Full guide to the computation of stability derivatives in MSC Nastran

The process of computing aeroelastic stability (and control) derivatives in Nastran is straightforward.
A proper aircraft model must be defined. This model shall contain at least:
- the main wing
- a control surface (depending on the desired derivative)

A half span model can be used to model the aircraft thanks to symmetry options.

The main wing is modelled in a specific way: first, the geometry is defined and the elastic axis is chosen; then the main spar is modelled.
The movement of the nodes of the main spar can be determined through a bar/beam model or inputted through a GENEL entry from prevoius tests.
The fuselage of the aircraft can be considered rigid in a first test phase.

The tail can be modelled in a similar fashion to the wing or defined as fully rigid.
Infact, the deflection of the tail can be modelled through the control surface option.

Where needed, lumped masses can be inserted in the model.

When the structural model is complete, the aerodynamics are to be modelled.
The best way is to model the wing as an aerodynamic surface composed of aerodynamic panels.
The tail can be treated in the same way.

After the definition of aerodynamic panels, the splining process shall be carried out.

Finally, after defining a suitable reference system for the rotation of the tail, the latter can be assigned as control surface.

More reference systems can be introduced to compute the aerodynamics of the problem.

IMPORTANT: if a half span model is used with symmetry, when asked to input span and surface the ENTIRE SPAN and SURFACE are to be inserted (double the half span).
The same applies for the tail.
Beware that the tail can be assigned a reduced effectiveness.

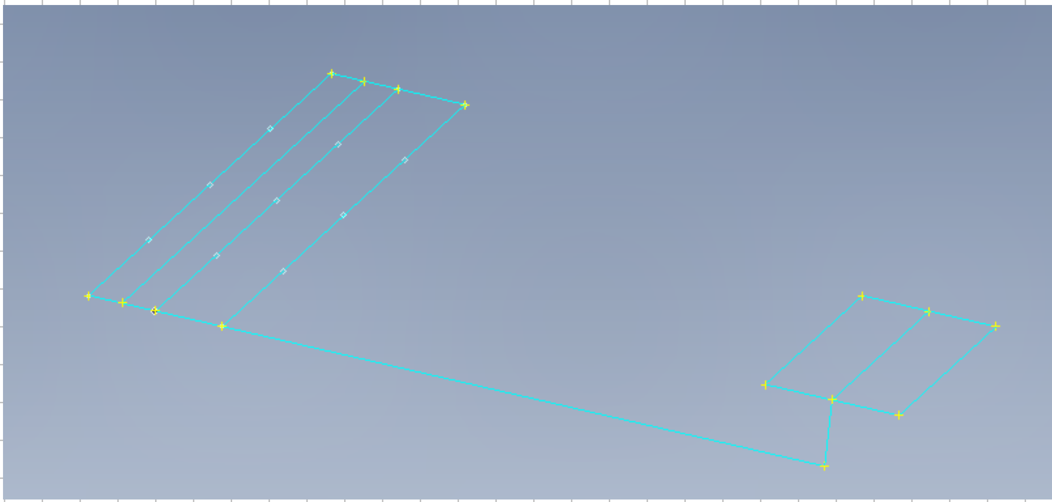
In order to perform a static aeroelastic analysis two constraints can be defined:

the first, positioned at the root of the wing, represents the blocked dofs, which are not studied in the problem at hand
the second set is called SUPORT and it's used by NASTRAN to determine the degrees of freedom of the problem, so it must be COMPLEMENTARY to the first one

Finally, trim conditions need to be applied. The trim conditions must be sufficient to fully determine the dofs. The use of a control surface is necessary.

OBS: the flow is directed in the positive direction of the x-axis, as all aero refs. must be

LONGITUDINAL STABILITY DERIVATIVES COMPUTATION



Half span 5 m

Chord 1 m

Tail span 2 m

Tail chord 1 m

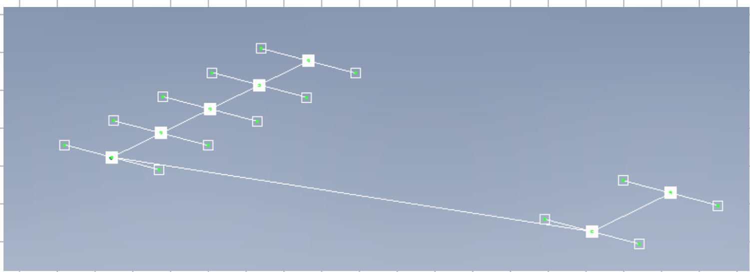
Distance of the tail EA from the wing EA 5 m

Material
E=7e10 Pa
nu=0.33

The elastic axis is at 50 % of the chord

Wing spar modelled as 4 bars, with circular section with r=0.3m

The tail is rigidly connected to the wing spar, ribs are modelled as rigid elements

