

# Chapter 15

## Large Eddy Simulation of compressible turbulent jets

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**Abstract** In this paper we will present a framework for the Large Eddy Simulation (LES) of compressible turbulent jet flows. In general the subgrid contribution in LES is a mixture of numerical dissipation and subgrid model dissipation which makes it difficult to judge the performance of a subgrid stress model. In this study, we use high order numerical schemes to minimize the numerical dissipation errors, and hence all dissipation is coming from the subgrid stress model. Some results for turbulent jet flows will be presented.

### 15.1 Introduction

Increasing noise regulation at urban airports force jet engine manufactures to develop and build quieter engines. Over the last 10-15 years a significant reduction in fan and mechanical noise has been achieved. However, the reduction in jet noise over the same time period is fairly small and a major reduction in acoustic emissions of jet engines has to come from a reduction in jet noise.

Traditional jet mixing-noise predictions are based on a statistical description of the jet turbulence; space-time correlations of the Lighthill quadrupoles, Lighthill (1952), Lighthill (1954), are specified in the jet. Further refinements are, however, needed to obtain a reasonable prediction of the directivity and spectral distribution of the radiated noise, (Goldstein 1976). Significant improvements are achieved by modeling the effects of source-convection, Lighthill (1954), Ffowcs Williams & Hawkins (1969), and mean-flow refraction, Mani (1976). Reynolds-averaged mean flow calculations can be used to provide the source-strength distribution, and the length and time-scale estimates needed in the source models, Bechara *et al.* (1994). The empirical input needed in such an approach places limits on the range of applicability of this method. It is, therefore, desirable to develop methods which obtain the unsteady flow data with much less empirical input.

Due to the inherently high Reynolds numbers of the jet formed by a jet engine LES seems to be the only feasible candidate to obtain the necessary unsteady data for the jet. Some attempts for round jets have been made by Choi *et al.* (1999) and Boersma & Lele (1999). For simpler geometries like