Unsteady Flow Calculation on a Moving Grid

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Objective

Develop a computational method for flutter analysis of a composite wing designed for B-777X

- Develop three computer programs by three graduate students
  1. CFD code for moving grid (Hayashi)
  2. Grid deformation code for deformed wing (Takayama)
  3. Modal analysis code for composite wing structure (Matsuoka)
- Combine into one flutter analysis code and conduct preliminary computations

➢ Preliminary flutter analysis of a composite wing designed for B-777

Numerical Methods

CFD code

- Conventional FVM for 3D Euler Equations
- Two-step explicit time integration
- Exact integration of 4D (space-time) conservation law on moving grid

Grid deformation

- Interpolating a coarse structured grid based on inverse distance weight

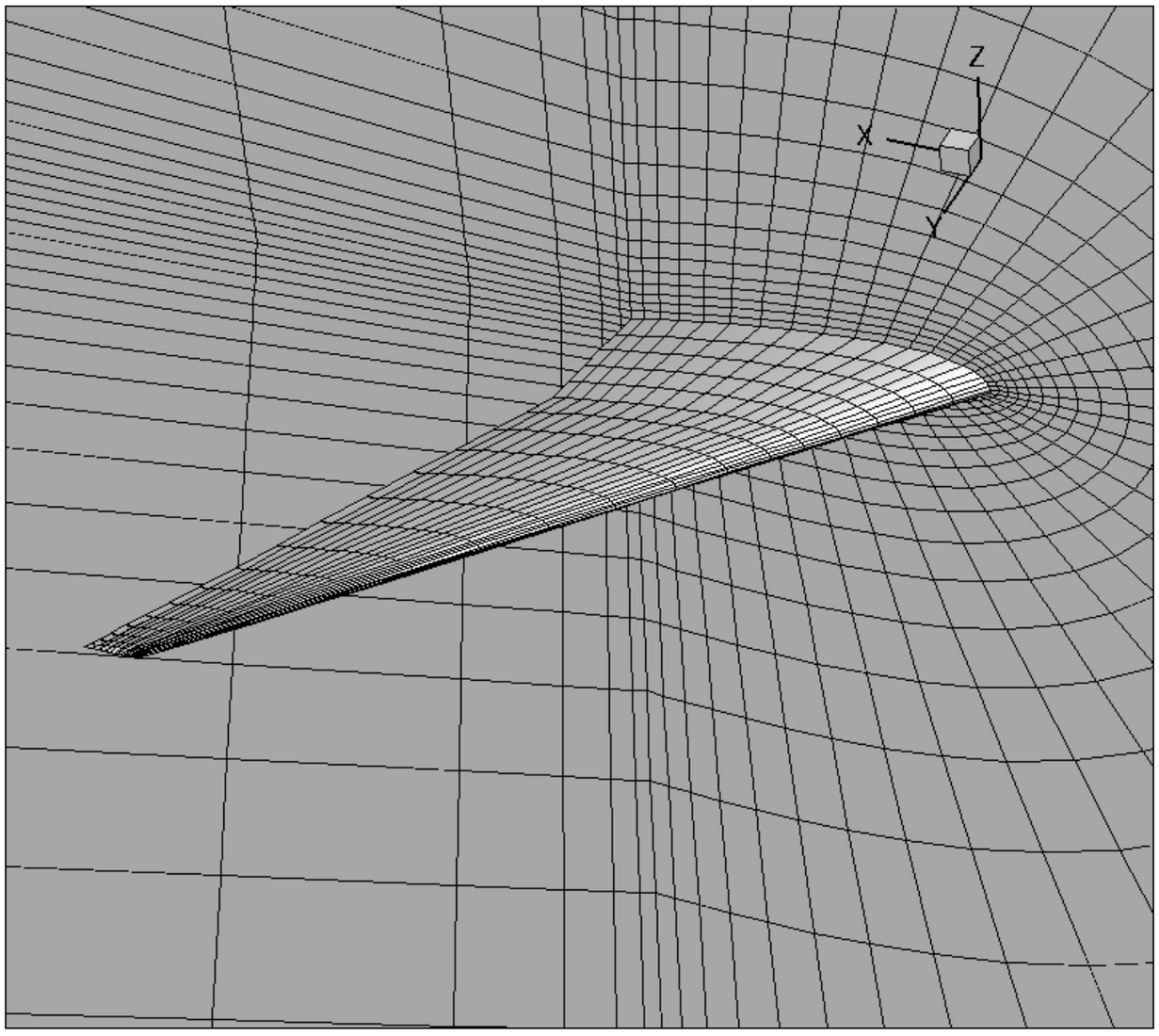
Structural analysis

- Modal analysis using up to 10th mode
- Two-step explicit time integration
- Damping is ignored

