8. CLASS I METHOD FOR EMPENNAGE SIZING AND DISPOSITION AND FOR CONTROL SURFACE SIZING AND DISPOSITION

The purpose of this chapter is to present a step-by-step method for deciding on the size and disposition of the empennage as well as on the size and disposition of the longitudinal and directional control surfaces. The method is presented as part of Step 8 in p.d. sequence I as outlined in Chapter 2.

Section 8.1 presents the method while Section 8.2 contains three example applications.

8.1 STEP-BY-STEP METHOD FOR EMPENNAGE SIZING AND DISPOSITION AND FOR CONTROL SURFACE SIZING AND DISPOSITION

Step 8.1: Decide on the overall empennage configuration to be used.

The possibilities which present themselves were already discussed in sub-section 3.3.5. The reader should consult that sub-section and make a decision.

As a general rule, the horizontal tail should not be placed directly in the propeller slipstream. By referring to section 3.1 the reader will observe that many airplanes in fact do have the horizontal tail in the slipstream. The reasons against this arrangement are:

a.) The slipstream will usually cause the tail to buffet which leads to structure-borne cabin noise. Tail buffet can also lead to early structural fatigue.

b.) Rapid power increases or decreases called for by the pilot can result in undesirably large trim changes.

These comments also apply to canards. There is not usually a problem with a vertical tail mounted in the slipstream at the aft end of a fuselage.

Note: Single engine propeller driven airplanes usually do have the empennage mounted in the slipstream. This does enhance elevator effectiveness and rudder effectiveness during the take-off roll. On the other hand, it also causes considerable tail buffet during the take-off roll in some airplanes.

Step 8.2: Determine the disposition of the empennage.

Having decided on the overall empennage configuration in Step 8.1 the location of the empennage components on the airplane should now be decided. This amounts to deciding on the empennage moment arms x_h, x_v and x_c as defined in Figure 8.1. These empennage moment arms can be determined from the general arrangement drawing of the fuselage which was prepared in Chapter 4.

To keep the airplane weight and drag down as much as possible it is obviously desirable to keep the empennage area as small as possible. This in turn can be achieved by locating the empennage components at as large a moment arm as possible relative to the critical center of gravity (aft c.g. for conventional layouts and forward c.g. for a canard).

Note: in some airplanes (carrier based airplanes are one example) severe restrictions are place on the allowable length, height and width!

Step 8.3: Determine the size of the empennage.

Three types of configurations will be considered:

a. Conventional configurations

b. Canard configurations

c. Three-surface configurations

d. Butterfly empennage configurations

a. Conventional configurations.

Sizing the empennage for a conventional configuration means deciding on the magnitude of S_h and S_v.

For a first 'cut' at the size of either the vertical or the horizontal tail, the so-called $\bar{V}$-method is often used. The tail volume coefficients are defined as follows:

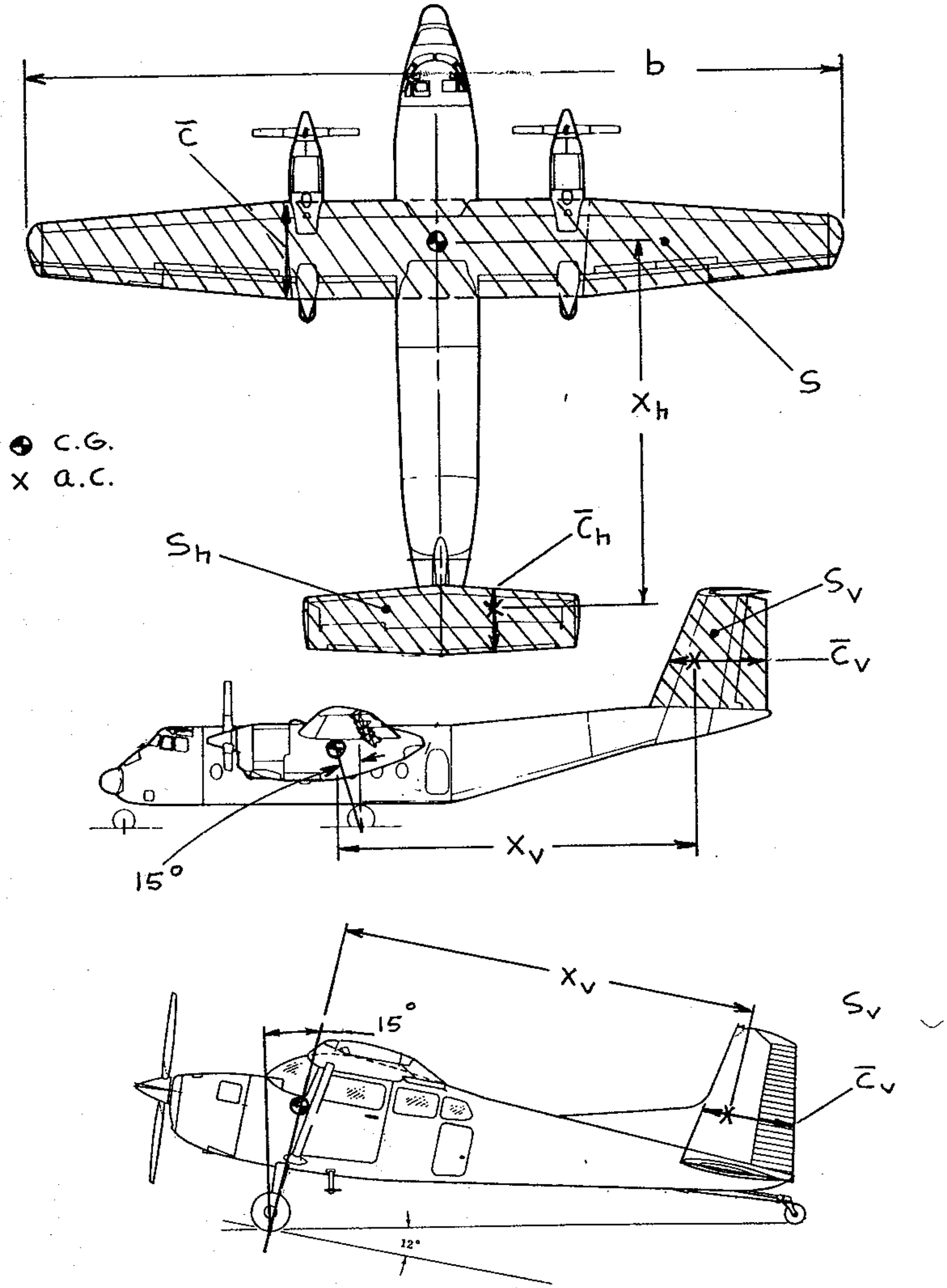


Figure 8.1 Definition of Volume Coefficient Quantities

$$\bar{V}_h = x_h S_h / S\bar{c} \quad (8.1)$$

$$\bar{V}_v = x_v S_v / Sb \quad (8.2)$$

Figure 8.1 defines the various quantities in Equations (8.1) and (8.2).

Tables 8.1 through 8.12 present the values of tail volume coefficients for twelve types of airplanes.

Having determined which type airplane best fits the airplane being designed, suitable values for $\bar{V}_h$ and $\bar{V}_v$ are selected. This can be done by averaging or by comparison to specific types. In deciding which value for $\bar{V}_v$ to use, care must be taken that the lateral disposition of the engines is not too dissimilar. Note that vertical tail sizes are often dictated by the engine-out (i.e. V_{mc}) condition. Section 11.3 contains a vertical tail sizing procedure for V_{mc}.

Having selected the volume coefficients, and having determined the moment arms x_h and x_v from the fuselage arrangement sketches mentioned in Step 8.2, the tail areas can be computed from:

$$S_h = \bar{V}_h S\bar{c} / x_h \quad (8.3)$$

$$S_v = \bar{V}_v Sb / x_v \quad (8.4)$$

The reader will have noted from the supersonic fighter configurations of Figures 3.25a and 3.27b that twin vertical tails are sometimes used. This is often done to avoid a very large single fin. The lateral placement of these twin verticals is a critical problem because of vortex shedding from the fuselage. These vortices can cause structural fatigue as well as a reduction in tail effectiveness.

b. Canard configurations.

The concept of volume coefficients can in principle be extended to a canard configuration. The problem is

Table 8.1a) Homebuilt Airplanes: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip $fr.c_h$
PIK-21	76.4	4.50	64212	10.4	0.45	10.1	0.30	0.45
Duruble RD-03C	119	4.30	23018/23012	22.2	0.33	11.3	0.49	.47/.32
PIEL								
CP-750	118	3.82	23012	23.5	0.51	12.6	0.66	.55/.47
CP-90	104	3.81	NA	22.3	0.50	11.8	0.66	.56/.38
POTTIER								
P-50R	80.7	3.74	23015/23012	13.4	0.52	10.6	0.47	.50/.55
P-70S	77.5	4.10	4415	14.5	0.60	9.68	0.44	0.60
O-O Aerosport	80.7	3.77	23012	15.4	0.48	10.6	0.54	0.48
Aerocar Micro-Imp	81.0	3.00	GA(Pc)-1	11.7	0.25	6.27	0.30	.28/.33
Coats SA-III	112	4.50	63415	16.5	0.46	10.9	0.36	0.46
Sequoia 300	130	4.37	64_2A215/64A210	25.5	0.43	13.2	0.59	0.43
Ord-Hume OH-4B	125	5.25	RAF48	25.4	0.49	11.1	0.43	0.49
Procter Petrel	135	4.54	3415	26.0	0.52	12.2	0.52	0.52
Bede BD-8	96.7	5.0	$63_2$015	19.4	0.14	7.64	0.31	0.17

0.467

* Unless otherwise indicated.

Table 8.1b) Homebuilt Airplanes: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip $fr.c_v$	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out $fr.c_w$
PIK-21	76.4	17.0	3.49	0.33	10.5	0.028	.24/.49	0.130	0/1.0	0.13
Duruble RD-03C	119	28.7	8.35	0.30	12.5	0.031	.38/.32	0.063	.63/.93	.22/.24
PIEL										
CP-750	118	26.4	9.49	0.55	12.9	0.039	.50/.64	0.077	.44/.96	.19/.14
CP-90	104	23.6	7.64	0.50	11.9	0.037	.47/.54	0.092	.42/.91	.22/.18
POTTIER										
P-50R	80.7	20.3	11.3	0.42	10.4	0.072	.34/.61	0.067	.60/.98	.24/.22
P-70S	77.5	19.4	4.36	0.67	10.5	0.031	.59/.76	0.082	.52/.88	0.20
O-O Aerosport	80.7	21.3	6.86	0.38	10.0	0.040	.34/.44	0.080	.54/.97	0.19
Aerocar Micro-Imp	81.0	27.0	7.15	0.31	6.27	0.020	.33/.43	0.140	.07/.95	0.16
Coats SA-III	112	25.0	7.53	0.44	10.6	0.028	.35/.68	0.130	.55/1.0	0.26
Sequoia 300	130	30.0	16.5	0.31	13.2	0.055	.27/.43	0.085	.60/.95	0.29
Ord-Hume OH-4B	125	25.0	6.73	0.71	12.5	0.027	.57/1.0	0.110	.35/.91	0.20
Procter Petrel	135	30.0	11.7	0.35	11.4	0.033	.31/.57	0.097	.62/.98	0.26
Bede BD-8	96.7	19.3	6.89	0.24	8.65	0.032	.20/.34	0.083	.53/.92	0.22

Table 8.2a) Single Engine Propeller Driven Airplanes: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
CESSNA								
Skywagon 207	174	4.55	2412	44.9	0.45	16.2	0.92	.48/.47
Cardinal RG	174	4.79	64A215/64A412	35.0	1.00	14.3	0.60	stabilator
Skylane RG	174	4.52	2412	38.8	0.41	14.3	0.71	.47/.39
PIPER								
Cherokee Lance	175	5.25	$65_{2}415$	34.6	1.00	16.1	0.61	stabilator
Warrior	170	4.44	$65_{2}415$	26.5	1.00	13.5	0.48	stabilator
Turbo Saratoga SP	178	4.71	NA	36.2	1.00	16.2	0.70	stabilator
Bellanca Skyrocket	183	5.30	$63_{2}215$	42.6	0.38	13.8	0.61	.36/.42
Grumman Tiger	140	4.44	NA	37.6	0.28	12.6	0.76	0.39
Rockwell Commander	152	4.58	63415	31.2	0.34	10.9	0.49	.33/.44
Trago Mills SAH-1	120	3.94	2413.6	22.0	0.46	17.8	0.83	0.46
Scottish Aviation Bullfinch	129	3.97	$63_{2}615$	27.5	0.58	11.9	0.63	0.45

* Unless otherwise indicated.

