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Aerodynamic centre of wing-fuselage-nacelle combinations: effect of rear-fuselage pylon-mounted nacelles

**Associated software: ESDUpac A1309
See ESDU 13009**



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THE PREPARATION OF THIS DATA ITEM

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**AERODYNAMIC CENTRE OF WING-FUSELAGE-NACELLE COMBINATIONS:
EFFECT OF REAR-FUSELAGE PYLON-MOUNTED NACELLES**

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AERODYNAMIC CENTRE OF WING-FUSELAGE-NACELLE COMBINATIONS: EFFECT OF REAR-FUSELAGE PYLON-MOUNTED NACELLES

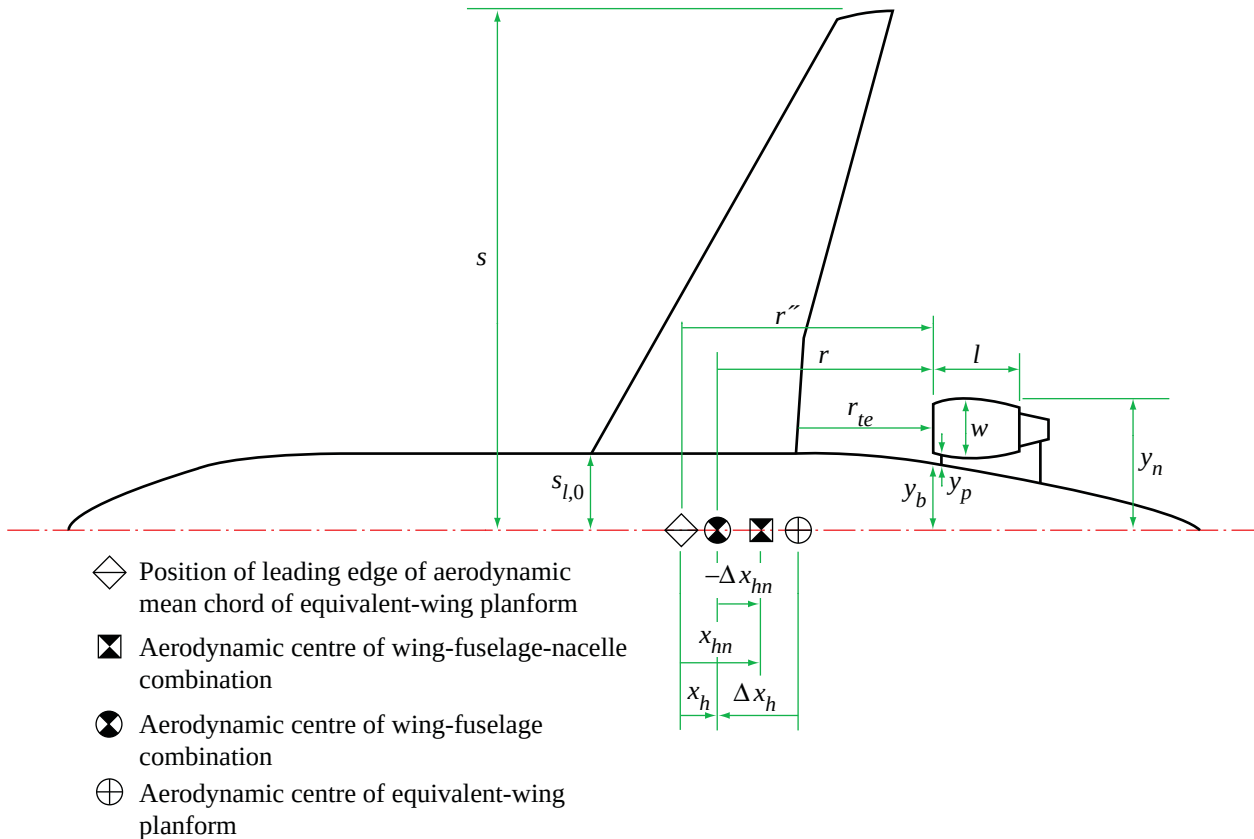
1. NOTATION AND UNITS (see Sketch 1.1)

