

**Small Business Innovation Research (SBIR) and
Small Business Technology Transfer (STTR)
Opportunity Announcement
HR001120S0019-13
Field Controllable Modulator Array (FCMA)**

Which program will fund this topic?

SBIR

What type of proposals will be accepted?

Direct to Phase II (DP2) Only

Technology Area(s): Electronics, Materials/Processes

I. INTRODUCTION

The Defense Advanced Research Projects Agency (DARPA) Small Business Programs Office (SBPO) is issuing an SBIR/STTR Opportunity (SBO) inviting submissions of innovative research concepts in the technical domain(s) of Electronics, Materials/Processes. In particular, DARPA is interested in understanding the feasibility of Field Controllable Modulator Array (FCMA).

This SBO is issued under the Broad Agency Announcement (BAA) for SBIR/STTR, HR001120S0019. All proposals in response to the technical area(s) described herein will be submitted in accordance with the instructions provided under HR001120S0019, found here: <https://beta.sam.gov/opp/b8abeb02f16a4450b2c2f859fc00c177/view>.

a. Eligibility

The eligibility requirements for the SBIR/STTR programs are unique and do not correspond to those of other small business programs. Please refer to Section 3.1, Eligible Applicants, of HR001120S0019 for full eligibility requirements.

b. Anticipated Structure/Award Information

Please refer to Section 1, Funding Opportunity Description provided in HR001120S0019 for detailed information regarding SBIR/STTR phase structure and flexibility.

If a proposer can provide adequate documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of the topic has been met and describes the potential commercial applications, the Direct to Phase II (DP2) authority allows the Department of Defense (DoD) to make an award to a small business concern under Phase II of the SBIR program without regard to whether the small business concern was provided an award under Phase I of an SBIR program. This SBO is accepting DP2 proposal submissions.

DARPA will accept DP2 proposals for cost of up to \$1,725,000. This includes a 15-month base period not to exceed a cost of \$975,000 and a 12-month option period not to exceed a cost of \$500,000. A separately priced option of up to \$250,000 may also be

proposed for contractors who would like to be considered for participation in the DARPA Entrepreneurial Investigator Initiative. Refer to Section 2.6, DARPA Embedded Entrepreneur Initiative (EEI), of HR001120S0019 for detailed information on EEI.

Proposers should refer to Section 4, Application and Submission Information, of HR001120S0019 for detailed proposal preparation instructions. Proposals that do not comply with the requirements detailed in HR001120S0019 and the research objectives of this SBO are considered non-conforming and therefore are not evaluated nor considered for award.

DP2 Feasibility Documentation shall not exceed 20 pages. DP2 Technical Proposal shall not exceed 40 pages. Phase II commercialization strategy shall not exceed 5 pages. It should be the last section of the Technical Volume and will not count against the 40-page limit. Please refer to Appendix B of HR001120S0019 for detailed instructions on DP2 proposal preparation.

c. Evaluation of Proposals

Section 5, Evaluation of Proposals, in HR001120S0019 provides detailed information on proposal evaluation and the selection process for this SBO.

d. Due Date/Time

Full proposal packages (Proposal Cover Sheet, Technical Volume, Price/Cost Volume inclusive of supporting documentation, and Company Commercialization Report) must be submitted via the DoD SBIR/STTR Proposal Submission website per the instructions outlined in HR001120S0019 no later than **2:00 pm ET, August 10, 2020**.

II. TOPIC OVERVIEW

a. Objective

Develop and demonstrate a singular lithium-niobate modulator that can be configured to provide multiple functions including electronic protection, signals intelligence, radar beamforming, and communications.

b. Description

Microwave photonics is an important technology for military applications including point-to-point radio-frequency (RF) links, RF signal processing, radar, and RF spectrum management. The military microwave photonic systems deployed to date leverage past developments by the massive telecommunication industry, repurposing commercial components for specific military functions. The most recent developments in industrial telecommunications have been in specialized, application-specific photonic integrated circuits (PICs). While these trends are expected to continue, the military applications cannot benefit from these advancements because application-specific PICs cannot be repurposed. Furthermore, the volume of military systems is insufficient to support a dedicated PIC infrastructure at a bearable cost. The objective of this SBIR is to solve this problem by developing field-configurable modulator arrays (FCMAs) that can be purposed for military and commercial applications alike.

The FCMA concept is based on a set of electro-optic modulators that can be programmed for various functions. This SBIR will focus on lithium-niobate FCMA's. Though many materials are being considered for PICs, lithium niobate is mature, cost-effective, and provides the performance needed for military applications.

Under this Direct-to-Phase 2 SBIR, performers will be required to design, fabricate, and demonstrate a FCMA that provides functionality for electronic protection, signals intelligence, radar beamforming, and communications. The progress and success of the SBIR will be measured by the following parameters. The FCMA must operate from 1 MHz to 18 GHz for all configurations. The electronic-protection configuration shall utilize the nonlinear response of a Mach-Zehnder modulator to suppress a continuous-wave interference signal by 60 dB and suppress an interference signal with 10 MHz instantaneous bandwidth by 40 dB, both while reducing the largest intermodulation distortion by 30 dB. The signals-intelligence configuration shall improve the intrinsic third-order-limited spurious-free dynamic range of a Mach-Zehnder modulator by 10 dB. The radar-beamforming application requires the FCMA to provide 360 degrees of RF phase shift that can be modulated at 100 kHz. The communications configuration must support 10 Gb/s modulation on each of the in-phase and quadrature components of a lightwave.

c. Phase I

Phase I feasibility should be demonstrated by a complete FCMA design to be fabricated at a lithium-niobate foundry. A foundry that can support the design must be identified. Calculations detailing how the design meets the technical goals of the SBIR should be presented.