Table 8.2b) Single Engine Propeller Driven Airplanes: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out fr.c_w
CESSNA										
Skywagon 207	174	35.8	16.0	0.44	18.0	0.046	.46/.46	0.10	.61/.94	.25/.22
Cardinal RG	174	35.5	17.4	0.37	13.5	0.038	.35/.43	0.11	.65/.97	.38/.37
Skylane RG	174	35.8	18.6	0.37	15.8	0.047	.41/.42	0.11	.47/.96	.17/.24
PIPER										
Cherokee Lance	175	32.8	13.8	0.31	15.3	0.037	.26/.50	0.064	.56/.88	0.20
Warrior	170	35.0	11.5	0.36	13.2	0.026	.29/.52	0.078	.48/.96	.27/.24
Turbo Saratoga SP	178	36.2	15.9	0.29	15.2	0.038	.23/.58	0.057	.52/.84	0.19
Bellanca Skyrocket	183	35.0	18.1	0.33	13.2	0.037	.28/.40	0.076	.60/1.0	.25/.22
Grumman Tiger	140	31.5	8.4	0.43	12.6	0.024	.36/.46	0.055	.56/.92	0.24
Rockwell Commander	152	32.8	17.0	0.28	11.4	0.039	.30/.46	0.072	.64/.97	.27/.36
Trago Mills SAH-1	120	30.7	17.1	0.40	18.6	0.086	.35/.54	0.080	.58/.97	.25/.29
Scottish Aviation Bullfinch	129	33.8	22.7	0.39	11.9	0.062	.35/.56	0.073	.61/.95	.23/.30

Table 8.3a) Twin Engine Propeller Driven Airplanes: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip $fr.c_h$
CESSNA								
310R	179	4.77	23018/23009	54.3	0.41	14.9	0.95	.42/.39
402B	196	4.77	23018/23009	60.7	0.29	16.5	1.07	.41/.39
414A	226	4.73	23018/23009	60.7	0.27	16.4	0.93	.37/.38
T303	189	4.9	23017/23012	48.1	0.42	14.9	0.78	.41/.44
PIPER								
PA-31P	229	5.79	$63_2415/63_2212$	68.7	0.44	16.2	0.84	.41/.51
PA-44-180T	184	4.34	NA	23.4	1.0	15.7	0.46	stabilator
Chieftain	229	6.00	$63_2A415/63_2A212$	61.4	0.38	16.1	0.72	0.38
Cheyenne I	229	5.69	$63_2A415/63_2A212$	70.5	0.40	15.7	0.85	.40/.41
Cheyen.III	293	7.33	$63_2A415/63_2A212$	61.8	0.39	23.7	0.68	.35/.44
BEECH								
Duchess	181	5.08	63_2A415	39.4	0.35	15.6	0.67	0.40
Duke B60	213	6.60	23016.5/23010.5	62.0	0.27	14.5	0.64	0.39
Lear Fan								
2100	163	4.36	NA	55.0	0.23	13.1	1.01	.36/.31
Rockwell								
Comdr 700	200	5.28	NA	55.4	0.37	19.7	1.03	0.37
Piaggio								
P166-DL3	286	6.06	230 series	51.6	0.27	17.2	0.51	.40/.50
EMB-121	296	6.62	NA	62.9	0.43	20.3	0.65	.39/.46

* Unless otherwise indicated

Table 8.3b) Twin Engine Propeller Driven Airplanes: Vertical Tail, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip $fr.c_v$	S_a/S	Ail. Span Loc. in/out $fr.b/2$	Ail. Chord in/out $fr.c_w$
CESSNA										
310R	179	36.9	26.1	0.45	15.9	0.063	.48/.41	0.064	.60/.90	.30/.29
402B	196	39.9	37.9	0.47	16.5	0.080	.48/.40	0.058	.64/.91	.29/.27
414A	226	44.1	41.3	0.38	17.0	0.071	.49/.37	0.061	.62/.87	.30/.28
T303	189	39.0	23.2	0.44	16.5	0.052	.46/.39	0.087	.64/.97	.31/.30
ConquestI	225	44.1	41.3	0.38	17.1	0.071	.47/.34	0.060	.61/.86	0.29
PIPER										
PA-31P	229	40.7	30.1	0.38	17.2	0.056	.37/.40	0.056	.59/.97	.24/.29
PA44-180T	184	38.6	21.5	0.37	14.4	0.044	.30/.50	0.077	.45/.90	.19/.18
Chieftain	229	40.7	29.5	0.40	17.3	0.055	.40/.38	0.060	.66/.98	.24/.30
Cheyen. I	229	42.7	26.5	0.40	16.5	0.045	.37/.42	0.057	.62/.93	.24/.29
Cheye.III	293	47.7	43.6	0.46	20.8	0.065	0.33	0.046	.66/.94	.23/.26
BEECH										
Duchess	181	38.0	25.6	0.29	14.2	0.053	.34/.42	0.059	.67/.97	0.28
Duke B60	213	39.3	28.8	0.43	17.4	0.060	.44/.46	0.054	.50/.84	.24/.26
Lear Fan										
2100	163	39.3	44.4	0.17	14.0	0.097	.32/.34	0.044	.72/.98	.31/.24
Rockwell										
Comdr 700	200	42.5	39.9	0.38	20.5	0.096	.37/.38	0.087	.58/.99	.28/.24
Piaggio										
P166-DL3	286	48.2	30.7	0.43	18.3	0.041	.38/.43	0.073	.61/.94	.19/.22
EMB-121	296	46.4	42.6	0.45	17.8	0.055	.42/.41	0.052	.71/.97	0.22

Table 8.4a) Agricultural Airplanes: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip $fr.c_h$
PZL-104	167	4.60	2415	34.0	0.60	17.3	0.77	0.51
PZL-106A	306	6.23	Clark Y	81.4	0.56	18.6	0.79	.30/.50
PZL-M18	431	7.50	4416/4412	70.0	0.49	17.4	0.38	0.49
NDN-6	338	6.71	NA	60.4	0.36	17.4	0.46	0.36
EMB201A	215	5.63	23015	50.3	0.32	13.6	0.56	0.56
Cessna Ag Husky	205	4.55	2412	40.7	0.41	15.6	0.68	.43/.37
Schweizer Ag-Cat B	392	4.83	4412	45.0	0.49	12.9	0.31	.38/.60
Aero Boero 260Ag	189	5.29	23012	25.5	0.41	14.1	0.36	0.44
Let Z-37A	256	5.91	33015/43012A	54.1	0.41	16.8	0.60	.44/.42
Hal HA-31	251	6.54	USA35B	45.6	0.43	17.9	0.50	0.46
IAR-822	280	6.90	23014	48.4	0.44	17.4	0.44	0.46
Piper PA-36	226	6.22	63_1618	43.3	0.48	15.0	0.46	.38/.62

* Unless otherwise indicated.

Table 8.4b) Agricultural Airplanes: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip $fr.c_v$	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out $fr.c_w$
PZL-104	167	36.5	20.3	0.49	16.1	0.054	.41/.50	0.10	.58/.94	0.25
PZL-106A	306	48.5	31.0	0.56	17.1	0.036	.45/.51	0.087	.53/.96	0.22
PZL-M18	431	58.1	28.5	0.65	18.5	0.021	.50/.46	0.11	.59/.92	0.32
NDN-6	338	50.3	31.0	0.54	18.4	0.034	.50/.64	0.047	.73/1.0	.19/.14
EMB201A	215	38.4	13.0	0.52	14.1	0.022	.39/.36	0.08	.57/.90	0.19
Cessna Ag Husky	205	41.7	18.5	0.38	16.2	0.034	.32/.39	0.11	.53/.94	.27/.28
Schweizer Ag-Cat B	392	42.3	30.0	0.40	13.5	0.024	.25/.31	0.08	.53/.86	0.29
Aero Boero 260Ag	189	35.8	9.94	0.39	15.1	0.022	.32/.51	0.11	.52/.94	.20/.19
Let Z-37A	256	40.1	22.1	0.52	15.3	0.033	.59/.65	0.086	.64/1.0	0.32
HAL HA-31	251	39.4	20.7	0.45	16.6	0.035	.50/.46	0.092	.55/.89	0.28
IAR-822	280	42.0	22.9	0.69	17.9	0.035	.56/.64	0.11	.63/.98	0.27
Piper PA-36	226	38.8	19.9	0.49	16.5	0.038	.59/.21	0.096	.52/.92	0.28

Table 8.5a) Business Jets: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
DASSAULT-BREGUET								
Falcon 10	259	6.71	NA	72.7	0.20	16.5	0.69	.31/.29
Falcon 20	440	9.33	NA	122	0.22	21.9	0.65	.28/.31
Falcon 50	495	9.31	NA	144	0.23	21.7	0.68	.31/.34
CESSNA CITATION								
500	260	6.44	23014/23012	70.6	0.29	17.3	0.73	.32/.23
II	323	6.77	NA	73.1	0.36	19.2	0.64	.37/.35
III	312	6.07	NASA Sprcrt	69.6	0.34	26.9	0.99	.39/.42
GATES LEARJET								
24	232	7.03	64A109	54.0	0.26	20.2	0.67	.36/.26
35A	253	7.22	64A109	54.0	0.33	21.9	0.65	.33
55	265	6.88	NA	57.8	0.32	23.8	0.76	.31/.35
Canadair Challenger								
CL-601	450	11.3	NA	105	0.28	32.2	0.67	.30/.31
Aerospatiale								
SN-601	237	5.60	NA	58.9	0.42	16.7	0.74	.40/.44
ISRAEL AIRCRAFT IND.								
Astra	317	5.62	Sigma 2	77.1	0.25	22.8	0.99	.30/.32
Westwind	308	7.58	64A212	70.1	0.25	19.8	0.59	.29/.26
British Aerospace HS								
125-700	353	7.52	NA	100	0.48	19.1	0.72	.37/.67
G.A.-III	935	13.8	NA	184	0.33	35.6	0.51	0.33
MU Diam.I	241	6.23	NA	57.2	0.37	22.4	0.85	0.37

* Unless otherwise indicated.