Computational Model for Composite Wing Designed for B-777

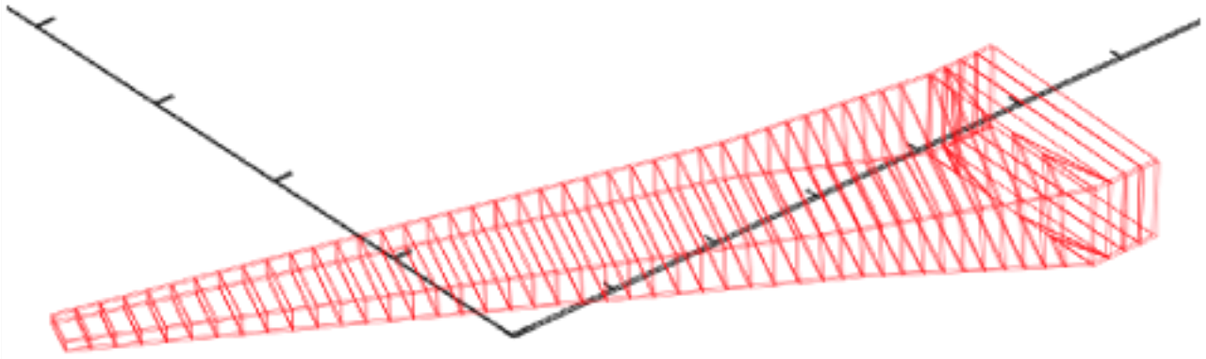
Computational grid

- Grid type : CO type
- Number of computational grid
  : 52 × 22 × 30



Structural model

- Shell and bar elements



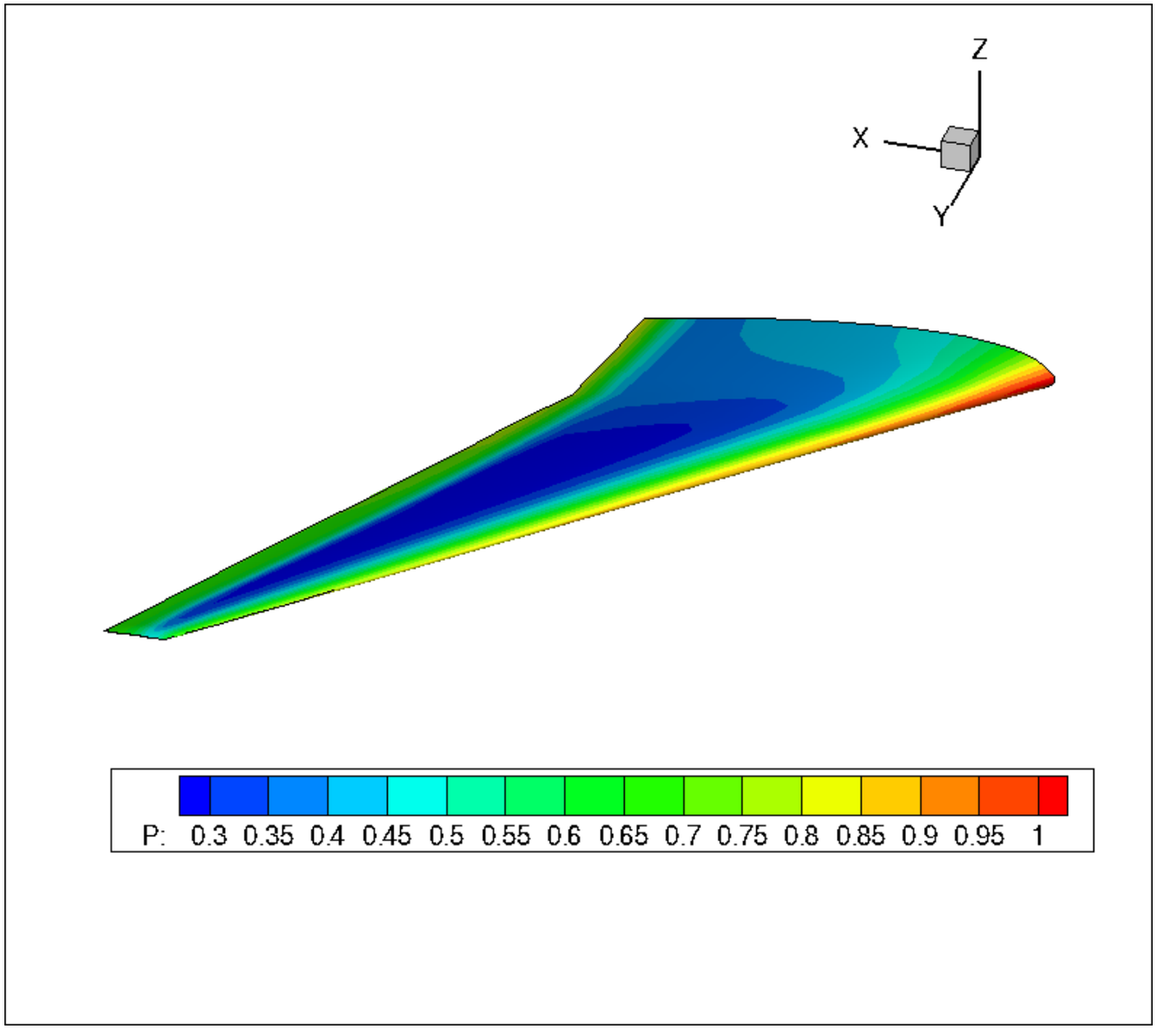
Computational Conditions for Composite Wing Designed for B-777