Proposers interested in submitting a Direct to Phase II (DP2) proposal must provide documentation to substantiate that the scientific and technical merit and feasibility described above has been met and describes the potential commercial applications. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. For detailed information on DP2 requirements and eligibility, please refer to Section 4.2, Direct to Phase II (DP2) Requirements, and Appendix B of HR001120S0019.

d. Phase II

The Phase II Base entails final design, fabrication, and experimental characterization of a FCMA chip. The fabrication shall be conducted in lithium niobate with RF and control electrodes attached. Optical, RF, and control connections should be made in a laboratory test fixture. The FCMA chip will be characterized in a laboratory environment to demonstrate the technical goals of the SBIR.

The Phase II Option will package the FCMA chip demonstrated during the Base effort. The chip demonstrated in the Option will be enclosed in a sealed package, constituting a FCMA prototype. The final prototype shall have a permanently attached fiber-optic input and output. Permanently attached RF and control connectors will be applied to the

electrodes. The FCMA prototype will be verified to perform at the same level as the unpackaged chip.

i. Schedule/Milestones/Deliverables

Phase II Base (15 months) fixed payable milestones for this program should include:

- Month 1: One-page bulleted summary of technical and financial status
- Month 2: One-page bulleted summary of technical and financial status
- Month 3: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice
- Month 4: One-page bulleted summary of technical and financial status
- Month 5: One-page bulleted summary of technical and financial status
- Month 6: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice
- Month 7: One-page bulleted summary of technical and financial status
- Month 8: One-page bulleted summary of technical and financial status
- Month 9: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice
- Month 10: One-page bulleted summary of technical and financial status
- Month 11: One-page bulleted summary of technical and financial status
- Month 12: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice
- Month 13: One-page bulleted summary of technical and financial status
- Month 14: One-page bulleted summary of technical and financial status
- Month 15: Demonstration of FCMA in an experimental test fixture; final review with detailed technical and financial status; program results detailed in an archival document with format of the contractor's choice

Phase II Option (12 months) fixed payable milestones for this program should include:

- Month 16: One-page bulleted summary of technical and financial status
- Month 17: One-page bulleted summary of technical and financial status
- Month 18: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice
- Month 19: One-page bulleted summary of technical and financial status
- Month 20: One-page bulleted summary of technical and financial status
- Month 21: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice
- Month 22: One-page bulleted summary of technical and financial status
- Month 23: One-page bulleted summary of technical and financial status
- Month 24: Quarterly review with detailed technical and financial status; technical process detailed in a format of the contractor's choice.
- Month 25: One-page bulleted summary of technical and financial status
- Month 26: One-page bulleted summary of technical and financial status

- Month 27: Demonstration of packaged FCMA; final review with detailed technical and financial status; program results detailed in an archival document with format of the contractor's choice

e. Dual Use Applications (Phase III)

There are four main applications of the FCMA: electronic protection, signals intelligence, radar beamforming, and communications. Signals intelligence is applicable to Defense Department and Intelligence Community missions. Radar beamforming supports Defense Department applications. Electronic protection and communications applies to Defense Department, Intelligence Community, and commercial systems.

f. References

[1] D. Marpaung, J. Yao, and J. Capmany, "Integrated microwave photonics," *Nature Photonics*, vol. 13, no. 1, pp. 80-90, Jan. 2019.

[2] V. J. Urick, "Requirements and application opportunities for integrated microwave photonics," in *Optical Fiber Communications Conference Technical Digest*, paper M2B.1, Mar. 2016.

g. Keywords

Photonics, modulator, lithium niobate, photonic integrated circuit, microwave photonics, analog photonics

III. SUBMISSION OF QUESTIONS

DARPA intends to use electronic mail for all correspondence regarding this SBO. Questions related to the technical aspect of the research objectives and awards specifically related to this SBO should be emailed to HR001120S0019@darpa.mil. Please reference BAA HR001120S0019-13 in the subject line. All questions must be in English and must include the name, email address, and the telephone number of a point of contact.

DARPA will attempt to answer questions in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered. DARPA will post a consolidated Frequently Asked Questions (FAQ) document. To access the posting please visit: <http://www.darpa.mil/work-with-us/opportunities>. Under the HR001120S0019-13 summary, there will be a link to the FAQ. The FAQ will be updated on an ongoing basis until one week prior to the proposal due date.

In addition to the FAQ specific to this SBO, proposers should also review the SBIR/STTR General FAQ list at: <http://www.darpa.mil/work-with-us/opportunities?tFilter=&oFilter=29934>. Under the HR001120S0019 summary, there is a link to the general FAQ.

Technical support for the Defense SBIR/STTR Innovation Portal (DSIP) is available Monday through Friday, 9:00 a.m. – 5:00 p.m. ET. Requests for technical support must be emailed to DoDSBIRSupport@reisystems.com with a copy to HR001120S0019@darpa.mil.