Table 8.5b) Business Jets: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out fr.c_w
DASSAULT BREGUET										
Falcon 10	259	42.9	48.9	0.32	14.4	0.063	.34/.49	0.051	.67/.95	.27/.31
Falcon 20	440	53.5	81.8	0.23	18.1	0.063	.25/.39	0.057	.62/.92	0.25
Falcon 50	495	61.9	106	0.12	18.7	0.064	.21/.32	0.049	.68/.97	0.27
CESSNA CITATION										
500	260	43.9	50.9	0.36	18.2	0.081	0.36	0.096	.55/.94	.32/.30
II	323	51.7	53.0	0.34	19.36	0.062	.35/.31	0.078	.56/.89	.32/.30
III	312	53.5	70.2	0.30	20.5	0.086	.37/.38	NA*	.70/.86	.21/.17
GATES LEARJET										
24	232	35.6	38.4	0.17	16.6	0.077	.23/.22	0.050	.63/.89	.25/.23
35A	253	38.1	38.4	0.17	16.6	0.066	.26/.25	0.066	.55/.79	.30/.27
55	265	43.8	52.4	0.17	19.2	0.086	.26/.25	0.062	.49/.71	0.30
Can.CL601	450	64.3	96.0	0.26	24.9	0.083	.29/.31	0.033	.73/.91	.23/.26
Aerospatiale										
SN-601	237	42.2	45.4	0.30	15.7	0.071	.36/.32	0.033	.68/.91	.22/.20
ISRAEL AIRCRAFT IND.										
Astra	317	52.7	48.3	0.21	22.0	0.064	.33/.32	0.040	.67/.95	.26/.25
Westwind	308	44.8	59.7	0.18	20.1	0.087	.34/.44	0.050	.59/.90	.21/.31
British Aerospace HS										
125-700	353	47.0	63.8	0.22	15.9	0.061	.31/.37	0.084	.66/1.0	.33/.46
G.A. III	935	77.8	159	0.24	26.9	0.059	0.28	0.038	.66/.86	.24/.27
MU Diam.I	241	43.4	55.9	0.25	17.4	0.093	.33/.28	0.012	.86/.94	.20/.22

* Also uses spoilers for lateral control

Table 8.6a) Regional Turboprop Airplanes: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
CASA C-212-200								
	431	6.68	653-218	135	0.35	24.9	1.17	.49/.53
SHORTS								
330	453	6.06	NA	83.6	0.33	27.3	0.83	0.50
360	453	6.06	NA	106	0.39	33.0	1.28	0.48
BEECH								
1900	303	5.35	23018/23015	71.3	0.43	30.3	1.33**	.43/.48
B200	303	5.35	23018.5/23011.3	68.0	0.28	24.6	0.91	0.42
CESSNA CONQUEST			*** I airfoils carry -63 mod.					
I***	225	4.73	23018/23009	62.0	0.33	16.4	0.95	.36/.43
II	254	4.98	23018/23009	63.4	0.29	18.0	0.90	.43/.40
GA Ic	610	8.28	NA	134	0.26	36.5	0.97	.29/.32
GAF N22B	324	5.94	23018	78.0	1.00	20.6	0.83	stabilator
Fokker F27-200								
	754	8.43	64-421/64-415	172	0.27	36.0	0.98	.29/.34
DeHAVILLAND CANADA								
DHC-6-300	420	6.50	NA	100	0.35	24.8	0.91	0.47
DHC-7	860	9.45	63A418/63A415	217	0.46	41.6	1.11	.42/.47
DHC-8	585	6.51	NA	154	0.42	36.3	1.47	.41/.43
EMB-120	409	6.57	23018/23012	108	0.39	31.7	1.27	.38/.44
BAe 31	270	5.27	63A418/63A412	84.0	0.46	20.7	1.22	.43/.48
Metro III	309	6.03	65_2A215/64_2A415	76.0	0.28	26.1	1.07	.31/.48

* Unless otherwise indicated. ** 1900 also has a small fixed stabilizer.

Table 8.6b) Regional Turboprop Airplanes: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out fr.c_w
CASA C-212-200										
	431	62.3	77.5	0.41	24.8	0.072	0.41	0.061	.69/1.0	.24/.26
SHORTS										
330	453	74.7	93.1	0.26	27.3	0.075	0.41	0.061	.70/.95	0.27
360	453	74.7	91.4	0.37	33.9	0.091	.39/.36	0.074	.69/.98	0.27
BEECH										
1900*	303	54.5	47.5	0.35	26.5	0.076	.40/.38	0.064	.60/1.0	0.21
B200	303	54.5	52.3	0.29	20.5	0.065	.47/.41	0.059	.60/1.0	0.21
CESSNA CONQUEST										
I	225	44.1	41.3	0.38	17.1	0.071	.46/.38	0.060	.61/.86	.29/.28
II	254	49.3	43.5	0.37	18.7	0.065	.48/.33	0.058	.62/.89	.30/.32
GA Ic	610	78.3	117	0.25	35.4	0.087	.29/.33	0.061	.65/.98	.27/.22
GAF N22B	324	54.2	70.2	0.44	21.6	0.086	.49/.43	0.085	.54/1.0	0.24
Fokker F27-200										
	754	95.2	153	0.30	36.0	0.077	.33/.29	0.050	.69/.98	.31/.29
DeHAVILLAND CANADA										
DHC-6-300	420	65.0	82.0	0.42	25.7	0.077	.35/.44	0.079	.44/.97	0.20
DHC-7	860	93.0	170	0.28	35.7	0.076	.25/.30	0.027	.81/1.0	.27/.31
DHC-8	585	84.0	190	0.26	31.4	0.121	.27/.35	0.031	.80/1.0	.23/.22
EMB-120	409	64.9	74.3	0.38	27.3	0.076	.32/.31	0.084	.63/.97	0.24
BAe 31	270	52.0	83.1	0.26	20.7	0.120	.34/.39	0.061	.59/.97	.28/.30
Metro III	309	57.0	56.0	0.35	27.9	0.089	.37/.56	0.046	.61/.98	.31/.36

* 1900 also has taillets on horizontal tail.

Table 8.7a) Jet Transports: Horizontal Tail Volume and Elevator Data

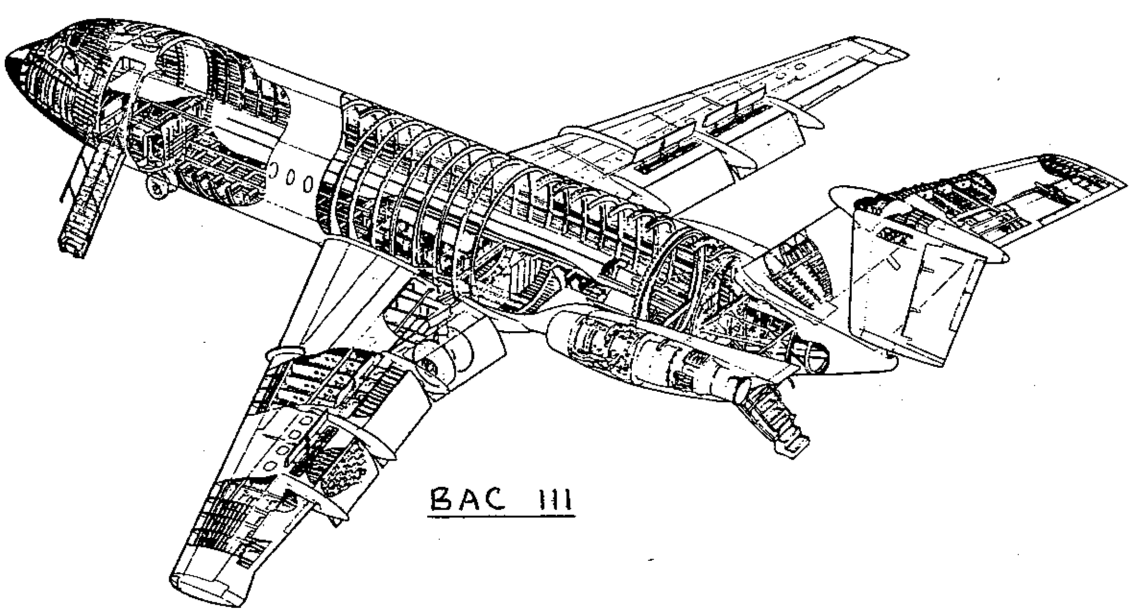
Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
BOEING								
727-200	1,700	18.0	BAC	376	0.25	67.0	0.82	.29/.31
737-200	980	11.2	BAC	321	0.27	43.8	1.28	.30/.32
737-300	1,117	10.9	BAC	330	0.24	49.7	1.35	.24/.34
747-200B	5,500	38.0	BAC	1,470	0.24	104.5	0.74	0.29
747SP	5,500	38.0	BAC	1,534	0.21	72.9	0.54	.32/.20
757-200	1,951	14.9	BAC	585	0.25	56.9	1.15	.29/.38
767-200	3,050	19.8	BAC	836	0.23	67.6	0.94	.30/.25
McDONNELL-DOUGLAS								
DC-9 S80	1,270	15.7	N.A.	314	0.34	61.4	0.96	.39/.38
DC-9-50	1,001	11.8	N.A.	276	0.38	56.8	1.32	.41/.47
DC-10-30	3,958	24.7	N.A.	1,338	0.22	65.9	0.90	.25/.30
AIRBUS								
A300-B4	2,799	19.2	N.A.	748	0.26	80.4	1.12	0.35
A310	2,357	19.3	N.A.	689	0.26	72.0	1.09	.33/.30
Lockheed L1011				geared elevator				
-500	3,541	24.5	N.A.	1,282	0.19	55.9	0.83	stabilator
Fokker F-28								
-4000	850	10.9	N.A.	210	0.20	47.2	1.07	.34/.33
Rombac/British Aerospace								
1-11 495	1,031	11.8	N.A.	258	0.27	40.7	0.86	.41/.35
British Aerospace								
146-200	832	10.2	N.A.	276	0.39	45.3	1.48	.42/.44
Tu-154	2,169	16.8	N.A.	436	0.18	58.9	0.71	.27/.25

Table 8.7b) Jet Transports: Vert. Tail Volume, Rudder, Aileron and Spoiler Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Inb'd Ail. Span in/out fr.b/2	Inb'd Ail. Chord in/out fr.c_w
BOEING										
727-200	1,700	108	422	0.16	47.4	0.110	.29/.28	0.034	.38/.46	.17/.24
737-200	980	93.0	233	0.24	40.7	0.100	.25/.22	0.024	none	none
737-300	1,117	94.8	239	0.31	45.7	0.100	.26/.50	0.021	none	none
747-200B	5,500	196	830	0.30	102	0.079	0.30	0.040	.38/.44	.17/.25
747-SP	5,500	196	885	0.27	69.5	0.057	.31/.34	0.040	.38/.44	.17/.25
757-200	1,951	125	384	0.34	54.2	0.086	.35/.33	0.027	none	none
767-200	3,050	156	497	0.35	64.6	0.067	.33/.36	0.041	.31/.40	.23/.20
McDONNELL-DOUGLAS										
DC-9 S80	1,270	108	168	0.39	50.5	0.062	.49/.46	0.030	none	none
DC-9-50	1,001	93.4	161	0.41	46.2	0.079	.45/.44	0.038	none	none
DC-10-30	3,958	165	605	0.18	64.6	0.060	0.35	0.047	.32/.39	.20/.25
AIRBUS										
A300-B4	2,799	147	487	0.30	79.5	0.094	.35/.36	0.049	.29/.39	.23/.27
A310	2,357	144	487	0.35	68.5	0.098	.33/.35	0.027	.32/.40	.23/.27
Lockheed L1011										
-500	3,541	164	550	0.23	58.2	0.055	.29/.26	0.051	.40/.49	.22/.23
Fokker F-28										
-4000	850	82.3	157	0.16	37.9	0.085	.29/.31	0.034	none	none
Rombac/British Aerospace										
1-11 495	1,031	93.5	117	0.28	31.6	0.038	.39/.37	0.030	none	none
British Aerospace										
146-200	832	86.4	224	0.44	38.9	0.12	0.29	0.046	none	none
Tu-154	2,169	123	341	0.27	43.3	0.055	0.37	0.036	none	none

Table 8.7c) Jet Transports: Vert. Tail Volume, Rudder, Aileron and Spoiler Data

Type	Outb'd Ail. Span in/out fr.b/2	Outb'd Ail. Chord in/out fr.c_w	Inb'd Spoiler Span Loc. in/out fr.b/2	Inb'd Spoiler Chord in/out fr.c_w	Inb'd Spoiler Hinge Loc. in/out fr.c_w	Outb'd Spoiler Span Loc. in/out fr.c_w	Outb'd Spoiler Chord in/out fr.c_w	Outb'd Spoiler Hinge Loc. in/out fr.c_w
BOEING								
727-200	.76/.93	.23/.30	.14/.37	.09/.14	.79/.69	.48/.72	.16/.20	.65/.63
737-200	.74/.94	.20/.28	.40/.66	.14/.18	.66/.67	none	none	none
737-300	.72/.91	.23/.30	.38/.64	0.14	.64/.70	none	none	none
747-200B	.70/.95	.11/.17	.46/.67	.12/.16	0.71	none	none	none
747-SP	.70/.95	.11/.17	.46/.67	.12/.16	0.71	none	none	none
757-200	.76/.97	.22/.36	.41/.74	.12/.13	.73/.69	none	none	none
767-200	.76/.98	.16/.15	.16/.31	.09/.11	.85/.78	.44/.67	.12/.17	.74/.71
McDONNELL-DOUGLAS								
DC-9 S80	.64/.85	.31/.36	.35/.60	.10/.08	.69/.65	none	none	none
DC-9-50	.78/.95	.30/.35	.35/.60	.10/.08	.69/.65	none	none	none
DC-10-30	.75/.93	.29/.27	.17/.30	.05/.06	.78/.74	.43/.72	.11/.16	.75/.70
AIRBUS								
A300-B4	.83/.99	.32/.30	.57/.79	.16/.22	.73/.72	none	none	none
A310	none	none	.62/.83	.16/.22	.69/.66	none	none	none
Lockheed L1011								
-500	.77/.98	.26/.22	.13/.39	.08/.12	.82/.73	.50/.74	.14/.14	.67/.67
Fokker F-28								
-4000	.66/.91	.29/.28	no lateral control spoilers					
Rombac/British Aerospace								
1-11 495	.72/.92	0.26	.37/.68	.06/.11	.68/.63	none	none	none
British Aerospace								
146-200	.78/1.0	.33/.31	.14/.70	.22/.27	.76/.68	none	none	none
Tu-154	.76/.98	.34/.27	.43/.70	.14/.20	.62/.60	none	none	none



