



ESDU TECHNICAL MEMORANDUM

Air data calibration using a GPS/INS (EGI)

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ESDU TECHNICAL MEMORANDA

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THE PREPARATION OF THIS TECHNICAL MEMORANDUM

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1. NOTATION, DIMENSIONS AND ABBREVIATIONS

1.1 Notation and Dimensions

		<i>Dimensions</i>
C_p	pressure coefficient	–
M	Mach number	–
p_S	static pressure	$ML^{-1}T^{-2}$
p_T	total pressure	$ML^{-1}T^{-2}$
q_C	impact pressure ($p_T - p_S$)	$ML^{-1}T^{-2}$
R	characteristic gas constant for air	L^2T^{-2}
T_S	static temperature	–
T_T	total temperature	–
u, v, w	components of aircraft velocity relative to the air along the Ox, Oy, Oz axes	LT^{-1}
u_K, v_K, w_K	components of aircraft velocity relative to the Earth	LT^{-1}
u_W, v_W, w_W	components of velocity of air relative to the Earth	LT^{-1}
V	velocity along the air-path (true airspeed of the aircraft)	LT^{-1}
V_K	resultant velocity of aircraft relative to the Earth	LT^{-1}
V_{HW}	horizontal component of wind velocity (see Appendix A)	LT^{-1}
V_W	resultant velocity of the air relative to the Earth (wind speed)	LT^{-1}
$(V_T)_i$	indicated true airspeed (derived from Equation (3.17) with $\Delta p_s = 0$)	LT^{-1}
α	angle of attack	–
β	angle of sideslip	–
γ	ratio of specific heats for air	–
γ	angle of climb (see Appendix A)	–
Δ	error in quantity	–
$\varepsilon[]_W$	error in quantity [] due to assuming wind velocity is zero	–
ϕ, θ, ψ	angles of bank, inclination (pitch) and azimuth	–

Subscripts

<i>Down</i>	component in down direction (that is, towards the centre of the Earth)
<i>E</i>	quantity in Earth axes (see Appendix A)
<i>East</i>	component in an easterly direction
<i>i</i>	indicated
<i>North</i>	component in a northerly direction

1.2 Abbreviations

AoA	Angle of Attack
EGI	Embedded GPS/INS
GPS	Global Positioning System
INS	Inertial Navigation System
PEC	Position Error Correction

An arrow above a quantity indicates a vector.

In line with convention, the terms airspeed and windspeed are used in this item even though they are vectors and consequently should be referred to as velocities.

2. INTRODUCTION

A method is presented for the determination of airdata calibrations from an aircraft equipped with an embedded GPS/INS (EGI). The airdata sensors to be calibrated are the angle of attack, sideslip and Pitot-static probes.

Reference 1 discusses a method for the derivation of air data from turning flight on an aircraft equipped with an embedded GPS/INS (EGI). The EGI is capable of giving the angles of bank, inclination (pitch) and azimuth (ϕ, θ, ψ) as well as the orthogonal components of aircraft velocity relative to the Earth (ground speed) $[(u_K)_E, (v_K)_E, (w_K)_E]$. Compared to a standard INS the GPS component of the system enables a much improved accuracy in horizontal speeds with the added benefit that the error does not increase with time.

The method of Reference 1 uses the three angles and three velocities from the EGI along with indicated true airspeed derived from the Pitot-static system to compute the horizontal components of wind (the vertical wind is assumed to be zero) and the error in airspeed (due to the error in measured static pressure, P.E.C.). From this information the angles of attack and sideslip, as well as true airspeed and altitude, are determined.

Alternatively, it is demonstrated that if the flight manoeuvres used for data gathering are restricted to wings level flight with zero climb gradient then a much simpler analysis is possible. Both methods allow the calibration of angle of attack and angle of sideslip sensors as well as the determination of static pressure errors.