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The Effect of Slipstream on the Longitudinal Stability of Multi-Engined Aircraft

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Summary.—Flight measurements of longitudinal stability power-off and power-on made on numerous aircraft have been analysed and a generalised curve for estimating the contribution of slipstream to longitudinal stability, applicable to both flaps-up and flaps-down cases, has been derived. Using this curve the change in stability due to slipstream at a given value of C_L can be estimated with a probable error of less than $\pm$ 0·02 in the position of the neutral point.

1. *Introduction.*—Predicting the effects of slipstream on longitudinal stability has been one of the more difficult tasks facing aircraft designers, and workers in the field of stability and control have made a number of attempts to produce generalised design data. For various reasons these attempts have not been successful and estimates of slipstream effects are still made by rule-of-thumb methods based largely on previous experience. The lack of knowledge of slipstream effects has been, no doubt, responsible to a large extent for the deficiency in stability shown by many prototype aircraft.

Bryant in R. & M. 2310[1,2] has shown by model tests what a complex pattern of speed and downwash exists in the slipstream. Stiesz has done similar work in flight (*see* Ref. 3). These investigations have shown that when the slipstream reaches the tailplane it has been flattened out considerably[1]. The velocity increments appear to be concentrated in a fairly narrow horizontal band whilst the downwash changes extend over a markedly wider band.

A detailed analysis of the slipstream pattern with a view to producing generalised data is not practicable. The normal method of approach is to assume that the velocity and downwash changes can be approximated to by taking mean values over the tailplane span and this has been done here.

The approach adopted in this report is purely empirical. The basic data were the results of flight measurements of stick-fixed longitudinal stability power-off and power-on made on a number of twin and four-engined aircraft. Most of the measurements available referred to the aircraft with flaps up, but a few measurements made with flaps down have helped to increase the scope of the analysis. The contributions of slipstream to the longitudinal stabilities under different conditions were obtained from these various measurements and the results then analysed empirically to obtain the form of their dependence on a number of parameters. The number of parameters used in the analysis has been kept to a minimum consistent with the scatter of the points in the final result being reasonably small and of the order of accuracy of the initial experimental results.

* R.A.E. Report Aero. 2304, received 4th February, 1949.

Only the results of flight tests have been included in the analysis. Systematic model tests are now in progress; tail height, tail size, etc., are being varied systematically. The results of these tests will be analysed on the lines of this report.

The form of the analysis is based on a suggestion by Perring that the wing is the main factor in determining the position of the slipstream and, hence, that the effect of slipstream on the tail may, for a given thrust coefficient, be simply expressed in terms of the relative geometric positions of the wing and tailplane.

The arguments given in section 2 below for the choice and forms of the various parameters are often very loose and no mathematical explanation is offered for the exact final form of the analysis. However, the satisfactory nature of the final result is considered a sufficient justification for publication.

The flight test work done by various firms in measuring the longitudinal stability of their aircraft, and the ready co-operation of the firms in supplying the Royal Aircraft Establishment with their results is gratefully acknowledged.

2. *Development of the Analysis.*—Details of the complete analysis are given in Table 1 at the end of the report.

For the purpose of this report longitudinal stability is considered to be defined by the position of the neutral point. The difference Δh_{n1} between the neutral point power-off and the netural point power-on at a given value of C_L was taken as a measure of the effect of slip-stream on the stability. For convenience in covering the usual ranges of trim curves the following values of C_L were chosen: 0·3, 0·6 and 0·9 flaps up and 0·6, 0·9, 1·2 and 1·5 with flaps down. When points on the trim curves appeared to show aero-elastic distortion effects, they were not used. In order to ensure a uniform method of analysis of the trim curves all the curves were re-drawn by one person from experimental points; this will explain any difference between the results quoted in this report and those given in the references.

The total change in stability due to slipstream, Δh_{n1}, includes the contribution of the thrust moment which can be calculated accurately from a knowledge of the thrust and the thrust moment arm about the c.g. The change in stability after allowing for the thrust contribution is denoted by Δh_n.

The parameter first chosen to determine the effective tail height was the angle ϕ, where ϕ is the angle contained between the root wing chord and the line joining the wing root trailing edge to the tailplane root leading edge. Even on this rough basis the results were promising enough to warrant further work.

2.1. *Wing Wake Position.*—It was clear that the first step in the analysis was to improve on the angle ϕ as an indication of the tailplane position relative to the slipstream. This was done by relating the tail position to the centre of the wing wake at the tail this being assumed to be the most important factor in determining the location of the slipstream. The height of the centre of the wing wake below the elevator hinge axis* was estimated directly for the no propeller case by using the method and charts of Ref. 4. The angle θ was then defined as the angle between the line joining the wing root trailing edge to the centre of the wing wake at the tail and the line joining the wing root trailing edge to the tailplane root leading edge (*see* Fig. 1b). It is important to note that no correction is applied to θ itself for propeller slipstream effects.

