Special Notice N00014-19-R-S002
Special Program Announcement for 2018 Office of Naval Research Research Opportunity:
Electronic Warfare Technology

I. INTRODUCTION

This announcement describes a research thrust, entitled "Electronic Warfare Technology," to be launched under the N00014-18-S-B001 Long Range Broad Agency Announcement (BAA) for Navy and Marine Corps Science and Technology which can be found at http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx. The 18-S-B001 BAA remains open through 31 December 2018, or until replaced by a successor ONR Long Range BAA. The opportunity announced in this Special Notice will continue under the successor BAA, subject to the deadlines and other requirements set forth herein. The research opportunity described in this announcement specifically falls under BAA Appendix-1-Program Description, Section II B, Electronics, Sensors and Network Research of the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (Code 31) sub-section. The submission of proposals, their evaluation and the placement of research grants and contracts will be carried out as described in that Broad Agency Announcement.

The purpose of this announcement is to focus attention of the scientific community on (1) the area to be studied, (2) the ONR Electronic Warfare Industry Day for dialogue amongst those interested in this arena, and (3) the planned timetable for the submission of white papers and proposals.

II. TOPIC DESCRIPTION

The proposed topic will explore and exploit the technical opportunities for discovery and invention in the area of Electronic Warfare (EW). The goal of EW is to control the Electromagnetic Spectrum (EMS) by exploiting, deceiving, or denying enemy use of the spectrum while ensuring its use by friendly forces. To that end, the Office of Naval Research (ONR) EW Discovery and Invention (D&I) program invests in Science and Technology (S&T) initiatives that will provide naval forces (including Navy and Marine Corps) with improved threat warning systems; Electronic warfare Support (ES); decoys and countermeasures against weapon tracking and guidance systems; Electronic Attack (EA) against adversary Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR); and Electronic Protection (EP) of our own weapons and C4ISR from intentional and unintentional interference.

ONR Code 312 Electronic Warfare (312EW) seeks proposals to develop and demonstrate technologies for the next generation systems in electronic warfare. White papers and subsequent proposals should address technology developments in one or more of the following Research Opportunity Technical Areas (TA) 1-4.

Background:

Historically, the Naval EW community has had the advantage of leveraging large, high power platforms such as the Navy's surface ships to support robust Electronic Warfare capabilities. The advance of adversary intelligence, surveillance and reconnaissance (ISR) capabilities across the spectrum and the proliferation of autonomous, unmanned platforms such as UAV's (for both adversary and friendly forces) has naturally led to the development of operational concepts that emphasize heavy signal processing and distributed capabilities realized by higher numbers of both conventional and less capable platforms. This move to data intensive and distributed operations has resulted in a trade-off of capabilities based on size, weight and power (SWAP) limitations. This Special Notice seeks to identify opportunities to develop technologies that overcome the limitations on electronic warfare capabilities driven by SWAP constraints.

Technical Area 1 (TA1): Alternative Computational Approaches Applied to EW

Introduction:
The need for signal processing across the range of EW missions has driven the desire for better computational capacity. For example, classifying radio frequency (RF) signals across a large bandwidth and high dynamic range presents a "Big Data" challenge to the Navy. However, the processing resources on naval platforms—particularly those operating at the edge—are often constrained by space and power. Scaling conventional computing approaches to solve these Big Data challenges in SWAP constrained situations, such as on Unmanned Aerial Vehicle (UAV)s, will be limited by the slowdown in Moore's Law. However, the power limits of Moore's Law are not just felt in small platforms. As larger systems seek to accomplish signal detection and localization over wide bandwidths through the use of digital phased arrays, these systems also require processing of a massive amount of data in addition to sharing a tremendous amount of

digital input/output (I/O) for functions such as beamforming and advanced direction finding. These trends demand a push for more computation capacity delivered efficiently.

While the slowdown in growth of computational capability derived from Moore's Law presents challenges, the needs of machine learning algorithms have provided commercial advancements (e.g. Google's Tensor Processing Units) and motivated DoD research investments such as DARPA's Electronic Resurgence Initiative in alternate computing directions such as near memory processing. These new approaches are delivering electronics based on new system-on-chip design approaches, hybrid integrated chips, and adaptable chip architectures. These technologies promise increased computational capability with lower SWAP and smaller form factor, and with reduced design and development time.

Technical Area 1 seeks to leverage these investments in novel chipsets and architectures and apply them to the specific challenges of signal processing for electronic warfare.

