

EXAMPLE OF STATISTICAL TECHNIQUES APPLIED TO ANALYSIS OF LANDING GROUND ROLL DISTANCE MEASUREMENTS

(Linear regression, correlation coefficient and F test)

1. NOTATION AND UNITS

a	regression relationship constant ("y" intercept)	*
b	regression relationship constant (slope)	*
D/W	drag to weight ratio	
F	F Variance Ratio test statistic	
n	number of data points	
r	correlation coefficient	
SE	residual error sum of squares	*
SR	regression sum of squares	*
s_g	ground roll distance	ft
$\bar{s}_g$	mean value of sample of s_g	ft
$\hat{s}_g$	predicted value of s_g	ft
V	true airspeed	kn
V_{screen}	true airspeed at screen	kn
V_{TD}	true airspeed at touchdown	kn
V_{stall}	stall speed	kn
Subscripts		
I	denotes indicated value (as in indicated airspeed)	
i	denotes i th data point	

* Quantities a , b , SE and SR are dimensional but take units which depend on the parameters involved in each regression.

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2. INTRODUCTION

This Data Item uses the analysis of a set of landing ground roll distance measurements to illustrate the following techniques.

The use of linear, two variable regression – see Section 3.2,

the application of a simple transformation to enable linear regression techniques to be applied to a non-linear data set – see Section 3.3,

the application of the “*F*” Variance Ratio test to test the significance of the derived regression relationships – see Sections 3.2 and 3.3,

the use of the Correlation Coefficient as a further test of the significance of the correlations – see Sections 3.2 and 3.3.

An introduction to all the above statistical techniques is given in Data Item No. 91017 (Reference 1).

3. USE OF LINEAR TWO VARIABLE REGRESSION IN ANALYSIS OF “AUTO-BRAKE” LANDING GROUND ROLL MEASUREMENTS

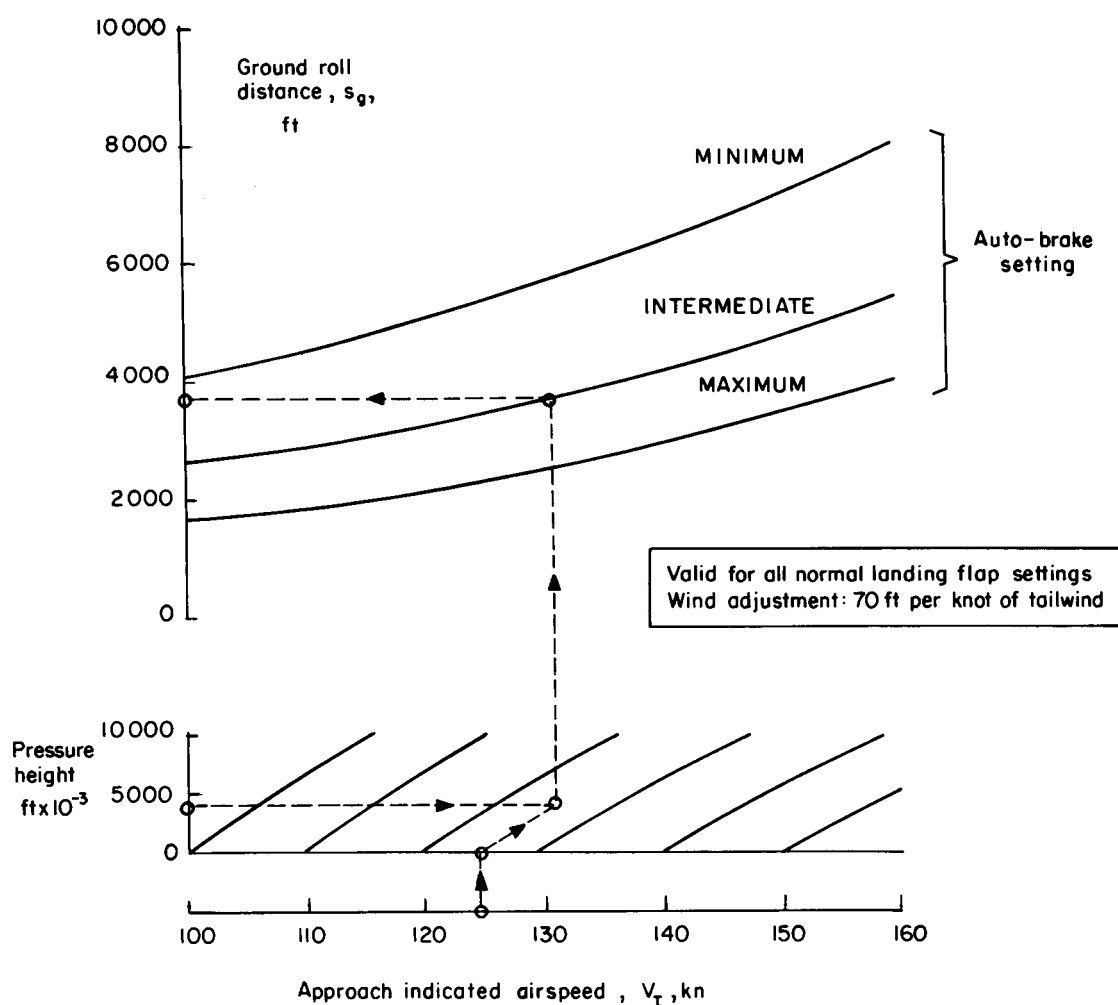
In civil operational landings it is common practice for the pilot to try to “judge” his landing touchdown point and ground roll so as to be able to turn off the runway at a particular “turn-off”, usually to minimise taxiing distance to the “stand”. It is desirable to obtain such performance without harsh braking and automatic braking systems are the primary mean of achieving this. In general, these systems work on the principle of modulating brake pressure to produce a constant level of deceleration and most systems have three or four deceleration settings available to the pilot.

To help the pilot decide which auto-brake setting to use to achieve the desired runway “turn-off”, some manufacturers provide charts similar to Sketch 3.1, permitting the pilot to relate his probable ground roll braking distance to his intended approach speed.

The basis for a chart such as Sketch 3.1 is a correlation between ground roll distance and approach speed for each retardation setting; one way such a correlation could be established is by the use of a least squares regression technique as illustrated here.

3.1 The Measured Data for Intermediate Auto-Brake Setting

The ground roll distances and corresponding approach indicated airspeeds tabulated below are the results of tests carried out for a range of weights and approach speeds using the landing flap setting and the “intermediate” auto-brake setting. All the distances have been adjusted to ISA, sea level, zero wind conditions and to zero runway slope.



Sketch 3.1 Example of auto-brake landing ground roll distance (guidance information only)

Approach indicated airspeed, V_I kn	Ground roll distance, s_g ft
114	2220
113	2210
117.5	2620
117	2580
116	2600
118.5	2550
113	2310
120	2780
117.5	2750
114.5	2550
126.5	3010

Approach indicated airspeed, V_I kn	Ground roll distance, s_g ft
124.5	2930
123	2900
125	2940
118.5	2680
121.5	2750
118.5	2670
117	2685
117	2470
125	2865
114	2200
123.5	2820

Approach indicated airspeed, V_I kn	Ground roll distance, s_g ft
122	2705
120	2690
121.5	2810
121	2790
130	3075
133	3300
130	3200
130	3160
125	2785
124	2960
125	2820