Associate Contractor are unable to agree upon any such interface matter of substance, or if the technical data identified is not provided as scheduled, the Contractor shall promptly notify the DARPA PIPES Program Manager. The Government will determine the appropriate corrective action and will issue guidance to the affected Contractor.
- (e) The Contractor agrees to insert in all subcontracts hereunder which require access to proprietary information belonging to the Associate Contractor, a provision which shall conform substantially to the language of this clause, including this paragraph (e).
- (f) Associate Contractors for this PIPES research effort will be determined through evaluation and selection of proposals to this BAA. It is intended that ACAs be established, after kickoff and no later than the end of Phase 1 period of performance, between:

Performer	ACA with
TA1 performers	TA1B performers
TA1B performers	TA1 performers

**E. Other Eligibility Criteria**

**1. Collaborative Efforts**

Collaborative efforts/teaming are strongly encouraged. After proposal selections, the Government reserves the right to seek contractual arrangements, such as Associate Contractor Agreements (ACAs), between separate performers if doing so benefits the overall program/project goals and objectives and mutual interests of the parties.

**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](http://www.darpa.mil), contact the administrative contact listed herein.

## **B. Content and Form of Application Submission**

### **1. Abstract Format**

Abstracts should follow the format described below in this section. The cover sheet should be clearly marked “ABSTRACT”. The total length of Section II should not exceed 8 pages in TA1 and TA2, and 5 pages in TA1B and TA3. All pages shall be printed on 8-1/2 by 11 inch paper with type not smaller than 12 point. Smaller font may be used for figures, tables and charts. The page limitation for abstracts includes all figures, tables, and charts. No formal transmittal letter is required. All abstracts must be written in English.

### **Section I. Administrative**

A. Cover sheet to include:

- (1) BAA number (HR001119S0004);
- (2) Technical area;
- (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 current state-of-art 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. Proposal abstracts

must provide quantitative, measureable milestones to assess progress toward BAA-defined end-of-phase and end-of-program goals.

**C. Differentiated Access**

Describe plans to provide or leverage PIPES technology and capabilities for DoD-relevant impact through a domestic ecosystem for differentiated access to unique capabilities.

**D. Deliverables**

Describe deliverables associated with the proposed research and the plans to accomplish technology transition and commercialization.

**E. 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.

**F. Capabilities and Teaming**

A clearly defined organization chart for the program team which includes, as applicable: (1) the programmatic relationship of team members; (2) expertise and unique capabilities of team members; (3) team member responsibilities.

**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. All pages shall be printed on 8-1/2 by 11 inch paper with type not smaller than 12 point. Smaller font may be used for figures, tables and charts. The page limitation for full proposals includes all figures, tables, and charts. Section II of Volume I, Technical and Management Proposal, shall not exceed 30 pages for proposals in response to TA1 and TA2, 20 pages for proposals in response to TA3, and 15 pages for proposals in response to TA1B. The optional Transition Accelerator sub-section does not count towards the Section II page count. There is no page limit for Volume II, Cost Proposal. All full proposals must be written in English.

A summary slide, schedule slide, and budget slides for Phases 1, 2, and 3 of the proposed effort (Phases 1 and 2 only for TA1B), in PowerPoint format, should be submitted with the proposal. Template slides are provided as Attachment 2 to the BAA. Submit this PowerPoint file in addition to Volumes I and II of your full proposal. These summary slides do not count towards the total page count.

Proposers should not propose to more than one Technical Area in a single proposal. Proposers who wish to submit to more than one Technical Area must submit a separate full proposal for each.

**a. Volume I, Technical and Management Proposal**



## **Section I. Administrative**

### A. Cover sheet to include:

- (1) BAA number (HR001119S0004);
- (2) Technical area;
- (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 (not to exceed 2 pages)

Summarize the technical approach, anticipated performance, and expected outcomes of the proposed effort. Provide a technology transition strategy and plans to participate in a Differentiating Access ecosystem. 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 not defined in the BAA or in the proposal. This section should demonstrate that the proposer has a clear understanding of the state-of-the-art and should provide sufficient justification for the feasibility of the proposed approach. Include a detailed technical rationale, technical approach, and constructive plan for accomplishment of technical goals in support of innovative claims and deliverable creation.