2.2. *Thrust coefficient.*—It was recognised that the magnitude of the thrust coefficient T_c must be of direct importance in determining the intensity of the slipstream effect. Making Δh_n proportional to various powers of T_c was tried first and it was found that the increments

* Note: This particular point is used in Ref. 4. The correction to obtain the centre of the wing wake at the tailplane leading edge is small and is not considered worth applying in the present analysis.

in stability at the different values of C_L, which meant different values of T_c could be brought together by assuming Δh_n proportional to $\sqrt{T_c}$. Later analysis has shown that a slight improvement is obtained if Δh_n is assumed proportional to $T_c^{0\cdot4}$. The gain in overall accuracy is, however, very small and the factor $\sqrt{T_c}$ has been retained for the sake of simplicity.

Fig. 2 presents $\Delta h_n/\sqrt{T_c}$ plotted against the angle θ.

2.3. *The factor $a/\bar{V}a_1$.*—This factor was introduced to allow for the tail size and also for variations in the tail-lift slope, a_1, both of which would be expected to have a proportional effect on Δh_n. The actual form of the factor was derived by means of the following rough argument. If the assumption is made that all the slipstream contribution comes from the downwash change then

$$\Delta h_n = \frac{\bar{V}a_1}{a}\left[\frac{d\varepsilon_s}{d\alpha} - \frac{d\varepsilon}{d\alpha}\right]$$

where ε_s is the mean downwash angle power on and ε is the mean downwash angle power-off. The tail volume coefficient and the wing lift-curve slope are, as usual, denoted by $\bar{V}$ and a, respectively. For this equation to be strictly correct it is necessary to make the further assumption that the tail lift-coefficients etc. are constants.

Fig. 3 presents $\Delta h_n\,.\,(T_c)^{-1/2}\,.\,(a/\bar{V}a_1)$ plotted against θ. It is seen that the points for the twin and four-engined aircraft have, with a few exceptions, separated out for values of θ less than about 16 deg, and the two sets of points now lie on two distinct curves with a reasonably small amount of scatter.

2.4. *Tail Arm.*—Inspection of Fig. 3 showed that the points for some twin-engined transport-type aircraft tended towards those for the four-engined aircraft. The outstanding difference between these and the other twin-engined aircraft is their large size. In Fig. 4 the values of l'/D for the various aircraft have been plotted, l' being the tail arm and D the propeller diameter. This factor is, in general, noticeably larger for the four-engined than for the twin-engined aircraft. This would be expected bearing in mind that the engines and propellers fitted to both types are almost the same. Exceptions are the large twin-engined transport aircraft comparable in size with four-engined aircraft.

It was first assumed that Δh_n was inversely proportional to l'/D, thus allowing roughly for a decrease in slipstream intensity in proportion to distance downstream. The expression $\Delta h_n\,.\,(T_c)^{-1/2}\,.\,(a/\bar{V}a_1)\,.\,(l'/D)$ is plotted against θ in Fig. 5. Introduction of the factor l'/D has had the effect of bringing together the points for the twin and four-engined aircraft for values of θ below about 16 deg where they had previously been separate. For larger values of θ the scatter is somewhat worse than before. The suggested explanation is that the downwash increments due to slipstream, die out more slowly than the velocity increments and at large values of θ the tail is affected only by the downwash (*see* sections 1 and 5).

3. *Effect of Flaps on Slipstream Contribution to Stability.*—Some results obtained with flaps down have been analysed in exactly the same way as the flaps-up results. The position of the centre of the wing wake at the tail with flaps lowered and without propellers was again estimated using the charts of Ref. 4. The angle θ was measured from the root trailing edge of the wing, not the flap trailing edge.

The points obtained from the flaps-down cases lie on the same curve as the flaps-up points with reasonably smaller scatter (*see* Fig. 2, 3 and 5). In the case of two aircraft, stability measurements have been made at two flap settings (points 14 and 15, 16 and 17). The points 14 and 15 are at opposite extremes of the scatter at large values of θ in Fig. 3 and 5 suggesting that the introduction of another parameter may be necessary in the flaps-down cases.

4. *Accuracy*.—There is practically no variation in the maximum scatter of $\Delta h_n . (T_c)^{-1/2} . (a/\bar{V}a_1) . (l'/D)$ along the curve of Fig. 5. Therefore, for a given aircraft the possible error in Δh_n will be proportional to $\sqrt{T_c}$. The following table shows the maximum errors that may be expected in using Fig. 5 to estimate Δh_n for typical high-powered twin and four-engined aircraft at a very low climbing speed (high power) and at a low cruising speed.

Aircraft Type	C_L	Maximum error in Δh_n
Twin-engined	0·9	$\pm$ 0·025
,, ,,	0·6	$\pm$ 0·019
Four-engined	0·9	$\pm$ 0·020
,, ,,	0·6	$\pm$ 0·016

The order of accuracy for the determination of Δh_n from flight measurements is within about $\pm 0 \cdot 02$; the scatter of the points on the final curve of Fig. 5 compares well with this.

It may be stated with a fair degree of confidence that the curves of Fig. 3 and 5 enable Δh_n to be estimated with a probable error of less than about $\pm$ 0·02.