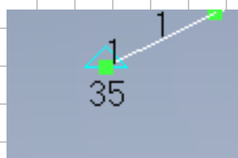


The tail is modelled as a single bar with the same properties as before

800 kg masses, representing the mass of the material, are positioned in the nodes

The constraints are defined: for the wing root all dofs are blocked except for vertical translation and pitch around the elastic axis.

constrained

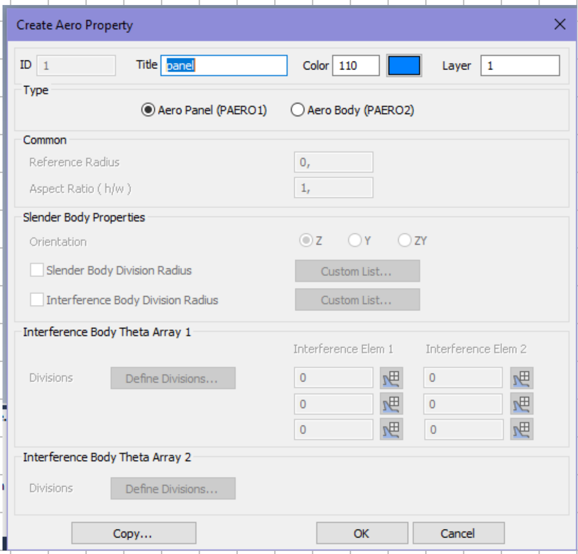


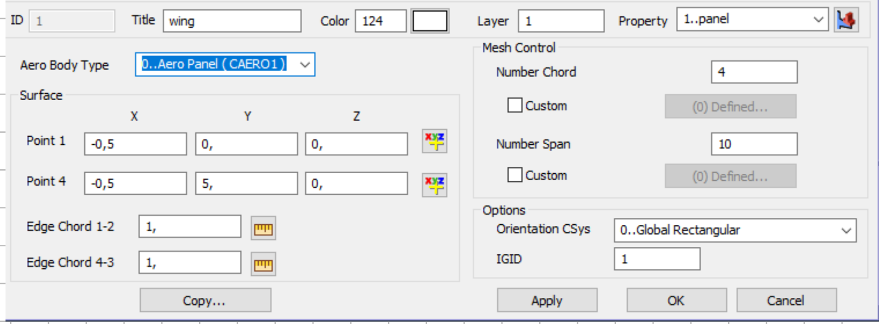
SUPORTed

OBS: the wing spar model can be used to produce a GENEL entry, to be used as usual

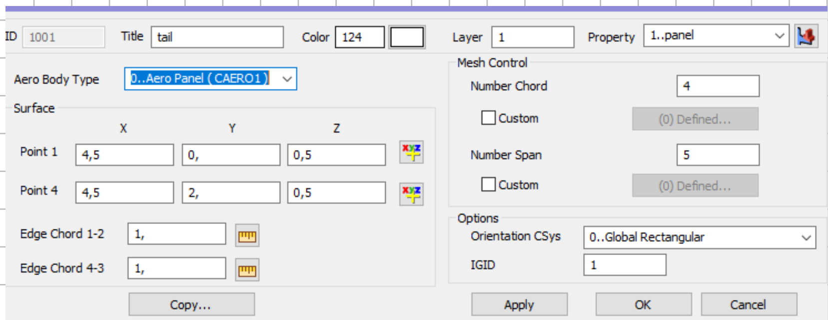
The inclusion of the UD entry does not cause any variation of the derivatives related to the SUPORTed dofs.

