C.P. No. 1176

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Civil Aircraft Airworthiness Data Recording Programme

Manoeuvre Loads During Training and Test Flying

by

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LONDON: HER MAJESTY'S STATIONERY OFFICE

1971

PRICE *20 p* NET

UDC 533.6.048.1 : 533.6.048.5 : 533.6.013.65

CP No.1176*
November 1970

CIVIL AIRCRAFT AIRWORTHINESS DATA RECORDING PROGRAMME

MANOEUVRE LOADS DURING TRAINING AND TEST FLYING

by

G. E. King

SUMMARY

Using continuous photographic trace records, the manoeuvre accelerations experienced in 35 hours of training flying were counted and measured to provide an estimate of the total number and magnitude of loads for a fleet's training flying over a five year period. These data are compared with counting accelerometer data giving the estimated total number of gust plus manoeuvre loads for five years of revenue flying by the same fleet. Both estimates were found to be of the same order in the number and magnitude of loads although the ratio of training to revenue flying hours was one in fifty.

The particular test flight analysed, which included an unusually large number of stalls, produced approximately as many extreme negative accelerations as one year's revenue flying.

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* Replaces RAE Technical Report 70226 - ARC 32850.

CONTENTS

1 INTRODUCTION

The frequency distributions of the loads an aircraft experiences during it's life are gradually being defined, i.e. manoeuvre, gust, flight phase, ground loads etc. These data are needed for the estimation of expected flight loads and for ground tests on aircraft and components. The present study provides data from a number of training flights and one certificate of airworthiness renewal test flight.

Analogue photographic paper trace recorders were carried in current rear engined jet transports during the Civil Aircraft Airworthiness Data Recording Programme (CAADRP Phase 2)[1]. Records from 34.92 hours of training flying on one aircraft type (Type D) became available and have been analysed to provide an estimate of the loads the whole fleet would have experienced over a five year period. These loads are compared with estimated loads during revenue flying by the same fleet in a five year period obtained from 1189 hours of counting accelerometer data. It is found that in a five year period the number of loads experienced at each acceleration level for training and revenue flying are roughly similar although the ratio of flying hours for the two activities is about 1 to 50. NASA data[2] from a different aircraft type (Type X) show a similar trend.

Another loading source is the certificate of airworthiness renewal test flight and one flight record from a mandatory recorder on aircraft Type E has been analysed. The results show that this particular test flight produced about the same number of extreme negative accelerations as a year of revenue flying.

2 DATA

The number and magnitude of the training manoeuvre normal accelerations for aircraft D were obtained from a continuous trace record of 34.92 flying hours by measuring the largest peak value between successive crossings of the 1g datum. Turbulence, which was in any case slight on this particular record, was ignored. Data for the combined gust and manoeuvre loads which occurred in 1189 hours of revenue flying on aircraft Type D were obtained from counting accelerometers which automatically record the number of times selected acceleration levels are exceeded.

The training and revenue flying loads for aircraft Type X were obtained from Ref.2, which provides data for 219.7 hours of training flying and 3766 hours of revenue flying. The gust and manoeuvre loads have been added together to provide the total revenue flying history. However the method of analysis was such that when a gust was superimposed on a manoeuvre, the gust was measured using the manoeuvre line as datum and therefore the true peak load history is not known. This is thought not to be too serious an error for the purposes of this report, but it must be remembered that the true load history for aircraft X revenue flying is necessarily slightly more severe than shown.

Data from a mandatory recorder carried by an aircraft Type E during a certificate of airworthiness renewal test flight lasting 2.87 hours has been analysed to give the number and magnitude of the normal manoeuvre accelerations.

All the above data are presented in Tables 1, 2 and 3.

3 RESULTS AND DISCUSSION

The data for aircraft Type D from Tables 1 and 2 have been scaled up to give estimates of the loads the fleet would experience in 7151 hours of training and 330917 hours revenue flying; these are the hours flown in each category in the last five years by the aircraft Type D fleet. Fig.1 shows these estimates as plots of log number of counts against acceleration increment for training and revenue flying. The numbers and magnitude of the normal accelerations, especially at the higher levels, are thus estimated to be similar for training and revenue flying during the life of a modern aircraft. There is evidence[3] to suggest that modern aircraft are manoeuvred less frequently during revenue flying than earlier types, mainly through the increased use of better autopilots. In addition storm warning radar, introduced some years ago now, reduced the intensity of severe turbulence encounters[4], so it appears that the training loads are becoming of more significance in relation to revenue flying loads.

