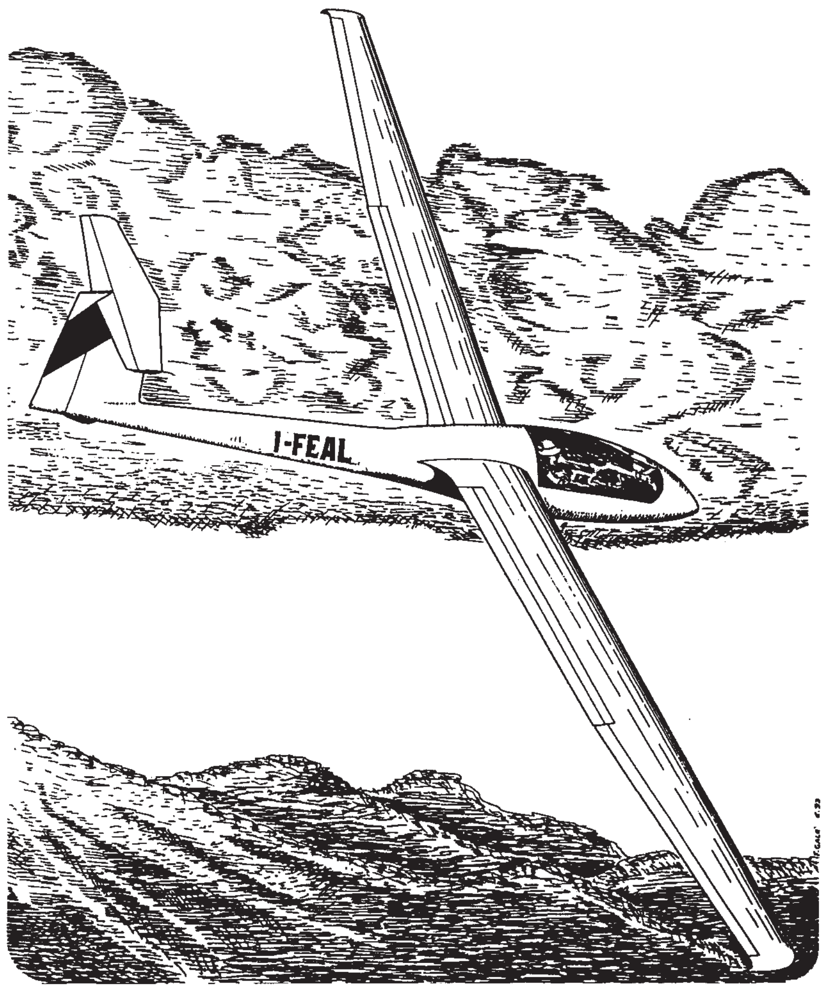
SCALING SAILPLANES



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Originally published as a part of *Sailplanes!*,
a book by Ferdinando Galè and Aldo Calza

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SCALING SAILPLANES

Aeromodeling, if one defines it as the design, construction and flight of aircraft models, preceded full size aviation in the history of mankind. Many aviation pioneers were builders of model airplanes before becoming builders of full size flying machines.

Once aviation had been born and was being developed, aeromodelling followed its progress, step by step, taking advantage from time to time of anything which could be adapted to the construction of flying models.

Airfoil sections used for airplanes and gliders during the period from 1900 to about 1950 have been used for decades in the construction of model airplanes. Some of them are still used, such as the thin airfoils, with great camber, adopted for use in some free flight models. If one looks at them with a critical eye, one finds that their profiles, often presented as novelties, are either elaborations of sections from World War I aircraft, or derived from the study of bird wing profiles.

Airfoils used for the wings of sailplanes can be referred to as being from one of two grossly different periods. The first period begins with the pioneering times of aviation and extends through World War II, while the latter begins in the early 1950's and continues to the present day.

During the first period, as it appears from TABLE 1 (page 2), airfoils with large camber of the mean line and hefty thickness, up to 20% in some cases, were predominantly used. A well-rounded nose helped in smoothing and delaying the stall. See the photograph on the page 17 for an example of this type of section. Almost all such airfoils were developed at the Göttingen Aeronautical Laboratory in Germany, or were derived from those. Thin airfoils, with thicknesses below 12%, were seldom used. The D-28 Windspiel (1932), Habicht (1936), and SO-P1 (1940) are exceptions to the general rule of the time.

After World War II, laminar airfoils started to be used. Their laminar boundary layer extended up to 40% of the wing chord. Laminar flow airfoils were developed both in the United States by NACA, and in Germany at Göttingen and Stuttgart. The Wortmann FX series serve as examples. See TABLE 2 (page 3).

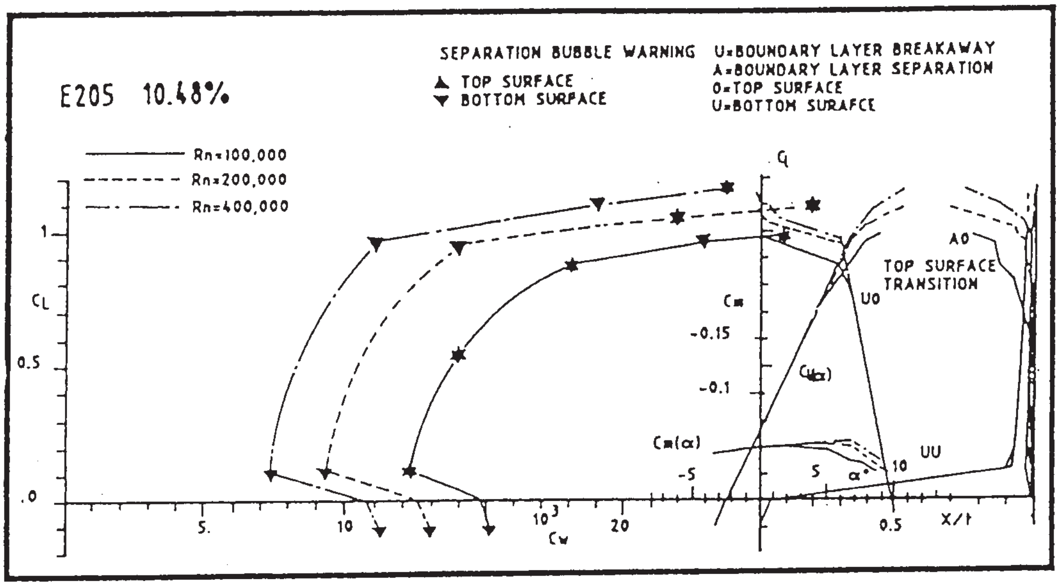
TABLE 1

SAILPLANE AIRFOILS/PROFILI ALIANTI
[*Before WW II*/Prima della II Guerra mondiale]

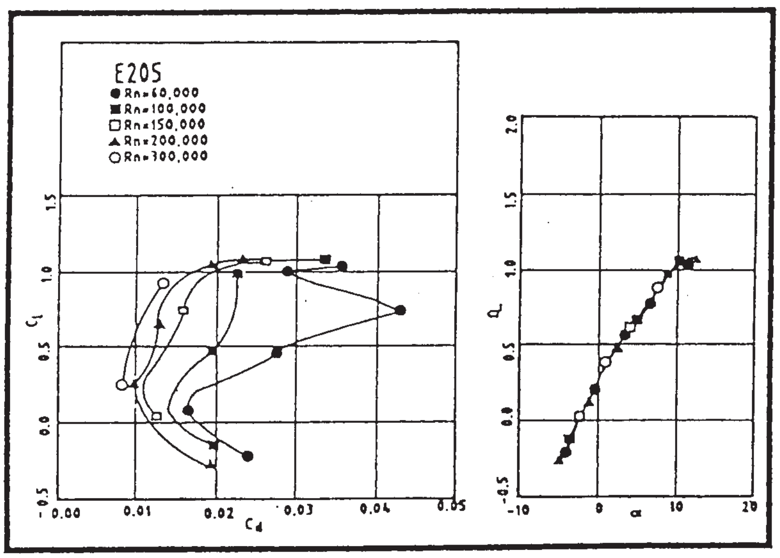
1921	VAMPYR	Goettingen 441
1922	DARMSTADT D-9 KONSUL	Goettingen 535
1923	DARMSTADT MARGARETE	Goettingen 533
1926	DARMSTADT D-1	Goettingen 535
1927	DARMSTADT D-2	Joukowsky
1928	PROFESSOR	Goettingen 549 mod.
1929	WIEN	Goettingen 549 mod.
1930	FAFNIR 1	Goett. 652-535, Clark Y
1930	CW-5	Goettingen 652
1930	TERN	Goettingen 549
1930	BOWLUS ALBATROSS	Goettingen 549
1931	FALKE	Goettingen 535 mod.
1931	GRUNAY BABY 1	Goettingen 535
1931	GOLDEN WREN	Goettingen 535
1931	AUSTRIA	Goettingen 652
1931	SPYR	Goettingen 535
1931	M-22	Goettingen 535
1932	STAKHANOVETS	TSAGI R-III [15.6% - 13%]
1932	FVA-10 B RHEINLAND	Joukowsky 433, Goett.532
1932	SG-3	WARSAW 192
1932	SCUD 2	Goettingen 535
1932	RHOENADLER	Goettingen 652
1932	CONDOR 2	Goettingen 532
1932	D-28 WINDSPIEL	Goettingen 535 [10% - 8%]
1933	D-30 CIRRUS	NACA 2414-4412
1933	HUETTER H-17	Goettingen 535, NACA M-6
1933	FAFNIR 2 SAO PAULO	DFS Special
1933	KOMAR	Goettingen 535-549
1933	MOAZAGOTL	Goettingen 535
1933	RHOENBUSSARD	Goettingen 535
1934	MÜ-10 MILAN	Scheibe
1934	HJORDIS	Goettingen 652, RAF 32
1934	GN-7	Goettingen 549
1935	SGS 2-8 TG-2	NACA 4412
1935	SCUD 3	Baynes
1935	RHOENSPERBER	Goettingen 535-409
1935	WOLF	Goettingen 535
1935	GÖ-3 MINIMOA	Goettingen 681-693
1935	KIRBY KITE	Goettingen 535
1935	KRANICH	Goettingen 535
1935	MOSWEY	Goettingen 535
1935	MU-13 ATALANTE	Scheibe
1935	HUETTER H-28	Joukowsky
1936	SG-3 bis/36	Goettingen 549
1936	SPERBER SENIOR	Goettingen 757-767
1936	SPERBER JUNIOR	Goettingen 535-409
1936	MINIMOA 38	Goettingen 681-693
1936	KADET	Goettingen 426
1936	HABICHT	Clark Y
1936	SALAMANDRA	Goettingen 387
1936	ZANONIA	NACA 2418-2412
1936	REIHER	Goettingen 549-676
1937	KING KITE	NACA 23021-4415
1937	BABY ALBATROSS	Goettingen 535
1937	KIRBY GULL	NACA 4416, RAF 34
1937	SPALINGER S-18	Goettingen 535
1937	GOLDEN EAGLE	Goettingen 535, Clark YH
1938	KIRBY PETREL	Goettingen 652, Clark YH
1938	SUPER ALBATROSS	Goettingen 549
1938	GÖ-4 GOEVIER	Joukowsky
1938	WEIHE	Goettingen 549, NACA M-12
1938	VIKING	Goettingen 535
1939	PELLICANO	NACA 24 [Series]
1939	MEISE	Goettingen 549-676
1940	SO-P1	SNCASO Special
1941	PRATT-READ G-1	GS-4, GS-M, GS-1
1941	YANKEE DOODLE	NACA 4418-4409
1942	LK-10 A	NACA 4413-4409