BAC III

Table 8.8a) Military Trainers: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
Turbopropeller Driven								
EMB-312	209	5.77	63_2A415/63A212	49.2	0.44	16.9	0.69	.42/.44
Pil. PC-7	179	5.23	64_2A415/64_1A612	36.9	0.49	16.2	0.64	.49/.50
NDN 1T	126	5.4	23012	25.8	0.47	14.0	0.53	0.44
T-34C	180	4.01	23016.5/23012	37.2	0.37	14.8	0.76	.43/.44
Epsilon	96.9	3.97	RA1643/RA1243	21.5	0.48	13.8	0.77	.49/.54
SF-260M	109	4.35	$64_1$212/$64_1$210	26.0	0.40	12.7	0.70	.35/.56
Yak-52	162	5.20	Clark YH	30.8	0.54	13.3	0.49	.54/.60
Neiva T25	185	5.19	63_2A315/63_2A212	33.0	0.44	15.0	0.52	.46/.40
Jet Driven								
Aero L39C	202	7.04	64A012	54.6	0.23	15.2	0.58	.35/.44
Microturbo Microjet 200B	65.9	2.79	RA16.3C3	22.9	0.32	8.98	1.12	.37/.34
Dassault-Breguet/Dornier Alphajet	188	7.37	N.A.	42.4	1.0	14.1	0.43	stabilator
Aermacchi MB-339A	208	6.34	64A114/64A212	46.9	0.23	14.6	0.52	.26/.36
SM S-211	136	5.40	KU .17 sprcrt.	36.4	0.40	15.2	0.75	.41/.40
PZL TS-11	188	5.80	64209/64009	38.1	0.33	16.3	0.57	.31/.32
CASA C101	215	6.32	Norcasa 15	47.8	0.23	15.2	0.54	.33/.46
British Aerospace Hawk Mk1	180	6.30	N.A.	46.6	1.0	14.8	0.61	stabilator

* Unless otherwise indicated.

Table 8.8b) Military Trainers: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out fr.c_w
Turbopropeller Driven										
EMB-312	209	36.5	22.4	0.70	16.6	0.049	.37/1.0*	0.100	.56/.99	.21/.31
Pil. PC-7	179	34.1	20.2	0.47	14.4	0.048	.52/.49	0.082	.56/.97	.23/.27
NDN 1T	126	26.0	13.5	0.52	11.8	0.049	.38/.57	0.110	.50/.87	0.26
T-34C	180	33.3	19.8	0.35	14.4	0.048	.41/.40	0.063	.55/.95	.22/.23
Epsilon	96.9	26.0	11.0	0.39	13.4	0.058	.48/.45	0.090	.58/.91	.30/.29
SF-260M	109	27.4	16.4	0.40	12.5	0.069	.35/.63	0.075	.61/.92	.23/.30
Yak-52	162	30.5	15.9	0.59	13.9	0.045	.46/.51	0.130	.47/.98	.27/.26
Neiva T25	185	36.1	18.5	0.52	15.7	0.043	.53/.52	0.085	.51/.96	.16/.22
Jet Driven										
Aero L39C	202	31.0	37.8	0.28	13.9	0.083	.36/.33	0.066	.62/.93	.36/.34
Microturbo Microjet 200B	65.9	24.8	14.5	0.39	10.0	0.089	.37/.43	0.073	.64/.96	.29/.32
Dassault-Breguet/Dornier Alphajet	188	29.9	32.0	0.21	14.8	0.084	.32/.36	0.059	.68/1.0	.23/.27
Aermacchi MB-339A	208	35.6	25.5	0.26	12.6	0.043	.30/.38	0.069	.60/.92	0.25
SM S-211	136	27.7	21.6	0.33	13.5	0.078	.37/.36	0.100	.58/.97	.22/.21
PZL TS-11	188	33.0	24.2	0.31	16.8	0.066	.24/.47	0.085	.55/.95	.23/.27
CASA C101	215	34.8	34.4	0.41	15.8	0.072	.37/.36	0.080	.61/.93	.26/.27
British Aerospace Hawk Mk1	180	30.8	27.0	0.23	12.1	0.059	.28/.31	0.063	.65/1.0	.26/.32

* Large hornbalance at tip.

Table 8.9a) Fighters: Horizontal Tail Volume and Elevator Data

Type	Wing Area	Wing mgc	Wing Airfoil	Hor. Tail Area	S_e/S_h	x_h	$\bar{V}_h$	Elevator Chord
	S	$\bar{c}$	root/tip	S_h				root/tip
	ft^2	ft	NACA*	ft^2		ft		$fr.c_h$
DASSAULT-BREGUET								
Mir. IIIE	377	17.7	NA	0	0	0	0	elevons
Mir. F1C	269	10.4	NA	96.9	1.0	14.9	0.51	stabilator
Mir. 2000	441	18.2	NA	0	0	0	0	elevons
Super Et.	306	10.5	NA	59.7	1.0	15.5	0.29	stabilator
FR A-10A	506	8.94	6716/6713	89.4	0.32	20.6	0.41	0.33
Grum.A6A	529	10.9	NA	109.8	1.0	24.2	0.46	stabilator
Grum.F14A	565	10.2	NA	140	1.0	16.4	0.40	stabilator
North.F5E	186	8.05	65A004.8	59.0	1.0	13.0	0.51	stabilator
Vht A7A	375	10.8	65A007	56.2	1.0	16.2	0.22	stabilator
McDONNELL DOUGLAS								
F-4E	530	15.5	64A005.9	96.9	1.0	22.2	0.26	stabilator
F-15	608	17.8	McD .003	104	1.0	20.7	0.20	stabilator
GENERAL DYNAMICS								
FB-111A	476	8.22	63(NA)	168	1.0	17.6	0.75	stabilator
F-16	300	11.4	64A204	66.6	1.0	15.4	0.30	stabilator
Cessna								
A37B	184	5.61	2418/2412	46.7	0.25	15.1	0.68	.34/.31
Aermacchi								
MB339K	208	6.30	64A114/64A212	36.4	0.29	14.5	0.40	.26/.37
MIG-25	612	17.3	NA	236	1.0	16.0	0.36	stabilator
Su-7BMK	329	12.5	0.008 thick	92.7	1.0	17.9	0.40	stabilator

* Unless otherwise indicated.

Table 8.9b) Fighters: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area	Wing Span	Vert. Tail Area	S_r/S_v	x_v	$\bar{V}_v$	Rudder Chord	S_a/S	Ail. Span Loc.	Ail. Chord
	S	b	S_v				root/tip		in/out	in/out
	ft^2	ft	ft^2		ft		$fr.c_v$		fr.b/2	$fr.c_w$
DASSAULT BREGUET										
Mir. IIIE	377	27.0	48.4	0.20	13.9	0.066	.22/.29	0.14	.18/1.0	.13/1.0
Mir. F1C	269	27.6	53.9	0.16	13.5	0.098	.21/.35	0.031	.77/1.0	.23/.25
Mir. 2000	441	29.5	71.8	0.16	13.6	0.075	.21/.34	0.13	.19/1.0	.13/1.0
Super Et.	306	31.5	48.3	0.18	12.4	0.062	.25/.49	0.053	.57/.81	.23/.27
FR A-10A	506	57.5	84.0	0.28	20.9	0.060	.31/.34	0.094	.58/.91	.42/.40
Grum.A6A	529	53.0	79.3	0.21	24.6	0.069	.28/.21	see Jane's 81-81		
Grum.F14A	565	64.1	118	0.29	18.4	0.060	.29/.33	see Jane's 81-82		
North.F5E	186	26.7	41.4	0.15	11.7	0.098	.26/.30	0.050	.76/.99	.34/.33
Vht A7A	375	38.8	115	0.13	16.1	0.13	.21/.29	0.053	.59/.90	.20/.24
McDONNELL DOUGLAS										
F-4E	530	38.4	59.6	0.20	18.3	0.054	.20/.29	0.040	.63/.98	.23/.28
F-15	608	42.8	143	0.25	17.8	0.098	.30/.50	0.053	.60/.86	.25/.27
GENERAL DYNAMICS								look under Grumman		
FB-111A	476	63.0	96.1	0.21	17.0	0.054	.25/.26	see Jane's 82-83		
F-16	300	31.8	62.2	0.25	14.4	0.094	.34/.33	0.13*	.30/.73	.21/.23
Cessna										
A37B	184	35.9	17.8	0.35	15.1	0.041	.37/.39	0.061	.56/.91	.27/.32
Aermacchi										
MB339K	208	36.2	25.5	0.26	12.6	0.043	.26/.41	0.069	.58/.90	.24/.26
MIG-25	612	45.8	174	0.15	16.8	0.10	0.24	0.053	.54/.79	.22/.21
Su-7BMK	329	29.3	58.2	0.26	16.9	0.10	.28/.25	0.11	.62/.97	.29/.35

* Flaperon

Table 8.10a) Military Patrol, Bomb and Transport Airplanes: Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
Turbopropeller Driven								
LOCKHEED								
C-130E	1,745	13.7	64A318/64A412	536	0.29	42.1	0.94	.34/.44
P3C	1,300	14.1	0014/0012	322	0.25	48.5	0.85	.29/.37
ANTONOV								
An-12BP	1,310	11.3	NA	319	0.24	52.5	1.13	.33/.36
An-22	3,713	18.8	NA	846	0.28	87.4	1.06	.34/.53
An-26	807	8.79	NA	213	0.28	43.5	1.31	.34/.38
Grum.E2C	700	9.73	NA	174	0.29	26.9	0.69	.29/.36
D/B Atlant.2	1,295	11.5	NA	355	0.25	43.4	1.04	.35/.36
Aerital.G222	883	8.65	NA	255	0.20	37.0	1.24	.39/.30
Jet Driven								
LOCKHEED								
S-3A Viking	598	9.85	NA	176	0.28	20.0	0.60	.35/.25
C-141B	3,406	21.4	NA	545	0.26	82.5	0.62	.28/.29
C-5A	6,200	32.9	NA	966	0.27	130.4	0.62	0.30
BA Nimrod 2	2,121	20.5	NA	435	0.31	50.5	0.51	.32/.40
Boeing YC-14	1,762	16.8	NA	690	0.40	61.5	1.43	0.46
McDD KC-10A	3,958	24.7	NA	1,338	0.22	65.1	0.89	0.27
Tu-16	1,772	15.9	NA	360	0.27	50.6	0.65	.26/.41
Il-76T	3,229	20.7	NA	639	0.25	71.2	0.68	.31/.30

* Unless otherwise indicated.

