Funding Opportunity Title: Low-Cost Chip-Scale Atomic Clock (LC CSAC)
Funding Instrument Type: Technology investment agreement
Funding Opportunity Number in Grants.gov: W911NF-17-S-0003-SPECIALNOTICE-LC-CSAC

Description:
The aim of this Special Notice under the ARL BAA (W911NF-17-S-0003), under Grants.gov Opportunity W911NF-17-S-0003-SPECIALNOTICE-LC-CSAC, is to fund a team or multiple teams to design, manufacture, and deliver a battery-powered atomic clock that achieves identical (or better) size, weight, and power (SWaP) and performance to the commercially available chip-scale atomic clock (CSAC) with a selling price goal of < $300/unit in high volume.

Precise timing is critical for numerous Army applications such as navigation, communications, surveillance, and synchronization of sensors and systems. Assured PNT solutions currently rely on acquiring GPS signals, which may not be readily available in increasingly contested environments. Commercially available silicon MEMS and quartz oscillators (TCXO, OCXO) are unable to provide GPS holdover in the event of a GPS outage, except for high-end OCXOs that may be considered large and power hungry for certain applications. To ease reliance on GPS, long-holdover clocks with SWaP-C appropriate for various DoD platforms are necessary to enable mission-critical functions even in contested environments. Current high-performance atomic clocks (maser, laser-cooled cesium fountain) serve as standards and are large, expensive, and require regular monitoring and exquisite environmental control.

Since the early 2000s, the chip-scale atomic clock (CSAC) has been developed and successfully matured into a commercial product with DARPA and industry investment. While an Army/Air Force/OSD Manufacturing Technology effort further reduced the manufacturing cost[1], the current selling price is still prohibitive for high-volume, low-SWaP DoD platforms. There is an opportunity to leverage the many advances in MEMS, photonics, and atomic physics over the past two decades to develop state-of-the-art, high-performance, battery-powered atomic clocks with improved manufacturability, significantly reduced cost, and improved performance.

This special notice seeks proposals from one or more for-profit firms in accordance with 32 CFR 37.210. A consortium, led by a for-profit firm, is also encouraged.

Schedule:
The program consists of three phases. The first phase is a one-year base period to develop key architectural designs and initial component developments. Phase 2 is a one-year option period in which the initial architectural developments will be produced and tested. Phase 3 is the final two-year option period resulting in the final deliverables achieving all metrics listed in Table 1. If the proposed schedule deviates from the listed timeline, for example the proposed timeline is expedited, the offeror must appropriately justify the timeline and metrics.

Cost Sharing:
Proposals must show a strong commitment to and self-interest in the success of the project. The Government is required to seek cost sharing to ensure the recipient incurs real risk that gives it a vested interest in the project's success. To the maximum extent practicable, the non-Federal parties carrying out the research project under a TIA are to provide at least half of the costs of the project. In the event that 50% is impracticable, the proposal should provide justification for why that is the case and also demonstrate the potential recipient's self-interest in the success of the project. If all other criteria are

rated equally, preference will be given to proposals with a higher percentage of cost share demonstrating the offeror's commitment to the success of the research effort.

Goals and Metrics:

The primary goal of this solicitation is to achieve a price point and volume capacity commensurate with the DoD needs for integration with GPS receivers for signal assurance over the next decade. Table 1 lists the high-level end-project goals in terms of threshold and objective.

Metric	Threshold	Objective	Comments
Unit Production cost	$220	$200	Target $300 sell price
Production capacity	>100k/year	>1M/year	
Size	< 8 cm^3	<1 cm^3	
Power	<120 mW	<60 mW	
Short-term stability	$\sigma_y \leq 3 \times 10^{-10}/\sqrt{\tau}$	$\sigma_y \leq 8 \times 10^{-11}/\sqrt{\tau}$	Fractional frequency over $1 < \tau < 30k$
Long-term aging	< 9 x 10^{-10}	< 1 x 10^{-10}	Fractional frequency per month
TempCo	$\pm 5 \times 10^{-10}$	$\pm 1 \times 10^{-10}$	Over temp. range
Operating temp. range	$-10\ °C\ -\ +70\ °C$	$-40\ °C\ -+85\ °C$	

Table 1: CSAC 2.0 project goals/Year 5 metrics. All metrics are expected to meet or exceed the currently available devices

Phase 1 (12 months):

- Develop concepts/designs for a complete low-cost CSAC;
- Develop a program plan (development schedule and cost, fab line changes, etc.);
- Develop a fabrication plan to enable volume manufacturing (refinement/update milestones);
- Develop initial components for performance enhancements and cost savings;
- Conduct early short-loop experiments.

Phase 2 (12 months):

- Produce 10 prototype clocks achieving a 2X reduction in cost while in low-volume production;
- Demonstrate short-term stability in Table 1;
- Initiate environmental testing for all parameters in Table 1;
- Finalize plan for high-volume production

Phase 3 (24 months):

- Produce 100 prototype clocks
- Demonstrate all metrics in Table 1

Deliverables:

- Biweekly review meetings
- Monthly financial reports
- Quarterly site visits
- Quarterly technical reports
- Each end-of-phase report
- Year 2: 10 prototype clocks
- Year 4: 100 prototype clocks

Evaluation criteria:

Proposals will be evaluated using the following criteria, listed in descending order of importance: (a) Overall Scientific and Technical Merit; (b) Potential contribution to the Army mission; (c) Realism of Proposed Schedule; (d) Plans and Capability to Accomplish Technology Transition; (e) Cost Realism; (f) Offeror's Capabilities and/or Related Experience; and (g) Cost Share

1. **Overall Scientific and Technical Merit**

   The proposed technical approach is 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.

2. **Potential contribution to the Army mission**

   The offeror details the effort's potential contributions to the Army mission and the extent to which the research effort will contribute to balancing the overall ARL research program.

3. **Realism of proposed schedule**

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

4. **Plans and Capability to Accomplish Technology Transition**

   The offeror clearly demonstrates its capability and commitment to transition technology to the operational military community for the sake of enhancing U.S. defense. In addition, the evaluation will consider the extent to which the proposed intellectual property (IP) rights will potentially impact the Government's ability to transition the technology.

5. **Cost Realism**

The proposed costs are realistic for the technical and management approaches offered and demonstrates the offeror's practical understanding of the effort. The costs proposed are based on realistic assumptions, reflect a sufficient understanding of the technical goals and objectives of the special notice, and are consistent with the offeror's technical approach (to include the proposed Statement of Work). At a minimum, the prime offeror and proposed subawardees substantiate the proposed costs with the type and number of labor hours proposed per task as well as the types and kinds of materials, equipment and fabrication costs proposed. It is expected that the effort will leverage all available relevant prior research in order to obtain the maximum benefit from the available funding. Both direct and indirect cost sharing may be a positive factor in the evaluation. ARL recognizes that undue emphasis on cost may motivate offerors 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. ARL discourages such cost strategies.

6. **Offeror's Capabilities and/or Related Experience**

   The offeror's prior experience in similar efforts clearly demonstrates an ability to deliver products that meet the proposed technical performance within the proposed budget and schedule. The proposed team has the expertise to manage the cost and schedule. Similar efforts completed/ongoing by the offeror in this area are fully described including identification of other Government sponsors.

7. **Cost Share**
   Cost share is required in the form of monetary and in-kind contributions provided by the recipients to cover the total project cost. If all other criteria are equal, preference will be given to proposals with a higher percentage of cost share demonstrating the offeror's commitment to the success of the research effort.

Proposal submission:

All whitepapers must be submitted electronically and must be emailed directly to the Technical Points of Contact, Dr. Jenna Chan and Dr. Jonathan Hoffman (jenna.f.chan.ctr@mail.mil, jonathan.e.hoffman.civ@mail.mil). A whitepaper sent by any other means (e.g., hand-carried, postal service mail, commercial carrier, or fax) will not be considered. Include the BAA number W911NF-17-S-0003 and "LC CSAC" in the email subject line. Whitepapers must be received at the government emails noted directly above no later than Friday, 29 May 2020 at 11:59 PM (EDT). Offerors shall account for potential delays in file transfer from the originator's computer server to the Government website/computer server and are encouraged to submit their response early to avoid potential file transfer delays due to high demand or problems encountered in the course of submission. For this special notice, whitepapers are limited to ten (10) pages, which includes any references plus a cover page and a one-page addendum for biographical sketches for each of the key personnel. The cost portion of the whitepaper shall contain a brief cost estimate for all of the component parts of the whitepaper, including: research hours, indirect costs, material costs, travel, etc. Whitepaper evaluations are expected to be complete by early June 2020, and once complete, all offerors will be informed via email whether or not they will be invited to submit a full proposal based on their Whitepaper submission.

Full proposal submissions must be submitted against Grants.gov Opportunity Announcement W911NF-17-S-0003-SPECIALNOTICE-LC-CSAC in accordance with the preparation and submissions instructions under BAA W911NF-17-S-0003, except as noted below. As a reminder, an offeror is not eligible to submit a proposal under the BAA for the LC CSAC unless their whitepaper submission is timely, is highly rated, and the offeror is INVITED to submit a proposal. Proposals shall be submitted electronically through the www.grants.gov portal. A proposal sent by any other means (e.g., hand-carried, postal service mail, commercial carrier, fax or email) will not be considered. INVITED proposals must be received no later than Tuesday, 30 June 2020 at 11:59 PM (EDT) to be considered for the LC CSAC. The proposal content information is as specified under BAA W911NF-17-S-0003, except the technical proposal (project description) portion of the full proposal must not exceed thirty (30) pages. If the technical proposal exceeds 30 pages, only the first 30 pages will be reviewed and evaluated. As described in the BAA W911NF-17-S-0003, the proposal must also include a budget for each year of support requested. In addition to the cost proposal, the Applicant must also include detailed information on the sources (by organization), timing, and amount of proposed cost share. This cost share plan must include the value, in dollars, for all in-kind cost sharing. This information must include a schedule of cost sharing that shows when the proposed cost share will be available and applied to the award, and how the cost share will be used in support of the proposed effort. Proposals will be evaluated using the criteria listed in this Special Notice. Proposal evaluation is expected to be complete and any award selections made by late July 2020. An offeror whose proposal is selected for award will be contacted by a Contracting/Grants Specialist.

Clarifying questions regarding the intent or scope of this special notice may be submitted. Answers to non-proprietary questions are expected to be posted online at https://www.arl.army.mil/lccsac/ within seven calendar days of receipt. All clarifying questions must be submitted to the website above before 16 June 2020 at 11:59 PM (EDT). Should an Applicant have questions they believe are of a proprietary nature, the Applicant must clearly state so and identify and mark the proprietary information in the question when submitted. Answers to questions of a proprietary nature will be provided via email directly to the requestor of the question and not posted on the SARA website. Any non-proprietary clarifying questions submitted outside of the website (e.g., submitted to an email address or by phone) will not be addressed.

[1]https://www.dodmantech.com/ManTechPrograms/Files/Army/ArmySuccess_ChipScaleAtomicClock_02Feb15.pdf

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