TABLE 2

SAILPLANE AIRFOILS/PROFILI ALIANTI *[After WW II]*/ Dopo la II Guerra mondiale]		
1951	KRANICH III	Goettingen 549
1951	BERGFALKE II	Muenchen 14%
1952	BOCIAN	NACA 43018A-012A
1952	LO 100	CLARK Y
1953	HKS I	NACA 65 -714
1955	HKS III	NACA 65 -1116
1955	Ka 6-E	NACA 63 -618.614 mod.
1956	BLANIK	NACA 63 -615A
1957	ZUGVOGEL	NACA 63 -616/614
1957	PHOENIX T	EC 86(-3)-914
1957	Ka 7	Goettingen 535/549[mixed],532
1958	ZEFIR	NACA 65 -515 mod.
1958	Ka 8-B	Goettingen 533[16.7%]-532
1958	AUSTRIA STANDARD	NACA 65 -416
1959	SB 5-B	NACA 63 -618
1960	FOKA 4	NACA 63 -618-4415
1961	VASAMA	WORTMANN FX 05-188 [14%]
1961	SB-6	STE 871-514
1962	SB-7B	FX 62-163[over]/E 306 [under]
1962	BS-1	EPPLER 348-K
1964	DARMSTADT D-36	WORTMANN FX 62-K-31.60-126
1964	PHOEBUS B-1	EPPLER 403
1964	LIBELLE H-301	HUETTER
1965	ASK 13	Goettingen 535-539 [mixed]
1965	SHK	EPPLER 266
1965	ELFE STANDARD	WORTMANN FX 61-163.FX 60-126
1965	ASW-12	WORTMANN FX 62-K-131, 60-126
1966	B-4	NACA 64-618
1967	CIRRUS B	WORTMANN FX 66-196, FX 66-161
1967	PHOEBUS C	EPPLER 403
1967	SB-8	FX 62-K-153/131, FX 60-126
1967	DIAMANT 18	WORTMANN FX 62-K-153 nmod.
1967	LIBELLE STANDARD	WORTMANN FX 66-17A II-182
1967	LS-1C	WORTMANN FX 66S-196 mod.
1968	FK-3	WORTMANN FX 62-K-153
1968	KESTREL 401	FX 67-K-176/17, 67-K-150/17
1968	ASW 15-B	WORTMANN FX 61-163, 60-126
1968	FS-25	FX-S-196/184/168/147.60-126
1969	SB-9	FX 62-K-153/131, 60-126
1969	NIMBUS II	FX 67-K-170/17, 67-K-150/17
1969	CIRRUS STANDARD	FX S-02-196, 66-17 A II-182
1970	F-101 SALTO	WORTMANN FX 66-17A-182
1970	CALIF	FX 67-K-170, 60-126
1970	KESTREL 604	FX 67-K-170/17, 67-K-150/17
1971	ASW 17	FX 62-K-131 [14.4%], 60-126
1971	SIGMA	WORTMANN FX 67-VC-170/136
1972	DARMSTADT D-38	WORTMANN FX 61-184, 60-126
1972	LSD-ORNITH	WORTMANN FX 66-S-196 mod.
1972	SB-10 [29 m]	FX 62-K-153/131
1972	BS-10 [26 m]	FX 62-K-153/131, 60-126
1973	JANTAR STANDARD	NN-8
1973	PIK 20-D	WORTMANN FX 67-K-170/150
1973	AN 66-C	EPPLER 562/569
1974	JANUS	WORTMANN FX 67-K-170/150
1974	LS-1F	WORTMANN FX 66-S-196 VI
1974	DG-100	WORTMANN FX 61-184, 60-126
1974	ASTIR CS	EPPLER 603
1974	HORNET	WORTMANN FX 66-17AII-182
1975	ASW 19	FX 61-163, FX 60-126
1975	FS-29	FX 73-170, FX 73-K-170/22
1976	LS-3	WORTMANN FX 67-K-170/150
1976	MOSQUITO	WORTMANN FX 67-K-150
1976	MINI NIMBUS	WORTMANN FX 67-K-150
1976	DG-200	WORTMANN FX 67-K-170 mod.
1976	TWIN ASTIR	EPPLER 603
1977	GLOBETROTTER	EPPLER 603
1977	B-12	WORTMANN FX 67-K-170/150
1977	ASW 20	WORTMANN FX 62-K-131 [14.4%]
1978	SPEED ASTIR	EPPLER 662
1978	SB-11	HQ 144-39 F3
1978	SFH	WORTMANN FX 61-184, FX 60-126
1979	ASK 21	FX 602-196, FX 60-126
1979	MÜ 27	WORTMANN FX 67-VC-170/130


E205 10.48%
SEPARATION BUBBLE WARNING
▲ TOP SURFACE
▼ BOTTOM SURFACE
U=BOUNDARY LAYER BREAKAWAY
A=BOUNDARY LAYER SEPARATION
O=TOP SURFACE
U=BOTTOM SURAFCE
Rn=100,000
Rn=200,000
Rn=400,000
CL
1.
0.5
.0
5.
10
20
Cw
Cm
-0.15
-0.1
-5
Cm(α)
α°
10
0.5
X/t
TOP SURFACE TRANSITION
AO
UO
UU

A


E205
Rn=60,000
Rn=100,000
Rn=150,000
Rn=200,000
Rn=300,000
Cl
Cd
0.00
0.01
0.02
0.03
0.04
0.05
-0.5
0.0
0.5
1.0
1.5
2.0
α
-10
0
10
20

B

FIGURE 1

(More recently designed laminar sections maintain a laminar boundary layer for nearly the entire chord.)

In aeromodelling, airfoils are often used which have been developed by the builders themselves, according to their own personal empirical rules. Sometimes the Joukowsky graphical method is used, or existing airfoils are modified.

Nowadays several computer programs are available which allow one to quickly produce a myriad of airfoils which are often dubbed laminar. Their superiority over the traditional ones, as evidenced by the computer derived characteristics, is quite far from being confirmed by scarce wind tunnel tests.

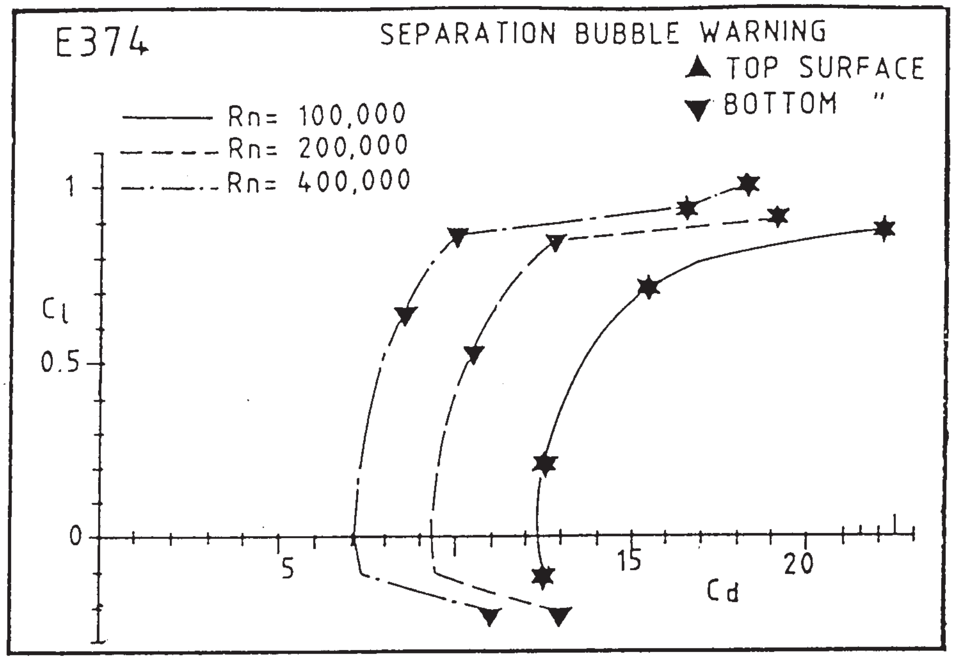
The reason for this is rather simple and well defined, even if this subject is seldom debated in specialized publications. At low Reynolds Numbers, such as those prevailing in aeromodelling, the formation of the so called laminar bubble is relevant and easy to detect by various means, visual and acoustic being the most commonly used methods.

