The Computational and Theoretical Fluid Dynamics (CTFD) Division at the National Aerospace Laboratories (NAL) has engaged itself, for more than two decades, in the development and application of Computational Fluid Dynamics (CFD) software, generally to deal with the numerical simulation of complex flow fields, the complexity arising both flow wise and geometry-wise.

**The Panel code**
The panel code continues to be a tool of considerable practical utility in the study of many real-life shapes of concern to aerospace engineers. This software has now gone through several upgradations in the nineties to make it applicable to rotating bodies such as marine propellers and helicopter rotors and also to unsteady flows.

**Flow simulation through Euler solvers**
An important step before the culmination of the RANS solvers was the maturity achieved in the solution of the set of Euler equations governing fluid flows. Through the generation of multi-block grids, the division has succeeded in the computation of flow over variety of complex aerospace configurations of practical interest.
Flow simulation through RANS solvers
Noteworthy has been the culmination of simulation capabilities using the state-of-the-art RANS (Reynolds-Averaged Navier-Stokes) solvers, which have matured during the nineties, in the speed regimes ranging from the subsonic, through the transonic and supersonic to the hypersonic speeds.

RANS solvers have reached amazing maturity to handle two-dimensional flows; it is, for example, possible to capture all the features of flow over an aerofoil and a flap, with remarkable accuracy for the entire range of incidences which includes the region around stall. Notable application of this capability has been in the improved high-lift system designed for NAL’s HANSA aircraft. 2-D RANS solvers extended for time accurate computation have been used successfully for flow around pitching aerofoils.
Pre and Post-processors for CFD Analysis

The geometry data to the flow codes are often provided through CATIA files or specifying coordinates of discrete points for each cross-section of a given configuration. The division has developed considerable expertise in the generation of surface and volume grids around complex geometric shapes using the structured multiblock as well as the unstructured methodology. The recently procured commercial code GRIDGEN has further strengthened the capabilities of the division to a great extent in surface modelling and grid generation.

The vast amount of flow data generated over millions of grid nodes in the flow domain can be visualized for intelligible presentation using the commercially available post-processing software.

Non-aerospace applications
Aircraft Wake Vortex

The capabilities achieved in the division in the numerical fluid flow makes it attractive for anyone to hope to achieve quick data generation related to flow over given shapes, in preference to the possibility of data generation through model simulation in a wind tunnel facility - the only means which existed before the CFD codes reached maturity to handle real-life flows. For low speed incompressible flow past complex geometry of marine and other non-aerospace applications, a 3-D unsteady RANS code using multi-block structured grid and different variants of $k$-$\varepsilon$ turbulence model has been developed and validated extensively.
Cost-effective solution of your flow problems

The CTFD Division of NAL is well poised to offer cost-effective solutions to your problems related to flow over complex shapes.

Other R&D capabilities
The CTFD division has also undertaken studies in diverse areas of fluid-flow such as fluid-sloshing, micro-gravity, underwater explosions, hydrodynamics of underwater bodies, aircraft wake vortices through a discrete-vortex model and in the fundamental studies related to vortex shedding behind blunt bodies and to the detailed structures of flow velocity and vorticity in lid-driven cavities. Natural laminar flow aerofoils have been designed as a part of the energy efficient general aviation technology development.

For more information please contact:
Director, CSIR-National Aerospace Laboratories, PB 1779, HAL Airport Road, Bangalore-560017, India.
Tel: +91-80-25086000, 25270584; Fax: +91-80-25260862; E-mail: director@nal.res.in; www.nal.res.in