In view of the small number of CAADRP training hours analysed, which may have been unusually severe, similar NASA data from Ref.2 have been plotted in Fig.2. These data derive from a different airline and aircraft type but still show similar results. In fact, at the higher levels the training loads are significantly the more severe but, as pointed out in section 2, the revenue load history is probably under-estimated.

A certificate of airworthiness renewal test flight is normally carried out once yearly on each aircraft, but some concession is made for large fleets of the same aircraft type. It has been assumed, however for this Report that the Type D fleet flies one test flight per aircraft per year, i.e. 140 flights in five years from a fleet of 28 aircraft. The Type E test flight loads from

Table 3 have been scaled up on this basis to provide an estimate of loads over five years. These results are compared with the revenue flight loads in Fig.3. Whilst it would obviously have been better to use test flight data from a Type D aircraft, the comparison does give a feel for the contribution test flights make to the total load history. It appears, from Fig.3, that the negative loads are the more significant and are comparable in number with the revenue flying loads at the more extreme values. Test flight sequences follow a standard pattern but additional special tests are incorporated if a particular snag has been found in any system. In this instance a larger than normal number of stalls were carried out. It is therefore likely that the number and possibly the magnitude of downward accelerations recorded was abnormal. More test flight records are therfore needed to establish: (i) the average loading pattern of standard sequences; (ii) the frequency of occurrence and the effect of various special additional tests; (iii) the overall average loading pattern.

As mentioned in section 2 turbulence has not been included in the training and test flight loads as it was considered that the loads would not be very different per hour to revenue flying. In addition, even if a significant difference exists, because the number of training hours flown is about 2% of the revenue flying and the test flying even less, the effect on the totals of loads experienced in a given period will be small.

4 CONCLUSIONS

From an analysis of CAADRP continuous trace records and counting accelerometer data, it is estimated that in a five year period approximately the same number and magnitude of loads are met in training flights as in revenue flying; NASA data show similar results.

The single annual certificate of airworthiness test flight analysed from aircraft Type E produced approximately as many extreme downward accelerations as a year of aircraft Type D revenue flying. However, a more quantitative appraisal can only be made when data for many test flights and revenue flying by the same type of aircraft become available.

Table 1

CUMULATIVE DISTRIBUTIONS OF MANOEUVRE ACCELERATIONS DURING TRAINING FLYING

Acceleration increment exceeded	CAADRP 34.92 hours aircraft Type D		NASA 219.7 hours aircraft Type X
	+	-	+ and -
0.25 g	415	232	
0.30	228	135	2239
0.35	109	82	
0.40	73	57	808
0.45	35	37	
0.50	26	26	381
0.55	18	14	
0.60	13	10	182
0.65	10	5	
0.70	6	3	91
0.75	4	3	
0.80	2	2	42
0.85	2	1	
0.90		1	18
0.95			
1.00			7
1.05			
1.10			4
1.15			
1.20			3
1.25			
1.30			2
1.35			
1.40			1

Table 2

CUMULATIVE DISTRIBUTIONS OF MANOEUVRE AND GUST ACCELERATIONS DURING REVENUE FLYING

Acceleration increment exceeded	Counting accelerometer 1189 hours aircraft Type D		NASA 3766 hours aircraft Type X
	+	-	+ and -
0.20 g	2076	953	
0.30	416	148	10227
0.40	101	25	2353
0.50	-	-	658
0.60	11	2	195
0.70	-	-	67
0.80	1	2	32
0.90			10
1.00			3
1.10			1

Table 3

CUMULATIVE FREQUENCY DISTRIBUTION OF MANOEUVRE ACCELERATIONS DURING ONE ANNUAL CERTIFICATE OF AIRWORTHINESS RENEWAL TEST FLIGHT

Acceleration increment exceeded	Aircraft Type E 2.87 hours	
	+	-
0.25 g	23	12
0.30	16	11
0.35	9	10
0.40	6	10
0.45	5	10
0.50	2	9
0.55	1	9
0.60		7
0.65		6
0.70		4
0.75		4
0.80		4
0.85		4
0.90		2
0.95		1
1.00		1
1.05		1
1.10		1

