

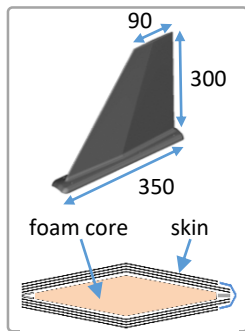
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Objectives

- Understanding of the interaction between a composite aileron and the turbulent transonic flow
- Prediction of the unsteady flow around a rocket for micro-satellites, based on numerical and experimental investigations
- Increase the reliability of rocket ailerons (shape and design robustness)

Context

- PERSEUS (University and Scientific European Student Project of Space Research)
- Geometry : SERA, Supersonic Experimental Rocket ARES
- Stabilization with three ailerons in composite material
 - Sandwich composite :
 - Core : epoxy foam
 - Skin : laminate structure

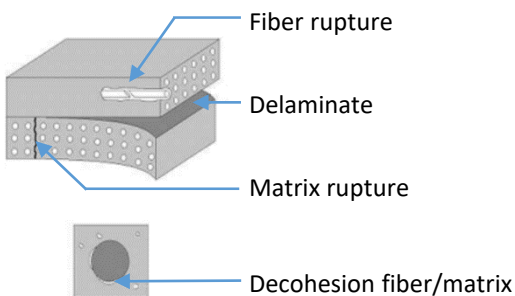


Fluid Structure Interaction

- The flexible behavior of composite materials potentially increases the need for Fluid Structure Interaction (FSI) studies
- Aero-elasticity can be associated to a risk of flutter or buffeting

Composite Material Damage

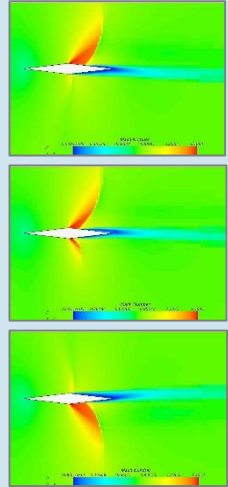
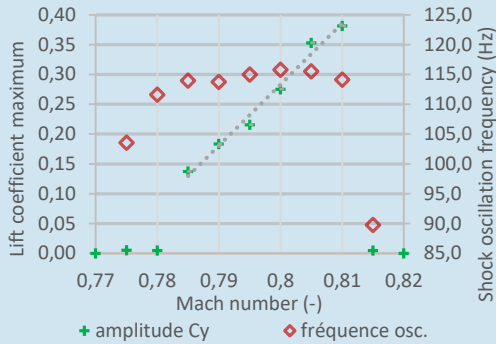
- Four damage types.



Numerical aerodynamic simulation

STEP 1 : 2D UNSTEADY-RANS (STARCCM+)

- Diamond geometry with 12% chord
- Flow conditions : $0,77 < Ma < 0,82$
- Buffeting observed for $0,785 < Ma < 0,810$



STEP 2 : 3D U-RANS

- Three cases :
 - Sweep-back aileron : no buffeting observed
 - No sweep-back aileron : no buffeting observed
 - Aileron with two wall conditions at the extremities : buffeting observed (as 2D-aileron)

STEP 3 : LARGE-EDDY SIMULATION (CHARLES^X)

- High performance computing capabilities

Experiments

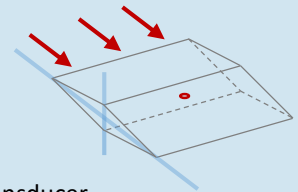
- Supersonic wind tunnel
- To validate simulations

STEP 1 :

- Shock visualisations by Schlieren photography

STEP 2 : PRESSURE MEASUREMENTS

- Ultra-miniature thin line pressure transducer



Fluid Structure Interaction simulation – StarCCM

- 2D study
- Rigid body
- Unsteady aerodynamic
- Chimera mesh
- Formulation : $m \frac{dv}{dt} = f \text{ et } J \frac{d\omega}{dt} + \omega \times (J \cdot \omega) = C$
- External forces
 - Aerodynamic force and moment
 - Retraction forces : $F = K_x \times \Delta x$ and $C = K_\theta \times \Delta \theta$