Unfortunately, a mathematical model has not yet been found which can accurately represent the laminar bubble and its evolution. As a consequence, nobody knows how to program a computer to properly calculate real performance. As a matter of fact, the laminar bubble is completely neglected in all but the most very recent of the aforementioned programs. The consequence is an anomalous drag increase, as appears in the typical example of FIGURE 1 (page 4).

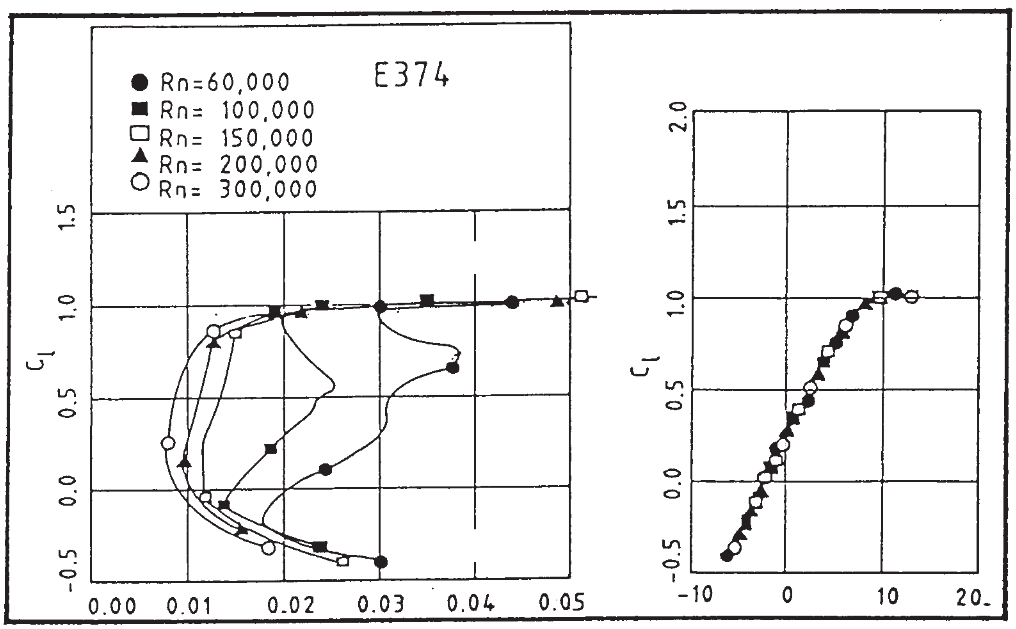
EXAMPLE: Let's assume that we intend to adopt the airfoil E 205 at an incidence equivalent to C_L = 0.5, at a Reynolds Number Re = 100,000.

In FIGURE 1 the polar diagram A (theoretical, computer derived) shows an aerodynamic efficiency

$$E = \frac{C_L}{C_D} = \frac{0.5}{0.0137} = 36.5$$


E374
SEPARATION BUBBLE WARNING
▲ TOP SURFACE
▼ BOTTOM "
Rn= 100,000
Rn= 200,000
Rn= 400,000
1
0.5
0
5
15
20
Cd

A


E374
Rn=60,000
Rn= 100,000
Rn= 150,000
Rn= 200,000
Rn= 300,000
1.5
1.0
0.5
0.0
-0.5
0.00
0.01
0.02
0.03
0.04
0.05
2.0
-10
0
10
20

B

FIGURE 2

On the contrary, the polar diagram B of FIGURE 1 (derived from wind tunnel testing) gives this much lower value

$$E = \frac{C_L}{C_D} = \frac{0.5}{0.02} = 25.0$$

If the Reynolds Number becomes smaller, for instance Re = 60,000, which is a typical value for many radioguided sailplanes of medium size, the end result would become even worse.

$$E = \frac{C_L}{C_D} = \frac{0.5}{0.028} = 17.85$$

Should we decide to increase the working angle of incidence so that $C_L = 0.74$, the aerodynamic efficiency will worsen even more.

$$E = \frac{C_L}{C_D} = \frac{0.74}{0.044} = 16.81$$

Another example is shown in FIGURE 2 (page 6). The difference between the theoretical polar (A) and the one derived from wind tunnel testing (B) is macroscopic and cannot be neglected.

By the same token, there is another empirical rule which cannot be ignored. The aerodynamic efficiency of a flying model is halved with respect to the airfoil $E = C_L/C_D$ as measured in the wind tunnel. From a practical point of view, this means that the flying model will hardly attain a glide ratio of 1:12 even though its wing airfoil shows a 1:24 ratio when tested in the wind tunnel.

Sometimes airfoils for flying models are "invented" by taking the upper contour from one airfoil and the bottom contour from another one. A common case is a concave bottom section which has been flattened, *a la* the Clark Y, for ease of construction, thus spoiling the aerodynamic performance. Something like this has been done also with full size sailplanes. For instance, the wing of the BS-1 (1962) has the top

TABLE 3

	1938	1960	1980
Max.Wing loading Carico alare max. Kg/m	12 - 20	18 - 32	42 - 50
Max, speed Velocita' max. Km/h	150 - 180	200 - 250	250 - 300
Wing airfoils Profili alari	Goettingen Joukowsky	NACA Eppler	Wortmann DFVLR HQ
Wing planform Pianta alre [FIG.6-A]	RT	RT DT	RT DT PT
Examples Esempi	FAFNIR II MOAZAGOTL MINIMOA SPYR III MU 13 REIHER	ZEFIR SKYLARK PHOENIX ELFE M Ka 6 FOKA	NIMBUS 3 ASW 20 DG 202 LS-4 JANTAR DISCUS
Construction Costruzione	*Wood*/Legno *Steel*/Acciaio	*GRP*/Vetrores *Light* alloy Lega legg.	*CRP*/Vetro- carbonio
Water ballast Zavorra [acqua] Kg	50 - 80	100	350

TABLE 4

Sailplane / Aliante	*Minimum Sink Speed* Velocita' Minima di Caduta	*At / a*	*With Wing Loading* Con Carico Alare	*Best Glide Ratio* Miglior Rapporto di Planata	*At / A*	*With Wing Loading* Con Carico Alare	*Max. Speed [VNE]* Velocita' Max.
	m/s	Km/h	Kg/m^2	E	Km/h	Kg/m^2	Km/h
DG-101/100 [Glaser Dirks]...	0.59	74	28.0	39.0	105	38.0	260
ASW 19 B [Schleicher]........	0.62	72	30.0	38.5	112	41.0	255
LS-4 [Schneider].............	0.60	82	33.0	40.5	118	45.0	270
JANTAR 2 STANDARD 48-1[SZD]..	0.65	77	34.7	39.5	130	48.8	280
DG-202 [Glaser Dirks]........	0.59	80	32.0	42.5	110	45.0	270
304 [Glasflugel].............	0.57	77	31.0	43.0	116	45.5	250
Mini-Nimbus [Schempp-Hirth]..	0.60	85	34.5	41.6	112	45.0	250
Mini-Nimbus C [Schempp-Hirth]	0.53	80	33.0	42.0	120	51.0	250
Ventus a [Schempp-Hirth].....	0.55	80	33.0	44.0	120	45.0	250
ASW 20 [Schleicher]..........	0.59	84	32.0	42.0	115	43.0	265
LS 3a [Schneider]............	0.60	80	33.0	41.8	100	33.0	270
Nimbus 2 B [Schempp-Hirth]...	0.48	80	30.0	49.0	110	40.0	270
Nimbus 2 C [Schempp-Hirth]...	0.47	80	30.0	49.0	115	45.0	270
Nimbus 3 [Schempp-Hirth].....	0.44	62	30.0	55.0	125	46.0	270
ASW 17 [Schleicher]..........	0.56	77	33.0	49.0	105	33.0	270
JANTAR 2 B- 42-2 [SZD].......	0.46	75	32.0	50.3	102	45.0	250
ASW 22 [Schleicher]..........	0.41	80	32.0	60.0	115	45.9	270
LAK 12 Lietuva [LAK].........	0.48	79	31.0	48.0	95	43.0	250
Diamant 18 [FFA].............	0.52	69	30.5	45.0	95	28.0	270
G 102 [Grob].................	0.60	75	30.6	37.5	85	36.0	250
G 103 [Grob].................	0.64	80	26.0	36.0	105	33.0	250
G 103 Twin III [Grob]........	0.64	73	27.0	38.0	109	35.0	280
SZD-42 Jantar 2 "AMBER".[SZD]	0.46	75	32.5	47.0	102	41.6	250
SB-9.[Akaflieg Braunschweig].	0.44	75	27.7	48.0	110	28.6	180
SB-11.[Akaflieg Braunschweig]	0.67	85	27.5	48.0	104	44.5	265
SZD-55-1.[SZD]...............	0.54	79	31.0	44.1	119	50.0	180
Discus.[Schempp-Hirth].......	0.59	80	29.5	42.4	105	50.0	180
SF-26.[Scheibe]..............	0.70	70	22.1	30.0	80	25.1	-
SB-12.[Glasflugel]...........	0.59	80	31.0	41.0	98	45.0	-
Phoebus C.[Bolkow-Laupheim]..	0.63	83	23.0	39.0	93	32.6	-
LS 7.[Rolladen-Schneider]....	0.58	80	32.0	43.0	105	50.0	-
Mistral.[Strauber-Frommhold].	0.59	83	32.9	39.0	98	32.9	-
L-10 Libelle.[Bitz-Linner-Z.]	0.65	65	22.4	28.0	70	24.0	-
Glasflugel 304.[Glasflugel]..	0.57	77	33.9	42.7	96	45.6	-
fs-32.[Akaflieg Stuttgart]...	0.60	85	35.7	43.0	105	50.3	-
Elfe S 4.[Oerlinghausen].....	0.59	79	27.1	37.0	90	29.7	-
AK-5.[Akaflieg Karlsruhe]....	0.58	85	30.0	39.0	105	28.4	-
Lo 150.[Wolf Hirth]..........	0.68	86	28.4	34.0	105	28.4	200
Janus.[Schempp-Hirth]........	0.58	83	30.0	43.5	95	36.5	250
Cirrus 75 [16 m].[Schempp-H.]	0.60	78	29.8	38.0	88	30.0	200