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No.	Author(s)	Title, etc.
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4	N. I. Bullen Judy E. Aplin	Loads experienced in turbulence by a Central African Airways Viscount without and with cloud warning radar. Aeronautical Research Council CP 1038

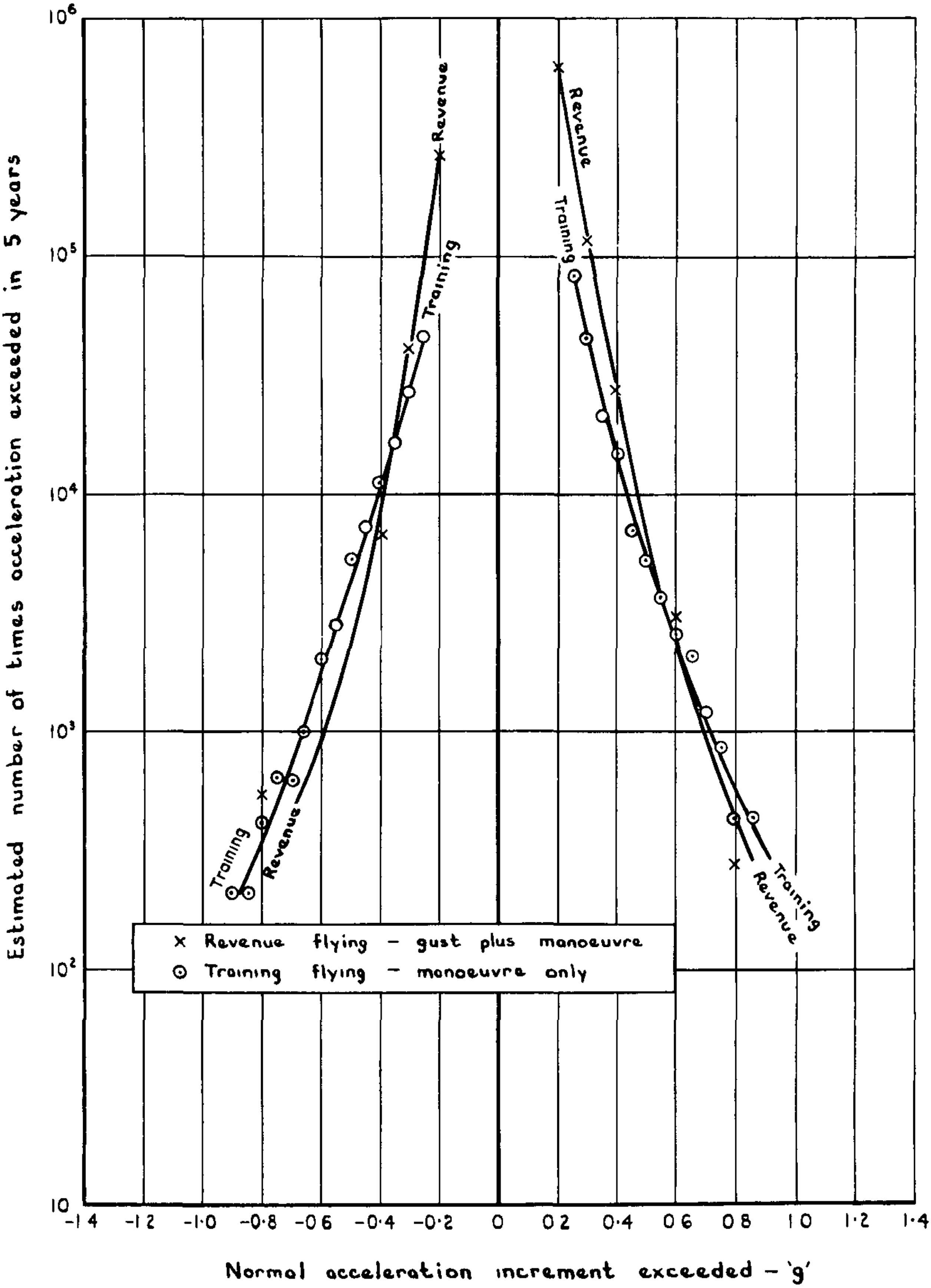

Fig 1 Comparison of estimated loads for a fleets training and revenue flying using CAADRP data – aircraft type D