Table 8.10b) Military Patrol, Bomb and Transport Airplanes: Vertical Tail Volume, Rudder, Aileron and Spoiler Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Inb'd Ail. Span in/out fr.b/2	Inb'd Ail. Chord in/out fr.c_w
Turbopropeller Driven										
LOCKHEED										
C-130E	1,745	133	300	0.25	40.5	0.053	.26/.31	0.063	none	none
P3C	1,300	99.7	176	0.34	46.1	0.063	.32/.39	0.069	none	none
ANTONOV										
An-12BP	1,310	125	205	0.28	48.9	0.061	.42/.44	0.064	none	none
An-22	3,713	211	700	0.44	82.6	0.074	.54/.40	0.040	none	none
An-26	807	95.8	171	0.40	39.9	0.088	.41/.43	0.071	none	none
Grum.E2C	700	80.6	199	0.52	27.7	0.098	.44/.64	0.077	none	none
D/B Atl.2	1,295	123	179	0.36	44.3	0.050	.37/.42	0.044	none	none
Aer.G222	883	94.2	207	0.37	36.7	0.091	.39/.47	0.045	none	none
Jet Driven										
LOCKHEED										
S-3A Viking	598	68.7	129	0.29	20.0	0.063	.37/.35	0.022	none	none
C-141B	3,406	160	455	0.21	72.1	0.060	.24/.28	0.056	none	none
C-5A	6,200	223	961	0.24	113	0.079	.27/.31	0.041	none	none
BA Nimr.2	2,121	115	118	0.35	50.4	0.024	.45/.37	0.058	none	none
B. YC-14	1,762	129	650	0.26	55.7	0.160	0.40	0.048	none	none
MDD KC10A	3,958	165	605	0.18	62.9	0.058	.39/.40	0.047	.32/.39	.20/.25
Tu-16	1,772	108	276	0.24	48.5	0.070	.35/.29	0.057	none	none
Il-76T	3,229	166	596	0.26	60.7	0.068	.46/.38	0.040	none	none

Table 8.10c) Military Patrol, Bomb and Transport Airplanes: Vertical Tail Volume, Rudder, Aileron and Spoiler Data

Type	Outb'd Ail. Span	Outb'd Ail. Chord	Inb'd Spoiler Span Loc.	Inb'd Spoiler Chord	Inb'd Spoiler Hinge Loc.	Outb'd Spoiler Span Loc.	Outb'd Spoiler Chord	Outb'd Spoiler Hinge Loc.
	in/out	in/out	in/out	in/out	in/out	in/out	in/out	in/out
	fr.b/2	fr.c_w	fr.b/2	fr.c_w	fr.c_w	fr.c_w	fr.c_w	fr.c_w
Turbopropeller Driven								
LOCKHEED								
C-130E	.70/.99	0.29	no lateral control spoilers					
P3C	.63/.96	.22/.25	no lateral control spoilers					
ANTONOV								
An-12BP	.68/.98	.31/.33	no lateral control spoilers					
An-22	.63/.98	.27/.32	no lateral control spoilers					
An-26	.66/.98	.32/.26	no lateral control spoilers					
Grum.E2C	.57/.98	.22/.33	no lateral control spoilers					
D/B Atl.2	.70/.95	.24/.25	.37/.65	.06/.08	.74/.68	none	none	none
Aer.G222	.72/1.0	.35/.45	.48/.70	.07/.08	.70/.66	none	none	none
Jet Driven								
LOCKHEED								
S-3A Vik.	.79/.96	.23/.25	.24/.79	.12/.15	.67/.56	none	none	none
C-141B	.67/1.0	.26/.23	.15/.41	.09/.12	.85/.80	.43/.66	.10/.13	.83/.83
C-5A	.72/.93	.28/.30	.36/.70	.13/.12	0.80	none	none	none
BA Nimr.2	.61/.96	.26/.27	no lateral control spoilers					
B. YC-14	.78/1.0	.37/.33	none	none	none	.53/.78	0.16	.74/.64
MDD KC10A	.75/.93	.29/.27	.17/.30	.05/.06	.78/.74	.43/.72	.11/.16	.75/.70
Tu-16	.66/.97	.25/.29	no lateral control spoilers					
Il-76T	.74/.98	.25/.26	.17/.71	.10/.13	.80/.69	none	none	none

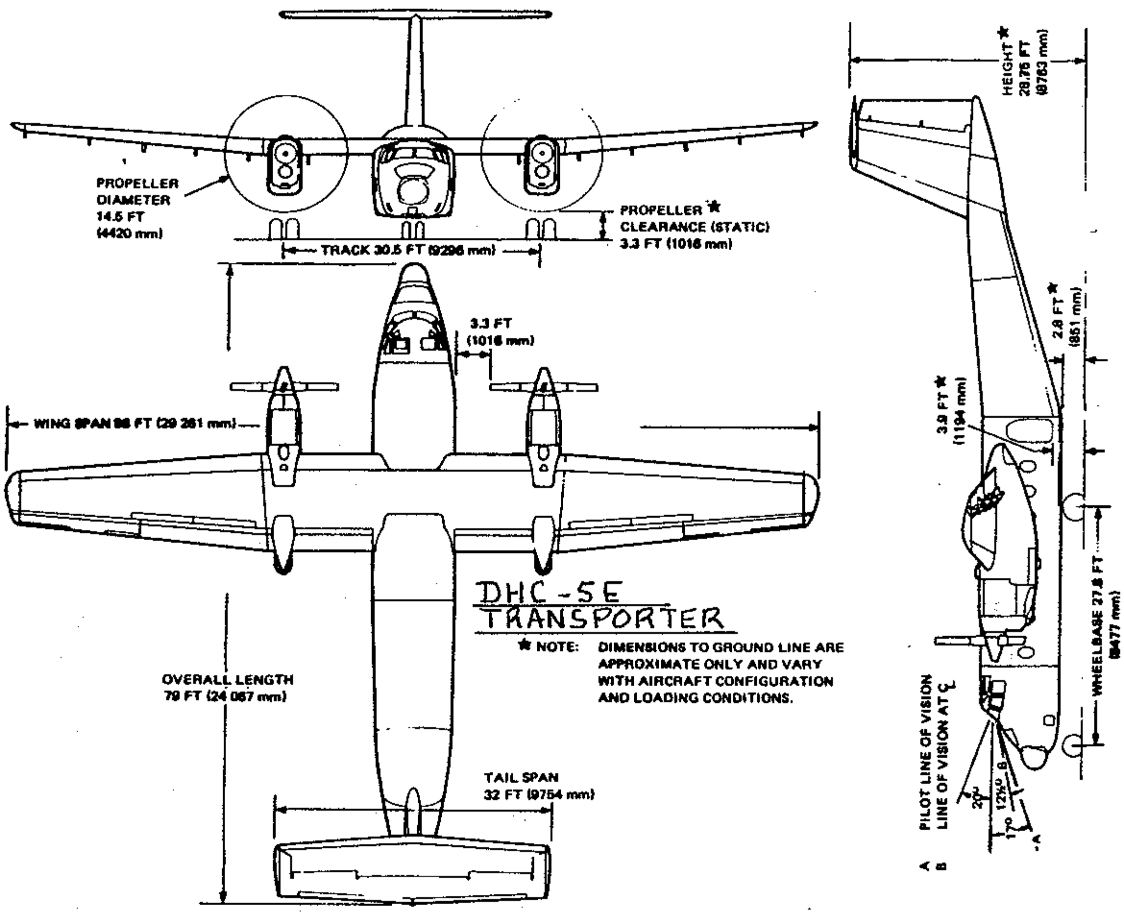


Table 8.11a) Flying Boats, Amphibious and Float Airplanes: Horizontal Tail Volume and Elevator Data (Piston/Prop. Except as Indicated)

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
SHORTS								
Sandringham	1,487	16.6	NA	259	0.35	44.1	0.46	.53/.35
Shetland	2,773	20.0	Gott. 436	388	0.32	55.8	0.39	.45/.41
DORNIER								
Do 24	1,162	13.8	NA	202	0.35	33.6	0.42	0.42
Do 24/72	1,129	12.4	NA	262	0.25	40.2	0.75	.25/.31
Do Seastar**	258	5.27	23018	52.6	0.41	18.7	0.72	0.41
GRUMMAN								
JRF-6B	375	8.33	NA	79.9	0.38	21.8	0.56	0.42
J4F-1	245	5.85	NA	50.4	0.43	16.8	0.56	.45/.48
SM S-700	258	5.31	NASA GAW-1	76.1	0.47	18.5	1.03	0.47
Can. CL-215	1,080	11.5	NA	306	0.28	28.2	0.70	0.40
BV-222	3,077	18.1	NA	413	0.23	59.0	0.44	.31/.17
SM US-1**	1,462	12.6	NA	343	0.28	51.3	0.95	.33/.34
Boeing 314-A	3,001	22.3	BAC	580	0.26	52.8	0.46	.31/.39
Martin PBM-3	1,385	12.8	NA	257	0.42	39.8	0.58	0.50
Beriev M-12***	1,130	10.2	NA	244	0.40	39.9	0.85	.37/.57
Part.P68B****	200	5.08	NA	47.5	1.00	15.7	0.74	stabilator
McK G-21G	378	7.78	23000	84.5	0.53	22.1	0.64	.49/.69

* Unless otherwise indicated. ** Turbopropeller driven *** Jet Driven
**** Float Airplane

Table 8.11b) Flying Boats, Amphibious and Float Airplanes: Vertical Tail Volume, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out fr.c_w
SHORTS										
Sandr'ham	1,487	113	157	0.31	43.5	0.041	.43/.36	0.089	.52/.93	.26/.20
Shetland	2,773	150	247	0.28	53.6	0.032	.33/.30	0.069	.51/.92	.22/.23
DORNIER										
Do 24	1,162	88.6	98.4	0.46	33.6	0.032	.41/.56	0.090	.32/.94	.15/.21
Do 24/72	1,129	91.8	200	0.38	42.2	0.081	.28/1.0	0.088	.63/.97	.29/.27
Do Seastar*	258	48.6	31.3	0.35	18.5	0.046	.33/.41	0.098	.60/.96	0.28
GRUMMAN										
JRF-6B	375	49.0	45.3	0.44	20.7	0.051	.41/.57	0.077	.56/.92	.27/.21
J4F-1	245	40.0	26.8	0.43	16.5	0.045	.35/.59	0.063	.57/.94	.20/.23
SM S-700	258	49.2	47.8	0.34	17.9	0.067	.29/.44	0.058	.63/.94	0.19
Can.CL215	1,080	93.8	186	0.35	29.2	0.053	.41/.57	0.080	.64/.95	0.26
BV-222	3,077	157	255	0.40	60.6	0.032	.36/.64	0.052	.56/.97	.12/.16
SM US-1*	1,462	109	265	0.29	46.4	0.077	.17/.30	0.047	.72/.98	.23/.21
B 314A	3,001	152	252	0.41	54.8	0.030	0.41	0.033	.58/.95	.09/.23
M PBM-3	1,385	118	196	0.44	39.7	0.048	.48/.39	0.053	.66/.96	.25/.28
Beriev M-12**	1,130	97.5	203	0.38	41.9	0.077	.36/.38	0.076	.58/.98	.29/.30
P68B***	200	39.4	21.9	0.22	15.5	0.043	.36/.40	0.096	.62/.96	0.21
McK G21-G	378	50.8	40.1	0.56	22.3	0.047	.39/.71	0.078	.55/.89	.23/.21

* Turbopropeller driven ** Jet Driven *** Float Airplane

Table 8.12a) Supersonic Cruise Airplanes: Horiz. Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip $fr.c_h$
NORTH AMERICAN AVIATION (Now Rockwell)								
XB-70A	6,297	78.5	NA	delta with elevons and small canard				
RA-5C	700	15.7	NA	356	1.0	17.1	0.56	stabilator
BOEING								
SST*	9,000	29.0**	NA	592	0.16	161	0.36	.24/.74
AST-100*	11,630	96.2	NA	547	1.0	107	0.052	stabilator
NASA*								
SSXjet I	965	30.6	.002/.003	65.0	1.0	47.2	0.10	stabilator
SSXjet II	965	30.6	.002/.003	80.0	1.0	41.2	0.09	stabilator
SSXjet III	1,128	33.1	.002/.003	80.0	1.0	41.9	0.09	stabilator
TUPOLEV								
Tu-144	4,715	58.3		delta with elevons and folding canard				
Tu-22M	1,585	15.4**	NA	727	1.0	37.2	1.11	stabilator
Tu-22	2,062	23.7***	NA	620	0.12	34.7	0.44	.29/.30
Dassault								
Mirage IVA	840	24.7	NA	delta with elevons				
GD F-111A	530	9.12**	NA	352	1.0	17.6	1.28	stabilator
Concorde	3,856	61.7	NA	ogive with elevons				
Rockwell B1B	1,950	15.8**	NA	494	1.0	49.9	0.80	stabilator
Convair B58	1,481	34.6	NA	delta with elevons				

