Wind tunnel CESAR model

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Abstract
This document comprises the geometrical definition of a Fowler flap for the LC2B laminar airfoil provided by DLR. For the purpose of small aircraft, the single slotted Fowler flap for the LC2B laminar airfoil was designed as a high lift device. This solution ensures a high performance and a simplicity of the design suitable for the intended category of aircraft

1 SYMBOLS

c Airfoil chord
c_f Flap chord
x Coordinate of the airfoil and flap shape
y Coordinate of the airfoil and flap shape
x_f Horizontal flap position (Fig. 3) [% c]
yf Vertical flap position (Fig. 3) [% c]
δ_f Flap deflection (Fig. 3) [°]

2 GEOMETRY

2.1 Basic Airfoil

The LC2B airfoil was selected as the baseline laminar airfoil.

2.2 Flap

The chord of the flap is 30% of the airfoil chord $c_f = 0.3$ c (Fig. 1).

The shape of the flap is defined by two polynomial functions defining the upper surface and the lower surface of the flap. These functions are:

$$y_{upper} = a_{u1} \cdot x^{0.5} + a_{u2} \cdot x^{1.1} + a_{u3} \cdot x^{1.8} + a_{u4} \cdot x^{2.6} + a_{u5} \cdot x^{3.5} + a_{u6} \cdot x^{4.5} \quad (1)$$

$$y_{lower} = a_{l1} \cdot x^{0.5} + a_{l2} \cdot x^{1.1} + a_{l3} \cdot x^{1.8} + a_{l4} \cdot x^{2.6} + a_{l5} \cdot x^{3.5} + a_{l6} \cdot x^{4.5} \quad (2)$$

The coefficients are:
Upper surface: *au*1 = +4.729118020835870E-01
*au*2 = -1.992910715638270E-01
*au*3 = +3.731860698323930E-01
*au*4 = -1.227953184994530E+00
*au*5 = +8.615574560617490E-01
*au*6 = -1.645677668318980E-01
Lower surface: *al*1 = -2.777270064546800E-01
*al*2 = +1.388531367133980E+00
*al*3 = -2.239472956149190E+00
*al*4 = +2.409696615367570E+00

*al*5 = -1.579559403929250E+00
*al*6 = +4.143746886190490E-01
These equations basically give an airfoil with chord c = 1 (Fig. 2). If it serve as a flap, the coordinates should be multiplied by the flap chord length c_f and located to the appropriate position relative to the basic airfoil. The position of the trailing edge of the flap is coincident with the trailing edge of the basic airfoil [1; 0].

2.3 Fixed part of the airfoil
The fixed part of the airfoil was designed with the focus on the design simplicity. The upper surface ends at 89.5% of the basic airfoil chord, the lower surface ends at 70.5% of the basic airfoil chord.
There is a hollow in the rear part of the airfoil body from 60% of the airfoil chord, where the aft spar is supposed to be located. See Figure 2.
The shape of the airfoil is given by 241 points and for the flap by 169 points.

2.4 Description of the assembly
In the sector of thin walls corresponding to the leading edge of flap, the wing was reinforced with 9 stiffening ribs of 6 mm, each one at the ends of the wing and seven in its span. These ribs prevent the wing deformation during processing, both on the upper surface and on the lower surface of the wing. Their form provides the flap assembling at 0°.
The flap is set on the wing by three sliders, one in the middle of the flap, and other two ,identical, at the ends of the flap, which provide horizontal and vertical movement of flap and rotate it around an axis at 25% c f ≈ 45 mm and 2.5 mm vertical displacement below the chord plane. The horizontal displacement is of 120 mm and the vertical one is of 60 mm, compared to zero flap position.
The wing has three lids on the lower surface, which allow inside installation of the 2 electromechanical scanivalves with 48 gates.
On the wing were made 59 static pressure holes, arranged in one section inclined at 20° over a vertical plane comprising the wing profile and on the flaps were made 29 static pressure holes, also in one section, parallel to a vertical plane located at Y = 853 mm. Pressure tubes plug out on the edge of the flap lid on the lower surface, near the central slider, and are connected to two electronic scanivalve located outside the testing room.

Flap position definition
The flap position is defined according to the picture below (fig. 3). The reference point for the flap position coordinates system is the lower trailing point on the main element.

Flap positions
The most promising area of flap positions is the rectangular area of [x_f; y_f] from [2; 2] to [-1; 5] for flap deflection of 38°. This area should be scanned with a flap coordinate resolution of at least 1% c.

Test Reynolds numbers

According EVEKTOR, the typical landing speed is around 140 km/h, which leads to Reynolds number of 5 million for the wing root airfoil. The lowest speed is 95 km/h, which leads to Reynolds number of 3.4 million.

Therefore the airfoil should be tested at these Reynolds numbers, or as close as possible.

Two end plates of 1200 mm diameter, the same as for the AVERT program, were mounted at the edges of the wing

The material utilised for the wing was EN AW 7075, T651 and for the flap was W1.4122 (X39CrMo17-1), annealed.

