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Numerical simulation of long-wavelength instabilities in aircraft wake vortex pairs

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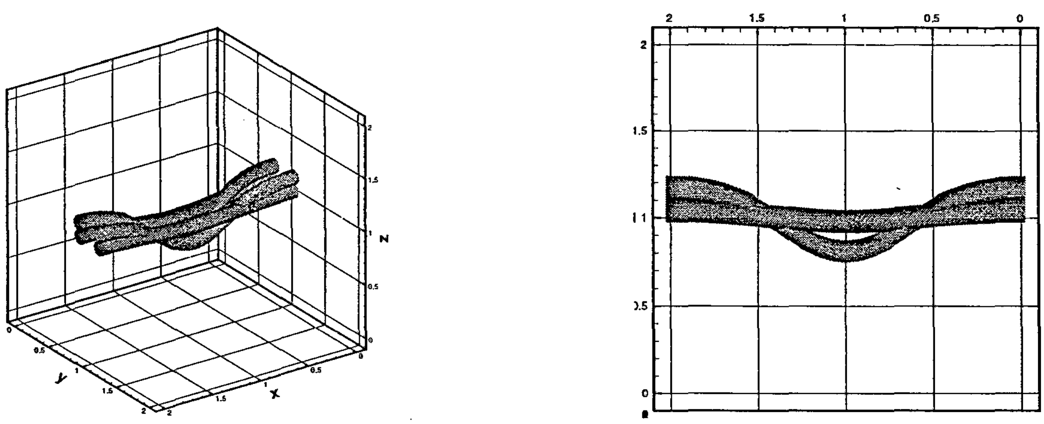
Abstract - In the present study the development of long-wavelength instabilities in wake vortex pairs is investigated. Aircraft shed two initially rectilinear counter-rotating vortices. The mutually induced velocity makes the vortices susceptible to instabilities that are commonly called *cooperative instabilities.* The most-studied instability is the Crow instability, which for aircraft cruise conditions has a wavelength of ± 8 times the initial separation distance of the vortices. The present study investigates the mechanisms of this type of instabilities. For this purpose a high-resolution Navier-Stokes solution method is developed that simulates time-dependent three-dimensional flows of an incompressible medium using a uniform Cartesian mesh. High-order accuracy (4th/6th order) is achieved for the spatial discretization. Parallelization makes large-scale simulations possible within acceptable computing times.



Iso-pressure contours at two different times in a time-dependent simulation of a evolving long-wavelength instability. 3D view (left) and side view (right)

The figures show results of a recent simulation of the growth of a long-wavelength instability in a computational domain periodic in x-direction. The initial solution is a counter-rotating vortex pair perturbed by the most unstable mode according to linear stability theory. This mode determines the length of the computational domain in the periodic direction. The influence of various parameters on the long-time behaviour is the subject of the proposed paper, as is a discussion on numerical aspects of the simulations.