* Study projects only ** Measured at forward sweep *** Fixed sweep airplane
See Refs. xx - yy

Table 8.12b) Supersonic Cruise Airplanes: Vertical Tail Volume, Rudder, Aileron and Spoiler Data

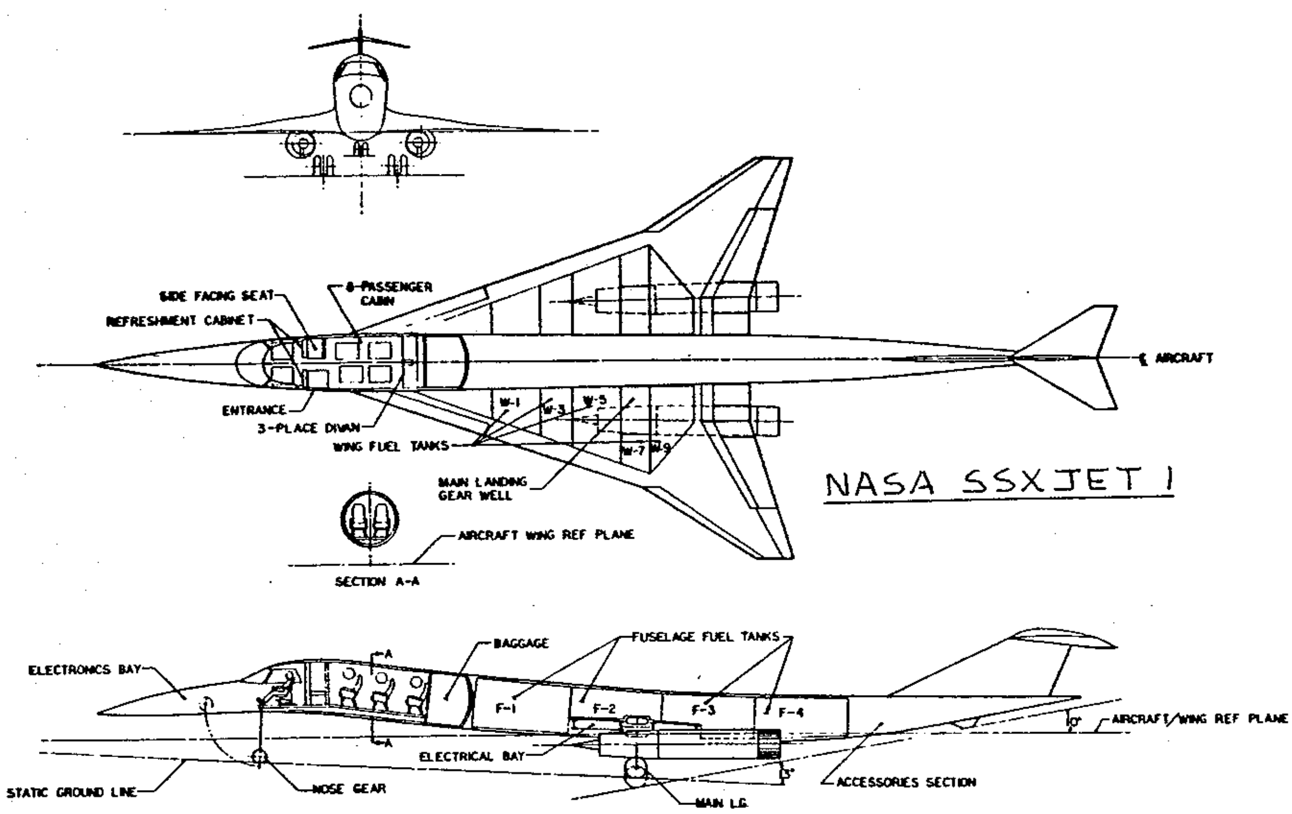
Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip $fr.c_v$	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out $fr.c_w$
NORTH AMERICAN AVIATION (Now Rockwell)										
XB-70A	6,297	105	468	0.75	48.5	0.034	****	0.067	.33/.72	.13/.31*
RA-5C	700	53.0	102	1.0**	21.8	0.060	1.0**	no ailerons		
BOEING***										
SST	9,000	174	866	0.26	88.5	0.049	.23/.46	0.014	.78/.96	.32/.43
AST-100	11,630	138	890	1.0**	121	0.067	1.0**	0.017	.72/1.0	.15/.29
NASA***										
SSXjet I	965	42.1	75.0	1.0**	38.3	0.071	1.0**	0.018	.76/1.0	.21/.26
SSXjet II	965	42.1	75.0	1.0**	35.5	0.066	1.0**	0.018	.76/1.0	.21/.26
SSXjt III	1,128	45.6	97.0	1.0**	32.1	0.061	1.0**	0.017	.74/1.0	.19/.26
TUPOLEV										
Tu-144	4,715	94.5	648	0.19	55.6	0.081	.20/.35	0.100	.31/.97	.11/.51*
Tu-22M	1,585	113	437	0.17	35.6	0.087	.39/.36	NA	.80/.95	.24/.28
Tu-22	2,062	90.9	376	0.14	29.6	0.059	.25/.33	0.051	.66/.95	.29/.31
Dassault										
Mirage IVA	840	38.9	129	0.12	14.1	0.056	.14/.24	0.120	.30/.96	.17/.63*
GD F-111A	530	63.0	115	0.25	18.6	0.064	.27/.29	no ailerons		
Concorde	3,856	84.0	477	0.24	54.1	0.080	.18/.47	0.089	.51/1.0	.15/.27*
Rockw.B1B	1,950	137	230	0.30	45.8	0.039	.29/.38	no ailerons		
Conv. B58	1,481	57.0	153	0.24	31.8	0.057	.32/.31	0.120	.18/.69	.16/.28*

* Elevon equipped ** Slab vertical tail ***Study projects only
**** Rudder hingeline skewed

Table 8.12c) Supersonic Cruise Airplanes: Vertical Tail Volume, Rudder, Aileron and Spoiler Data

Type	Inb'd Ail. Span in/out fr.b/2	Inb'd Ail. Chord in/out fr.c_w	Inb'd Spoiler Span Loc. in/out fr.b/2	Inb'd Spoiler Chord in/out fr.c_w	Inb'd Spoiler Hinge Loc. in/out fr.c_w	Outb'd Spoiler Span Loc. in/out fr.c_w	Outb'd Spoiler Chord in/out fr.c_w	Outb'd Spoiler Hinge Loc. in/out fr.c_w
NORTH AMERICAN AVIATION (Now Rockwell)								
XB-70A	none	none	no lateral control spoilers					
RA-5C	none	none	none	none	none	.25/.73	.14/.19	.60/.65
BOEING*								
SST	none	none	none	none	none	.36/.78	.17/.15	.69/.67
AST-100	none	none	none	none	none	.60/.70	.08/.11	.73/.65
NASA*								
SSXjet I	none	none	none	none	none	.38/.75	.04/.07	.88/.78
SSXjet II	none	none	none	none	none	.31/.75	.04/.07	.85/.78
SSXjt III	none	none	none	none	none	.31/.74	.04/.06	.86/.78
TUPOLEV								
Tu-144	none	none	no lateral control spoilers					
Tu-22M	none	none	none	none	none	.32/.80	.08/.13	.69/.66
Dassault								
Mir. IVA	none	none	no lateral control spoilers					
GD F111A	none	none	none	none	none	.25/.79	0.17	.65/.66
Concorde	none	none	no lateral control spoilers					
Rockw.B1B	none	none	none	none	none	.47/.81	.36/.35	.64/.65
Conv. B58	none	none	no lateral control spoilers					

* Study projects only



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that not enough different canard configurations have been built for a reliable data base.

For this reason it is suggested that the reader use the so-called X-plot method for the sizing of a canard. This method is explained in Chapter 11.

c. Three-surface configurations.

The comments made under b. also apply here. The reader should use the X-plot method of Chapter 11 to size the canard and the horizontal tail of a three-surface airplane.

d. Butterfly empennage configurations.

For a butterfly arrangement, the first step is to apply the sizing method as if the tail were conventional. The surface areas S_h and S_v obtained in this manner must now be considered to be equal to the projections of the butterfly arrangement onto the horizontal and vertical reference planes. The required 'butterfly angle', Γ_h follows from this projection analogy:

$$\Gamma_h = \arctan(S_v/S_h) \tag{8.5}$$

Step 8.4: Decide on the planform geometry of the empennage.

This involves making the following choices:

1. aspect ratio
2. sweep angle
3. taper ratio
4. thickness ratio
5. airfoil
6. dihedral
7. incidence angle

Tables 8.13 and 8.14 provide some guidance in making these choices. The selection of items 1-7 follow some of the same reasoning used in selecting these items for the wing in Chapter 6.

In selecting sweep angle/thickness ratio combinations for tail aft configurations it is important to ensure that the critical Mach number for the tails is higher than that of the wing. An increment of $\Delta M = 0.05$ is usually sufficient.

Table 8.13 Planform Design Parameters for Horizontal Tails

Type	Dihedral Angle, Γ_h deg.	Incidence Angle, i_h deg.	Aspect Ratio, A_h	Sweep Angle, $\Lambda_{c/4_h}$ deg.	Taper Ratio, λ_h
Homebuilts	+5 - -10	0 fixed to variable	1.8 - 4.5	0 - 20	0.29 - 1.0
Single Engine Prop. Driven	0	-5 - 0 or variable	4.0 - 6.3	0 - 10	0.45 - 1.0
Twin Engine Prop Driven	0 - +12	0 fixed to variable	3.7 - 7.7	0 - 17	0.48 - 1.0
Agricultural	0 - +3	0	2.7 - 5.4	0 - 10	0.59 - 1.0
Business Jets	-4 - +9	-3.5 fixed	3.2 - 6.3	0 - 35	0.32 - 0.57
Regional Turbo-Props.	0 - +12	0 - 3 fixed to variable	3.4 - 7.7	0 - 35	0.39 - 1.0
Jet Transports	0 - +11	variable	3.4 - 6.1	18 - 37	0.27 - 0.62
Military Trainers	-11 - +6	0 fixed to	3.0 - 5.1	0 - 30	0.36 - 1.0
Fighters	-23 - +5	0 fixed to variable	2.3 - 5.8	0 - 55	0.16 - 1.0
Mil. Patrol, Bomb and Transports	-5 - +11	0 fixed to variable	1.3 - 6.9	5 - 35	0.31 - 0.8
Flying Boats, Amph. and Float Airplanes	0 - +25	0 fixed	2.2 - 5.1	0 - 17	0.33 - 1.0
Supersonic Cruise Airplanes	-15 - 0	0 fixed to variable	1.8 - 2.6	32 - 60	0.14 - 0.39

Table 8.14 Planform Design Parameters for Vertical Tails

Type	Dihedral Angle, Γ_v deg.	Incidence Angle, i_v deg.	Aspect Ratio, A_v	Sweep Angle, $\Lambda_{c/4_v}$ deg.	Taper Ratio, λ_v
Homebuilts	90	0	0.4 - 1.4	0 - 47	0.26 - 0.71
Single Engine Prop. Driven	90	0	0.9 - 2.2	12 - 42	0.32 - 0.58
Twin Engine Prop Driven	90	0	0.7 - 1.8	18 - 45	0.33 - 0.74
Agricultural	90	0	0.6 - 1.4	0 - 32	0.43 - 0.74
Business Jets	90	0	0.8 - 1.6	28 - 55	0.30 - 0.74
Regional Turbo-Props.	90	0	0.8 - 1.7	0 - 45	0.32 - 1.0
Jet Transports	90	0	0.7 - 2.0	33 - 53	0.26 - 0.73
Military Trainers	90	0	1.0 - 2.9	0 - 45	0.32 - 0.74
Fighters	75 - 90	0	0.4 - 2.0	9 - 60	0.19 - 0.57
Mil. Patrol, Bomb and Transports	90	0	0.9 - 1.9	0 - 37	0.28 - 1.0
Flying Boats, Amph. and Float Airplanes	90	0	1.2 - 2.4	0 - 32	0.37 - 1.0
Supersonic Cruise Airplanes	75 - 90	0	0.5 - 1.8	37 - 65	0.20 - 0.43

For most horizontal tails and vertical tails NACA symmetrical airfoils are in use. Typical of such airfoils are NACA 0009/0018. Ref.20 provides data on these airfoils.

