Aeroacoustic Computation Using Large-Eddy Simulation and Acoustic Analogy

Meng Wang
University of Notre Dame

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1 Introduction

Computational techniques for flow-generated sound generally fall into two broad categories: direct computation and indirect, or hybrid, computation. In the direct approach, the sound is computed together with its fluid dynamic source field by solving the compressible flow equations. Because it avoids modeling approximations, the direct computation method is an ideal research tool for studying sound generation mechanisms and generating databases for developing and evaluating sound prediction models. However, it is generally too expensive as an engineering prediction tool, particularly at low Mach numbers. This is because of the well-known difficulties in computational aeroacoustics pointed out early on by Crighton (1993). The large ratio of acoustic to flow length scales, which is inversely proportional to the fluctuating Mach number M, requires a large computational domain to include all the sound sources of interest and at least part of the acoustic near field. The extremely small magnitude of acoustic disturbances relative to that of fluid dynamic disturbances ($\sim M^4$) places a stringent requirement on numerical accuracy. High-resolution