A steady flowfield over a semi-span wing is obtained

- Flutter analysis is performed using the steady flowfield as an initial condition

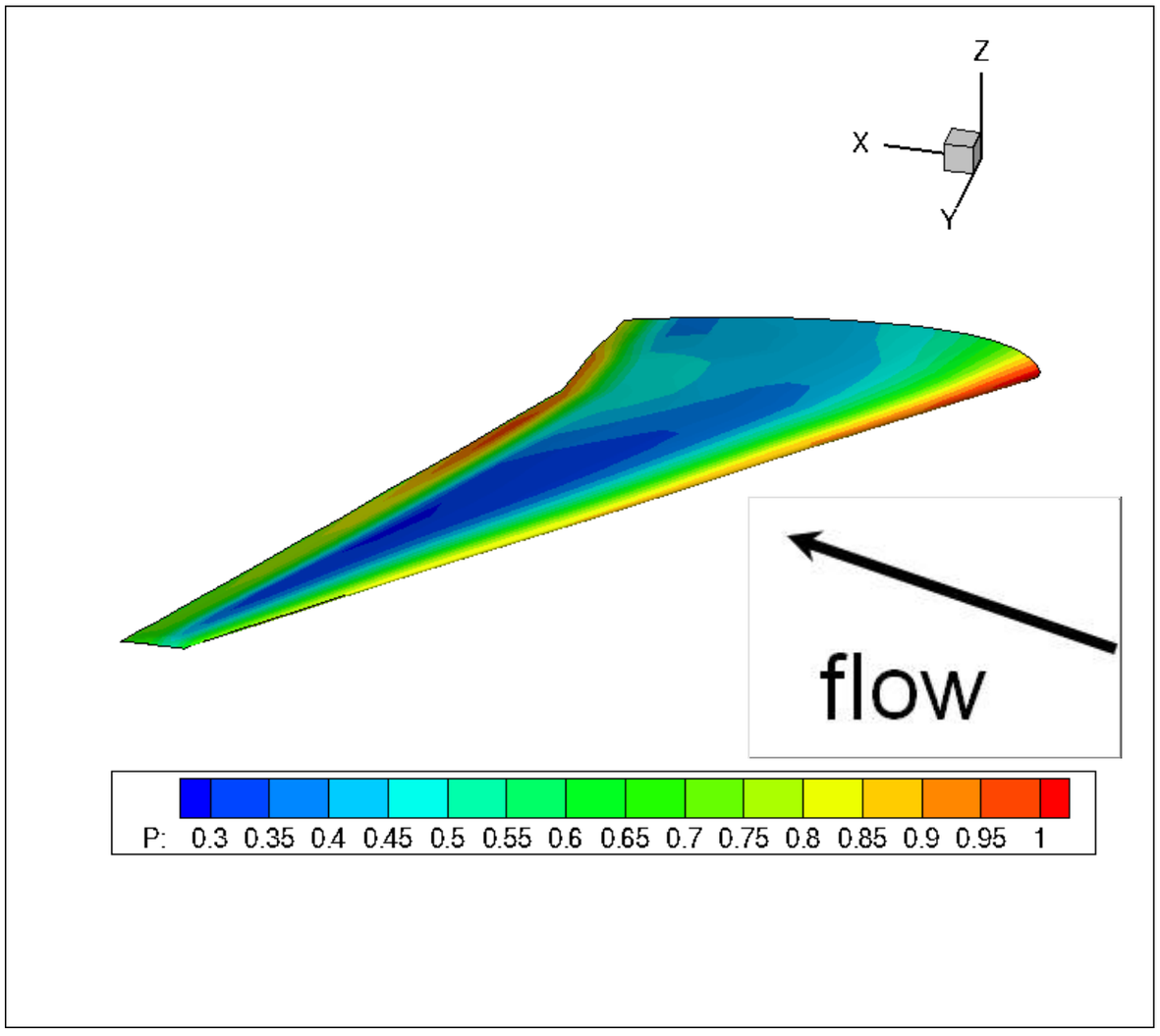