5. *Discussion and Conclusions*.—The shape of the curves confirm the suggestions of R. & M. 2310[1]. At low values of θ the tailplane is in the high velocity band of the slipstream (*see* section 1) where the stabilising effect of the increased air speed over the tail plane is counteracted by the destabilising effect of increased downwash (due mostly to the increased local loading of the wing, though there may also be contributions from slipstream rotation). As the tailplane is raised it moves out of the high velocity band but the increased downwash is maintained and there is a consequent increasing loss in stability. At still higher positions, the tailplane begins to move out of the band of increased downwash and hence the loss in stability decreases, finally becoming zero as would be expected at very large values of θ.

The analysis described in this report has resulted in the establishment of generalised curves (Figs. 3 and 5) using which the slipstream contribution to longitudinal stability can be estimated with a reasonable degree of accuracy ($\pm$ 0·02 in Δh_n). The curve of Fig. 5 in which $\Delta h_n . (T_c)^{-1/2} . (a/\bar{V}a_1) . (l'/D)$ is plotted against θ (*see* Fig. 1b) should be used for values of θ less than 16 deg. For larger values of θ the use of the curve of Fig. 3 which gives $\Delta h_n . (T_c)^{-1/2} . (a/\bar{V}a_1)$, omitting the factor (l'/D), is recommended as giving slightly better accuracy.

The results of routine model tests and of the systematic wind-tunnel tests now in progress (*see* section 1) will be analysed and compared with the flight test results. This analysis may lead to the introduction of more parameters or to some modification to θ to enable flight and model results to be compared on the same basis.

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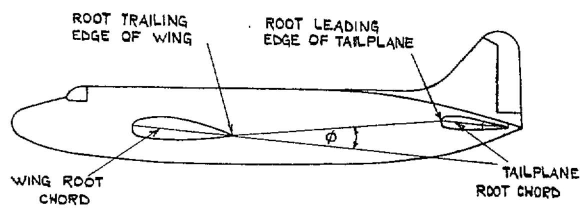

FIG. 1a. Diagram showing geometric angle ϕ.

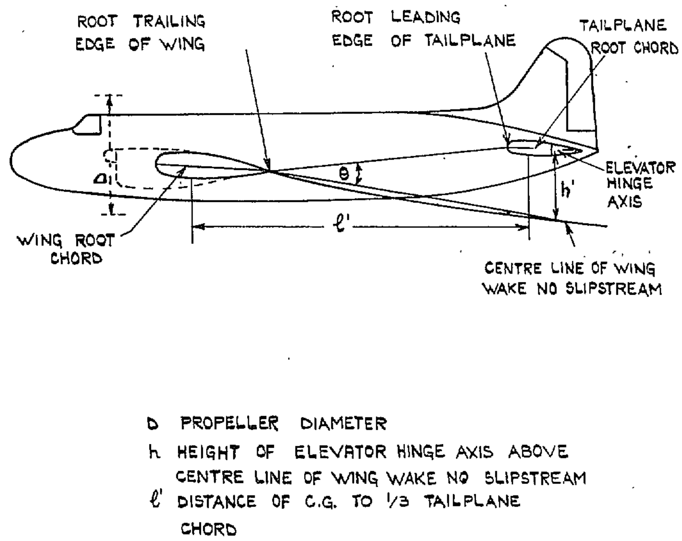

FIG. 1b. Diagram showing angle θ.