contour of the Wortmann FX 62-163 airfoil and the bottom contour of the Eppler 306.

In full size gliding, duration contests have been abandoned a long time ago and duration flights are no longer recorded by the Federation Aeronautique Internationale. As a matter of fact, a remarkable improvement in glider performance has been achieved in the few last decades, as depicted in FIGURE 9-B (page 35), so that the duration potential is far beyond human endurance under certain meteorological conditions.

Once the proper correction for scale effect has been made, the design requirements of modern sailplanes appear to be comparable with those of radioguided gliders, for both thermal and slope soaring, according to class rules established by the Federation Aeronautique Internationale and other ruling bodies. As a consequence, many aeromodelers keep looking rather closely at 3-view plans and characteristics of vintage and contemporary sailplanes, not only for possible scale reproduction, but also for design and construction hints.

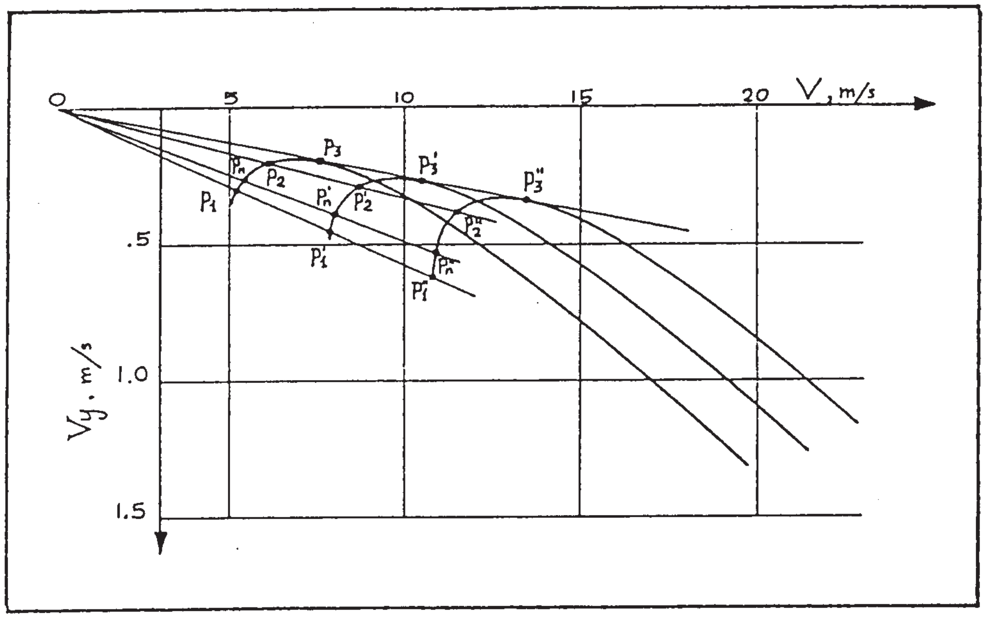
The comparison between full size gliders and model gliders, which every reader can make using information available in this digest, concerns only basic geometrical proportioning. Some simple considerations can be made by examining the plans of hundreds of sailplanes. To this effect, let's focus our attention at three cutoff dates which characterize the development of gliding, namely 1938, 1960, and 1980. TABLE 3 (page 8) synthesizes the essential parameters and information.

Other lessons can be learned from TABLE 4 (page 9), which summarizes the performance of some contemporary sailplanes.

It appears clear that the minimum sink speed, V_y, is achieved at a translation speed, V, and with a wing loading, W/S, which are lower than those required to obtain the maximum aerodynamic efficiency,

$$E = \frac{C_L}{C_D} = \frac{L}{W} = \frac{D}{H}$$

See also FIGURE 4 (page 16).



Speed polars
Polari odografiche

FIGURE 3

This confirms what one learns when studying the speed polar of any sailplane. See for instance FIGURE 3, above, taken from Reference 3.

Points P, P', and P" correspond to the minimum sink speed, V_y. By tracing a tangent line to the curves from the point 0 (pole), one finds the points P, P', P" which indicate the maximum aerodynamic efficiency, $E = C_L/C_D$, for three different wing loading, W/S. The aerodynamic efficiency, E, simply shows the length of the glide path for a given tow release altitude.

By increasing the wing loading, both the translation speed, V, and the sink speed, V_y, increase. Also, the smaller the latter becomes, the better the thermaling performance.

EXAMPLE: A scale RC glider, having an efficiency E = 20, released at 100 m altitude, may glide straight for 2000 m, if there is no wind and control surfaces (ailerons, elevator, rudder, flaps) are not actuated.

If the sink speed of such a sailplane is 0.5 m/s, it will climb at 1.5 m/s when entering a rising thermal which has a vertical velocity of 2 m/s.

The lesson to be learned here is that for radioguided sailplanes which are supposed to soar in thermals, the wing loading must be reduced to the minimum required by the necessary structural strength (Reference 18).

As far as aerodynamic design is concerned, that is, the selection of airfoils for wings and tails, one must remember the specific operating conditions of flying models, as characterized by a relatively low Reynolds number.

Let's now complete some considerations for airfoils which are perfect scale reproductions of those used on full scale sailplanes, to be adopted for radioguided sailplanes.

First of all, the concept "scale" must be properly clarified.

Since radioguided gliders fly in the air, exactly as their full size counterparts, it appears to be quite logical to follow the "dynamic similitude" principle.

Let's avoid complicated reasonings by means of a practical example. If a flying model is built on a 1:5 scale, any one of its linear dimensions is equal to 1/5 of the equivalent dimension of the full size aircraft.

EXAMPLE: If a full size aircraft has a wingspan of 15 m, the span of its 1:5 scale reproduction is equivalent to 15:5 = 3 m.

The number 5 represents the "scale factor," usually indicated with the letter F.

So far, so good!

Let us now consider any flat surface, for instance a square, having sides of 10 dm. Its area measures 10 dm • 10 dm = 100 dm^2 = 1 m^2.

If one wants to reduce it to 1:10 scale, its side becomes 10/1 = 1 dm.

Now the fun!

The area of a 1:10 scale square measures 1 dm • 1 dm = 1 dm^2, which is 100 times smaller (1/100) than the full scale square.

If the same reasoning is repeated for a cube having an edge of 10 dm, the volume of the 1:10 scale model becomes 1000 times smaller (1/1000)!

Similar reasonings, which are here omitted since they are beyond the scope of this work, allow one to establish some simple rules which are required for the perfect scale realization of dynamic models, such as radioguided scale sailplanes. These rules are to be followed when a scale model of a dynamic full scale vehicle has to be built, no matter whether the scale is reduced or enlarged. The latter is the case of some flying machines which are first built as reduced scale radioguided models, then as full scale versions with human pilots at the control column. Actually, reduced scale radioguided models replace time consuming wind tunnel testing, since some aeronautical builders cannot afford expensive aeronautical laboratories. TABLE 5 (page 14) summarizes these simple rules.

As an example, let's apply them to the elegant Minimoa (1935) sailplane, since we intend to build a 1:5 scale reproduction of it.

The following is thus obtained:

Dimension	Symbol	Unit of measurement	Full scale	1:5 scale
Wing span	b	m	17	3.4
Wing area	S	m^2	19	$19/5^2$ = 19/25 = 0.76
Mean chord	c	m	1.12	0.224
Weight	W	Kg	350	2.8
Wing loading	W/S	Kg/m^2	18.42	3.73
Speed	V	Km/h (m/s)	100 (27.7)	44.72 (12.4)

TABLE 5

To convert full scale values to apply to a model constructed to a scale ratio of F to 1, divide by the factors shown:

Per convertire valori in scala reale per applicarli a modelli costruiti secondo un rapporto di scala di F:1, dividere per i fattori qui elencati:

Type of units/ Tipo di unita'		*Factor*/Fattore
Linear dimension/Dimensione lineare		F
Area/Area	F*F=	F^2
Volume/Volume	F*F*F=	F^3
Weight/Peso	F*F*F=	F^3
Force/Force	F*F*F=	F^3
Work or Energy/Lavoro o Energia	F*F*F*F=	F^4
Torque/Coppia	F*F*F*F=	F^4
Moment (static)/Momento (statico)	F*F*F*F=	F^4
Moment of inertia/Momento d'inerzia	F*F*F*F*F=	F^5
Strength of materials/Resistenza materiali		1/F
Time/Tempo		$\sqrt{F}$
Speed/Velocita'		$\sqrt{F}$
Linear accelleration/Accellerazione lineare		1
Angular accelleration/Accellerazione angolare		1/F
Horsepower/Potenza	$F*F*F*\sqrt{F}=$	$F^3*\sqrt{F}$
Power loading/Potenza unitaria		$1/\sqrt{F}$
RPM/Giri/minuto		$1/\sqrt{F}$
Angles and revolutions/Angoli e rotazioni		1
Wing loading/Carico alare	$F^3/F^2=$	F

To convert observed or measured values of the model to full scale values, multiply by the factors above.