- The technical approach for TA1 proposals **must**:

- Address all program metrics included in Table 1 (Section D. Technical Areas: Technical Area 1 (TA1) – Photonically-Enabled MCMs), and describe how the proposed approach will achieve each with supporting experimental measurements, modeling, calculations, and/or simulations. Any unique testing and characterization capabilities and/or requirements should also be described. In support of these metrics, proposals should also detail:
  1. The proposed performer-provided MCM and proxy IC cores necessary for technology demonstrators, with an explanation of the anticipated commercial and DoD impact made possible by integration with PIPES photonic interconnect technology;
  2. Notional packaged form factors and designs, including descriptions and figures. It is anticipated that packaged device characteristics will be similar to those of traditional MCM form factors. Any deviations should be supported and/or mitigated. (A detailed quantitative design, inclusive of all anticipated integration, packaging, and system layout will be required at the 6 month CDR.)
  3. The link power budget must be provided and analyzed in detail. The anticipated energy per bit must be evaluated by considering the electrical power consumed by all circuits, including modulation, conditioning/tuning (thermal or other), SerDes, receiver amplification, coding, error correction, etc. and laser drive/control power. Evaluation of the optical portion of the link must include anticipated coupling losses, component insertion losses, and electrical/optical conversion efficiency, and be consistent with the receiver sensitivity and required margin for the modulation format proposed and BER metric given.
  
- The technical approach for TA1B proposals **must**:
  - Address all three required TA1B proposal elements specifically outlined in Section D. Technical Areas: TA1 Track B (TA1B) – Defense Applications and Demonstration.
  
- The technical approach for TA2 proposals **must**:
  - Address all program metrics included in Table 2. (Section D. Technical Areas: Technical Area 2 (TA2) – Photonics for Massive Parallelism), and describe how the proposed approach will achieve each with supporting experimental measurements, modeling, calculations, and/or simulations. Any unique testing and characterization capabilities and/or requirements should also be described. In support of these metrics, proposals should also include:
    1. The link power budget, provided and analyzed in detail. The anticipated energy per bit must be evaluated by considering the electrical power consumed by all circuits, including modulation, conditioning/tuning (thermal or other), SerDes, receiver amplification, coding, error correction, etc. and laser drive/control power. Evaluation of the optical portion of the link must include anticipated coupling losses, component insertion losses, and electrical/optical conversion

- efficiency, and be consistent with the receiver sensitivity and required margin for the modulation format proposed and BER metric given;
2. A discussion of the proposed proxy IC core and other support capabilities needed to validate the performance of the technology demonstrators.
- The technical approach for TA3 **must**:
    - Address all program metrics for the relevant thrust(s) included in Table 3. (Section D. Technical Areas: Technical Area 3 (TA3) – Interconnect Fabrics), and describe how the proposed approach will achieve each with supporting experimental measurements, modeling, calculations, and/or simulations.

### C. Differentiated Access and Technology Transition

Address how the approach will further the goals of the ERI Phase II, which seeks to facilitate access to advanced, specialty technologies for U.S. national defense needs. Include anticipated elements of the domestic PIPES ecosystem for differentiated DoD access to unique capabilities (detailed in Section I.B.) that will be provided, describing any unique performance or cost advantages that would result from the proposed effort. Specific activities should also be included in the following section, Statement of Work.

Describe plans to mature and transition funded technologies for use beyond the conclusion of the program. DARPA anticipates PIPES technologies to be relevant for both commercial and defense applications, and impact through successful technology transition is a key goal of the Electronics Resurgence Initiative. Proposals with an expected outcome limited to scientific papers, new ideas, or patents acquired without tangible, product-based impact on national defense will not be strongly considered.

Within the Differentiated Access and Technology Transition section:

- TA1 proposals **must**:
  - Describe which elements of the domestic ecosystem for differentiated access to unique capabilities will be provided through the proposed effort and how those elements will be accessible to users, including for the development of DoD-relevant ASICs. Additionally, detail anticipated impacts of the technology for commercial applications.
- TA1B proposals **must**:
  - Describe the necessary and desired aspects of a photonics interconnect ecosystem that would facilitate the proposer's future use and how they envision partnering with potential providers to demonstrate disruptive capabilities.
- TA2 proposals **must**:
  - Describe how and where the photonics technologies, processes, and integration approaches proposed could transition to manufacturability, if successful, and highlight elements that could be made accessible to users.
- TA3 proposals **must**:

- Describe how elements of the proposed technology will enhance the system impact of photonics I/O, and which elements of the proposed capabilities will be relevant within the photonics interconnect ecosystem.

