



ESDU PERF EG 5/1

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Estimation of take-off distance

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THE PREPARATION OF THIS DATA ITEM

The work of the Engineering Sciences Data Unit on this series is monitored and guided by Technical Committees of the Royal Aeronautical Society. The Committee responsible for this particular Data Item was the Performance Committee, which first met in 1946, and has the following constitution:

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The members of staff of the Royal Aeronautical Society associated with the Performance Committee were Miss E.C. Pike and Mr D.C. Smith.

ESTIMATION OF TAKE-OFF DISTANCE

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ESTIMATION OF TAKE-OFF DISTANCE

1. NOTATION AND UNITS

		<i>SI</i>	<i>British</i>
D	airframe drag	N	lbf
F_N	net thrust (see ESDU 69006, Reference 1, for thrust definitions)	N	lbf
g	acceleration due to gravity	m/s ²	ft/s ²
h	screen height	m	ft
L	lift	N	lbf
m	aircraft mass	kg	slug
s	horizontal distance	m	ft
s_1	length of ground run	m	ft
s_2	transition distance	m	ft
s_3	climb distance	m	ft
t	time	s	s
t_3	time taken during climb phase	s	s
V	true ground speed	m/s, kn	ft/s, kn
V_a, V_b	limits of an arbitrary speed interval	m/s, kn	ft/s, kn
V_m	mean speed (see Section 3 and Figure 1)	m/s, kn	ft/s, kn
V_w	horizontal component of wind speed (headwind positive)	m/s, kn	ft/s, kn
V_1	true airspeed at unstick	m/s, kn	ft/s, kn
V_2	true airspeed during climb	m/s, kn	ft/s, kn
W	aircraft weight, mg	N	lbf
x	runway gradient (positive downwards)	—	—
γ	angle of steady climb	—	—
μ	coefficient of rolling friction	—	—

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2. INTRODUCTION

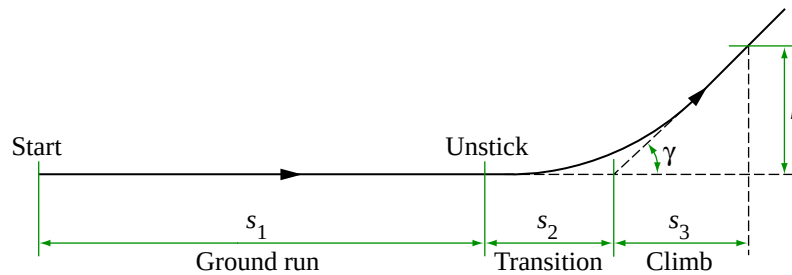
The method presented in this Data Item is suitable only in the early stages of a design project. It is also assumed that the tyre-runway friction interaction is dealt with in an approximate way using gross assumptions: other Items in the Performance Series provide more comprehensive methods (see, for example, ESDU 05011, Reference 2).

This Data Item contains formulae for the estimation of take-off distance over a screen, usually of height 35 ft (10.7 m) or 50 ft (15.2 m). Information on the calculation of accelerate-stop distances is also included. The methods apply to all types of propulsive unit.

For some general considerations of the take-off problem, see Reference 3. A useful summary of methods for estimating take-off distance will be found in Reference 4.

3. BASIC FORMULAE

The take-off is assumed to be divided into three phases as shown in Sketch 3.1 – ground run, transition, and climb to the screen height.



Sketch 3.1 Phases of take-off

For the *ground run*

$$F_N - D - \mu(W - L) = \frac{W}{g} V \frac{dV}{ds}$$

and the length of run is given by

$$s_1 = \frac{W}{g} \int_0^{V_1} \frac{V dV}{F_N - D - \mu(W - L)} \quad (3.1)$$

In general, however, sufficient accuracy will be obtained by assuming a mean value for the effective thrust.

The value of s_1 can be obtained by graphical integration of the function $V/(F_N - D - \mu(W - L))$ plotted against V or using the formula

$$s_1 = \frac{W}{2g} \frac{V_1^2}{(F_N - D - \mu(W - L))} \quad (3.2)$$