Flow conditions

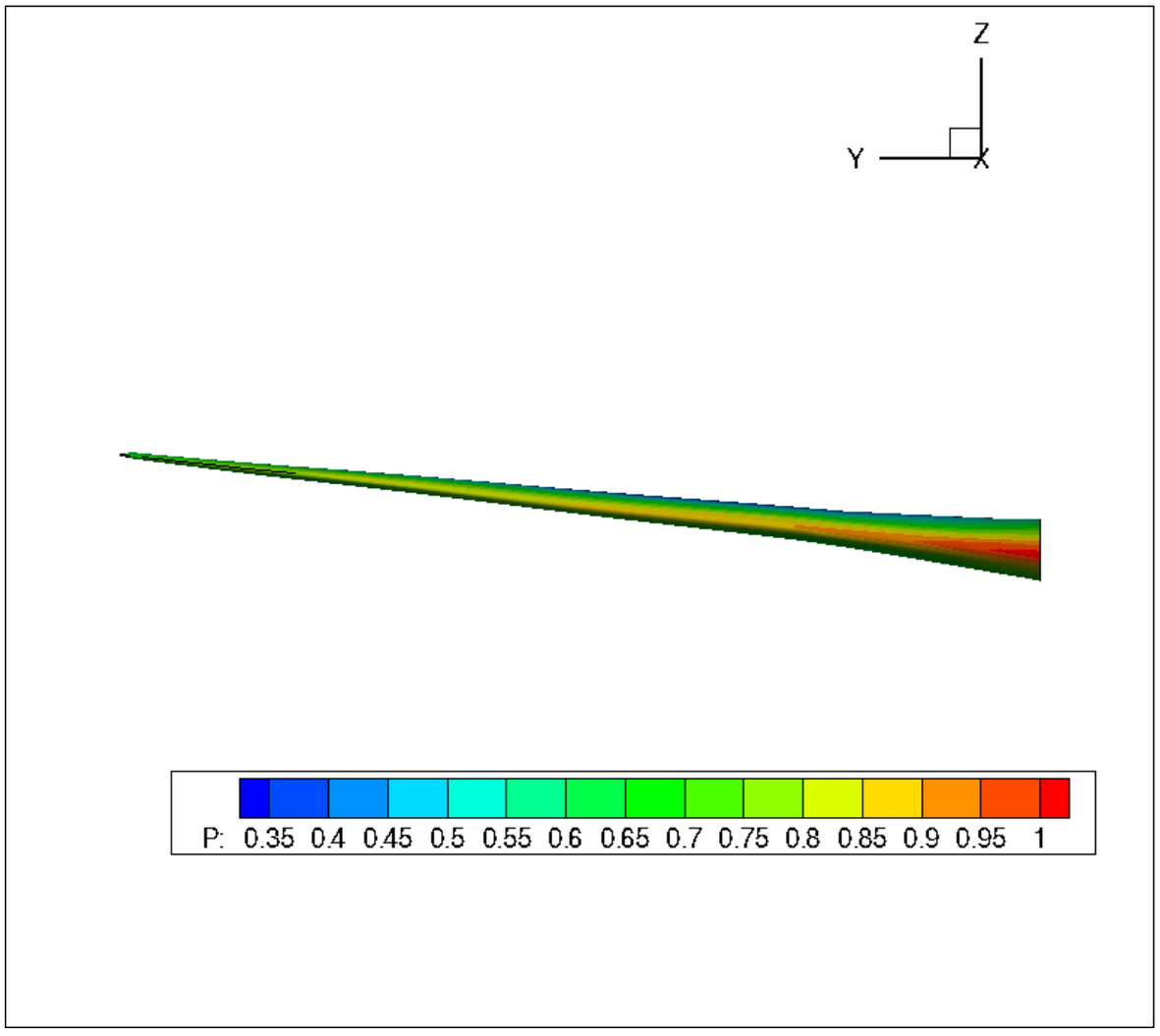
- Mach number : 0.9
- Angle of attack : 4.0 [deg.]
- Flight altitude : 11,000 [m]



