# INTRODUCTION

The chief task of an aerodynamicist is the prediction of forces and force distributions on realistic configurations, coupled with a conscious effort to optimize these loads as per the need of the design. Experimentation of scaled models using wind-tunnels is the first choice. However experiments are costly and time consuming. The alternative is to setup a mathematical model for fluid flow and obtain solutions. This method is used in all design fields. The ability to exploit this alternative lies in the selection of the model for the problem at hand, the ability to obtain solutions and recognition of the limitations of the model.

One of the most accurate mathematical models for fluid flow, for a fluid assumed to be a continuum, is the Navier-Stokes equations. They are field representations for conservation of mass, momentum and energy together with a thermodynamic equation of state. Except for nearly trivial cases these equations cannot be solved analytically. Notwithstanding the phenomenal advancement in recent years in both numerical methods and computing power the ability to solve these equations numerically as a routine matter for realistic problems of interest is very limited. In cases where thermal and viscous effects are small it can be argued as to whether such a complex model is indeed required. In such cases one of the most common assumptions incorporated in the mathematical models is that of inviscid flow. This gives us the set of Euler equations which greatly enhances our ability to obtain solutions past complex geometries.

Discretization of the flow domain is as important as the flow solution. For complex geometries this is a formidable task. A grid generation code has been developed by the author to treat complex 2- and 3-dimensional geometries using a multiblock topology. The grids are generated by solution of elliptic partial differential equations following the techniques of Thomson et al. [1977] and Thomas [1982], with graphics interfaces to significantly reduce a labour-intensive and time-consuming process. Grid generation has been made as automatic as possible and there are no limitations on the number of blocks that it can handle. The code can handle any number of slabs, fixed and re-entrant surfaces in the flowfield. The ability to discretize complex domains is further enhanced by the ability to control the grid spacings in regions of interest, prescribed either a priori or through initial solutions of the flow solver. A method for generating control functions has been developed in the present work to adapt the grid such that a large concentration of grid points is obtained in regions of high flow gradients.

One of the major restrictions in obtaining even inviscid flow solutions past complex configurations is the requirement of extensive computing resources. Most algorithms are CPU intensive and also require a large amount of core memory. Such resources are not commonly available in our country. On the other hand, general purpose mini-computers or workstations connected in a network with modest core memory sizes are generally available. Attention has been focused in this thesis to efficiently utilize these computing resources to solve complex CFD problems by development of a simple model for distributed parallel processing wherever a network of mini-computers are available. Distributed processing has been achieved by sub-division of the computational space. This model is capable of handling any explicit flow algorithm. The model has the capability to be incorporated on heterogeneous networks. A software making use of the model has been developed by the author and put to use on an "APOLLO DOMAIN" network. The software developed has been made as portable as possible and is designed to parallelize existing serial codes with almost no changes in the codes required by the user. The development of this model and relevant software is also presented in this thesis.

Euler equations can be used to model inviscid flow with and without shocks past airfoils, wings and aircraft. Present trends in aircraft design have focused attention on sustained transonic flight for transport aircraft and optimum performance of fighter aircraft at supersonic speeds. The Euler equations are most suitable for analysys of these flow situations and are being widely used in modern aircraft design. The ability of the Euler equations to correctly model leading edge separated vortex dominated flows such as those past delta wings at high angles of attack is still controversial due to the fact that these equations have no mechanism for developing boundary layer separation. However for sharp leading edge configurations satisfactory results have been obtained by many authors and they have also been investigated in this thesis.

Solutions to the Euler equations may be obtained using a variety of techniques. Perhaps one of the most attractive is the finite volume method. One advantage of the finite volume discretisations is their ability to deal with complex geometries in a simple manner, since no global transformation need be specified. Another important advantage is that the finite volume methods are more likely to capture the correct weak solution since they are derived directly from the integral form of the conservation laws. In this thesis, the Euler equations have been solved using a code developed by the author; this code is based on the multistage integration scheme due to Jameson [1983].

This explicit time-stepping finite volume formulation has been run using the distributed processing concept mentioned previously. The grids used have been obtained using the grid generation code developed by the author. The grid generation code has also been run through the distributed processing system developed by the author. Test cases have been studied in both two and three dimensions for both subsonic and supersonic onset flows. For shock dominated flows studies have also been made on the improvement of the results obtained by grid adaptation in two dimensions. In three dimensions, the flow past the ONERA M6 wing and the Dilliner wing have been investigated.

This thesis consists of five chapters. Chapter I gives a brief review of literature in this field. Chapter II deals with multi-block elliptic grid generation in two and three dimensions. Chapter III deals with the development of a distributed processing system and the related software. Chapter IV is devoted to the solution of the Euler equations. Finally, Chapter V gives the concluding remarks.