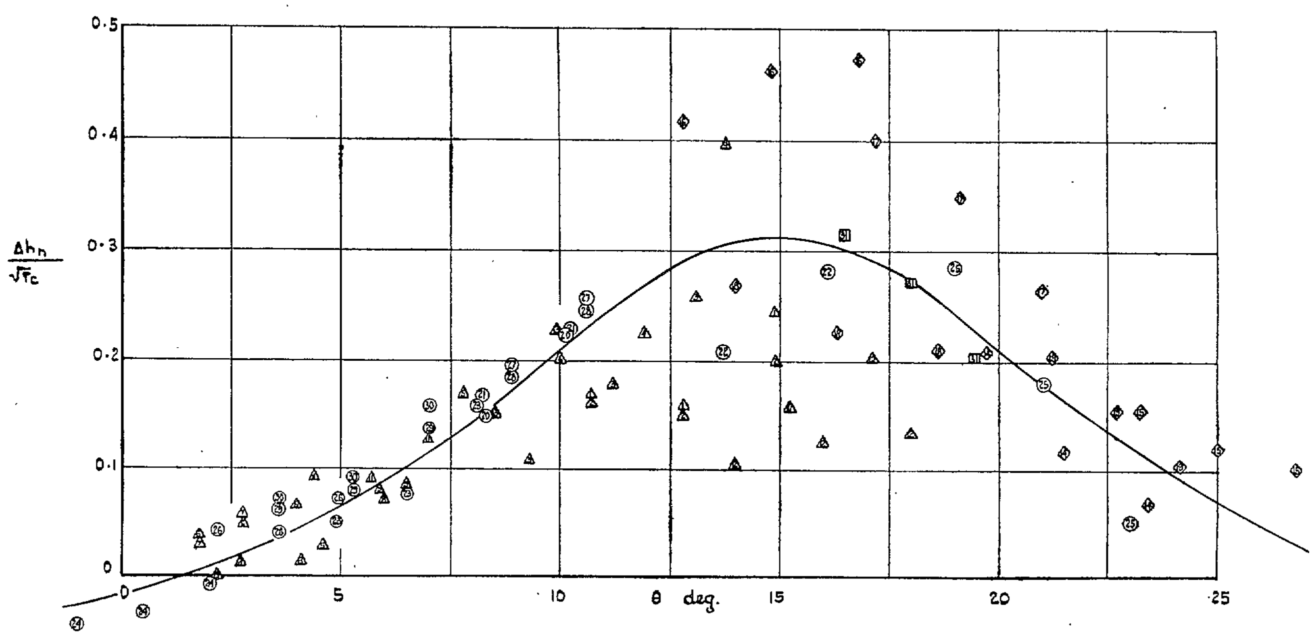

FIG. 2. $\Delta h_n/\sqrt{T_c}$ plotted against θ (deg).

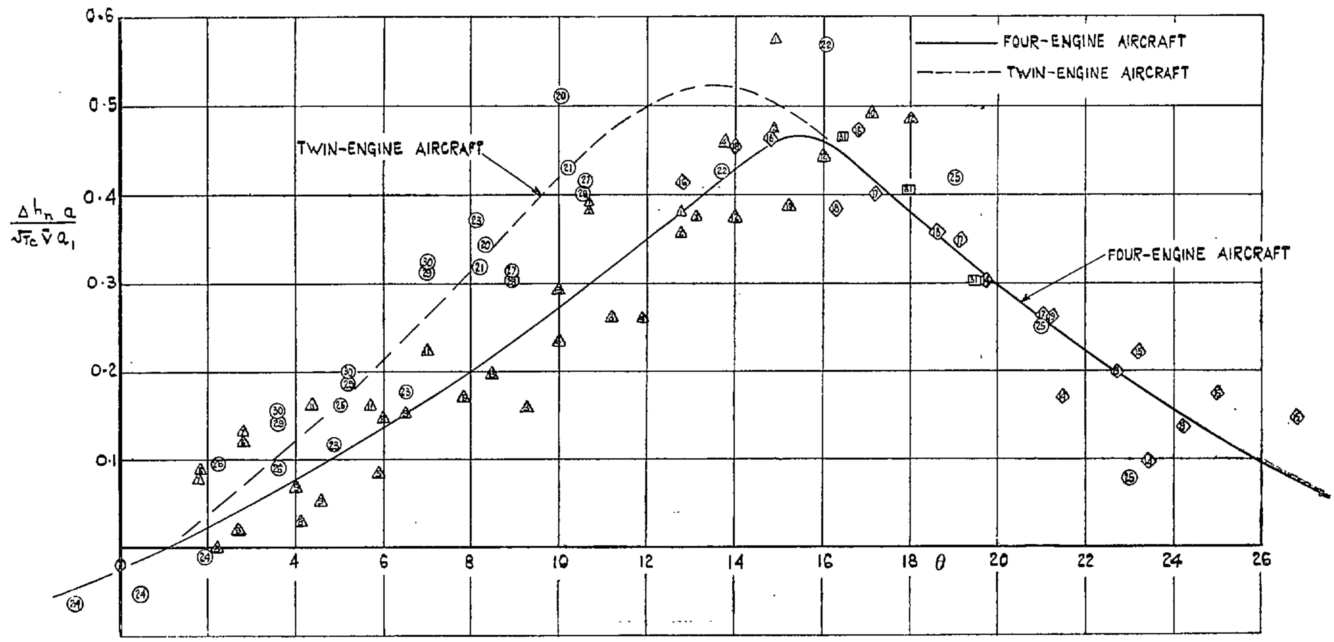

FIG. 3. $\Delta h_n a/\sqrt{T_c}\,.\,\bar{V}a_1$ plotted against θ (deg).