		SI	British
A	aspect ratio of equivalent-wing planform*		
a	lift-curve slope of equivalent-wing planform*	radian ⁻¹	radian ⁻¹
a_n	lift-curve slope of nacelle in isolation, based on area wl	radian ⁻¹	radian ⁻¹
c_0	centre-line chord of equivalent-wing planform*	m	ft
$\bar{c}$	aerodynamic mean chord of equivalent-wing planform*	m	ft
c_r	root chord of equivalent-wing planform*	m	ft
c_{ref}	general reference chord for stability calculations	m	ft
H	downwash parameter (see Equation (2.3))	radian	radian
K	ratio of lift on nacelle-pylon-fuselage combination to lift on nacelle and pylon in isolation		
l	length of nacelle forward-cowl or overall length of single-cowl nacelle, see Figure 1	m	ft
M	Mach number		
m	fuselage length forward of leading edge of root chord of equivalent wing planform*	m	ft
n	fuselage length aft of trailing edge of root chord of equivalent-wing planform*	m	ft
r	distance of nacelle inlet aft of wing-fuselage aerodynamic centre	m	ft
r_{te}	distance of nacelle inlet aft of wing trailing-edge, measured from centre of nacelle inlet, see Sketch 1.1	m	ft
r'	distance of nacelle inlet aft of quarter-chord point of centre-line chord of equivalent-wing planform*	m	ft
r''	chordwise distance of nacelle lip (or inlet) from leading edge of aerodynamic mean chord of equivalent wing planform, measured positive aft, see Sketch 1.1	m	ft

For footnote refer to end of Notation.

S	area of equivalent-wing planform*	m^2	ft^2
s	semi-span of equivalent-wing planform*	m	ft
$s_{l, 0}$	spanwise distance to side of fuselage planform at point where leading edge of true wing planform meets side of projected fuselage planform*	m	ft
w	maximum spanwise width of single-engine nacelle; half-width of nacelle containing two engines (see Sketches 1.1 and 2.1)	m	ft
$\bar{x}$	chordwise location of aerodynamic centre of equivalent-wing planform, measured positive aft from leading edge of aerodynamic mean chord of equivalent-wing planform*	m	ft
$\bar{\bar{x}}$	chordwise location of leading edge of aerodynamic mean chord of equivalent-wing planform, measured positive aft from apex of equivalent wing planform*	m	ft
x_h	chordwise location of aerodynamic centre of wing-fuselage combination measured positive aft from leading edge of aerodynamic mean chord of equivalent-wing planform*	m	ft
Δx_h	shift in chordwise location of aerodynamic centre due to presence of fuselage (positive forwards)*	m	ft
x_{hn}	chordwise location of aerodynamic centre of wing-fuselage-nacelle combination, measured positive aft from leading edge of aerodynamic mean chord of equivalent-wing planform*	m	ft
Δx_{hn}	shift in chordwise location of aerodynamic centre due to presence of nacelles (positive forwards)	m	ft
y_b	fuselage half-width in plane of nacelle inlet	m	ft
y_n	spanwise location of outer limit of nacelle	m	ft
y_p	width of pylon leading-edge between nacelle and fuselage side	m	ft
β	compressibility parameter, $(1 - M^2)^{1/2}$		
Λ_0	leading-edge sweep of equivalent-wing planform*	degree	degree
$\Lambda_{1/4}$	quarter-chord sweep of equivalent-wing planform*	degree	degree
$\partial \varepsilon / \partial \alpha$	rate of change of downwash angle with incidence at nacelle inlet plane and centre of trailing vortex sheet		

* See ESDU 76015 for definition of equivalent-wing planform and calculation of x_h and Δx_h .



Sketch 1.1

2. METHOD

This Item calculates the shift at subsonic speeds in aerodynamic centre position, Δx_{hn} , caused by mounting nacelles on short pylons on the rear fuselage of wing-fuselage combinations. The shift is calculated by treating the nacelles as annular aerofoils located in the wing downwash field and subject to nacelle-fuselage interference effects. The shift is then subtracted from the wing-fuselage aerodynamic centre position x_h , calculated from ESDU 76015, to provide the overall aerodynamic centre position of the wing-fuselage-nacelle combination, x_{hn} . Rear-mounted nacelles cause a rearward shift in the aerodynamic centre position.

In ESDU 76015 the wing-fuselage aerodynamic centre position, x_h , is found by representing the actual gross wing by an equivalent straight-tapered wing, by using ESDU 70011 to calculate the aerodynamic centre position, $\bar{x}$, of this equivalent wing and then including a correction term, $-\Delta x_h$, to allow for the forward shift due to the fuselage. The aerodynamic centre position of the wing-fuselage-nacelle combination, measured positive aft from the leading edge of the aerodynamic mean chord of the equivalent-wing planform, is therefore written

$$\frac{x_{hn}}{\bar{c}} = \frac{x_h}{\bar{c}} - \frac{\Delta x_{hn}}{\bar{c}}, \quad (2.1)$$

where

$$\frac{x_h}{\bar{c}} = \frac{\bar{x}}{\bar{c}} - \frac{\Delta x_h}{\bar{c}}, \quad (2.2)$$

as calculated from ESDU 76015.