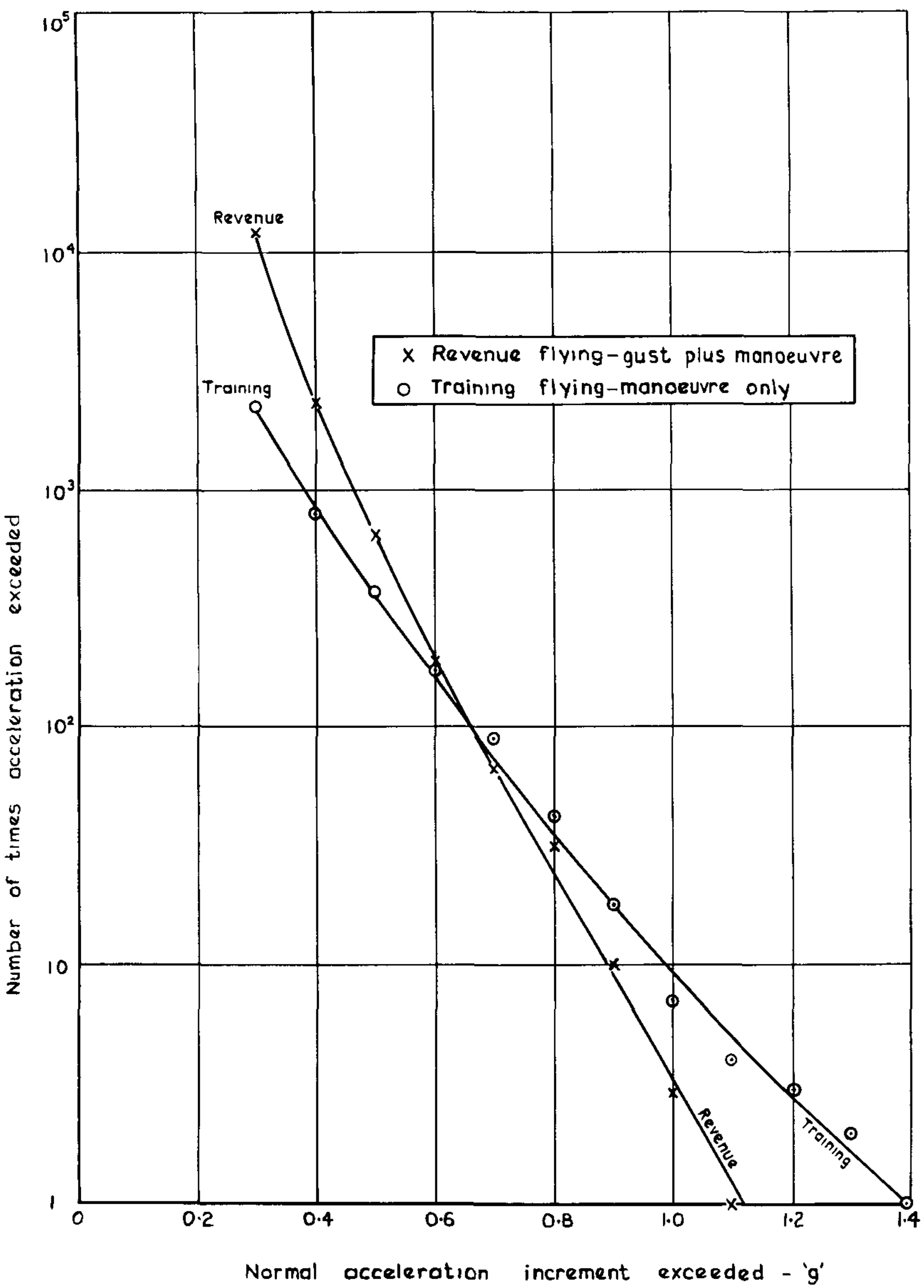

Fig. 2 Comparison of loads during training and revenue flying using NASA data-aircraft type X

