SOCOM254-007: Acoustic-based UAS Rainbow Oscillation Refraction Architecture (AURORA)

ADDITIONAL INFORMATION

N/A

TECHNOLOGY AREAS:

Air Platform | Electronics | Sensors

MODERNIZATION PRIORITIES:

Advanced Computing and Software | Advanced Materials | FutureG | Human-Machine Interfaces | Hypersonics | Integrated Network Systems-of-Systems | Integrated Sensing and Cyber | Microelectronics | Trusted AI and Autonomy

KEYWORDS:

communications; awareness; acoustic; sound; refraction; swarm; obstacle avoidance; robotics; metaheuristics; propellers; oscillation; transmit; receive; encoding; pulse code modulation; modulation; drones; synchronization; cohesion; decentralized; self-organizing; collective behavior; swarm optimization; boids

OBJECTIVE:

The objective of this topic is to conduct applied research toward an innovative capability to achieve spatio-spectral decomposition of sound produced by small uncrewed aerial systems (sUAS) within a swarm to enable the transmission and reception of information encoded on those sound waves and support relative position awareness within a multi-agent system.

ITAR:

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

DESCRIPTION:

This topic seeks innovative research and development efforts towards an acoustic-based communications system that enables sUAS within a swarm to communicate and exchange information about their relative positions. This capability will support intra-swarm communications by using sound primarily generated by the sUAS's propellors as a carrier wave to encode data between drones. The system should spatially decompose incoherent sound waves produced by the sUAS's propellors during normal operation into its component frequencies and refract them across different vectors based on their respective frequencies. The system will also need to process these signals to enable decentralized, multi-agent swarming by applying Boids model or a similar self-organizing, flocking algorithm for autonomous systems. As a part of this feasibility study, the proposers shall address all viable overall system design options with respective specifications on the key system attributes.

Key system attributes include:

1. Must use the mixture of incoherent sound waves generated by the propellors of a sUAS to enable intra-swarm communications.
2. Must refract the sound waves produced by a sUAS's propellors into separate coherent frequencies that can be modulated to encode data.
3. Must receive and transmit omnidirectionally.
4. Must enable sUAS to independently determine their position relative to the rest of the swarm based on the direction and magnitude of frequencies that it receives. This may be achieved by refracting higher or inaudible frequencies downward and lower frequencies upward, allowing each sUAS to determine their

elevation and general position relative to other sUAS.
5. Must enable heterogenous sUAS to effectively transmit and receive data intra-swarm. This includes enabling heterogenous sUAS to organize in the most optimal formation to improve signal quality and mobility.
6. Must address reciprocal interference either through isolation of transmit and receive paths or some other means.
7. Must enable individual, autonomous sUAS to avoid collisions and align positions within a larger multi-agent swarm.
8. Must address the variability of acoustic frequencies generated by different models and sizes of sUAS as well as environmental factors that may affect the propagation of sound waves.
9. Must not rely on additional oscillators to generate sound waves.
10. May use low-noise amplifiers or other means of improving signal quality.
11. Must address the impact of Doppler shift that may be caused by the changing position of sUAS travelling at variable speeds relative to other sUAS within a multi-agent system.
12. Must not impede the normal operation of the sUAS.

PHASE I:

Conduct a feasibility study to assess what is in the art of the possible that satisfies the requirements specified in the above paragraphs entitled “Objective” and “Description.” Determine the data rates that are achievable with an acoustic-based receiver and transmitter with the characteristics outlined above.
The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study (“Technology Readiness Level 3”) to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II:

Develop, install, and demonstrate a prototype system determined to be the most feasible solution during the Phase I feasibility study on an acoustic-based, intra-swarm communications and awareness system.

PHASE III DUAL USE APPLICATIONS:

This system could be used in a broad range of military applications where large, multi-agent systems of drones are operating and collaborating in close proximity to each other in support of Special Operations Forces without reliance on GPS or the transmission of radio frequencies.

REFERENCES:

1. Christiansen, R.E. et al (June 25). Morphogenesis of sound creates acoustic rainbows. Science Advances. Retrieved from https://www.science.org/doi/10.1126/sciadv.ads7497

TOPIC POINT OF CONTACT (TPOC):

None