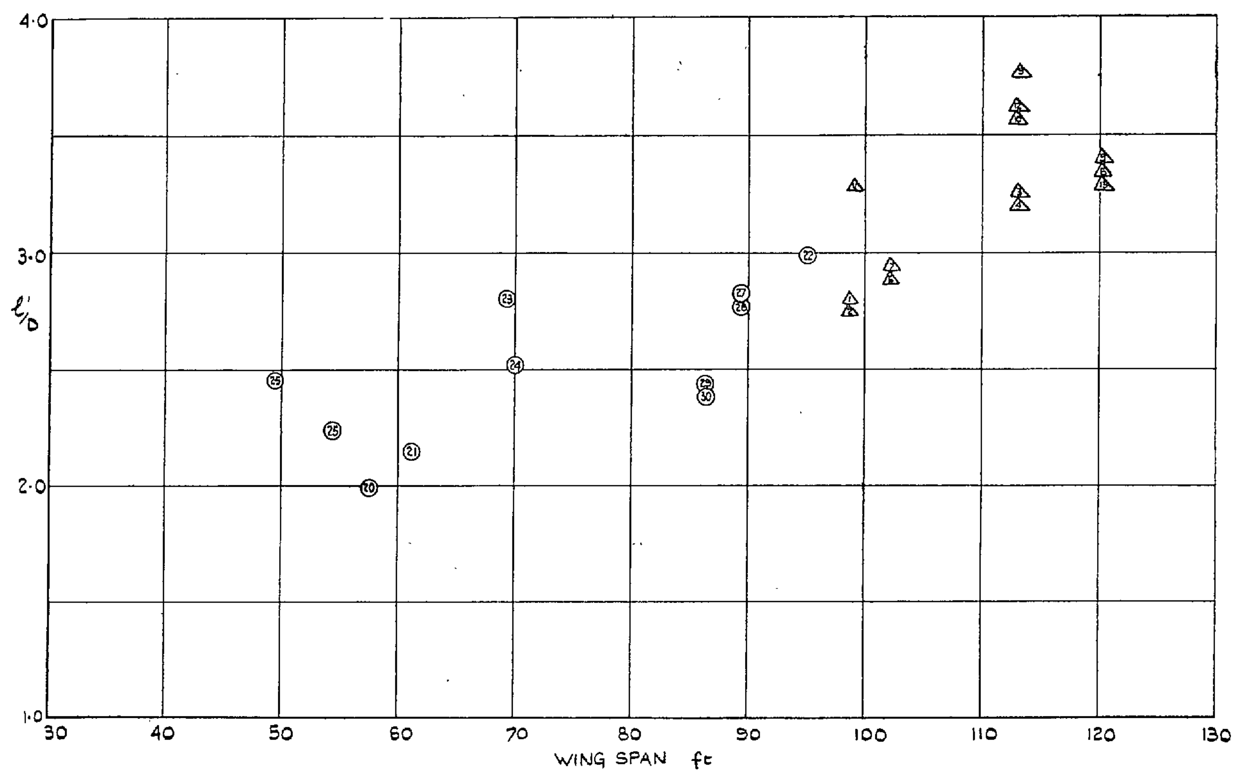

FIG. 4. l'/D plotted against wing span.

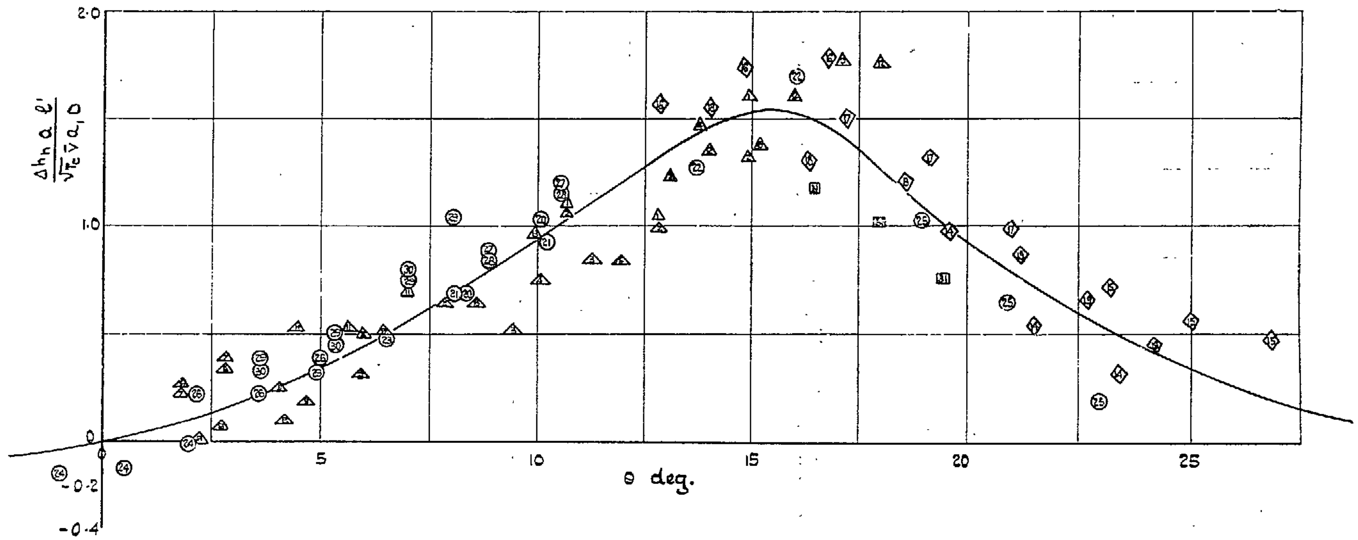

FIG. 5. $\Delta h_n al'/\sqrt{T_c}\,.\,\bar{V}a_1D$ plotted against θ (deg).