For canards the choice of airfoil is particularly critical. The required maximum lift coeffficient capability at the canard Reynold's number must be determined so that the canard always stalls first. If a laminar flow airfoil is selected for the canard it will be necessary to verify that the canard lift is not altered drastically when the flow becomes turbulent such as may happen when suddenly encountering rain.

Step 8.5: Prepare dimensioned drawings of the selected empennage planforms.

Step 8.6: Decide on the sizes and disposition of the longitudinal and directional control surfaces.

Tables 8.1 through 8.12 provide data for twelve types of airplanes on the size and location of:

1. elevators and stabilators
2. rudders

After deciding which type of airplane best 'fits' the type being designed, initial control surface sizes can be determined directly from Tables 8.1 through 8.12.

The control surfaces should now be sketched into the planform drawings of Step 8.5. Watch out for a possible conflict between rudder and elevator deflections. Such conflicts often arise in conventional arrangements and lead to inboard cut-outs of one of these surfaces. Typical examples are shown in Figures 3.4b and 3.4d.

Step 8.7: Document the decisions made under Steps 8.1 through 8.6 in a brief, descriptive report including clear dimensioned drawings.

8.2 EXAMPLE APPLICATIONS

Three examples applications will now be discussed:

8.2.1 Twin Engine Propeller Driven Airplane: Selene
8.2.2 Jet Transport: Ourania
8.2.3 Fighter: Eris

8.2.1 Twin Engine Propeller Driven Airplane

Step 8.1: It was decided in sub-section 3.5.1 to employ a conventional configuration. That implies a tail aft arrangement.

Step 8.2: From the general arrangement drawing of the fuselage in Figure 4.2b (p.113) the following moment arms are 'guestimated':

$x_h = 21.4$ ft. and $x_v = 16.8$ ft.

Step 8.3: The following table summarizes volume coefficient and control surface size data for comparable airplanes. The data are taken from Tables 8.3a and b:

Airplane Type	$\bar{V}_h$	S_e/S_h	$\bar{V}_v$	S_r/S_v
Cessna 310R	0.95	0.41	0.063	0.45
Cessna 402B	1.07	0.29	0.080	0.47
Cessna 414A	0.93	0.27	0.071	0.38
Cessna T303	0.78	0.42	0.052	0.44
Beech Duke B60	0.64	0.27	0.060	0.43
Piaggio P166-DL3	0.51	0.27	0.041	0.43
Averages:	0.81	0.32	0.061	0.43

For the Selene the following values are selected:

$\bar{V}_h = 0.94$, $S_e/S_h = 0.32$, $\bar{V}_v = 0.10$, $S_r/S_v = 0.43$

The reason for selecting higher volume coefficients is the higher wing loading of the Selene. With a relatively smaller wing this could lead to tail surfaces which are too small.

For the Selene, $S = 172$ ft^2, $\bar{c} = 4.92$ ft and $b = 37.1$ ft. With Eqns (8.3) and (8.4) this leads to the following tail sizes:

$S_h = 37$ ft^2 and $S_v = 38$ ft^2.

Step 8.4: The following table summarizes the geometric parameters for the horizontal and for the vertical tail of the Selene. These quantities are in overall agreement with those listed in Tables 8.13 and 8.14 for twin engine propeller driven airplanes:

Parameter	Hor. Tail	Vert. Tail
Aspect ratio, A	3.85	1.0
Leading edge sweep angle	30 deg.	50 deg.
Taper ratio	0.40	0.56
Thickness ratio	0.12	0.15
Airfoil	NACA 0012	NACA 0015
Dihedral angle	0 deg.	not appl.
Incidence angle	variable	0 deg.

Step 8.5: Figure 8.2 presents dimensioned drawings of the proposed empennage arrangement for the Selene.

Step 8.6: Using the control surface ratios selected in Step 8.3, the elevator and rudder outlines are drawn into the planforms of Figure 8.2.

Step 8.7: This step has been omitted to save space.

8.2.2 Jet Transport

Step 8.1: It was decided in sub-section 3.5.2 to employ a conventional configuration. That implies a tail aft arrangement.

Step 8.2: From the general arrangement drawing of the fuselage in Figure 4.7 (p.120) the following moment arms are 'guestimated':

$x_h = 51.0$ ft. and $x_v = 54.0$ ft.

Step 8.3: The following table summarizes volume coefficient and control surface size data for comparable airplanes. The data are taken from Tables 8.7a and b:

Airplane Type	$\bar{V}_h$	S_e/S_h	$\bar{V}_v$	S_r/S_v
Boeing 737-200	1.28	0.27	0.100	0.24
Boeing 737-300	1.35	0.24	0.100	0.31
McDD DC-9-S80	0.96	0.34	0.062	0.39
McDD DC-9-50	1.32	0.38	0.079	0.41
Fokker F-28-4000	1.07	0.20	0.085	0.16
Rombac/BAe 1-11-495	0.86	0.27	0.038	0.28
Averages:	1.14	0.28	0.077	0.30

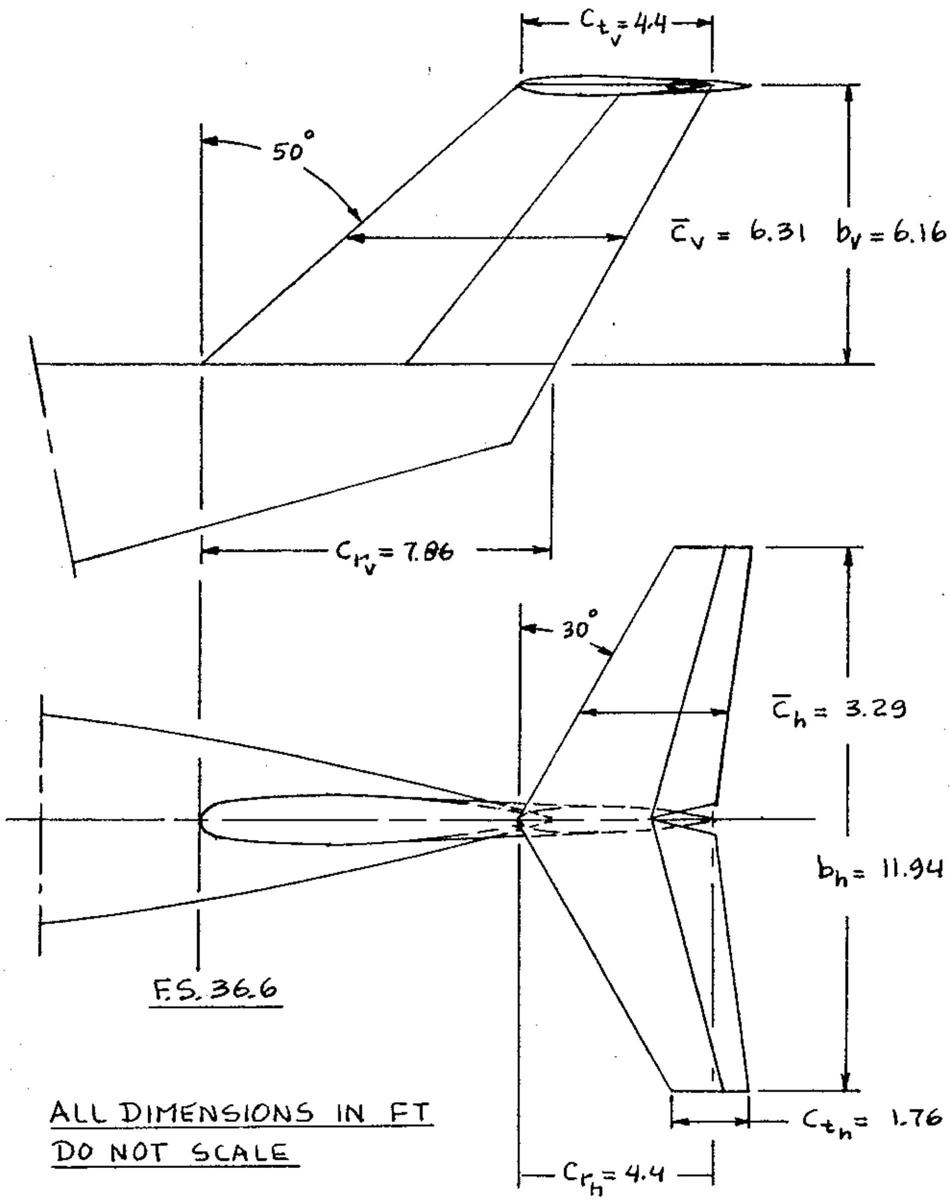


Figure 8.2 Selene: Empennage Configuration

For the Ourania the following values are selected:

$\bar{V}_h = 0.80$, $S_e/S_h = 0.30$, $\bar{V}_v = 0.06$, $S_r/S_v = 0.35$

The reason for selecting lower volume coefficients is the fact that it was decided in sub-section 3.5.2 to employ 'relaxed' static stability combined with a digital 'fly-by-wire' flight control system.

For the Ourania, $S = 1,296\ ft^2$, $\bar{c} = 12.5$ ft and $b = 113.8$ ft. Using Eqns (8.3) and (8.4) this leads to the following tail sizes:

$S_h = 254\ ft^2$ and $S_v = 164\ ft^2$.

Step 8.4: The following table summarizes the geometric parameters for the horizontal and for the vertical tail of the Ourania. These quantities are in overall agreement with those listed in Tables 8.13 and 8.14 for jet transports.

Parameter	Hor. Tail	Vert. Tail
Aspect ratio, A	5.0	1.8
Leading edge sweep angle	35 deg.	45 deg.
Taper ratio	0.32	0.32
Thickness ratio	0.12	0.15
Airfoil	NACA 0012	NACA 0015
Dihedral angle	0 deg.	not appl.
Incidence angle	variable	0 deg.

The reader should verify with the help of Figure 6.1a (p.150) that the critical Mach number of both tail surfaces is higher than that of the wing.

Step 8.5: Figure 8.3 presents dimensioned drawings of the proposed empennage arrangement for the Selene.

Step 8.6: Using the control surface ratios selected in Step 8.3, the elevator and rudder outlines are drawn into the planforms of Figure 8.3.

Step 8.7: This step has been omitted to save space.

8.2.3 Fighter

Step 8.1: It was decided in sub-section 3.5.3 to employ a conventional, twin boom configuration. That implies a tail aft arrangement.