Per convertire in scala reale i valori osservati o misurati relativi al modello, moltiplicare per i suddetti valori.

TABLE 6

	METRIC SYSTEM SISTEMA METRICO Kg – m – sec	BRITISH SYSTEM SISTEMA INGLESE Lb – ft – sec
ρ	0.125 $Kg \cdot m^4/s$ ▲	0.0002378 $lb \cdot ft^4/s$ ▲
V	m/s	ft/s
l	m	ft
μ	$1.81 \cdot 10^{-6}$ $Kg \cdot s/m^2$ *	$0.3728 \cdot 10^{-6}$ $lb \cdot s/ft^2$ *

* = TEMP.: 15 °C PRESS.: 760 mm Hg ▲ = AT 0 ALTITUDE A QUOTA 0

ρ/μ	SPEED VELOCITA'	CHORD CORDA
69'000	m/s	m
690	m/s	cm
192	Km/h	cm
6378	ft/s	ft
9354	miles/h	ft

1 mile = 1609.32 m 1 ft = 30.48 cm

First remark: It will be very difficult to keep the total weight within the limit established by the "true scale" rule. Most likely the weight will turn out to be very close to about 4 Kg. As a consequence, the wing loading will increase to about 53 g/dm^2

As far as the choice of the airfoil is concerned, the Reynolds number must be taken into consideration. It is given by the following formula, which appears in any textbook of applied aerodynamics

$$Re = V \bullet c \bullet \left(\frac{\rho}{\mu}\right)$$

where

V = speed, m/s
c = wing chord, m
ρ = (rho) air density, 0.125
μ = (mu) air viscosity

From a practical point of view, speed V, chord c, and ρ/μ (rho/mu) are multiplied by each other. The value of the ratio ρ/μ (rho/mu) depends upon the units of measurement, as indicated in TABLE 6 (page 14).

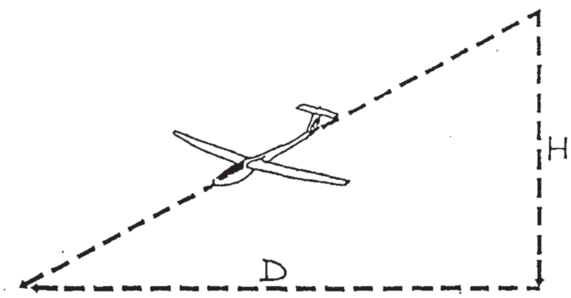
In our case one gets

FULL SIZE SAILPLANE: 27.7 • 1.12 • 69,000 = 2,140,656

MODEL SAILPLANE: 12.4 • 0.224 • 69,000 = 191,654

Second remark: Under these circumstances, it becomes obvious that the airfoils used on the full scale sailplane cannot be adopted for scale models because they are too thick. Drag would be magnified and the glide ratio would be highly penalized.

From a practical point of view, the efficiency, E, indicates the horizontal distance flown for a given tow release altitude. See FIGURE 4 below.



Glide path definition
Definizione del rapporto di planata

E = CL/CD = D/H

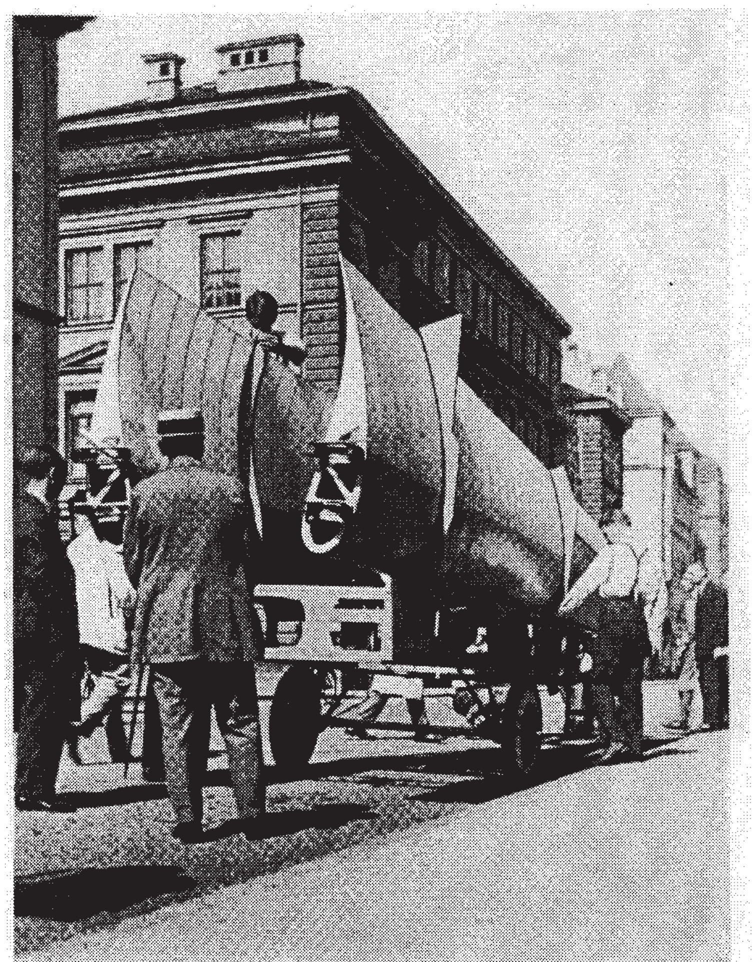
FIGURE 4

Characteristic data of a significant number of vintage and contemporary sailplanes are listed in TABLE 7 (pages 18 to 27). The definitions of the various terms are summarized in FIGURES 5, 6, 7-A and 7-B, and 8 (pages 28 to 32).

FIGURE 9-A (page 34) shows the trend of the aerodynamic efficiency, $E = C_L/C_D$ versus the wing aspect ratio, AR. This confirms what one learns at any aeromodeling course: At comparable Reynolds Numbers the lift/drag ratio, that is the glide angle, improves when the aspect ratio, AR, increases, since the induced drag is reduced.

FIGURE 9-B (page 35) shows the increase of the sailplanes efficiency, E, through the years, from the pioneering days up to now.

In aeromodelling, the increase of the aspect ratio must be adopted with caution, because an excessive reduction of both the mean aerodynamic chord and the tip chord causes a deterioration of characteristics, mainly due to the decrease of the Reynolds Number and to less precise reproduction of the airfoil contour.



