

DARPA-SN-25-03

Special Notice

Request for Information:

Addressing Next-Generation RF System Opportunities with
Low-Noise Photonic Microwave Oscillators

DARPA-SN-25-03

October 9, 2024



Defense Advanced Research Projects Agency

Microsystems Technology Office

675 North Randolph Street

Arlington, VA 22203-2114

**Request for Information (RFI)
Special Notice DARPA-SN-25-03**

**Addressing Next-Generation RF System Opportunities with Low-Noise Photonic Microwave Oscillators
Defense Advanced Research Projects Agency (DARPA)
Microsystems Technology Office (MTO)**

Posting Date: 9 October 2024

Responses Due: 15 November 2024, 5:00 p.m. Eastern Time (ET)

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RFI DESCRIPTION:

The Defense Advanced Research Projects Agency (DARPA) Microsystems Technology Office (MTO) seeks information from technology developers, system integrators, and the domestic manufacturing ecosystem regarding the next steps to advance photonic oscillators into radio frequency (RF) systems of disruptive defense and commercial capability. DARPA is interested in identifying the outstanding technical challenges and opportunities through analyses of the following areas: (1) mission identification and photonics oscillator roadmapping, (2) maintaining low phase noise under environmental stress, and (3) microsystem integration and manufacturing.

This RFI is not seeking new, unproven concepts to develop low-phase-noise photonic oscillators.

Responses to this RFI will be used to assess the feasibility of potential approaches, as well as to chart a path forward in the development of integrated photonics oscillators in RF systems as a prelude to developing a potential future program.

BACKGROUND:

In 2022, DARPA launched the Generating RF with Photonic Oscillators for Low Noise (GRYPHON) program to investigate whether chip-scale photonics can produce microwaves with an unprecedented combination of low phase noise, broad frequency agility, compact form factor, and mass manufacturability. Since then, oscillator demonstrations under the program have achieved orders of magnitude superior performance compared to any microwave sources of comparable size, as summarized in a series of landmark publications by performer teams led by Caltech¹, hQphotonics Inc.², and the University of Virginia³. This RFI aims to identify the next steps to advance photonic oscillators into RF systems of disruptive defense and commercial capability.

REQUESTED INFORMATION:

DARPA seeks innovative insights to address the technical challenge areas described below. This RFI is not seeking new, unproven concepts to develop low-phase-noise photonic oscillators. Where photonic oscillators are noted in the area descriptions, DARPA expects responses to consider the results and

¹ Kudelin, I., Groman, W., Ji, QX. *et al.* Photonic chip-based low-noise microwave oscillator. *Nature* **627**, 534–539 (2024). <https://doi.org/10.1038/s41586-024-07058-z>

² He, Y., Cheng, L., Wang, H., *et al.* Chip-scale high-performance photonic microwave oscillator. *Science Advances* **10**, eado9570 (2024). <https://doi.org/10.1126/sciadv.ado9570>

³ Sun, S., Wang, B., Liu, K. *et al.* Integrated optical frequency division for microwave and mmWave generation. *Nature* **627**, 540–545 (2024). <https://doi.org/10.1038/s41586-024-07057-0>

findings from the GRYPHON program (see appendices) as a baseline from which to extrapolate future solutions. Responses are welcome from all capable sources—including, but not limited to, private or public companies, individuals, universities, university-affiliated research centers, not-for-profit research institutions, and U.S. Government-sponsored labs—and may address one or more of the following areas:

1. Mission identification and photonic oscillator roadmapping, with consideration to factors such as:
 - a. Envisioned mission system and platform description
 - b. Envisioned system key performance parameters and comparison to current system capabilities
 - c. Microwave source flow-down metrics: center frequency; tuning range; phase noise; intensity noise/spur suppression; output power; operating temperature range and thermal stability; operating vibration spectra and acceleration sensitivity; other environmental considerations (e.g., shock, EMI, radiation, etc.); size, weight, and power; interface requirements; any other relevant physical and/or functional requirements
 - d. Technology development and maturation roadmap necessary to integrate photonic oscillators into envisioned mission system
 - e. Potential vendor relationships, development partnerships and collaboration, technology transfer paths, and intellectual property considerations
 - f. Expected microwave source production needs to address envisioned mission: unit price, unit cost, production volume, production rate, trust and security
 - g. Significant system architectural changes—if any—required to leverage photonic microwave sources compared to current state of the art (e.g., differences in system clock distribution for direct microwave generation vs. multiplication from radio band)
 - h. If applicable, dual-use opportunity assessment and metrics differentiation between military and commercial use cases
2. Maintaining low noise under environmental stress, with consideration to factors such as:
 - a. Thermal stability and acceleration sensitivity of optical microsystem components: passives (e.g., waveguides, resonators, filters), actives (e.g., modulators, detectors), light-generating (e.g., lasers, optical amplifiers), electronic (e.g., control and signal manipulation circuits)
 - b. Thermal stability and acceleration sensitivity of optical microsystem interfaces between components: photonic integrated circuit die, multi-chip alignment, photonic wire bonds, electrical wire bonds, die bonds, epoxy or solder connections, optical sub-mounts, printed circuit boards
 - c. Impact of challenging environmental conditions on photonic oscillator performance at ultra-low noise levels: phase noise due to vibration, thermally induced frequency transients
 - d. Potential solutions and methods to overcome environmental condition impacts: component ruggedization, vibration isolation, acceleration compensation, ovenization
3. Microsystem integration and manufacturing, with consideration to factors such as:
 - a. Identification of optimal strategies to integrate photonic microwave oscillators
 - b. Analysis of alternatives for trends in the state of the art: heterogeneous integration, electronic-photonic integration, multi-chip active alignment, micro-optic packaging, photonic wire bonding
 - c. Impact of microsystem integration strategy on photonic oscillator performance, yield, cost, production rate, and other producibility factors
 - d. Identification of processing facilities and component supply chain required to implement microsystem integration strategy
 - e. Assessment of the domestic manufacturing ecosystem's ability to implement microsystem integration strategy

SUBMISSION INSTRUCTIONS:

Responses to this RFI should be submitted no later than 5:00 p.m. ET on 15 November 2024.

Unclassified responses to this RFI should be submitted to DARPA-SN-25-03@darpa.mil. NO CLASSIFIED INFORMATION SHOULD BE SENT TO DARPA-SN-25-03@darpa.mil.

Classified responses should be coordinated with DARPA prior to submission. Respondents wishing to provide a classified response should send an e-mail to DARPA-SN-25-03@darpa.mil with the subject line "Classified Coordination Requested." Respondents should allow at least three (3) business days for processing requests. NO CLASSIFIED INFORMATION SHOULD BE SENT TO DARPA-SN-25-03@darpa.mil.

To the maximum extent possible, respondents should submit non-proprietary information. If proprietary information is submitted, it must be appropriately and specifically marked. It is the respondent's responsibility to clearly define to the Government what is considered proprietary data. Any proprietary information should be clearly labeled as "Proprietary." DARPA will disclose submission contents only for the purpose of review by DARPA staff, other Government agencies, or DARPA Support Contractors/SETAs.

NOTE: DARPA intends to conduct individual discussions with respondents as necessary to gain a full understanding of the technical and partnership models submitted. DARPA will contact respondents individually via e-mail.

FORMAT INSTRUCTIONS:

No formal template will be required, however responses to the RFI should be concise. Respondents should submit a single integrated response addressing the areas described above. DARPA will only review responses submitted as an unprotected Microsoft Word or PDF file

DARPACONNECT:

Entities who have not worked with DARPA before are encouraged to learn more about DARPAConnect, an initiative established to facilitate collaboration between DARPA and potential performers. The DARPAConnect team offers customized support, resources, and guidance on how to prepare your ideas for high-impact conversations with DARPA program managers. Please visit DARPAConnect.us to access a digital hub of online resources, including a curriculum for self-paced learning, personalized support, and in-person and virtual events. In addition to the self-paced online materials, the DARPAConnect team is able to schedule one-on-one conversations to discuss your specific ideas, questions, and paths to DARPA. You can use the contact form at DARPAConnect.us or email the DARPAConnect team directly at darpaconnect@darpa.mil to request assistance.

ADMINISTRATIVE:

This announcement contains all information required to submit a response. No additional forms, kits, or other materials are needed. All administrative and technical questions should be directed to DARPA-SN-25-03@darpa.mil. Please refer to the Special Notice number (DARPA-SN-25-03) in all correspondence.

This RFI is issued solely for information and program planning purposes and does not constitute a formal solicitation for proposals or proposal abstracts; any so sent will be disregarded. In accordance with FAR 15.201(e), responses to this notice are not offers and cannot be accepted by the Government to form a binding contract. Submission of a response is strictly voluntary and is not required to propose to subsequent Announcements (if any) or Solicitations (if any) on this topic. DARPA will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that DARPA is under

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no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI.