INTRODUCTION

Electromagnetic Metamaterial is an artificial composite material displaying novel electromagnetic properties unavailable in naturally occurring materials and radically different from those of any of the constitutive components. The novel electromagnetic properties derive from closely spaced constituent elements with specifically chosen geometrical, mechanical, and electromagnetic characteristics.

Electromagnetic metamaterials may be supplemented or complemented by other technologies to achieve desired operational performance characteristics in the proposed application demonstration. Such complementary technologies may include, but not necessarily be limited to, active (e.g., Non-Foster) electronic matching networks, frequency selective structures, periodic structure with engineered dispersion, including photonic band-gap materials, acoustic metamaterials. The proposer should clearly identify the role played by the complementary technology in the proposed application. Innovative advancements in using metamaterials and/or these complementary technologies that leverage commercial economies of scale are highly desired. Finally, if there are simpler, well known engineering solutions to problems for which metamaterial or complementary solutions are proposed, the burden is placed on the proposer to compare their proposed solution to the traditional paradigm in a fair engineering "apples to apples" comparison.

Similarly to electromagnetic metamaterial, an acoustic metamaterial is defined as an artificial composite material displaying novel acoustic properties unavailable in naturally occurring materials and radically different from those of any of the constitutive components. The novel acoustic properties derive from closely spaced constituent elements with specifically chosen geometrical, mechanical characteristics.

TOPIC AREAS:

1) Radio Frequency (RF)

a. Antennas, Arrays and Front-End Components

i. Objectives: Demonstrate new capabilities for military use through metamaterials-enabled components or structures that advance the State-of-the-Art (SOA) in antennas, antenna arrays, or associated front-end components in such areas as RF Performance (gain, bandwidth, multi-band, impedance matching, radiation pattern, beam steering, scan angle, frequency agility, low profile), size (miniaturization or weight reduction) and cost reduction.

ii. Performance Metrics: The offeror shall describe succinctly and quantitatively the performance metrics (e.g. x more dB gain over % bandwidth increase) that will be used to evaluate the effort and track its progress. The offeror must describe how their metamaterial concept attains new capability or pushes performance and is scientifically and engineering plausible. Some examples of efforts that will not be considered: antenna solutions that purport to violate the Fano-Chu gain bandwidth product limit with passive materials; the use of materials to match an antenna where conventional matching circuits at the feed would suffice ; an increase in one performance metric at the expense of another without describing the trade-offs.

iii. Applications of Interest: Applications may include, but are not limited to airborne, ground or space-based antenna systems for communications, radar, electronic warfare, imagine, chemical or biological detection.

b. Waveguides, Electromagnetic Interference (EMI) Reduction/Control, Circulators and Filtering Components

i. Objectives: Demonstrate concepts of metamaterial-enabled waveguide, EMI control, circulators or RF filtering components/structures that provide a new military capability in such areas as RF Performance (Electromagnetics band-stop or band-pass, phase control, electromagnetic shielding or co-site interference reduction), size (miniaturization) or weight reduction, cost reduction or interests include UHF-THz operating frequencies.
ii. Performance Metrics: The offeror shall describe succinctly and quantitatively the performance metrics (e.g. x more dB gain over % bandwidth increase) that will be used to evaluate the effort and track its progress. The offeror must describe how their metamaterial concept attains new capability or pushes performance and is scientifically and engineering plausible. For example: Filter architectures that simply replace conventional lumped components with metamaterial or meta-inspired elements must be compared to the best conventional approach.
iii. Applications of Interest: Applications may include, but are not limited to airborne, ground or space-based antenna systems for communications, electronic warfare, imaging or chemical or biological detection.

c. Synthesis, Design and Fabrication

i. Objectives: Demonstrate techniques or methods that advance the synthesis, design, and fabrication of metamaterial-enabled components or structures, not the synthesis of the metamaterial itself.
ii. Performance Metrics: The offeror shall describe succinctly and quantitatively the performance metrics (e.g. x more dB gain over % bandwidth increase) that will be used to evaluate the effort and track its progress. The offeror must describe how their metamaterial concept attains new capability or pushes performance and is scientifically and engineering plausible.
iii. Applications of Interest: Applications may include, but are not limited to airborne, ground or space-based antenna systems for communications, electronic warfare, imaging, chemical or biological detection.

2) Optical Metamaterials

a. Active Optical Metamaterials

i. Objectives: Demonstrate metamaterial-enabled devices involving gain and/or other active components and advancing one or more of the following attributes: Low-loss, reduced energy consumption, broad bandwidth, multi-band, angle and polarization independence, enhanced directional selectivity, survivability and ability to perform in harsh environment, size and weight reduction, cost reduction, enhanced sensing performance, active approaches to violate or soften Kirchhoff's law connection between emissivity and absorptivity.

ii. Performance Metrics: The offeror shall describe succinctly and quantitatively the performance metrics that will be used to evaluate the effort and track its progress. The offeror must describe how their metamaterial concept attains new capability or pushes performance and is scientifically and engineering plausible.
iii. Applications of Interest: Applications include, but are not limited to airborne, ground or space-based imaging and communication systems, chemical/biological/radiation/motion/ magnetic field detection, broadband focusing and signal routing.

b. Plasmonic Optical Metamaterials

i. Objectives: Demonstrate components based on plasmonic metamaterial media that provide enhanced optical sensors, solar cell efficiency, thermal energy mitigation and other applications involving extraordinary optical transmission (EOT).
ii. Performance Metrics: The offeror shall describe succinctly and quantitatively the performance metrics that will be used to evaluate the effort and track its progress. The offeror must describe how their metamaterial concept attains new capability or pushes performance and is scientifically and engineering plausible.
iii. Applications of Interest: Applications include, but are not limited to energy collection, blackbody radiation mitigation and chemical/biological/radiation sensing.

c. Optical Metamaterial Component Fabrication

i. Objectives: Fabrication techniques of Optical Metamaterials-based components are sought that will advance 3D large-scale fabrication for random as well as ordered array media. Fabrication processes must be developed exploiting this higher resolution E-beam Lithography (EBL) which is critical for high density metamaterials structures in the visible regime.
ii. Performance Metrics: Development of techniques for functionalization/self assembly is also sought out for simplified fabrication cost effective solutions.
iii. Applications of Interest: Applications include fabrication techniques for conformal metamaterial structure applications are also of interest. Applications include but are not limited to optical filters, lenses, RF/Photonic coupling concepts.

3) **Other (Acoustic and Bio-Related)**: Metamaterials may also hold potential for revolutionary solutions to challenges facing military systems which lie beyond RF and Optical Systems. This solicitation will also accept submissions regarding metamaterials-based solutions to a broader scope of applications within Acoustic and Bio-Related Metamaterials. For such submissions to be considered, the offeror is expected to identify both the solution and the potential application area.

a. Acoustic Metamaterials

i. Objectives: Development of broadband, active, metamaterial-based, acoustic devices providing control of acoustic energy flow, acoustic radiation, and acoustic detection. Demonstrate new capabilities of acoustic metamaterials for military use.

ii. Performance Metrics: The offeror shall describe the performance metrics that will be used to evaluate the effort and track its progress. The performance metrics must be tailored to the intended applications of a particular acoustic metamaterial. It should clearly reflect the practical advantages expected from implementation of new technology.
iii. Applications of Interest: Applications include, but are not limited to: Metamaterial based acoustic isolator (acoustic diode), acoustic circulator, and acoustic switch. Acoustic metamaterials for acoustic cloaking. Phononic hetero-structures for the enhancement of acousto-optic, piezoelectric, and piezomagnetic interactions for light modulation and sensing. Acoustic metamaterials for thermal management.

b. Bio-Related Metamaterials

i. Objectives: Demonstrate new capabilities for military use through metamaterials utilizing biomaterials and bio-inspired metamaterials-enabled components or structures that advance the State-of-the-Art (SOA) in the optical or RF domain such as antennas, antenna arrays, or associated front-end components, RF Performance (gain, bandwidth, multi-band, impedance matching, radiation pattern, beam steering, scan angle, frequency agility or low profile), size (miniaturization) or weight reduction, cost reduction, low-loss, broad bandwidth, multi-band, angle and polarization independence or enhanced sensing performance.
ii. Performance Metrics: The offeror shall describe succinctly and quantitatively the performance metrics that will be used to evaluate the effort and track its progress. The offeror must describe how their metamaterial concept attains new capability or pushes performance and is scientifically and engineering plausible.
iii. Applications of Interest: Applications include but are not limited to airborne, ground, or space-based imaging and communication systems, chemical/biological/radiation, energy collection, blackbody radiation mitigation, detection, broadband focusing and signal routing.

SECURITY:

General OPSEC procedures, policies and awareness will be required in an effort to reduce program vulnerability from successful adversary collection and exploitation of critical information. OPSEC will be applied throughout the lifecycle of any resultant contract. The Critical Information list will be provided upon request by the RYOY security office.

The Contractor shall participate with the Government in the development of a Program Protection Plan (PPP), to include the identification of Critical Program Information (CPI), and shall also participate with the Government in determining countermeasures needed to safeguard the CPI throughout the acquisition process. The Contractor shall plan for and execute program protection in accordance with the PPP and program guidance.