Spatio-temporal correlations for turbulent jet flows using the point reference global correlation (PRGC) technique

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Significant progress has been made in recent years in understanding the relationship between turbulence structures and noise sources mechanisms. This is mainly due to significant improvements in measurement and numerical prediction methods. Since most turbulent flows have a strong multi-dimensional character, modelling of noise source mechanisms necessitates a detailed knowledge of the flow physics. For modeling based on the acoustic analogy approach, the mechanisms of conversion of the turbulence kinetic energy into acoustic energy are based on the multi-order velocity space time correlation tensor. The length and time scales associated with the turbulence are determined from these and these are crucial to the noise prediction methodology.

Two-point measurements combining intrusive or optical techniques have been used extensively to extract the turbulence statistics required for source modelling. However, with this type of measurement procedure, only one component of the tensor in one direction can be estimated. To obtain the complete 3-D model from such point measurements is unrealistic. The use of Particle Image Velocimetry (PIV) can extract the spatial correlations over a 2D but, due to the low sampling rate of these systems, time scales cannot generally be obtained. Thus, the frequency content of mechanisms considered potential noise sources in high speed flows cannot be obtained using PIV.

It has recently been shown by Chatellier & Fitzpatrick that a single point measurement can be used in conjunction with a field measurement to obtain the space time correlation for a range of flows. The method, referred to as the Point Reference Global Correlation (PRGC) technique enables high sample rate single point and low sample rate global measurements to be used to determine the 2-D space time correlation functions over a large area of the flow. This means that the statistical characteristics of the turbulence can be derived in terms of length and time scales together with the inhomogeneous and anisotropic features. This is of significance for noise source modelling.

The present paper examines the sensitivity of the Point-Reference Global Correlation Technique (PRGC). Simulated data for typical LDV and PIV measurements are used so that a parametric study can be performed to examine how sensitive the PRGC technique is as a function of sample frequency and the number of samples of both the LDV and PIV data. These parameters are shown to be critical to errors associated with the calculated space time correlations and that low data rates can lead to significant variations in the estimates. Measurements conducted in a Mach 0.2 jet flow using PIV and LDV systems are reported and the two dimensional spatio-temporal correlation functions as well as the associated length and time scales are shown to be as expected. Typical results from a jet flow at Mach 0.24 are shown in the figure.


Fig. 1 Iso-Contours of Space Time Correlations in a Jet