Transition Accelerator (optional sub-section; does not count toward Section II page count)

To catalyze technology transition, the Microsystems Technology Office offers applicants the opportunity for additional funding and technology transition assistance through participation in the Transition Accelerator (TrAc) program. Transition Accelerator participants will work closely with the Commercial Services group at DARPA and their extensive network of investors and strategic partners to develop a transition plan which identifies key transition partners, funding sources, and mentors to support the further maturation of technology beyond the life of the DARPA program.

PIPES proposers wishing to participate in TrAc must:

- Include in their proposal a separately costed optional task describing plans to build and refine a viable Transition Plan over the course of the DARPA program.
- Include an initial Transition Plan describing how this technology will be developed from its current status to its future integration into new capabilities. Elements of the Transition Plan could include a customer description, product description, industry partnerships, etc.

Proposers to any TA are eligible to submit an optional task in response to the TrAc program.

Participation in the TrAc program is voluntary but encouraged. Prospective participants are not expected to form a new company or leave their current research positions, but are expected to, throughout the lifecycle of the program, identify appropriate partners for enabling transition. Selection for the TrAc program is made independently following selection of the PIPES program. TrAc funding requests should be consistent with the proposed work scope and program timeline, but are anticipated to be in the range of \$250K per performer over the duration of the program.

#### **D. 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 complexity and level of 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).*

**E. National Security Impact Statement (not to exceed 2 pages)**

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

**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 and Proposer Accomplishments (not to exceed 2 pages)**

Compare the proposed effort with other ongoing research, indicating advantages and disadvantages. Discuss previous accomplishments and work in closely related research areas.

**H. Teaming and Facilities (not to exceed 2 pages)**

Describe the formal teaming arrangements that 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.

Describe the facilities that would be used for the proposed effort and how they will support meeting program metrics.

**I. Schedules and Measurable Milestones**

Provide 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. The task structure must be consistent with that in the SOW. Additionally, proposals should clearly explain (or reference relevant section(s) of Section B, Technical Approach and/or Section C, SOW) 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.

Include a table of program milestones with completion dates. In addition to BAA-required milestones defined in Section E. Schedule/Milestones, proposer-defined quantitative program milestones must be defined for at least every 6 months after the start of the effort. Milestones should be inclusive of and consistent with metrics defined in Section D. Technical Areas and deliverables defined in Section F. Deliverables. The milestones should represent measureable progressive goals that demonstrate a credible path to the final end-of-program goals.

### **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 (HR001119S0004);
- (2) Technical area;
- (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 \$1,000 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-compliant 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).

#### **I. Fundamental Research**

For submissions to TA2 and TA3 where 6.2 funding may be used, 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 OT must include a detailed list of milestones. 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.

### **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. 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.

#### **b. Classified Submissions**

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).

When a proposal includes a classified portion, and when able according to security guidelines, we ask that proposers send an e-mail to HR001119S0004@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 HR001119S0004, proposer organization, proposal title (short title recommended), and Copy \_ of \_.

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.

### **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: HR001119S0004  
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"

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>.

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 Research Subjects/Animal Use**

Proposers that anticipate involving Human Research Subjects or Animal Use must comply with the approval procedures detailed at <http://www.darpa.mil/work-with-us/additional-baa>.

## **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](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. Grant Abstract**

Per Section 8123 of the Department of Defense Appropriations Act, 2015 (Pub. L. 113-235), all grant awards must be posted on a public website in a searchable format. To comply with this requirement, proposers requesting grant awards must submit a maximum one (1) page abstract that may be publicly posted and explains the program or project to the public. The proposer should sign the bottom of the abstract confirming the information in the abstract is approved for public release. Proposers are advised to provide both a signed PDF copy, as well as an editable (e.g., Microsoft word) copy. Abstracts contained in grant proposals that are not selected for award will not be publicly posted.

## **10. 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 submits a contract proposal and includes subcontractors might be required to submit a subcontracting plan with their proposal. The plan format is outlined in FAR 19.704.

## **11. 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](http://www.darpa.mil/work-with-us/additional-baa) for further information. Proposers may use a list following the format below. The Government will use the list during the evaluation process to evaluate the impact of any identified restrictions, and

may request additional information from the proposer, as may be necessary, to evaluate the proposer’s assertions. If no restrictions are intended, then the proposer should state “NONE.” Failure to provide full information may result in a determination that the proposal is not compliant with the BAA – resulting in nonselectability of the proposal.