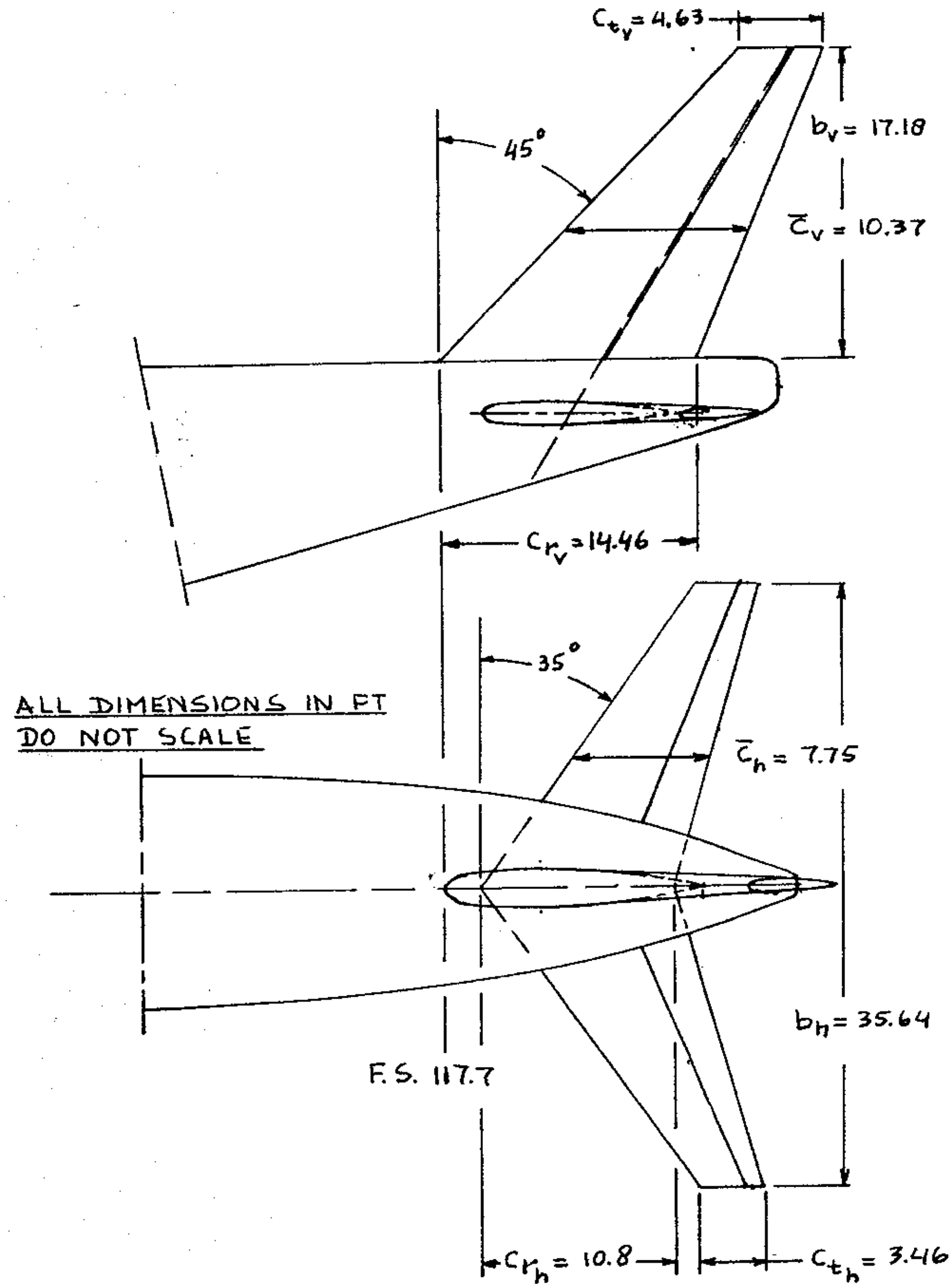


Figure 8.3 Ourania: Empennage Configuration

Step 8.2: From the general arrangement drawing of the fuselage in Figure 4.9 (p.122) the following moment arms are 'guestimated':

x_h = 25.3 ft. and x_v = 22.0 ft.

Step 8.3: The following table summarizes volume coefficient and control surface size data for comparable airplanes. The data are taken from Tables 8.9a and b:

Airplane Type	$\bar{V}_h$	S_e/S_h	$\bar{V}_v$	S_r/S_v
Fairchild Rep. A-10A	0.41	0.32	0.060	0.28
Grumman A6A	0.46	1.00*	0.069	0.21
Aermacchi MB339K**	0.40	0.29	0.043	0.26
Vought A7A**	0.22	1.00*	0.130	0.13

*stabilator **single engine fighter

Averages:	0.37	0.31	0.076	0.22

For the Eris the following values are selected:

$\bar{V}_h = 0.25$, $S_e/S_h = 0.31$, $\bar{V}_v = 0.06$, $S_r/S_v = 0.22$

The reason for selecting lower volume coefficients is the fact that it was decided in sub-section 3.5.3 to employ 'relaxed' static stability combined with a digital 'fly-by-wire' flight control system.

For the Eris, S = 787 ft^2, $\bar{c}$ = 11.9 ft and b = 68.7 ft. Using Eqns (8.3) and (8.4) this leads to the following tail sizes:

$S_h = 93\ ft^2$ and $S_v = 147\ ft^2$.

Step 8.4: The following table summarizes the geometric parameters for the horizontal and for the vertical tail of the Eris. These quantities are in overall agreement with those listed in Tables 8.13 and 8.14 for fighters.

Parameter	Hor. Tail	Vert. Tail
Aspect ratio, A	3.6	1.2
Leading edge sweep angle	0 deg.	45 deg.
Taper ratio	1.0	0.55
Thickness ratio	0.10	0.15
Airfoil	NACA 0010	NACA 0015
Dihedral angle	0 deg.	not appl.
Incidence angle	0 deg.	0 deg.

The reader should verify with the help of Figure 6.1a (p.150) that the critical Mach number of both tail surfaces is higher than that of the wing.

Step 8.5: Figure 8.4 presents dimensioned drawings of the proposed empennage arrangement for the Eris.

Step 8.6: Using the control surface ratios selected in Step 8.3, the elevator and rudder outlines are drawn into the planforms of Figure 8.4.

Step 8.7: This step has been omitted to save space.

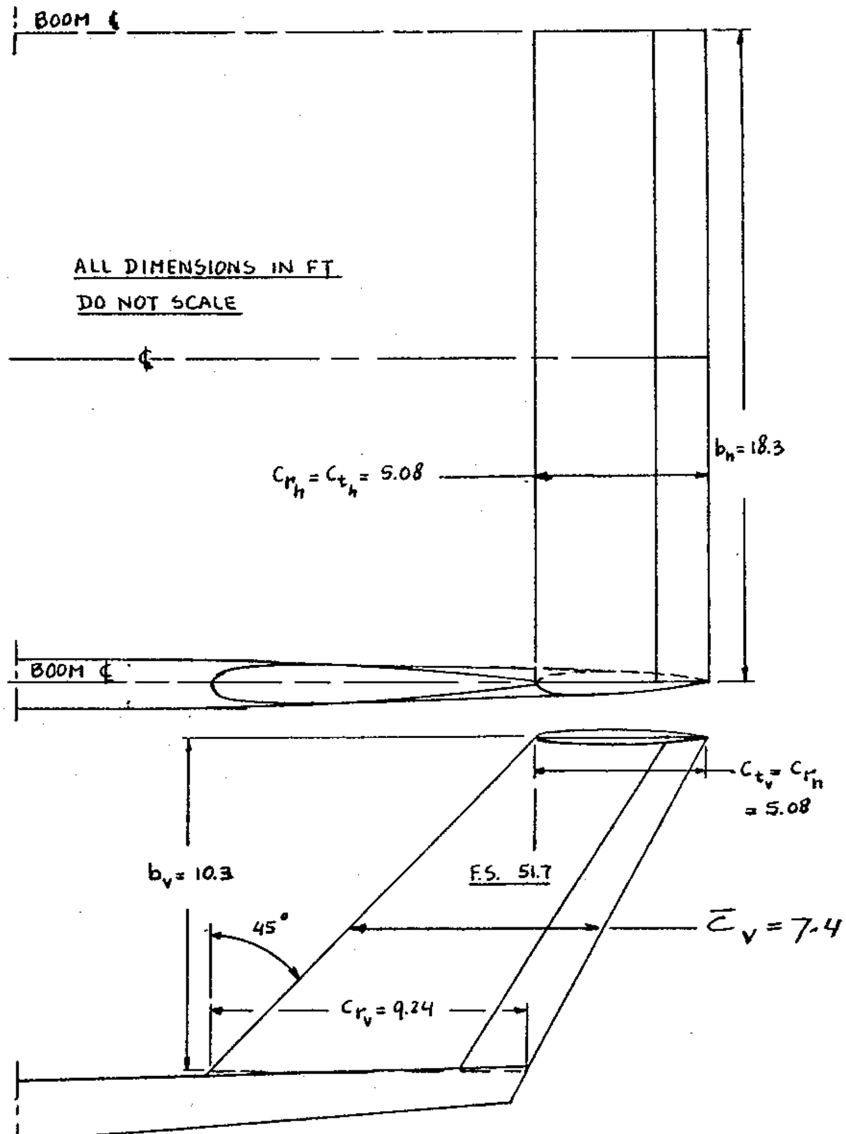
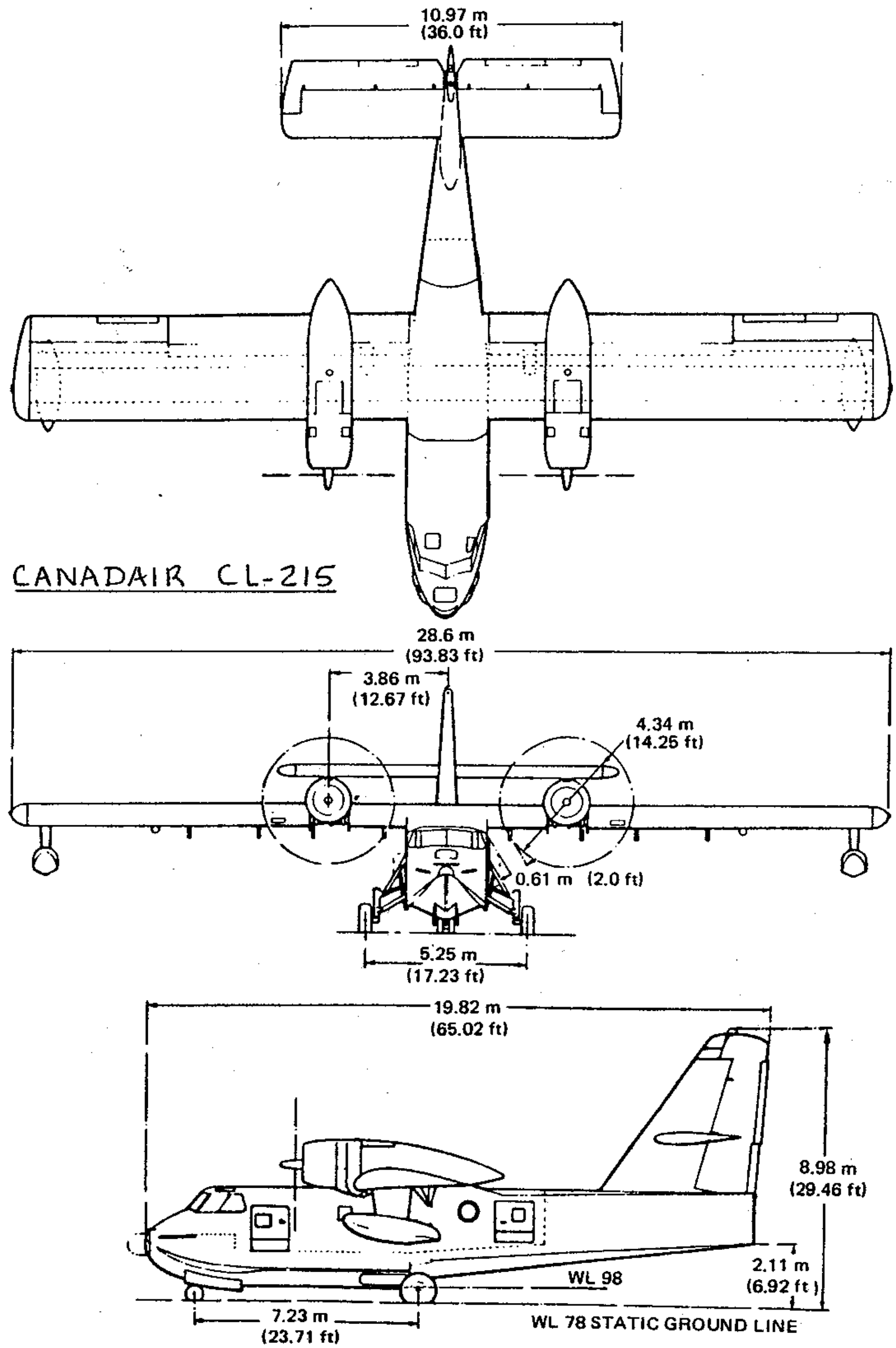


Figure 8.4 Eris: Empennage Configuration


10.97 m
(36.0 ft)
CANADAIR CL-215
28.6 m
(93.83 ft)
3.86 m
(12.67 ft)
4.34 m
(14.25 ft)
0.61 m (2.0 ft)
5.25 m
(17.23 ft)
19.82 m
(65.02 ft)
8.98 m
(29.46 ft)
WL 98
2.11 m
(6.92 ft)
7.23 m
(23.71 ft)
WL 78 STATIC GROUND LINE