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TABLE I

	FLAP CONDITION	AIRCRAFT	SYMBOL	WHERE ESTABLISHED	REPORT REFERENCE	REF. No	SPAN	TAIL VOLUME RATIO $\bar{V}$	a/a_1	$\phi°$	l'/D	C_L	h_n POWER OFF	h_n POWER ON	Δh_{n_1}	Δh_n DUE TO THRUST MOMENT	Δh_n	$\sqrt{T_c}$	$\frac{\Delta h_n}{\sqrt{T_c}}$	$\frac{\Delta h_n a}{\sqrt{T_c}\bar{V}a_1}$	$\frac{\Delta h_n a l}{\sqrt{T_c}\bar{V}a_1 D}$	$\theta°$	C_L	h_n POWER OFF	h_n POWER ON	Δh_{n_1}	Δh_n DUE TO THRUST MOMENT	Δh_n	$\sqrt{T_c}$	$\frac{\Delta h_n}{\sqrt{T_c}}$	$\frac{\Delta h_n a}{\sqrt{T_c}\bar{V}a_1}$	$\frac{\Delta h_n a l}{\sqrt{T_c}\bar{V}a_1 D}$	$\theta°$	C_L	h_n POWER OFF	h_n POWER ON	Δh_{n_1}	Δh_n DUE TO THRUST MOMENT	Δh_n	$\sqrt{T_c}$	$\frac{\Delta h_n}{\sqrt{T_c}}$	$\frac{\Delta h_n a}{\sqrt{T_c}\bar{V}a_1}$	$\frac{\Delta h_n a l}{\sqrt{T_c}\bar{V}a_1 D}$	$\theta°$
FOUR ENGINES	UP	HALIFAX	△1	AAEE	AAEE/760, b	5	98·6	0·530	1·25	15·0	2·77	0·3	0·452	0·399	0·053	-0·008	0·045	0·185	0·243	0·574	1·590	14·9	0·6	0·436	0·380	0·056	-0·008	0·048	0·302	0·159	0·375	1·039	12·8	0·9	0·438	0·365	0·073	-0·008	0·065	0·395	0·165	0·389	1·078	10·7
	"	HALIFAX	△2	AAEE	AAEE/760, b	5	98·6	0·530	1·25	15·0	2·77	0·3	0·459	0·414	0·045	-0·008	0·037	0·185	0·200	0·472	1·307	14·9	0·6	0·448	0·395	0·053	-0·008	0·045	0·300	0·150	0·354	0·981	12·8	0·9	0·457	0·385	0·072	-0·008	0·064	0·395	0·162	0·382	1·058	10·7
	"	HASTINGS (S.T/P)*	△3	HANDLEY PAGE	0/HASTINGS/PRO/11/12	6	113	0·726	1·05	14·75	3·25	0·3	0·341	0·274	0·067	-0·020	0·047	0·188	0·259	0·375	1·219	13·1	0·6	0·340	0·267	0·073	-0·020	0·053	0·297	0·178	0·258	0·839	11·2	0·9	0·336	0·270	0·066	-0·024	0·042	0·389	0·108	0·156	0·507	9·3
	"	HASTINGS (L.T/P)*	△4	HANDLEY PAGE	0/HASTINGS/PRO/22/23	7	113	0·885	1·02	15·0	3·21	0·3	0·429	0·339	0·090	-0·016	0·074	0·186	0·398	0·459	1·473	13·8	0·6	0·425	0·340	0·085	-0·020	0·065	0·292	0·223	0·257	0·825	11·9	0·9	0·413	0·300	0·113	-0·032	0·081	0·403	0·201	0·232	0·745	10·0
	"	HERMES II	△5	HANDLEY PAGE	UNPUBLISHED		113	1·025	1·02	11·0	3·76	0·3	0·485	0·440	0·045	-0·016	0·029	0·171	0·170	0·168	0·632	7·8	0·6	0·422	0·380	0·042	-0·019	0·023	0·284	0·081	0·080	0·301	5·9	0·9	0·415	0·370	0·045	-0·021	0·024	0·372	0·065	0·064	0·241	4·0
	"	LANCASTER I	△6	RAE	AERO 1799	8	102	0·536	1·25	5·5	2·92	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·389	0·392	-0·003	0·018	0·015	0·291	0·052	0·120	0·350	2·8	0·9	0·389	0·397	-0·008	0·023	0·015	0·400	0·038	0·087	0·254	1·8
	"	LANCASTER VI	△7	AAEE	AAEE/766, d	9	102	0·536	1·25	6·0	2·92	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·396	0·395	0·001	0·014	0·015	0·272	0·055	0·128	0·374	2·8	0·9	0·396	0·400	-0·004	0·016	0·012	0·358	0·034	0·078	0·228	1·8
	"	LINCOLN (S.T/P)*	△8	AAEE	AAEE/822	10	120	0·619	1·23	6·0	3·38	0·3	0·520	0·520	0·000	0·012	0·012	0·164	0·073	0·145	0·490	6·0	0·6	0·530	0·538	-0·008	0·012	0·004	0·278	0·014	0·027	0·091	4·1	0·9	0·530	0·546	-0·016	0·016	0·00	0·366	0·00	0·0	0·000	2·2