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 Grant, Cooperative Agreement, Technology Investment Agreement, or Other Transaction for Prototype 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 those award instruments in question. This includes both Noncommercial Items and Commercial Items. Although not required, proposers may use a format similar to that described in Paragraph a. above. The Government will use the list during the evaluation process to evaluate the impact of any identified restrictions, and may request additional information from the proposer, as may be necessary, to evaluate the proposer’s assertions. If no restrictions are intended, then the proposer should state “NONE.” Failure to provide full information may result in a determination that the proposal is not compliant with the BAA – resulting in nonselectability of the proposal.

**12. 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.

**13. 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](https://www.fsd.gov/fsd-gov/answer.do?sysparm_kbid=dbf8053adb119344d71272131f961946&sysparm_search=KB0013221).

#### **14. Funding Restrictions**

Not applicable.

#### **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 HR001119S0004. 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 [HR001119S0004@darpa.mil](mailto:HR001119S0004@darpa.mil). DARPA intends to use electronic mail for correspondence regarding HR001119S0004. 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**

For consideration during the initial round of selections, proposers are required to follow the deadlines specified below. Proposers are warned that the likelihood of available funding is greatly reduced for proposals submitted after the initial closing date deadline.

##### **a. Abstract Due Date**

Abstracts must be submitted to DARPA/MTO on or before 1:00 PM, Eastern Time, November 27, 2018. Abstracts received after this time and date may not be reviewed.

##### **b. Full Proposal Date**

The full proposal must be submitted on or before 1:00 PM, Eastern Time, January 17, 2019. If deemed compliant, the Government will evaluate all such proposals in the initial round of selections.

Additionally, proposals may be submitted after the above due date until 1:00 PM, Eastern Time, March 1, 2019. If deemed compliant, such proposals will be reviewed at the Government's discretion, contingent upon the availability of funds.

Proposers are warned that the likelihood of available funding is greatly reduced for proposals submitted after the initial closing date deadline.

### **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 HR001119S0004 summary will be a link to the FAQ. Submit your question/s by e-mail to [HR001119S0004@darpa.mil](mailto:HR001119S0004@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, January 3, 2019.

## **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 HR001119S0004 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 darpa.mil as a trusted domain), or visit DISA's site to download the Root Certificate

Authority (CA): <http://dodpki.c3pki.chamb.disa.mil/rootca.html>.

Technical support for DARPA's BAA Website may be reached at [BAAT\\_Support@darpa.mil](mailto: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 in support of one or more related technical concepts or ideas. 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 Grants or Cooperative Agreements:

Proposers requesting grants or cooperative agreements must submit proposals through one of the following methods: (1) electronic upload per the instructions at <https://www.grants.gov/applicants/apply-for-grants.html>; or (2) hard-copy mailed directly to DARPA. If proposers intend to use Grants.gov as their means of submission, then they must submit their entire proposal through Grants.gov; applications cannot be submitted in part to Grants.gov and in part as a hard-copy. Proposers using Grants.gov do not submit hard-copy proposals in addition to the Grants.gov electronic submission.

Submissions: Proposers must submit the three forms listed below.

SF 424 Research and Related (R&R) Application for Federal Assistance, available on the Grants.gov website at [https://apply07.grants.gov/apply/forms/sample/RR\\_SF424\\_2\\_0-V2.0.pdf](https://apply07.grants.gov/apply/forms/sample/RR_SF424_2_0-V2.0.pdf). *This form must be completed and submitted.*

To evaluate compliance with Title IX of the Education Amendments of 1972 (20 U.S.C. A§ 1681 Et. Seq.), the Department of Defense is using the two forms below to collect certain demographic and career information to be able to assess the success rates of women who are proposed for key roles in applications in science, technology, engineering, or mathematics disciplines. Detailed instructions for each form are available on Grants.gov.

Research and Related Senior/Key Person Profile (Expanded), available on the Grants.gov website at [https://apply07.grants.gov/apply/forms/sample/RR\\_KeyPersonExpanded\\_2\\_0-V2.0.pdf](https://apply07.grants.gov/apply/forms/sample/RR_KeyPersonExpanded_2_0-V2.0.pdf). *This form must be completed and submitted.*

Research and Related Personal Data, available on the Grants.gov website at [https://apply07.grants.gov/apply/forms/sample/RR\\_PersonalData\\_1\\_2-V1.2.pdf](https://apply07.grants.gov/apply/forms/sample/RR_PersonalData_1_2-V1.2.pdf). *Each applicant must complete the name field of this form, however, provision of the demographic information is voluntary. Regardless of whether the demographic fields*

*are completed or not, this form must be submitted with at least the applicant's name completed.*

Grants.gov requires proposers to complete a one-time registration process before a proposal can be electronically submitted. If proposers have not previously registered, this process can take between three business days and four weeks. For more information about registering for Grants.gov, see [www.darpa.mil/work-with-us/additional-baa](http://www.darpa.mil/work-with-us/additional-baa). See the Grants.gov registration checklist at <http://www.grants.gov/web/grants/register.html> for registration requirements and instructions.

