MEMS Microphone Arrays for Aeroacoustic Testing

Understanding and controlling aircraft noise is one of the major research topics of the NASA Fundamental Aeronautics Program. The successful development of noise reduction technologies has relied not only on physics-based modeling but also on the acquisition of quantitative databases with which to validate the models. One of the measurement technologies used to acquire noise data is the microphone directional array (DA). The current generation of array instrumentation is capable of extracting accurate noise source location and directivity on a variety of airframe components using sophisticated data reduction algorithms. The gain in test productivity using DA instrumentation has been significant, and has resulted in the desire to install larger and more complex array systems in closed reverberant wind tunnels. Traditional directional array hardware, consisting of commercially available condenser microphones and preamplifiers can be too expensive and their installation in hard-walled wind tunnel test sections too complicated. To overcome these challenges, a significant effort has been expended by the NASA Langley team to develop effective MEMS-based microphone directional array instrumentation to acquire noise data. The objectives of the research study are:

1. Characterize the acoustic response of a suitable MEMS microphone and evaluate its suitability for directional array use,
2. Develop and evaluate methods to install MEMS microphones in ground test facilities quickly and efficiently,
3. Integrate commercially-available signal conditioning and data acquisition hardware with the MEMS array and evaluate the performance of the data system,
4. Evaluate the beamforming performance of the MEMS array, and
5. Use the MEMS array to obtain aeroacoustic data on relevant airframe noise model(s).

Note that commercially available MEMS microphone devices suffer from certain important shortcomings. Based on early experiments with array prototypes, it has been found that both the bandwidth and the sound pressure level dynamic range of the microphones should be increased significantly to improve the performance and flexibility of the overall array. Thus, in collaboration with commercial vendors, the team modified a commercially available MEMS design to satisfy the new requirements. These microphones are currently being characterized for background noise level and are being calibration using a free-field substitution method at frequencies up to 80 kHz using a random, ultrasonic broadband centrifugal sound source located in a small anechoic chamber. Phase calibrations of the new microphones are derived from cross spectral comparisons between the reference and test substitution microphones and an adjacent and invariant grazing-incidence 1/8" microphone. The new microphones will be incorporated into a series of evaluation arrays for evaluation of their suitability for aeroacoustic measurements.

Team Members: Qamar A. Shams, William M. Humphreys, Allan J. Zuckerwar, Scott M. Bartram, Bradley S. Sealey, and Toby Comeaux
NASA Langley Research Center, Hampton VA 23681

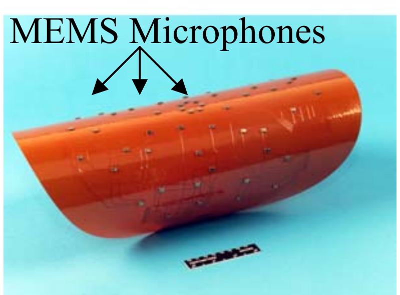

Figure 1: Flexible Circuit Board

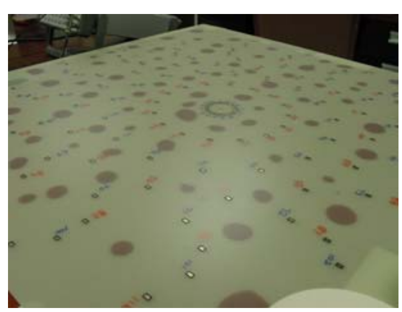

Figure 2: 128-Channel Microphone Array