REFERENCES

[1] *M. ZABLOUDIL*, "***Report on high lift system definition HL-L*",** VZLU, Document Code: CESAR-VZLU-T11-D1.1.1-3, pp. 4-7, 2007

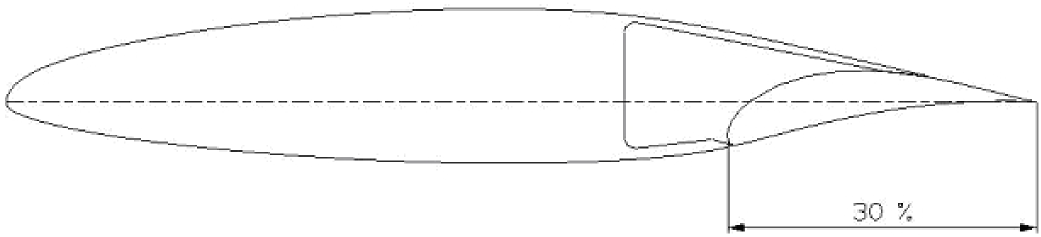

Fig. 1 Airfoil with flap

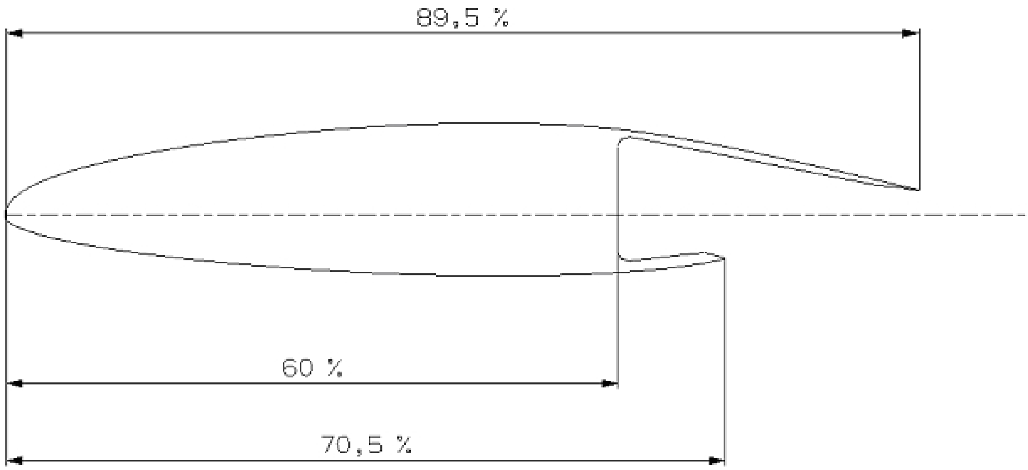

Fig. 2 Fixed part of the airfoil

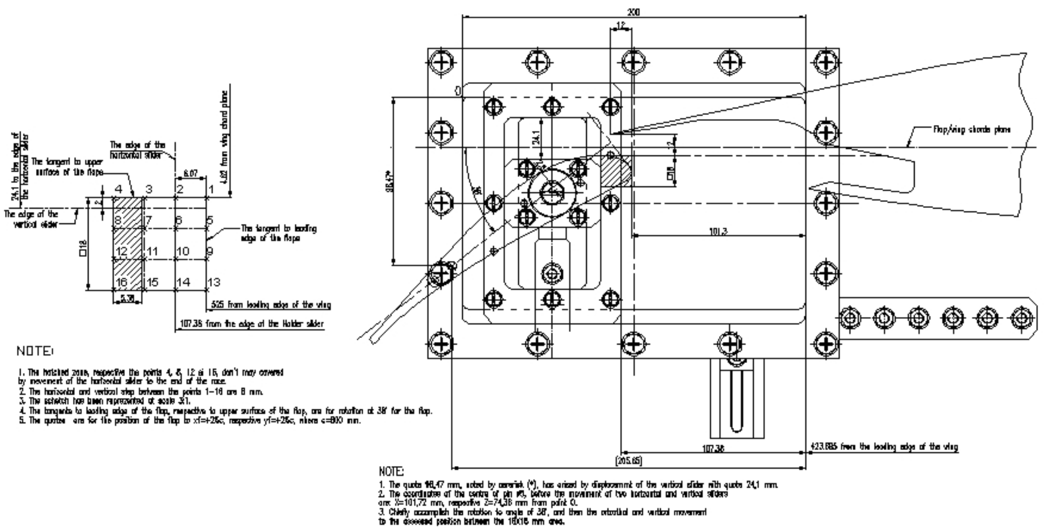
200
12
Flap/wing chords plane
101,3
107,38
[205,65]
525 from leading edge of the wing
107,38 from the edge of the Holder slider
NOTE:
1. The hatched zone, respective the points 4, 8, 12 si 16, don't may covered by movement of the horizontal slider to the end of the race.
2. The horizontal and vertical step between the points 1–16 are 8 mm.
3. The sketch has been represented at scale 3:1.
4. The tangents to leading edge of the flap, respective to upper surface of the flap, are for rotation at 38° for the flap.
5. The quotes are for the position of the flap to xf=+2%c, respective yf=+2%c, where c=800 mm.
NOTE:
1. The quote 98,47 mm, noted by asterisk (*), has arised by displacement of the vertical slider with quote 24,1 mm.
2. The coordinates of the centre of pin #3, before the movement of two horizontal and vertical sliders are: X=101,72 mm, respective Z=74,38 mm from point O.
3. Chiefly accomplish the rotation to angle of 38°, and then the orizontal and vertical movement to the assessed position between the 16X16 mm area.