Once Grants.gov has received a proposal submission, Grants.gov will send two email messages to advise proposers as to whether or not their proposals have been validated or rejected by the system; IT MAY TAKE UP TO TWO DAYS TO RECEIVE THESE EMAILS. The first email will confirm receipt of the proposal by the Grants.gov system; this email only confirms receipt, not acceptance, of the proposal. The second will indicate that the application has been successfully validated by the system prior to transmission to the grantor agency or has been rejected due to errors. If the proposal is validated, then the proposer has successfully submitted their proposal. If the proposal is rejected, the proposed must be corrected and resubmitted before DARPA can retrieve it. If the solicitation is no longer open, the rejected proposal cannot be resubmitted. Once the proposal is retrieved by DARPA, the proposer will receive a third email from Grants.gov. To avoid missing deadlines, proposers should submit their proposals in advance of the final proposal due date with sufficient time to receive confirmations and correct any errors in the submission process through Grants.gov. For more information on submitting proposals to Grants.gov, visit the Grants.gov submissions page at: <http://www.grants.gov/web/grants/applicants/apply-for-grants.html>.

Proposers electing to submit grant or cooperative agreement proposals as hard copies must complete the same forms as indicated above.

#### **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](https://arpa.mil) as a trusted domain), or visit DISA's site to download the Root Certificate Authority (CA): <http://dodpki.c3pki.chamb.disa.mil/rootca.html>.

Technical support for DARPA's BAA Website may be reached at [BAAT\\_Support@darpa.mil](mailto: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.

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 team has the expertise and experience to accomplish the proposed tasks.

## **2. Potential Contribution and Relevance to the DARPA Mission**

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.

In addition, the evaluation will take into consideration the proposed technology transition strategy and the extent to which the proposed intellectual property (IP) rights will potentially impact the Government's ability to transition the technology, as applicable.

## **3. Cost 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. Similar efforts completed/ongoing by the proposer in this area are fully described including identification of other Government sponsors. For efforts with a likelihood of commercial application, the level of performer cost share will be considered as a significant element of the Cost Realism 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.

## **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 (FAPIS)**

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 FAPIS). 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 FAPIS 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 full proposals submitted 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.

#### **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](http://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](http://www.darpa.mil/work-with-us/additional-baa).

#### **4. Representations and Certifications**

If a procurement contract is contemplated, prospective awardees will need to be registered in the SAM database prior to award and complete electronic annual representations and certifications consistent with FAR guidance at 4.1102 and 4.1201; the representations and certifications can be



found at [www.sam.gov](http://www.sam.gov). Supplementary representations and certifications can be found at <http://www.darpa.mil/work-with-us/additional-baa>.

## **5. Terms and Conditions**

A link to the DoD General Research Terms and Conditions for Grants and Cooperative Agreements and supplemental agency terms and conditions can be found at <http://www.darpa.mil/work-with-us/contract-management#GrantsCooperativeAgreements>.

### **C. Reporting**

The number and types of reports will be specified in the award document, but will include as a minimum monthly financial status reports and quarterly technical 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 patent reports and notifications to be submitted electronically through i-Edison (<https://public.era.nih.gov/iedison>).

## **VII. Agency Contacts**

Administrative, technical or contractual questions should be sent via e-mail to [HR001119S0004@darpa.mil](mailto:HR001119S0004@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. Gordon Keeler  
DARPA/MTO  
ATTN: HR001119S0004  
675 North Randolph Street

Arlington, VA 22203-2114  
Email: [HR001119S0004@darpa.mil](mailto:HR001119S0004@darpa.mil)

## **VIII. Other Information**

### **A. Proposers Day**

The PIPES Proposers Day will be held on November 1, 2018 in Arlington, VA. Advance registration is required in order to attend the meeting. See DARPA-SN-19-04 posted at [www.fbo.gov](http://www.fbo.gov) for details. Attendance at the PIPES 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>.