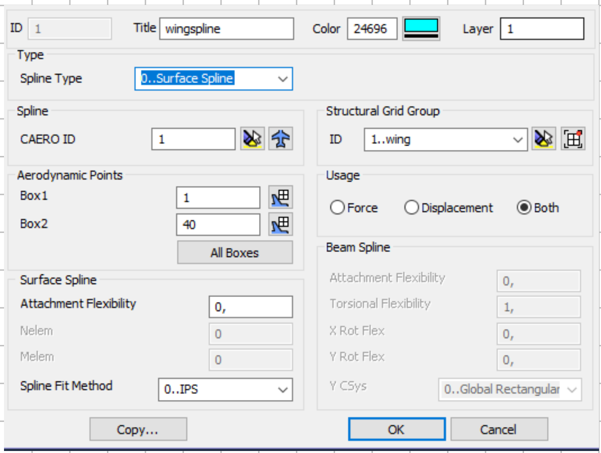
Aerodynamics





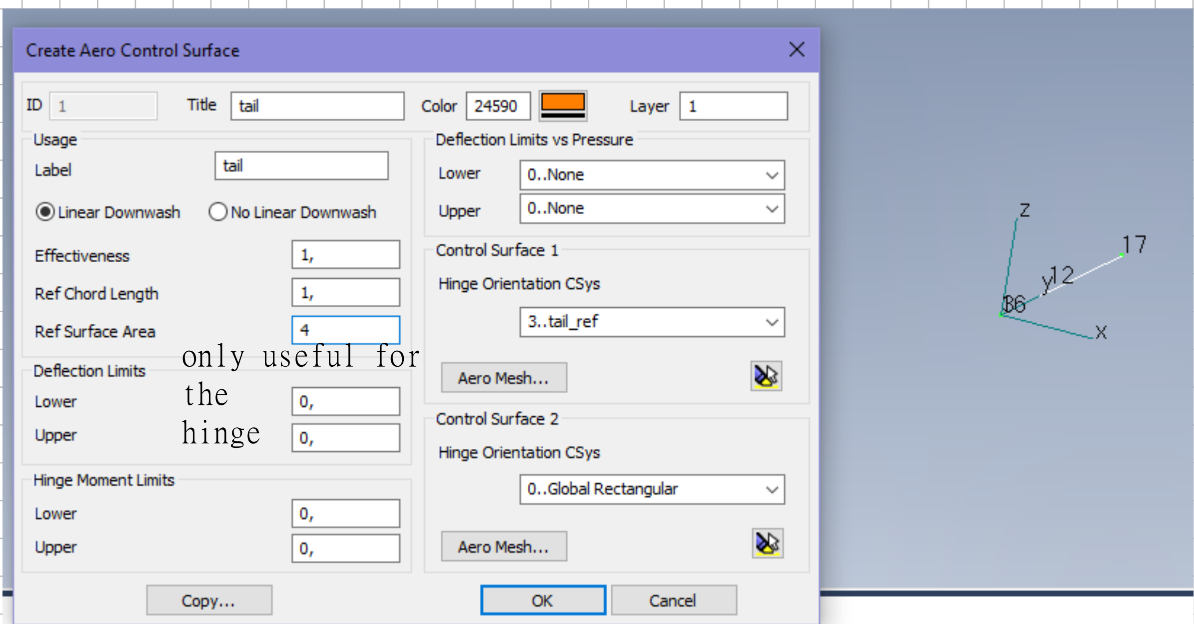
Creation of aerodynamic panel





Creation of aerodynamic surfaces

Splining procedure



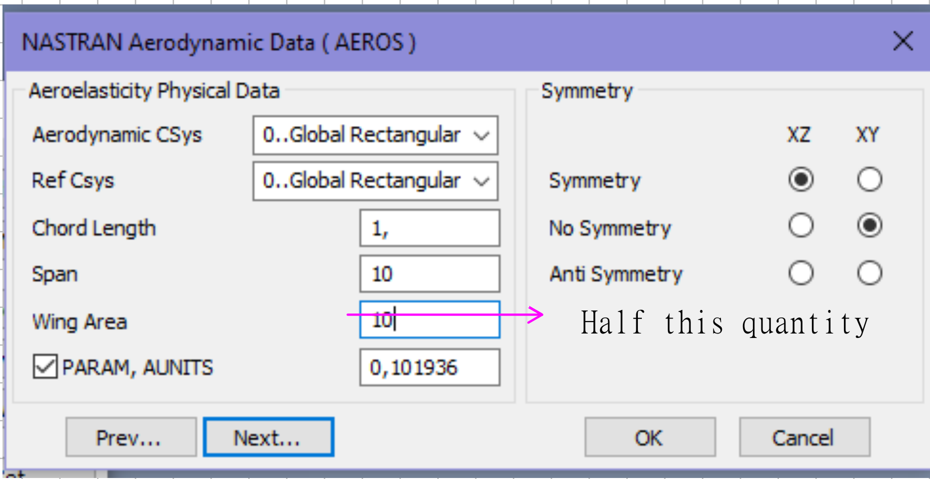
only useful for the hinge

Effectiveness only scales the aero forces

Creation of control surface, note that the ref area is 4, based on the full tail span