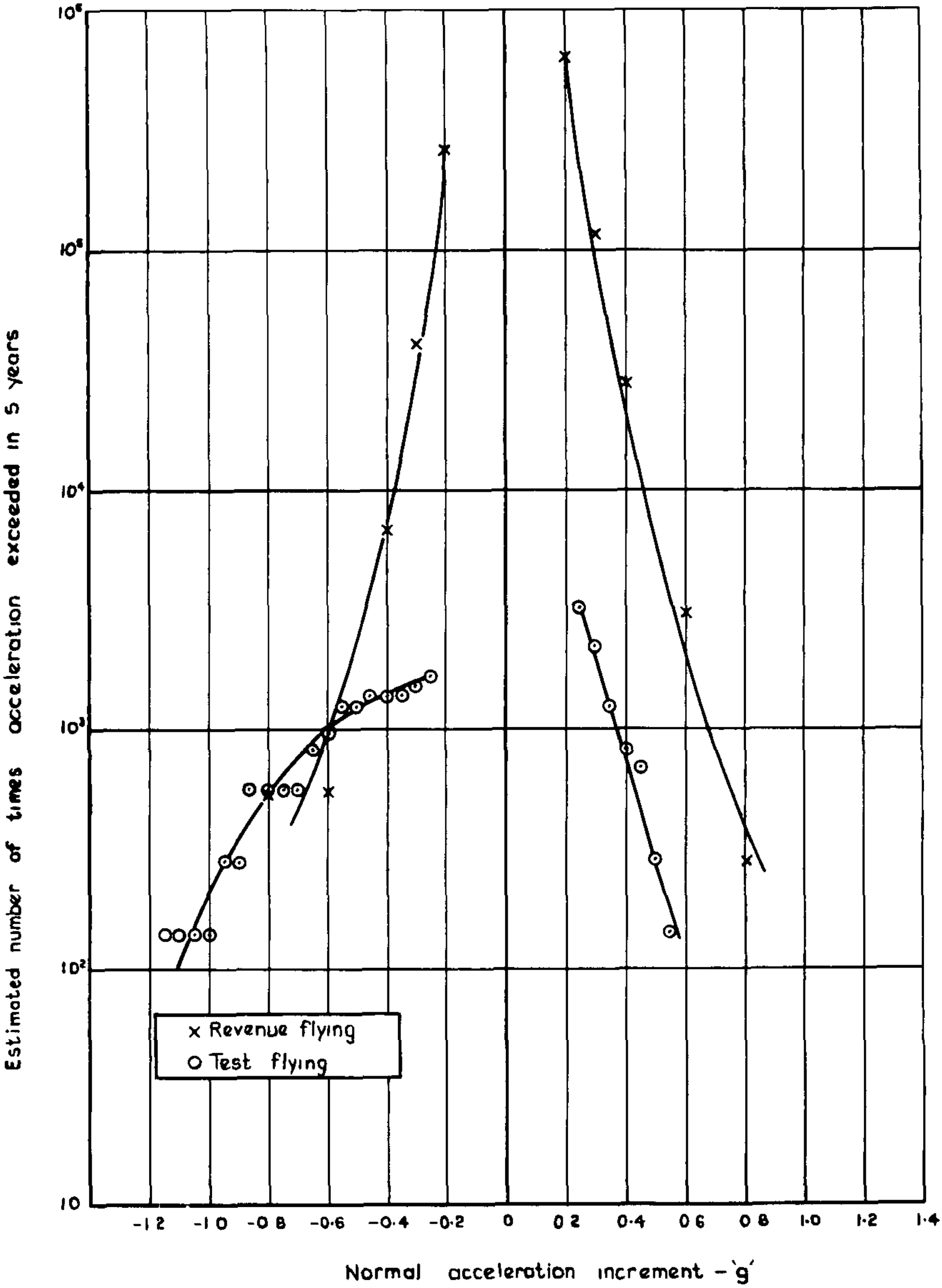

Fig.3 Comparison of estimated loads for aircraft type D revenue flying and aircraft type E certificate of airworthiness renewal test flight

Printed in England for Her Majesty's Stationery Office by the Royal Aircraft Establishment, Farnborough Dd 502109 K 4

DETACHABLE ABSTRACT CARD

ARC CP No 1176	533.6.048.1
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