Objective:
TA 1 seeks EW research ideas that capitalize on emerging compute technologies and applies them to EW capabilities to either dramatically reduce SWaP, while maintaining today's system performance, or solve a previously computationally prohibitive problem at a reasonable SWaP. Relevant EW capabilities include, but are not limited to, signal detection, localization, and classification of EW systems on single platforms as well as across distributed platforms.

Successful efforts are expected at the intersection of signal processing algorithms and emerging computational technologies to deliver EW solutions. Anticipated solutions range from implementing EW applications on emerging Commercial-off-the-shelf (COTS) devices to extending current DoD experimental Application Specific Integrated Circuit (ASIC)s to EW applications. Alternative approaches to scaling computational density ($Ops/s/mm^2$) and efficiency (J/Ops) for processing real-time ultra-high bandwidth signals/digital information that can be optimized for both model-based and training-based problem sets are encouraged.

Implementation of algorithms solely on conventional platforms such as Field Programmable Gate Array (FPGA)s, Graphics Processing Unit (GPU)s or Central Processing Unit (CPU)s are specifically excluded, and these proposals will be considered non-responsive.

Proposed efforts should highlight the quantitative benefits of the approach to a potential application, and specifically address metrics such as Floating Point Operations Per Second (FLOPS)/watt, watts/detection, data throughput, SWaP, detection sensitivity, detection accuracy, probability-of-intercept, or any other metrics deemed relevant by the proposer.

Technical Area 2 (TA2): Compact, Efficient, Beam-Agile Transmitters

Introduction:
Navy dominance of the EMS has derived in part from the prime power and deck space that surface combatant ships can provide EW systems to handle the RF spectrum enabling high power emission and high dynamic range reception. Our future Navy will include unmanned

systems that challenge the ability to undertake current tasks such as ES and EA. The smaller classes of unmanned systems in particular will be challenged to emit in the EMS with tighter prime power budgets and smaller form factors. Additionally, payload requirements will need to be balanced with endurance needs of the platform.

RF front-end technology has historically provided an enduring trade between spectrum performance and power consumption. Wide bandwidth requirements typically levied on EW systems also drive high power amplifiers into low-efficiency regimes and limit average power. Solid state technology has advanced in recent years to provide more RF performance as measured by RF power, bandwidth, linearity and efficiency for a given amount of SWAP. For systems recently fielded, or fielding in the next few years, the thermal management of solid state devices still limits average transmit power for active electronically scanned arrays (AESAs). However, new thermal management solutions have been demonstrated that potentially enable realization of higher power amplifiers. Similarly, vacuum technology has developed promising potential for high power solutions for the extreme bandwidths targeted for EW applications. In the extreme case of small SWAP constraints, the solution set may even expand to consider other high power RF devices that were not well suited to phased array application but offer benefits to the SWAP constrained platforms.

Technical Area 2 seeks to leverage advances in solid-state devices, tunable devices, thermal management, and potentially vacuum devices to obtain efficient agile RF emitters for EW systems on size and power constrained platforms.

Objective:
TA2 seeks EW research projects that target key components as a subset of a scalable solution that will enable sources of electronically-steered energy that covers at least an octave bandwidth within L-X bands and applies sub-areas 2A or 2B below.

Proposed efforts are requested to target one of the following two sub-areas:

Technical Area 2.A. Improved peak power handling of 10 dB greater than current state of art for low duty-cycle (below 10%), long pulse-length emitter systems with all supporting electronics that fit within a volume of 8 ft^3 and an antenna aperture area no larger than $4ft^2$.

Technical Area 2.B. Improved average power handling of 10 dB greater than current state of art for nearly continuous duty operation with all associated electronics that fit within a volume of 1 ft^3 and an antenna aperture area no larger than 2 ft^2.

Proposed concepts are expected to provide detail on key EW system metrics for the concept, such as SWaP, efficiency, effective isotropic radiated power (EIRP), instantaneous bandwidth, operational bandwidth, beamforming capabilities, waveform capabilities, and any other metrics deemed relevant by the proposer. Proposers shall also include information on external cooling requirements and other assumptions regarding thermal management if relevant to the proposed concept.

Proposals that develop component technologies or partial demonstrators in these sub-areas that are scalable to larger designs are desired. System volumes and aperture areas are provided as guidance for how proposers should size partial demonstrators or component technology demonstrators. Proposals shall provide a narrative on how a proposed partial demonstrator or component technology would scale to the targets of Technical Area 2A or 2B, and also discuss how the RF power handling of the concept compares to similar state-of-art technology.