The y-axis must be coincident with the hinge line

Definition of static aeroelastic analysis

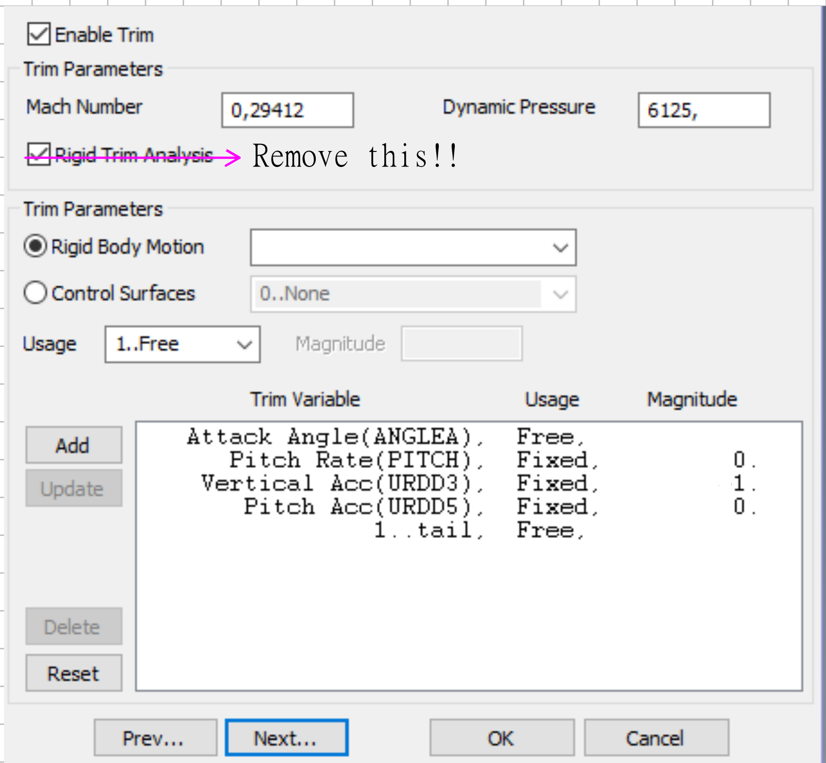


Half this quantity

Note the PARAM, AUNITS entry: if set to 1/9.81 allows for simpler input of the vertical acceleration as a load factor

Always put the aero ref in the plane of symmetry

Note the full span, but half-surface for a half-model and the symmetry indication



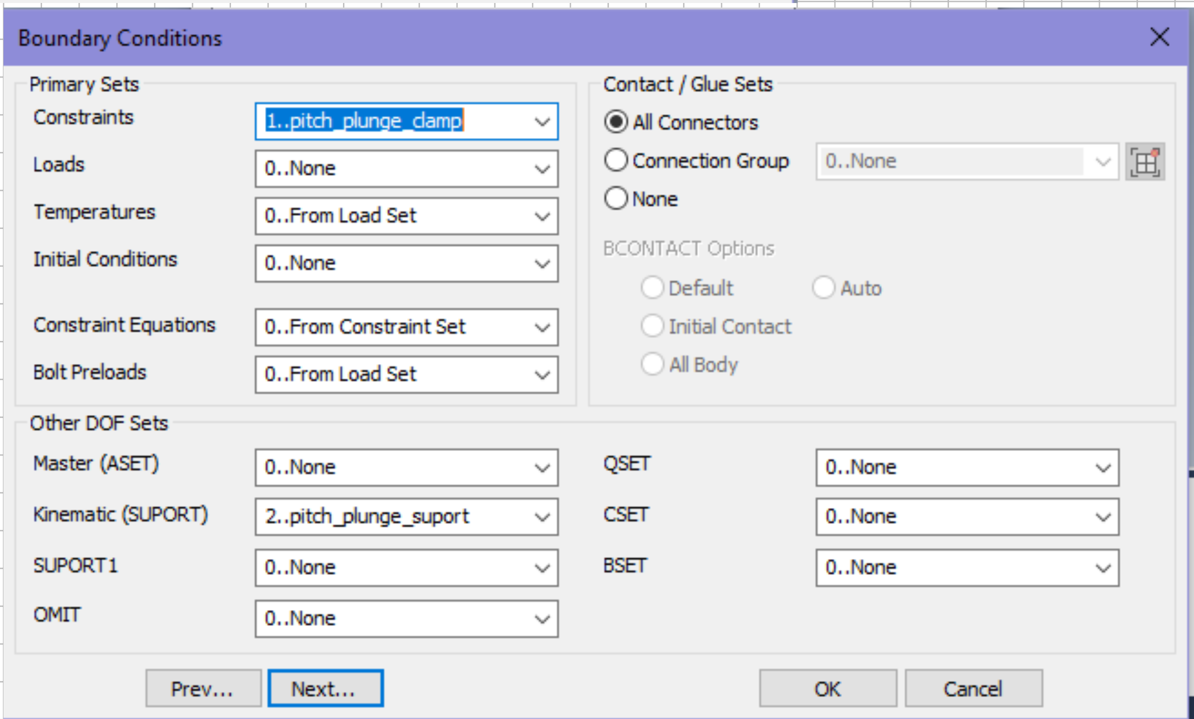
Remove this!!

The test is performed at 100 m/s

This is a static trim test, where q=0, theta acc = 0, vert acc=1

The angle of attack and the tail deflection are left free

The vertical acc is set to 1, as z is upwards and AUNITS has been employed



This last tab requires the indication of the constraints and SUPORT