Fig. 3

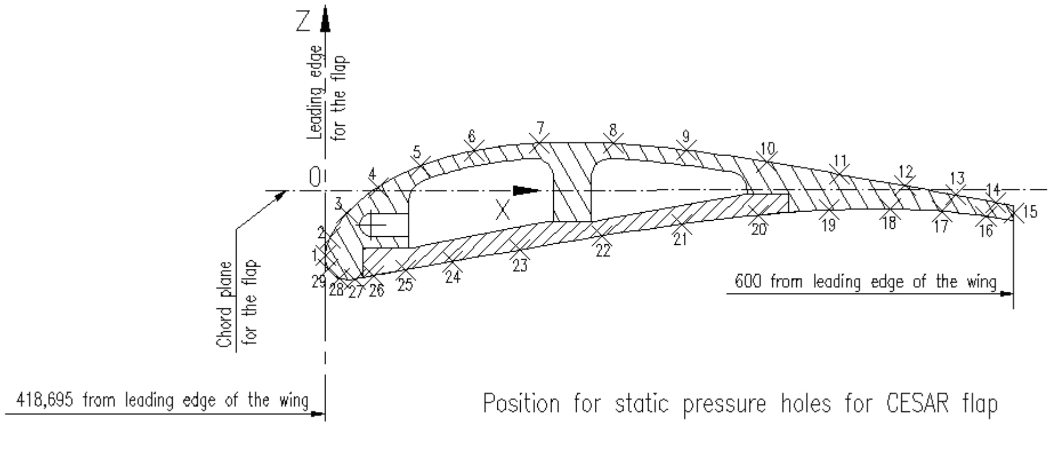
Z
Leading edge for the flap
O
X
Chord plane for the flap
600 from leading edge of the wing
418,695 from leading edge of the wing
Position for static pressure holes for CESAR flap

Fig. 4

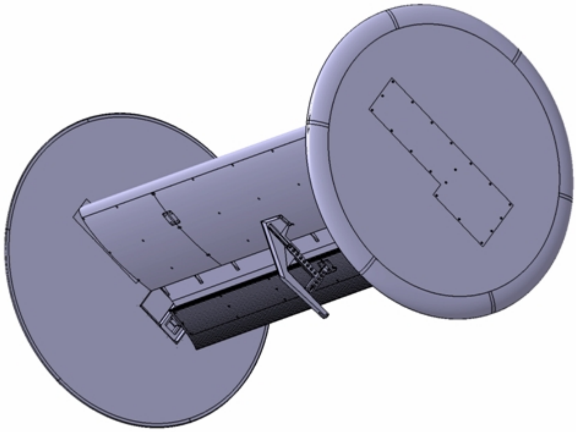

Fig. 5

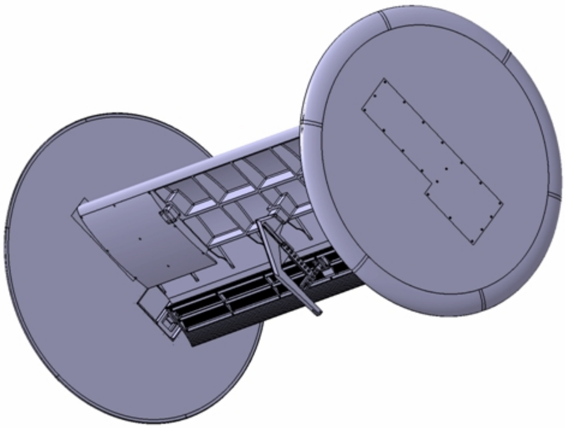

Fig. 6 CESAR assembly (without central lid of the wing and lower surface lid of the flap)

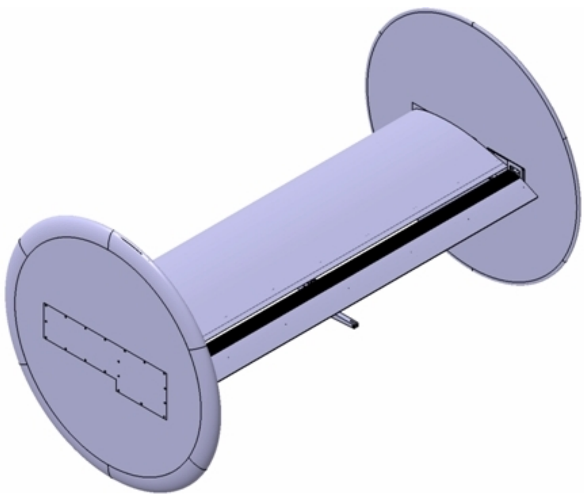

Fig. 7 CESAR assembly (upper surface view)