Proposals that could potentially address the challenges of Technical Areas 2A or 2B are anticipated to include but are not limited to:

- High-efficiency designs or architectures tolerant to higher temperatures that minimize need for active cooling technologies.
- New technologies for higher W/mm periphery on solid state devices
- Tunable or adaptive technologies that are compatible with array grid spacing when scaling to larger arrays that provide benefits such as optimal matching with array scan parameters or otherwise optimize efficiency in real time as waveform parameters change
- Vacuum devices with advances in wide-band efficiency, such as magnetrons modified with electronic and mechanical tuning capabilities
- Other means of achieving high power beam agile systems using lensing or other analog concepts

Technical Area 3 (TA3): Compact, Efficient, EO/IR Transmitters

Introduction:
The use of the EMS has proliferated beyond just conventional RF technologies. In order for Naval dominance to continue in Electromagnetic Maneuver Warfare (EMW), the entire spectrum, from DC to daylight, needs to be fully addressed. The use of visible and infrared regions of the spectrum is now common and Technical Area 3 (TA3) seeks to address some of the critical challenges of moving optical spectrum coverage to smaller, SWaP constrained platforms.

Objective:
TA3 seeks to develop and advance multi-spectral laser component technologies to provide increased capability for distributed EW operations on Size, Weight and Power – Cost (SWaP-C) constrained platforms. Semiconductor-based lasers have enabled lower SWaP, higher-power sources in the Ultraviolet, Visible, Mid-Wave Infrared, and Long-Wave Infrared spectrums. Beam combining methods have also allowed the scaling to higher powers by combining multiple emitters. However, power and cooling requirements – driven largely by the wall plug efficiency of the emitters – are the largest SWaP drivers for a compact laser system.

Proposed efforts are requested to address at least one of the following sub-areas:

Technical Area 3.A. Novel concepts for developing an efficient, multi-band semiconductor laser system with reduced total system size from current state-of-the-art systems with similar performance. It is desired the laser should include at least two bands from (Visible, Mid Wave Infrared (MWIR) and Long Wave Infrared (LWIR)), with MWIR being preferred. The laser should have a single, high brightness output (M^2 <3), and each band should have at

least 10W CW output power. If combining multiple emitters, it is preferred that minimal to no free-space optics are used in order to reduce the effects of shock, vibration and extreme temperature variations. It is desired that the total system size (including cooling) should be less than 200 cubic inches. Proposals should discuss trades that were made (e.g., cooling efficiency, operational times, etc.) to enable significant reductions in system size.

Technical Area 3.B. Development of more efficient, higher power emitters and laser systems in the Ultraviolet A (UVA) (315-400 nm). In order to achieve higher power UVA sources, a variety of methods have been attempted to varying degrees of success. One such method that shows promise is spectral beam combining of individual emitters. However, current commercial UV diodes are less than 250mW in the UVA band. Ultimately, the ideal system would be able to accommodate 3 or more lines anywhere within the UVA band, provide greater than 10W power output, permit 2 to 3 orders of magnitude amplitude control, quickly switch between waveforms (DC thru 10kHz), and couple to a 100 micron core fiber output. If the laser is not truly continuous wave, then pulse repetition frequencies of greater than 100 kHz and pulse widths greater than 10ns are required. The volume of the full system should not exceed 75 cubic inches. Both higher power emitter technologies and/or novel system designs to meet the above metrics are of interest.

Technical Area 3.C. Development of more efficient, higher power Quantum Cascade Laser sources in the atmospherically transparent windows of the MWIR (3-5 um) and LWIR (7-10.5 um) wavelength bands. Proposed efforts should specify the level of expected increase in Wall Plug Efficiency (WPE) and/or device power over state-of-the-art systems.

Technical Area 4: Component Technologies for Innovative Distributed EW

Introduction:
This Special Notice has targeted specific challenges that have been identified in realizing a future vision of Electronic Warfare that is conducted across a distributed set of platforms and much more limited set of resources. While the focus of this Notice is on the preceding three technical areas, it is recognized that discovery and innovation can arise in unexpected ways.

Technical Area 4 allows a pathway to consider those concepts that do not fit neatly into Technical Areas 1-3 but offer truly transcendent advances in capability that push forward the vision for the future of EW.

Objective:
Technical Area 4 is open to explore additional, innovative, distributed EW concepts that would fundamentally transform the Navy's current EW capabilities (attack, support, protection).