Computed Results for Composite Wing Designed for B-777

Temporal variation of the pressure distribution



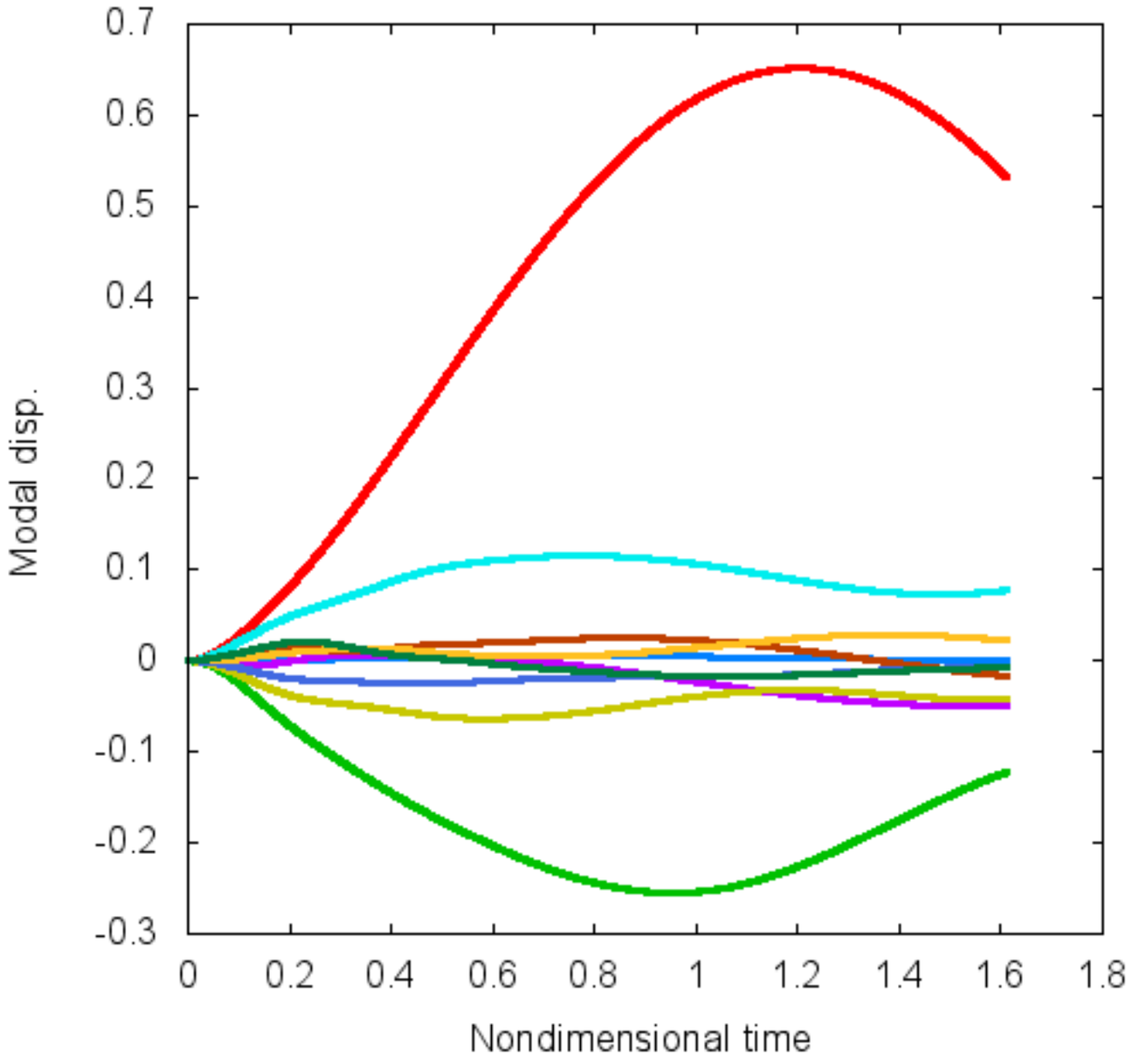


view from the upstream position

- Large bending deflection occurs in the wing
- First bending mode is dominant

Computed Results for Composite Wing Designed for B-777

Modal analysis



Bending mode

- 1st mode
- 2nd mode
- 5th mode
- 7th mode
- 10th mode

Torsion mode

- 3rd mode
- 4th mode
- 6th mode
- 8th mode
- 9th mode

Summary

- Three programs are combined to study wing flutter problem
- Preliminary study of flutter analysis for a composite wing designed for B-777 is attempted
  - Large bending deflection occurs in the wing
  - First bending mode is found dominant
- Further studies are needed to examine the possible flutter of a composite wing in more details