	"	LINCOLN (L.T/P)*	△9	AAEE	AAEE/822	11	120	0·716	1·28	6·4	3·38	0·3	0·489	0·487	0·002	0·012	0·014	0·164	0·085	0·152	0·514	6·5	0·6	0·529	0·533	-0·004	0·012	0·008	0·275	0·029	0·052	0·176	4·6	0·9	0·556	0·568	-0·012	0·016	0·004	0·366	0·011	0·019	0·064	2·7
	"	SEAFORD	△10	MAEE	MAEE F/170	12	112·8	0·504	1·24	15·0	3·57	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·422	0·370	0·052	0·008	0·060	0·300	0·200	0·492	1·756	17·1	0·9	0·395	0·344	0·051	0·012	0·063	0·403	0·156	0·384	1·371	15·2
	"	STIRLING	△11	AAEE	AAEE/RES/157	13	99	0·600	1·06	6·5	3·28	0·3	0·417	0·400	0·017	0·002	0·019	0·150	0·126	0·224	0·735	7·0	0·6	0·428	0·407	0·021	0·002	0·023	0·255	0·090	0·160	0·525	5·7	0·9	0·447	0·420	0·027	0·004	0·031	0·342	0·091	0·161	0·525	4·4
	"	SUNDERLAND	△12	MAEE	MAEE H/RES/155	14	112·8	0·357	1·29	15·0	3·62	0·3	0·347	0·346	0·001	0·024	0·025	0·187	0·134	0·483	1·748	18·0	0·6	0·347	0·338	0·009	0·028	0·037	0·303	0·122	0·441	1·596	16·0	0·9	0·347	0·341	0·006	0·036	0·042	0·409	0·103	0·371	1·343	14·0
	"	TUDOR	△13	A.V. ROE	UNPUBLISHED		120	0·840	1·09	14·0	3·30	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·369	0·284	0·085	-0·008	0·077	0·344	0·224	0·291	0·960	10·0	0·9	0·354	0·279	0·075	-0·008	0·067	0·448	0·150	0·195	0·644	8·5
	DOWN (40°)	HASTINGS (S.T/P)*	◇14	HANDLEY PAGE	0/HASTINGS/PRO/11/12	6	113	0·726	1·05	—	3·25	0·6	0·317	0·277	0·040	-0·020	0·020	0·297	0·068	0·097	0·315	23·4	0·9	0·315	0·246	·069	-0·024	0·045	0·389	0·116	0·167	0·543	21·5	1·2	0·312	0·185	0·127	-0·026	0·101	0·489	0·207	0·301	0·978	19·6
	" (80°)	HASTINGS (S.T/P)*	◇15	HANDLEY PAGE	0/HASTINGS/PRO/11/12	7	113	0·726	1·05	—	3·25	0·6	0·322	0·272	0·050	-0·020	0·030	0·297	0·101	0·146	0·475	26·8	0·9	0·328	0·258	0·070	-0·024	0·046	0·389	0·118	0·171	0·556	25·0	1·2	0·355	0·254	0·101	-0·026	0·075	0·489	0·153	0·222	0·722	23·2
	" (40°)	HERMES II	◇16	HANDLEY PAGE	UNPUBLISHED		113	1·025	1·02	—	3·76	0·6	0·448	0·295	0·153	-0·019	0·134	0·284	0·472	0·470	1·770	16·8	0·9	0·448	0·255	0·193	-0·021	0·172	0·372	0·462	0·460	1·730	14·8	1·2	0·448	0·236	0·212	-0·022	0·190	0·456	0·415	0·413	1·556	12·8
	" (80°)	HERMES II	◇17	HANDLEY PAGE	UNPUBLISHED		113	1·025	1·02	—	3·76	0·6	0·385	0·291	0·094	-·019	0·075	0·284	0·264	0·263	0·992	21·0	0·9	0·440	0·290	0·150	-0·021	0·129	0·372	0·348	0·246	1·300	19·1	1·2	0·470	0·270	0·200	-0·022	0·178	0·456	0·400	0·398	1·495	17·2
	" (56·5°)	LINCOLN (L.T/P)*	◇18	AAEE	AAEE / 822	10	120	0·755	1·28	—	3·38	0·6	0·516	0·450	0·066	-0·008	0·058	0·276	0·210	0·356	1·203	18·6	0·9	0·516	0·417	0·099	-0·016	0·083	0·368	0·226	0·384	1·298	16·3	1·2	0·516	0·377	0·139	-0·020	0·119	0·444	0·268	0·454	1·535	14·0
	" (56·5°)	TUDOR	◇19	A.V. ROE	UNPUBLISHED		120	0·840	1·09	—	3·30	0·9	0·400	0·346	0·054	-0·008	0·046	0·448	0·103	0·136	0·449	24·2	1·2	0·375	0·283	0·092	-0·009	0·083	0·544	0·153	0·198	0·653	22·7	1·5	0·400	0·265	0·135	-0·009	0·126	0·625	0·202	0·262	0·865	21·2