In order to allow for diverse possibilities but limit responses to truly revolutionary ideas, TA4 proposed efforts should quantitatively describe how the proposed effort would realize a figure of merit (FoM) increase of 1000X over state of the art. In order to arrive at this FoM, proposers should quantify the benefits of their technology over existing technology. Individual FoMs of a concept may be combined/multiplied. For example, a conceptual multichannel, distributed receiver system-of-systems that provides 10 dB more dynamic range, 10x more beam-

bandwidth, and 10x more instantaneous signal bandwidth would be responsive to this technical area.

Proposed efforts that do not quantify this 1000X benefit of their approach will be considered non-responsive.

III. Industry Day

The ONR EW D&I Program will conduct an unclassified Industry Day for potential Offerors to provide a better understanding of the scope of the ONR EW D&I Program and objectives of this Special Notice.

The details regarding the Industry Day will be provided in an amendment to this Special Notice.

It is the responsibility of potential offerors to watch FEDBIZOPS, Grants.gov and the ONR website for the amendment.

IV. WHITE PAPER SUBMISSION

Although not required, white papers are strongly encouraged for all offerors seeking funding. Each white paper will be evaluated by the Government to determine whether the technology advancement proposed appears to be of particular value to the Department of the Navy. Initial Government evaluations and feedback will be issued via e-mail notification from the Technical Point of Contact. The initial white paper appraisal is intended to give entities a sense of whether their concepts are likely to be funded.

Detailed Full Proposal (Technical and Cost volumes) will be subsequently encouraged from those Offerors whose proposed technologies have been identified through the above referenced e-mail as being of "particular value" to the Government. However, any such encouragement does not assure a subsequent award. Full Proposals may also be submitted by any offeror whose white paper was not identified as being of particular value to the Government or any offeror who did not submit a white paper.

For white papers that propose efforts that are considered of particular value to the Navy but either exceed available budgets or contain certain tasks or applications that are not desired by the Navy, ONR may suggest a full proposal with reduced effort to fit within expected available budgets or an effort that refocuses the tasks or application of the technology to maximize the benefit to the Navy.

White papers should not exceed 4 single-sided pages, exclusive of cover page and resume of principal investigator, and should be in 12-point Times New Roman font with margins not less than one inch. White papers shall be in Adobe PDF format (preferred) or in Microsoft Word format compatible with MS Office 2007.

The cover page should be labeled "White Paper for ONR 2018 Research Opportunity: "Electronic Warfare Technology" and include the following information: title of the proposed effort, technical point of contact, telephone number, fax numbers, and e-mail address.

The 4-page body of the white paper should include the following information:

(1) Principal Investigator;
(2) Relevance of the proposed effort to the research areas described in Section II;
(3) Technical objective of the proposed effort;
(4) Technical approach that will be pursued to meet the objective;
(5) A summary of recent relevant technical breakthroughs; and
(6) A funding plan showing requested funding per fiscal year.

A resume of the principal investigator, not to exceed 1 page, should also be included after the 4-page body of the white paper.

To ensure full, timely consideration for funding, white papers should be submitted **no later than 07 December 2018**. White papers received after that date will be considered as time and availability of funding permit.

The planned date for completing the review of white papers is **10 January 2019**.

V. FULL PROPOSAL SUBMISSION AND AWARD INFORMATION

Full proposals should be submitted under N00014-18-S-B001/ N00014-19-S-B001 by **28 February 2019.** Full Proposals received after that date will be considered as time and availability of funding permit.

ONR anticipates that both grants and contracts will be issued for this effort.

Full proposals for contracts should be submitted in accordance with the BAA instructions at Section IV, Application and Submission Information, item 2.b, Full Proposals and item 6, Submission of Full Proposals for Contracts, Cooperative Agreements, and Other Transactions.

The Technical Proposal/Content shall be single spaced and not exceed 15 pages. The cover page, resumes, bibliographies, and table of contents are excluded from the page count. For contract proposal submission, all submissions should be submitted electronically per section VIII unless submitting a classified proposal. Classified submissions can be sent electronically or mailed.

Full proposals for grants should be submitted in accordance with the instructions at BAA Section IV, Application and Submission Information, item 5, Submission of Grant Proposals through Grants.gov. All full proposals for grants must be submitted through www.grants.gov. The following information must be completed as follows in the SF 424 to ensure that the application is directed to the correct individual for review: Block 4a, Federal Identifier: Enter N00014; Block 4b, Agency Routing Number, Enter the three (3) digit Program Office Code 312) and the Program Officer's name, last name first, in brackets (Green). All attachments to the application should also include this identifier to ensure the proposal and its attachments are received by the appropriate Program Office.

