HALE AirEcoDesign

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Introduction

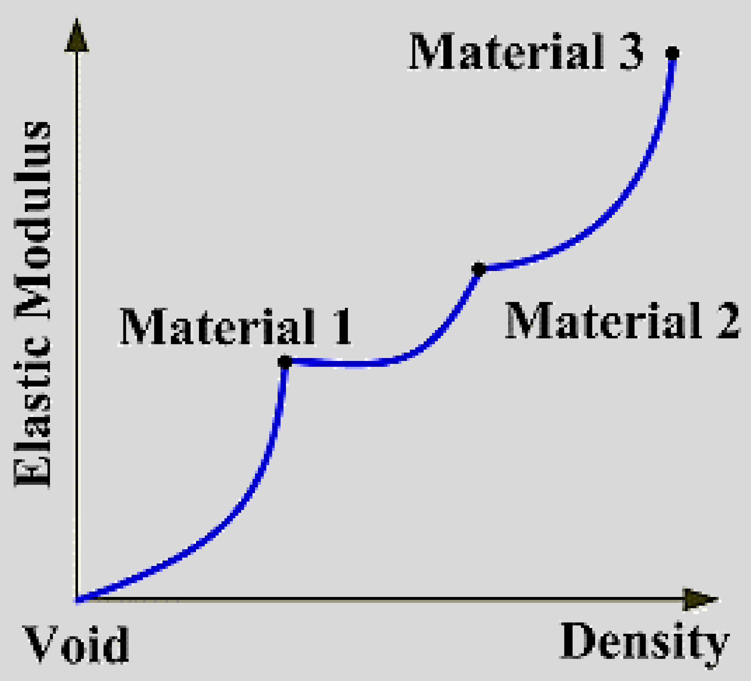
High-Altitude Long Endurance (HALE) drones are also called **atmospheric satellites** because they provide services conventionally provided by satellites.
They are powered by **solar energy** so their CO_2 emissions come from the manufacturing and the materials. This project studies the **CO_2 footprint optimization** of a HALE.

Multidisciplinary Design Optimization (MDO) consists in finding an optimum for the interaction of different disciplines.
A modified version of **OpenAeroStruct** is used. It is a global low-fidelity tool based on the **OpenMDAO** framework that performs **aeroestructual optimization**.

Milestones

Materials

Figure 1: Material interpolation with penalization



The material variable (density) has been made continuous by interpolating each material property among the real materials of a database, with a penalization factor For intermediate fictitious materials.
Two different materials are chosen:

- one for the spars
- another for the skins.

Engines

Two symmetrical engines have been added as point masses, considering the distance from the HALE plane of symmetry as a new design variable to optimize.

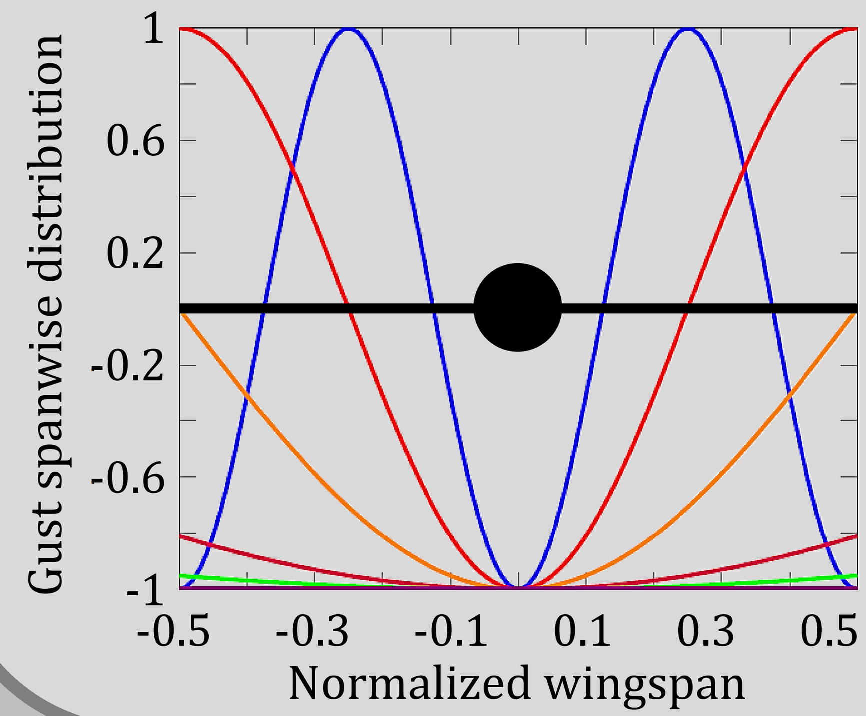
Buckling

A new analytical buckling model has been added considering the wing skins as curved plates under combined axial compression and shear.

$$\frac{\sigma}{\sigma_{cr}} + \left(\frac{\tau}{\tau_{cr}}\right)^2 < 1$$

Cosine Spanwise Gust

A two dimensional spanwise gust has been taken into account:



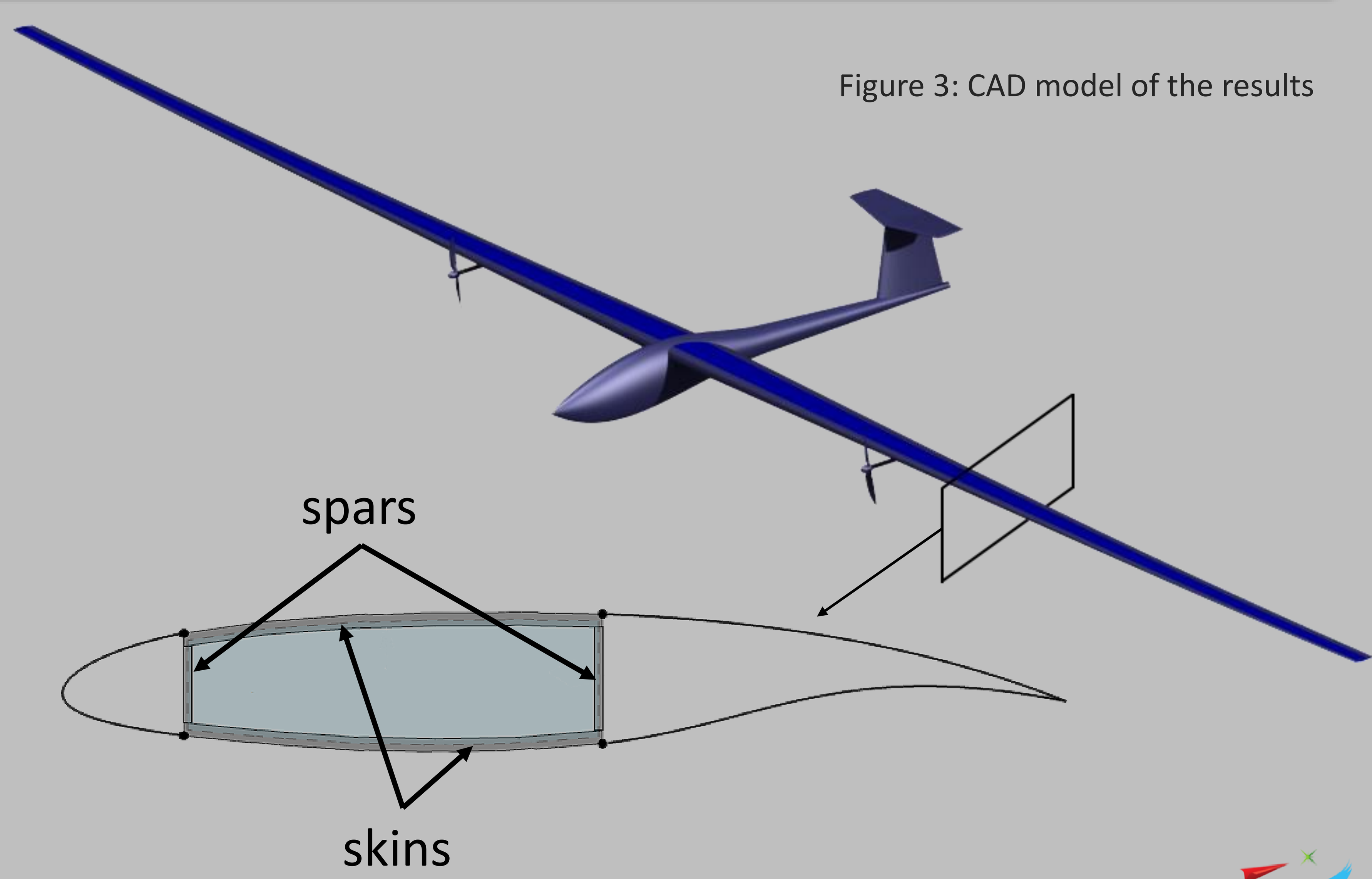
$$w_g(y) = -U\cos\left(\frac{2\pi y}{a\,L_{span}}\right)$$

Figure 2: Spanwise distribution of cosine gusts

Results

Design variable	Units	FB HALE [1]	Results
Spar density	kg/m^3	-	504.5
Skin density	kg/m^3	-	504.5
Span	m	45.6	49.5
Root chord	m	-	1.4
Taper ratio	-	-	0.30
Total mass	kg	320	201
Wing surface	m^2	71.8	43.9
Aspect ratio	-	29	56
C_L^{cruise}	-	1.33	1.37
$(C_L^{3/2}/C_D)^{cruise}$	-	40.1	52.2
$y_{engine}/(b/2)$	-	0.46	0.31
CO_2 emissions	kg	-	6008

Figure 3: CAD model of the results



[1] D. Colas, N. H. Roberts, and V. S. Suryakumar, “HALE multidisciplinary design optimization Part I: Solar-powered single and multiple-boom aircraft,” in 2018 AviationTechnology, Integration, and Operations Conference, p. 3028, 2018.