TWO ENGINES	UP	BEAUFIGHTER	○20	RAE	R & M 2191	15	57·8	0·500	1·15	11·5	1·99	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·310	0·245	0·065	0·00	0·065	0·292	0·223	0·510	1·015	10·1	0·9	0·304	0·245	0·059	0·00	0·059	0·400	0·148	0·340	0·677	8·3
	"	BOSTON	○21	RAE	R & M 2191	15	61·2	0·685	1·31	10·0	2·14	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·428	0·372	0·056	0·004	0·060	0·268	0·224	0·428	0·916	10·2	0·9	0·406	0·350	0·056	0·004	0·060	0·361	0·166	0·318	0·681	8·2
	"	DAKOTA	○22	RAE	UNPUBLISHED		95	0·660	1·34	15·5	2·98	0·3	0·384	0·314	0·070	-0·004	0·066	0·235	0·281	0·570	1·699	16·1	0·6	0·348	0·265	0·083	-0·004	0·079	0·379	0·208	0·424	1·264	13·7	0·9	—	—	—	—	—	—	—	—	—	—
	"	HAMPDEN	○23	RAE	BA 1631	16	69·4	0·530	1·18	8·0	2·81	0·3	0·295	0·252	0·043	0·0	0·043	0·259	0·166	0·370	1·040	8·1	0·6	0·289	0·259	0·030	0·000	0·030	0·384	0·078	0·174	0·489	6·5	0·9	0·288	0·259	0·029	0·000	0·029	0·566	0·051	0·114	0·320	4·9
	"	INVADER	○24	NACA	NACA/TIB/1306	17	70	0·795	1·18	5·0	2·52	0·3	0·358	0·363	-0·005	0·004	-0·001	0·151	-0·007	-0·01	-0·025	2·0	0·6	0·332	0·345	-0·013	0·004	-0·009	0·251	-0·036	-0·053	-0·134	0·5	0·9	0·320	0·338	-0·018	0·004	-0·014	0·318	-0·044	-0·065	-0·164	-1·0
	"	LOCKHEED 12A	○25	RAE	BA 1504	18	49·5	0·775	1·14	22·5	2·45	0·3	0·475	0·443	0·032	-0·022	0·010	0·195	0·051	0·075	0·184	23·0	0·6	0·475	0·392	0·083	-0·028	0·055	0·308	0·179	0·262	0·642	21·0	0·9	0·475	0·324	0·151	-0·034	0·117	0·412	0·285	0·418	1·024	19·0
	"	MOSQUITO	○26	RAE	R & M 2371	19	54·2	0·493	1·12	6·5	2·23	0·3	0·315	0·306	0·009	0·004	0·013	0·182	0·071	0·162	0·362	5·0	0·6	0·316	0·308	0·008	0·004	0·012	0·293	0·041	0·093	0·207	3·6	0·9	0·316	0·304	0·012	0·004	0·016	0·380	0·042	0·095	0·212	2·2
	"	VIKING	○27	VICKERS ARMSTRONG	VIK 1/1001/4	20	89·4	0·705	1·14	13·0	2·80	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·367	0·270	0·097	-0·006	0·091	0·354	0·257	0·416	1·165	10·6	0·9	0·367	0·270	0·097	-0·008	0·089	0·462	0·192	0·310	0·8681	8·9
	"	VIKING	○28	VICKERS ARMSTRONG	VIK 1/1001/4	20	89·4	0·705	1·14	13·0	2·80	0·3	—	—	—	—	—	—	—	—	—	—	0·6	0·359	0·255	0·104	-0·008	0·096	0·385	0·249	0·402	1·126	10·6	0·9	0·359	0·255	0·104	-0·008	0·096	0·504	0·190	0·307	0·860	8·9
	"	WELLINGTON	○29	RAE	UNPUBLISHED		86·2	0·520	1·20	8·5	2·42	0·3	0·284	0·261	0·023	0·006	0·029	0·212	0·137	0·314	0·760	7·0	0·6	0·284	0·261	0·023	0·006	0·029	0·354	0·082	0·189	0·457	5·3	0·9	0·284	0·261	0·023	0·006	0·029	0·459	0·063	0·145	0·351	3·6
	"	WELLINGTON	○30	RAE	UNPUBLISHED		86·2	0·560	1·15	8·5	2·42	0·3	0·304	0·277	0·027	0·006	0·033	0·212	0·156	0·318	0·770	7·0	0·6	0·304	0·277	0·027	0·006	0·033	0·354	0·093	0·191	0·462	5·3	0·9	0·304	0·277	0·027	0·006	0·033	0·459	0·072	0·147	0·356	3·6
	DOWN (58°)	INVADER	□31	NACA	NACA/TIB/1306	17	70	0·795	1·18	—	2·52	0·9	0·398	0·326	0·072	-0·009	0·063	0·311	0·202	0·300	0·756	19·5	1·2	0·408	0·302	0·106	-0·014	0·092	0·340	0·271	0·402	1·013	18·0	1·5	0·417	0·288	0·129	-0·016	0·113	0·360	0·314	0·465	1·172	15·5

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