

Localizing the broadband and tonal noise sources of coplanar propellers

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A significant issue with regard to the quickly developing technology that will make Urban Air Mobility (UAM) and Advanced Air Mobility (AAM) a reality in the near future is the foreseeable noise levels associated with the technology. There are many aspects of this problem that can be investigated in expectation of the technology. The Acoustics Research Group of the Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Fluid Mechanics has approached the question from the angle of better understanding the noise sources in order to mitigate them with engineering design guidelines in the hope of lowering noise levels to a point where they will no longer be a nuisance to society. This will help in achieving a better acceptance of the technology and the beginning of a new era in transportation.

In order to better understand propeller noise sources, the research team utilizes phased array microphone systems and beamforming technology. Commercially available beamforming tools are seldom specialized for use in the investigation of turbomachinery applications. Therefore, the research group invests a significant amount of time and energy in the development of specialized beamforming tools that make the investigation of various turbomachinery noise sources more effective. The research team is among the top institutions that actively carry out research and development, continuously contributing to the state of the art in beamforming for turbomachinery applications. The research team's first contributions came while studying Counter-Rotating Open Rotor (CROR) unducted aircraft engines. Since that time, the research team has moved on to the investigation of UAM and AAM aircraft configurations.

The current contribution to the workshop focuses on introducing beamforming tools developed for the investigation of various turbomachinery applications and how these will be combined to study various drone configurations on the research team's new aerodynamic and aeroacoustic drone testbench. The first beamforming tools to be introduced provide a means for separating apart turbomachinery broadband noise from turbomachinery tonal noise in order to beamform the broadband noise sources separately from the tonal noise sources. The technology allows for the extraction of noise source maps for rotating broadband noise sources [1] separately from rotating tonal noise sources [2]. This is especially significant in investigating counter-rotating configurations and coplanar configurations, where the two rotors' relative positions and RPMs are rarely synchronized. In order to study the interactions of coplanar rotors, the above-mentioned beamforming tools will be combined with a further

development of the ROTating Source Identifier (ROSI) beamforming method called Segmented ROSI [3]. Segmented ROSI allows for the investigation of various segments of a rotation on an individual basis. This provides a more detailed picture regarding the interactions between the blades when they are relatively close to one another instead of an average picture of what happens during the course of a full revolution.

The beamforming tools described above might seem relatively simple and straightforward, but in order to create signals which can be beamformed to localize noise sources accurately, many obstacles have been overcome during the development process. Combining these methods will bring about further obstacles, but it is our goal to apply these combined methods in carrying out investigations on our drone testbench, acquiring a more profound knowledge of the behavior of coplanar propellers as a function of RPM, inter-rotor spacing (for counter-rotating applications), blade number, and in-plane spacing.

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Bibliography:

- [1] K. Tokaji, B. Soós, and Cs. Horváth. Beamforming Method for Extracting the Broadband Noise Sources of Counter-Rotating Open Rotors. AIAA JOURNAL 1: 1 pp. 1-12., 12 p. (2020).
- [2] B. Soós, K. Tokaji, and Cs. Horváth. Development and Application of Beamforming Method for Extracting the Tonal Noise Components of Counter-Rotating Open Rotors. AIAA JOURNAL (under submission).
- [3] H. Zhang, B. Kocsis, and Cs. Horváth. Segmented ROSI Method: Beamforming Method for Investigating Turbomachinery Noise Sources Along Segmented Trajectories. NOISE CONTROL ENGINEERING JOURNAL 70: 1 pp. 62-76., 15 p. (2022).