ONR plans to allocate $25-30M dollars for efforts related to the Technical Areas in this Special Notice. The period of performance for projects will be one to three (1-3) years. Proposed multi-year efforts are requested to be structured with a base effort of 6 months, followed by option years pursuant to a program review on an annual basis. It is anticipated that multiple awards will be made in Technical Areas 1-3 based on the quality of the proposed efforts. White papers are strongly encouraged for all offerors seeking funding.

Although ONR expects the above described program plan to be executed, ONR reserves the right to make changes according to program priorities and funding availability.

Selected proposers will be notified by March 2019. Selected projects will have an estimated award date of June 2019.

VI. SIGNIFICANT DATES AND TIMES

Event	Date	Time
Industry Day	Information will be provided in an amendment	Information will be provided in an amendment
White Paper Submission Date	12/07/2018	4:00pm Eastern Local Time
Notification of White Paper Evaluation*	01/10/2019	
Oral Presentation - Invitation Only	01/23/2019 – 01/24/2019	
Notification of Oral Presentation Evaluation	01/29/2019	
Full Proposal Submission Date	02/28/2019	4:00pm Eastern Local Time
Notification of Selection: Full Proposals *	March 2019	
Awards *	June 2019	

Note: * These are approximate dates**.**

VII. POINTS OF CONTACT

In addition to the points of contact listed in the Long Range BAA, the specific points of contact for this announcement are listed below:

Technical Points of Contact:

Dan Green, Electronic Warfare Program Manager, daniel.s.green2@navy.mil

Please copy:
Bob Kusuda, Program Analyst Contractor Support, bob.a.kusuda.ctr@navy.mil
Adrien Fairweather, Program Analyst Contractor Support, adrien.m.fairweather.ctr@navy.mil

Business Point of Contact:

Stephen Hughes, Contracting Officer, stephen.t.hughes@navy.mil

VIII. ADDRESS FOR THE SUBMISSION OF WHITE PAPERS AND FULL PROPOSALS FOR CONTRACTS

White Papers/Full Proposal:

White papers and Full Proposals submitted under this notice are expected to be unclassified; however, classified proposals are permitted up to GENSER SECRET. If a classified proposal is submitted and selected for award, the resultant award will be unclassified.

Unclassified white papers and unclassified full proposals should be submitted electronically to onr.ncr.312.list.fct@navy.mil by 4:00PM Eastern Daylight Time on 07 December 2018 (white paper) and 28 February 2019 (full proposals). Files exceeding 10MB in size should not be emailed, but instead transmitted via a file transfer service, for example AMRDEC Safesite, https://safe.amrdec.army.mil/safe/Guide,

Classified White Papers/ Full Proposals:

Classified white papers and proposals can be sent to Robert.Kusuda.ctr@navy.smil.mil by 4:00PM Eastern Local Time on 07 December 2018 (white paper) and 28 February 2019 (full proposals).

Classified proposals can also be submitted directly to the attention of ONR's Document Control Unit at the following address and marked in the following manner:

OUTSIDE ENVELOPE
(no classification marking):

Office of Naval Research
Attn: Document Control Unit
ONR Code 43
875 North Randolph Street
Arlington, VA 22203-1995

The inner wrapper of the classified proposal shall be addressed to the attention of the cognizant Technical Point of Contact (TPOC), ONR Code 312 and marked in the following manner:

INNER ENVELOPE
(stamped with the overall classification of the material)

Program Name: Electronic Warfare Technology
Office of Naval Research
ATTN: Dr. Daniel Green
ONR Code: 312
875 North Randolph Street
Arlington, VA 22203-1995

All response submissions will be protected from unauthorized disclosure in accordance with FAR Subpart 15.207, applicable law, and DoD/DoN regulations. Offerors are expected to appropriately mark each page of their submission that contains proprietary information. In either case of an unclassified or classified proposal submission, it is the responsibility of the submitting individual to ensure he/she receives an email confirming receipt from the TPOC (listed below).

IX. SUBMISSION OF QUESTIONS

Any questions regarding this announcement must be provided to the Technical Points of Contact and/or the Business Point of Contact listed above. All questions shall be submitted in writing by electronic mail.

Answers to questions submitted in response to this Special Notice will be addressed in the form of an Amendment and will be posted to the following web pages:

- Federal Business Opportunities (FEDBIZOPPS) Webpage – https://www.fbo.gov/
- Grants.gov Webpage – http://www.grants.gov/
- ONR Special Notice Webpage - http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Special-Notices.aspx

Questions regarding **White Papers or Full Proposals** should be submitted No later than two weeks before the dates recommended for receipt of White Papers and/or Full Proposals. Questions after this date may not be answered.