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# Calculation of Aerodynamic Characteristics of STOL Aircraft

A method developed for predicting the lift and pitching moment characteristics of STOL aircraft with externally-blown, jet-augmented wing-flap combinations uses a potential-flow approach which involves the combination of two flow models: (1) A wing-flap lifting surface model which uses a vortex-lattic approach to represent a wing of arbitrary planform, camber, and twist, and a multiply-slotted flap which can be large and highly deflected; (2) A high-bypass-ratio turbofan engine wake model which consists of a series of closely-spaced vortex rings normal to a wake centerline which is permitted to have vertical and lateral curvature to accommodate the local perturbed flow under the wing. Use of the two models in sequence permits calculation of the wing-flap load distribution, including the influence of the engine wake. The method can accommodate multiple engines per wing panel and part-span flaps, but is limited to the case where the flow and geometry of the configuration are symmetric about a vertical plane containing the wing-root chord.

A three-dimensional horseshoe vortex lattice is used as the distribution of singularities representing the lifting surfaces to determine aerodynamic loadings on the wing-flap surfaces and to predict wing-flap induced perturbation velocities at field points in the vicinity of the configuration. The flow tangency boundary condition, including all wing-flap interference effects, is applied at a finite number of control points on the wing-flap surfaces, which results in a set of simultaneous equations from which the vortex strengths are determined. Wing angle of attack and flap deflection angles are accounted for in terms of trigonometric functions instead of linear terms because the magnitudes of the angles can be large. The jet-wake is considered an external source of perturbation velocities which are included in the wing-flap flow tangency condition as part of the jet wing-flap aerodynamic interference calculation. Yaw effects and compressibility effects are not included, and flow separation or other viscous effects are not taken into account.

The jet-wake program calculates the velocity field induced by the jet wake of a turbofan engine, both inside and outside the boundary of the jet, and is oriented principally toward use with the wing-flap program described above. The program represents the wake by a series of closely-spaced rings on the boundary of the jet; the strength of the vortices is determined from the initial jet velocity. The ring vortices and jet boundary are centered on a wake centerline that is permitted to have curvature in accordance with the flow field induced in the region of the wake by the wing flap and the free stream velocity. Once the ring vortex system is defined, induced velocities are computed at points in the vicinity of the jet wake corresponding to the control points on the wing.

**Notes:**

1. The programs are written in FORTRAN IV for use with an IBM 360/67 computer.
2. Inquiries concerning the programs should be directed to:

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