Photograph from Howard Siepen

A GLIDER, MADE BY MUNICH COLLEGE STUDENTS, READY FOR SHIPMENT TO THE WASSERKUPPE FLYING GROUND

NATIONAL GEOGRAPHIC, JUNE 1929

TABLE 7.1.2

✱ = FLEXIBLE FLAPS
FLAPS ELASTICI

W&C = WOOD AND CALICO CONSTRUCTION = COSTRUZIONE IN LEGNO E TELA

W&C-15 = WOOD AND CALICO CONSTRUCTION 15 m CLASS = COSTRUZIONE IN LEGNO E TELA CLASSE 15 m

		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
		AILERON SPAN / APERT. ALETT.	AIL. MEAN CHORD / CORDA MEDIA AL.	EMPENN. ARRAN. / SIST. IMPENN.	STABILATOR SPAN / APERT. STABIL.	STABILATOR AREA / SUP. STABILIZZ.	STABILATOR AR / ALLUNG. STAB	STAB. MEAN CHORD / CORDA MEDIA STA.	ELEVATOR CHORD / CORDA ELEVATORE	ELEV. LEVER ARM / BRACCIO ELEV.	TAIL VOL. COEFF. / RAPP. VOLUMETR.	FIN HEIGHT / ALTEZZA DERIVA	TOTAL FIN AREA / SUP. TOT. DERIVA	FIN ASPEC. R. / ALLUNG. DERIVA	FIN MEAN CH. / CORDA M. DERIVA	RUDDER CHORD / CORDA DIREZ.	RUDDER L. ARM / BRACCIO DIR.	TAIL VOL. COEF. / RAPP. VOLUM.	SPOILERS ARR. / SIST. DIRUTT.	AIR BRAKE SPAN / APERT. DIRUTT.
		sa [%s]	ca [m]	FIG. 7	bt [m]	st [m²]	ARt [–]	ct [m]	ht [%ct]	A [m]	TVC [–]	y [m]	sv [m²]	ARv [–]	cv [m]	hv [%cv]	B [m]	VVC [–]	FIG. 15	sb [m]
W&C	VAMPYR	32	0.46	A	2.50	1.88	3.33	0.75	100	3.40	0.31	0.90	1.28	0.63	1.42	38	2.50	0.016		
W&C	FAFNIR			A	3.50							1.66								
W&C	GRUNAU BABY II b	52	0.32	A	2.90	2.32	3.63	0.80	47	3.45	0.40	1.20	0.81	1.78	0.68	91	3.90	0.016	C	0.72
W&C	MINIMOA	58	0.40	A	3.00	1.98	4.55	0.66	41	4.13	0.38	1.94	1.20	3.14	0.62	100	4.50	0.017		
W&C	WEIHE 50	64	0.33	A	3.50	2.25	5.44	0.64	55	4.70	0.56	1.15	1.27	1.04	1.10	69	5.00	0.019	C	0.89
W&C	HKS I	✱	✱	D	2.70	1.97	3.70	0.73	44	4.72	0.56	1.13	1.65	3.10	0.73	44	4.72	0.023	A	1.30
W&C	HKS III	✱	✱	D	2.45	1.39	4.32	0.57	44	4.00	0.47	1.03	1.17	3.63	0.57	44	4.00	0.019	A	1.30
W&C	ZUGVOGEL III	32	0.23	A	2.60	1.81	3.73	0.70	46	4.28	0.63	1.50	1.37	1.64	0.91	59	4.66	0.026	C	1.11
W&C	ZEFIR	42	0.17	A	2.40	1.28	4.50	0.53	44	4.45	0.50	1.34	0.99	1.81	0.74	44	4.10	0.017	A	
W&C	SHK	38	0.18	D	2.73	1.94	3.84	0.71	100	3.73	0.57	1.32	1.87	3.73	0.71	100	3.73	0.028	C	1.79
W&C	FK 3	32	0.14	B	2.80	1.28	6.13	0.46	45	3.95	0.46	1.68	1.35	2.09	0.80	51	4.20	0.023	C	1.50
W&C - 15 m	MEISE	30	0.20	A	2.90	2.35	3.58	0.81	40	4.13	0.65	1.40	1.07	1.83	0.76	67	4.53	0.022	C	0.88
W&C - 15 m	Ka 6E	29	0.20	A	2.80	1.61	4.87	0.58	100	3.75	0.59	1.43	1.15	1.78	0.80	55	3.95	0.024	C	1.01
W&C - 15 m	Ka 8B	32	0.23	A	2.80	1.95	4.02	0.70	49	3.82	0.53	1.50	1.40	1.61	0.93	54	4.18	0.027	C	1.01
W&C - 15 m	STANDARD AUSTRIA	28	0.20	D	2.60	2.00	3.38	0.77	100	3.80	0.62	1.30	2.00	3.38	0.77	100	3.80	0.037	C	1.76
W&C - 15 m	SB 5B	36	0.25	D	2.80	1.70	4.61	0.61	41	3.96	0.60	0.98	1.20	3.20	0.61	41	3.96	0.024	C	0.98
W&C - 15 m	FOKA 4	40	0.15	A	2.70	1.40	5.21	0.52	40	4.00	0.55	1.20	0.98	1.47	0.82	45	3.80	0.020	C	1.06
W&C - 15 m	VASAMA	32	0.18	B	2.20	1.27	3.81	0.58	50	3.65	0.50	1.35	1.10	1.66	0.81	50	3.80	0.024	C	0.95

TABLE 7.1.1

Class	REMARKS NOTE	❶ FIRST FLIGHT / PRIMO VOLO	❷ TAKE OFF WEIGHT / PESO AL DECOLLO *	❸ MAX. TAKE OFF W. / PESO MAX. DECOLLO	❹ WING WEIGHT / PESO ALA	❺ FUSELAGE WEIGHT / PESO FUSOLIERA **	❻ STABILATOR WEIGHT / PESO STABILIZZATORE	❼ BALLAST WATER / ZAVORRA ACQUA	❽ OVERALL LENGTH / LUNGHEZZA F.T.	❾ WING SPAN / APERTURA ALARE	❿ ASPECT RATIO / ALLUNGAMENTO	⓫ WING AREA / SUPERFICIE ALARE	⓬ MIN. WING LOADING / CARICO ALARE MIN.	⓭ MAX. WING LOADING / CARICO ALARE MAX.	⓮ MEAN WING CHORD / CORDA MEDIA ALARE	⓯ ROOT WING CHORD / CORDA ALARE: RADICE	⓰ TIP WING CHORD / CORDA ALARE: ESTR.	⓱ WING PLANFORM / PIANTA ALARE	⓲ TAPER RATIO / RAPP. RASTRENAZ.	⓳ TAPER POINT / INIZIO RASTREM.	⓴ WING TWIST / SVERGOLAM. ALA
		YEAR	W	W'	Ww	Wf	Wt	Wb	L	b=2s	AR	S	W/S	W'/S	c	cr	ce	FIG. 6	TR	yi	αw
		ANNO	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[m]	[m]	[–]	[m²]	[Kg/m²]	[Kg/m²]	[m]	[m]	[m]		[ce/cr]	[%s]	[°]
W&C	VAMPYR	1921	210	210	–	–	–	–	5.00	12.6	10.0	16.0	13.1	13.1	1.27	1.35	0.76	RT	0.56	0.54	–
W&C	FAFNIR	1930	290	315	–	–	–	–	7.76	19.0	20.0	18.6	15.6	16.9	0.98	1.63	0.41	T	0.27	–	0
W&C	GRUNAU BABY II b	1933	239	250	85	57	7	–	6.05	13.6	13.0	14.2	16.8	17.6	1.04	1.18	0.49	RT	0.42	0.53	-3.5
W&C	MINIMOA	1935	340	350	145	95	10	–	7.00	17.0	15.2	19.0	17.9	18.4	1.12	1.30	0.75	RT	0.58	0.58	-2
W&C	WEIHE 50	1938	335	335	140	93	12	–	8.14	18.0	17.7	18.34	18.3	18.3	1.02	1.56	0.43	T	0.28	–	-6.5
W&C	HKS I	1953	540	588	250	183	17	–	8.30	19.0	20.3	17.79	30.4	33.1	0.94	1.27	0.59	T	0.47	–	0
W&C	HKS III	1955	389	410	173	109	17	75	7.16	17.2	20.8	14.23	27.3	28.8	0.83	1.23	0.54	T	0.44	–	0
W&C	ZUGVOGEL III	1957	335	365	150	88	7	–	7.10	17.0	20.1	14.37	23.3	25.4	0.85	1.16	0.38	DT	0.33	0.52	0
W&C	ZEFIR	1958	385	415	185	103	7	–	7.07	17.0	20.6	14.0	27.5	29.6	0.82	0.96	0.34	RT	0.36	0.56	0
W&C	SHK	1965	350	370	164	87	11	–	6.30	17.0	19.7	14.65	23.9	25.3	0.86	1.20	0.51	T	0.43	–	0
W&C	FK 3 ✸	1968	364	400	152	113	9	50	7.22	17.4	21.9	13.8	26.4	29.0	0.79	0.87	0.30	T	0.34	–	0
W&C - 15 m	MEISE	1939	250	255	82	71	7	–	7.27	15.0	15.0	15.0	16.7	17.0	1.00	1.45	0.55	T	0.38	–	0
W&C - 15 m	Ka 6 E	1955	281	300	116	69	6	–	6.70	15.0	18.1	12.4	22.7	24.2	0.83	1.17	0.37	DT	0.32	0.61	-2
W&C - 15 m	Ka 8B	1958	281	310	110	74	7	–	7.00	15.0	15.5	14.5	19.4	21.4	0.97	1.30	0.49	DT	0.38	0.60	-4
W&C - 15 m	STANDARD AUSTRIA	1958	298	323	122	78	8	–	6.20	15.0	16.7	13.5	22.1	23.9	0.90	1.20	0.60	T	0.50	–	-1.5
W&C - 15 m	SB 5B	1959	293	300	122	69	12	–	6.50	15.0	17.3	13.0	22.5	23.1	0.87	1.00	0.56	RT	0.56	0.54	0
W&C - 15 m	FOKA 4	1960	335	385	130	107	8	–	7.00	15.0	18.5	12.16	27.5	31.7	0.81	1.22	0.38	T	0.31	–	0
W&C - 15 m	VASAMA	1961	303	300	124	83	6	–	5.97	15.0	19.1	11.75	25.8	26.5	0.78	1.08	0.40	DT	0.37	0.62	0

** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIU' CODA VERTICALE

* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIU' 90 KG

✸ = METAL CONSTR. / COSTRUZ. METALLICA

TABLE 7.2.2

W&C-15 = WOOD AND CALICO CONSTR. 15 m CLASS = COSTR. LEGNO E TELA, CLASSE 15 m

GRP-F = GLASS REINFOR. PLASTIC CONSTR. FREE CLASS = COSTRUZIONE IN VETRORESINA CLASSE LIBERA

Class	Glider	21 AILERON SPAN / APERT. ALETT. sa [%s]	22 AIL. MEAN CHORD / CORDA MEDIA AL. ca [m]	23 EMPENN. ARRAN. / SIST. IMPENN. FIG.7	24 STABILATOR SPAN / APERT. STABIL. bt [m]	25 STABILATOR AREA / SUP. STABILIZZ. st [m²]	26 STABILATOR AR / ALLUNG. STAB ARt [–]	27 STAB. MEAN CHORD / CORDA MEDIA STA. ct [m]	28 ELEVATOR CHORD / CORDA ELEVATORE ht [%ct]	29 ELEV. LEVER ARM / BRACCIO ELEV. A [m]	30 TAIL VOL. COEFF. / RAPP. VOLUMETR. TVC [–]	31 FIN HEIGHT / ALTEZZA DERIVA y [m]	32 TOTAL FIN AREA / SUP. TOT. DERIVA sv [m²]	33 FIN ASPEC. R. / ALLUNG. DERIVA ARv [–]	34 FIN MEAN CH. / CORDA M. DERIVA cv [m]	35 RUDDER CHORD / CORDA DIREZ. hv [%cv]	36 RUDDER L. ARM / BRACCIO DIR. B [m]	37 TAIL VOL. COEF. / RAPP. VOLUM. VVC [–]	38 SPOILERS ARR. / SIST. DIRUTT. FIG.15	39 AIR BRAKE SPAN / APERT. DIRUTT. sb [m]
W&C – 15 m	STANDARD ELFE	32	0.18	A	2.90	1.45	5.80	0.50	100	4.27	0.66	1.43	1.05	1.94	0.74	40	4.33	0.025	C	1.11
GRP – F	PHÖNIX T	29	0.12	C	3.20	1.55	6.61	0.48	35	4.04	0.54	0.95	1.21	0.75	1.27	58	4.33	0.022		
GRP – F	SB 6	28	0.13	B	2.60	1.20	5.63	0.46	100	4.47	0.57	1.50	1.27	1.77	0.85	40	4.51	0.024	A	
GRP – F	SB 7 B	35	0.12	C	2.50	1.05	5.95	0.42	100	4.10	0.46	1.35	1.00	1.82	0.74	37	4.12	0.019	C	
GRP – F	BS 1	39	0.14	C	3.00	1.33	6.77	0.44	100	4.53	0.54	1.35	1.33	1.37	0.99	40	4.66	0.024	C	
GRP – F	D 36	38	0.14	C	2.30	1.00	5.29	0.43	21	3.89	0.42	1.57	1.27	1.94	0.81	52	4.02	0.022	C	
GRP – F	ASW 12	37	0.15	C	2.50	1.00	6.25	0.40	35	4.17	0.45	1.50	1.20	1.88	0.80	50	4.30	0.022	A	
GRP – F	CIRRUS B	37	0.15	B	2.50	1.05	5.95	0.42	28	4.16	0.49	1.48	1.15	1.90	0.78	45	4.30	0.022	C	
GRP – F	PHOEBUS C	32	0.16	C	3.20	1.56	6.56	0.49	100	4.24	0.57	1.20	1.16	1.24	0.97	49	4.28	0.020	C	
GRP – F	SB 8	34	0.15	C	2.70	1.30	5.61	0.48	30	4.65	0.55	1.45	1.30	1.62	0.90	35	4.72	0.024	C	
GRP – F	DIAMANT 18	41	0.16	C	2.80	1.19	6.59	0.43	100	4.67	0.49	1.32	1.01	1.73	0.77	59	4.63	0.018	C	
GRP – F	KESTREL 401	39	0.09	C	2.85	1.28	6.35	0.45	19	3.76	0.61	1.30	1.00	1.69	0.77	35	3.85	0.020	C	
GRP – F	SB 9	43	0.15	C	2.70	1.30	5.61	0.48	30	4.40	0.53	1.40	1.30	1.51	0.93	43	4.65	0.018	C	
GRP – F	NIMBUS II	38	0.12	C	2.40	1.02	5.65	0.43	100	4.60	0.46	1.27	1.24	1.30	0.98	38	4.46	0.019	σ FIG.15	
GRP – F	KESTREL 604	30	0.09	C	3.55	1.50	8.40	0.42	50	4.40	0.55	1.35	1.29	1.42	0.95	30	4.45	0.016		
GRP – F	ASW 17	37	0.12	B	2.90	1.43	5.88	0.49	30	4.22	0.55	1.70	1.44	2.01	0.84	51	4.43	0.021	σ FIG.15	
GRP – F	SB 10 [29 m]	68	0.16	B	3.30	1.47	7.41	0.45	41	5.74	0.47	2.40	2.61	2.20	1.09	49	6.14	0.024	B σ u	
GRP – F	FS 29 [13 m] [19 m]	46 32	0.24	C	2.40	1.03	5.59	0.43	100	4.64 4.63	1.41 0.94	1.27	1.24	1.30	0.98	38	4.50 4.49	0.048 0.023	σ A	

TABLE 7.2.1

Group	REMARKS NOTE	❶ FIRST FLIGHT / PRIMO VOLO	❷ TAKE OFF WEIGHT * / PESO AL DECOLLO	❸ MAX. TAKE OFF W. / PESO MAX. DECOLLO	❹ WING WEIGHT / PESO ALA	❺ FUSELAGE WEIGHT ** / PESO FUSOLIERA	❻ STABILATOR WEIGHT / PESO STABILIZZATORE	❼ BALLAST WATER / ZAVORRA ACQUA	❽ OVERALL LENGTH / LUNGHEZZA F.T.	❾ WING SPAN / APERTURA ALARE	❿ ASPECT RATIO / ALLUNGAMENTO	⓫ WING AREA / SUPERFICIE ALARE	⓬ MIN. WING LOADING / CARICO ALARE MIN.	⓭ MAX. WING LOADING / CARICO ALARE MAX.	⓮ MEAN WING CHORD / CORDA MEDIA ALARE	⓯ ROOT WING CHORD / CORDA ALARE: RADICE	⓰ TIP WING CHORD / CORDA ALARE: ESTR.	⓱ WING PLANFORM / PIANTA ALARE	⓲ TAPER RATIO / RAPP. RASTREMAZ.	⓳ TAPER POINT / INIZIO RASTREM.	⓴ WING TWIST / SVERGOLAM. ALA
		YEAR	W	W'	Ww	Wf	Wt	Wb	L	b=2s	AR	S	W/S	W'/S	c	cr	ce	FIG. 6	TR	yi	αw
		ANNO	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[m]	[m]	[–]	[m²]	[Kg/m²]	[Kg/m²]	[m]	[m]	[m]		[ce/cr]	[%s]	[°]
W&C – 15 m	STANDARD ELFE	1965	234	350	147	89	8	–	7.30	15.0	19.0	11.86	23.2	29.5	0.79	0.90	0.37	RT	0.41	0.57	0
GRP – F	PHÖNIX T	1957	269	300	96	75	8	–	6.90	16.0	17.8	14.36	18.7	20.9	0.81	1.25	0.53	T	0.42	–	-2
GRP – F	SB 6	1961	350	350	145	119	6	–	7.50	18.0	24.9	13.00	26.9	26.9	0.72	0.90	0.48	DT	0.53	0.66	0
GRP – F	SB 7B	1962	390	390	181	112	7	–	7.08	17.0	22.8	12.66	30.8	30.8	0.74	0.92	0.37	RT	0.36	0.41	
GRP – F	BS 1	1962	425	500	192	134	9	–	7.58	18.0	22.8	14.20	29.9	35.2	0.79	0.99	0.40	DT	0.41	0.56	0
GRP – F	D 36	1964	375	401	166	110	9	–	7.35	17.8	24.8	12.80	29.3	31.3	0.72	0.95	0.34	DT	0.36	0.60	-3
GRP – F	ASW 12	1965	409	430	194	117	8	–	7.35	18.3	25.8	13.00	31.5	33.1	0.71	0.76	0.26	DT	0.34	0.59	-3
GRP – F	CIRRUS B	1967	366	400	165	104	7	100	7.20	17.7	24.9	12.60	29.0	31.7	0.71	0.87	0.35	DT	0.40	0.58	-2
GRP – F	PHOEBUS C	1967	333	459	176	85	9	–	6.98	17.0	20.6	14.06	23.7	32.6	0.83	1.21	0.37	T	0.31	–	
GRP – F	SB 8	1967	301	334	129	76	6	–	7.70	18.0	23.0	14.10	21.3	23.7	0.78	0.97	0.45	DT	0.46	0.62	-3
GRP – F	DIAMANT 18	1967	385	440	182	105	8	–	7.72	18.0	22.7	14.28	27.0	30.8	0.79	0.93	0.36	RT	0.39	0.56	
GRP – F	KESTREL 401	1968	362	400	149	115	8	50	6.72	17.0	25.0	11.58	32.3	34.5	0.68	0.71	0.32	DT	0.45	0.59	0
GRP – F	SB 9	1969	415	421	218	100	7	100	7.50	22.0	31.3	15.48	26.8	27.2	0.70	0.97	0.25	DT	0.26	0.51	-1.5
GRP – F	NIMBUS II	1969	446	580	230	120	6	150	7.28	20.3	28.6	14.41	31.0	40.2	0.71	0.76	0.27	DT	0.36	0.57	0
GRP – F	KESTREL 604	1970	551	650	294	159	8	100	7.56	22.0	29.8	16.23	33.9	40.0	0.74	0.98	0.40	DT	0.41	0.68	
GRP – F	ASW 17	1971	495	570	266	127	11	180	7.55	20.0	27.0	14.84	33.4	38.4	0.74	0.94	0.40	DT	0.43	0.61	0
GRP – F	SB 10 [29 m]	1972	647	897	419	127	11	100	10.36	29.0	36.7	22.90	28.3	39.0	0.79	0.97	0.77 0.29	DT	0.80 0.30	0.30 0.67	-1.5
GRP – F	FS 29 [13 m] [19 m]	1975	458	461	241	121	6	(70)	7.16	13.3 19.0	20.7 28.5	8.67 12.65	52.8 36.2	53.2 36.4	0.65 0.67	0.76 0.73	0.41 0.49	RT	0.40	0.54 0.68	-1.5

** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIU' CODA VERTICALE

* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIU' 90 KG

TABLE 7.3.2

TWS = TWIN SEAT SAILPLANES = ALIANTI BIPOSTO

✱ = METAL CONSTRUCTION = COSTRUZ. METALLICA

		21 AILERON SPAN / APERT. ALETT. sa [%s]	22 AIL. MEAN CHORD / CORDA MEDIA AL. ca [m]	23 EMPENN. ARRAN. / SIST. IMPENN. FIG. 7	24 STABILATOR SPAN / APERT. STABIL. bt [m]	25 STABILATOR AREA / SUP. STABILIZZ. st [m²]	26 STABILATOR AR / ALLUNG. STAB ARt [–]	27 STAB. MEAN CHORD / CORDA MEDIA STA. ct [m]	28 ELEVATOR CHORD / CORDA ELEVATORE ht [%ct]	29 ELEV. LEVER ARM / BRACCIO ELEV. A [m]	30 TAIL VOL. COEFF. / RAPP. VOLUMETR. TVC [–]	31 FIN HEIGHT / ALTEZZA DERIVA y [m]	32 TOTAL FIN AREA / SUP. TOT. DERIVA sv [m²]	33 FIN ASPEC. R. / ALLUNG. DERIVA ARv [–]	34 FIN MEAN CH. / CORDA M. DERIVA cv [m]	35 RUDDER CHORD / CORDA DIREZ. hv [%cv]	36 RUDDER L. ARM / BRACCIO DIR. B [m]	37 TAIL VOL. COEF. / RAPP. VOLUM. VVC [–]	38 SPOILERS ARR. / SIST. DIRUTT. FIG. 15	39 AIR BRAKE SPAN / APERT. DIRUTT. sb [m]
TWS	KRANICH II	69	0.40	A	3.00	2.20	4.09	0.73	45	4.35	0.33	1.58	1.36	1.82	0.86	73	4.78	0.016	C	1.67
TWS	GOEVIER	61	0.34	A	3.18	2.64	3.83	0.83	42	4.26	0.46	1.74	1.72	1.76	0.99	64	4.64	0.028	C	0.90
TWS	KRANICH III	46	0.37	A	3.50	2.32	5.28	0.66	41	4.70	0.45	1.26	1.68	0.95	1.33	82	5.00	0.022	C	1.21
TWS	BERGFALKE II/55	46	0.26	A	2.80	2.00	3.92	0.71	46	4.11	0.43	1.27	1.09	1.48	0.86	77	4.87	0.018	C	1.10
TWS	BOCIAN	48	0.34	A	3.85	2.80	5.29	0.73	45	4.35	0.52	1.63	1.51	1.76	0.93	60	4.85	0.020	C	1.18
TWS	BLANIK ✱	42	0.34	A	3.45	2.66	4.47	0.77	42	4.76	0.56	1.53	1.61	1.46	1.05	56	4.74	0.024	C	
TWS	Ka 7	37	0.27	A	3.00	2.55	3.53	0.85	42	4.43	0.59	1.45	1.34	1.57	0.92	58	4.95	0.024	C	1.47
TWS	ASK 13	37	0.27	A	3.00	2.55	3.53	0.85	42	4.40	0.58	1.45	1.21	1.74	0.83	57	5.05	0.022	C	1.47
TWS	CALIF	28	0.18	C	3.15	1.70	5.84	0.54	20	5.08	0.68	1.95	1.34	2.84	0.69	47	4.92	0.020	B	3.50
TWS	SB 10 [26 m]	64	0.16	B	3.30	1.47	7.43	0.44	41	5.74	0.46	2.40	2.61	2.20	1.09	49	6.14	0.028	°B	1.20
TWS	LSD-ORNITH			C	2.30	0.84	6.30	0.37	100			1.30	1.20	1.41	0.92					
TWS	JANUS	37	0.15	C	2.70	1.24	5.88	0.46	100	5.39	0.44	1.30	1.24	1.36	0.95	30	5.25	0.021	°C	1.21
TWS	TWIN ASTIR	36	0.18	C	3.30	2.05	5.31	0.62	27	4.81	0.52	1.60	1.43	1.79	0.89	38	4.68	0.021	°C	1.40
TWS	GLOBETROTTER			C	2.75	1.47	5.14	0.53				1.20	1.00	1.44	0.83				°C	
TWS	B-12	37	0.15	B	3.28	1.44	7.47	0.44				1.79	1.46	2.19	0.82				°C	1.21
TWS	SFH 34			C					25							40			°C	1.40
TWS	ASK 21			C															°C	
	PHOEBUS B1	32	0.17	C	3.20	1.56	6.56	0.49	100	4.24		1.20	1.16	1.24	0.97	49	4.28	0.045	°C	1.51

TABLE 7.3.1

REMARKS NOTE	❶ FIRST FLIGHT / PRIMO VOLO	❷ TAKE OFF WEIGHT * / PESO AL DECOLLO	❸ MAX. TAKE OFF W. / PESO MAX. DECOLLO	❹ WING WEIGHT / PESO ALA	❺ FUSELAGE WEIGHT ** / PESO FUSOLIERA	❻ STABILATOR WEIGHT / PESO STABILIZZATORE	❼ BALLAST WATER / ZAVORRA ACQUA	❽ OVERALL LENGTH / LUNGHEZZA F.T.	❾ WING SPAN / APERTURA ALARE	❿ ASPECT RATIO / ALLUNGAMENTO	⓫ WING AREA / SUPERFICIE ALARE	⓬ MIN. WING LOADING / CARICO ALARE MIN.	⓭ MAX. WING LOADING / CARICO ALARE MAX.	⓮ MEAN WING CHORD / CORDA MEDIA ALARE	⓯ ROOT WING CHORD / CORDA ALARE: RADICE	⓰ TIP WING CHORD / CORDA ALARE: ESTR.	⓱ WING PLANFORM / PIANTA ALARE	⓲ TAPER RATIO / RAPP. RASTRENAZ.	⓳ TAPER POINT / INIZIO RASTREM.	⓴ WING TWIST / SVERGOLAN. ALA
** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIU' CODA VERTICALE; * = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIU' 90 KG; ✸ = METAL CONSTRUCTION / = COSTRUZ. METALLICA	YEAR / ANNO	W [Kg]	W' [Kg]	W_w [Kg]	W_f [Kg]	W_t [Kg]	W_b [Kg]	L [m]	b=2s [m]	AR [–]	S [m²]	W/S [Kg/m²]	W'/S [Kg/m²]	c [m]	c_r [m]	c_e [m]	FIG. 6	TR [c_e/c_r]	y_i [%s]	α_w [°]
KRANICH II	1935	380	465	163	117	10	–	7.70	18.00	14.3	22.70	16.7	20.5	1.26	1.60	0.61	RT	0.38	0.33	–
GOEVIER	1938	325	410	122	102	11	–	6.24	14.84	11.6	19.00	17.1	21.6	1.28	1.45	0.56	RT	0.39	0.37	0
KRANICH III	1951	410	520	204	105	11	–	9.10	18.10	15.6	21.06	19.5	24.7	1.16	1.75	0.58	T	0.33	–	-8
BERGFALKE II/55	1951	349	440	152	97	10	–	7.88	16.60	15.6	17.70	19.7	24.9	1.07	1.51	0.91	T	0.40	–	0
BOCIAN	1952	423	510	166	155	12	–	8.00	18.11	16.4	20.00	21.2	25.5	1.10	1.60	0.53	T	0.33	–	-2
BLANIK ✸	1956	382	500	172	106	14	–	8.40	16.20	13.7	19.15	19.9	26.1	1.18	1.67	0.70	T	0.42	–	-3
Ka 7	1957	382	480	162	120	10	–	8.10	16.00	14.6	17.50	21.8	27.4	1.09	1.50	0.61	T	0.41	–	-4
ASK 13	1965	408	480	161	147	10	–	8.18	15.95	14.5	17.50	23.3	27.4	1.10	1.50	0.61	T	0.41	–	-4
CALIF	1970	532	644	257	169	16	–	7.74	20.38	25.7	16.19	32.9	39.8	0.79	0.90	0.68	RT	0.36	0.63	0
SB 10 [26 m]	1972	708	889	397	211	10	100	10.36	26.00	31.0	21.80	32.4	40.8	0.84	0.97	0.77 0.45	RT	0.80 0.46	0.34 0.82	-.5
LSD-ORNITH	1972	377	450					7.50	18.00	26.1	12.40	29.0	36.3		0.96					
JANUS	1974	472	620	220	154	8	–	8.57	18.20	20.0	16.60	28.4	37.3	0.91	1.20	0.48	DT	0.40	0.59	0
TWIN ASTIR	1976	495	650	194	196	15	100	8.10	17.50	17.1	17.90	27.7	36.3	1.05	1.30	0.66	DT	0.51	0.58	0
GLOBETROTTER	1977	498	600					7.66	17.00	18.1	15.72	31.7	35.2		1.30		DT			0
B-12	1977	492	582					8.67	18.20	20.0	16.60	29.6	35.1	0.91	1.20	0.48	DT	0.40	0.59	0
SFH 34	1978	390	490					7.50	15.80	17.0	14.80	26.4	33.1	1.07			T			
ASK 21	1979	440	550					8.35	17.00	16.1	17.95	24.5	30.6	1.06			T			
PHOEBUS B 1	1964	314	350					6.98	15.0	17.2	13.11	24.0	26.7	0.87	1.21		DT			

TWS (bracket spanning KRANICH II – ASK 21)

TABLE 7.4.2

GRP-S = GLASS REINFORC. CONSTRUCTION, STANDARD CLASS
= COSTRUZIONE IN VETRORESINA, CLASSE STANDARD

GRP-15 = GLASS REINFORCED CONSTRUCTION, 15 m CLASS
= COSTRUZIONE IN VETRORESINA, CLASSE 15 m

		21 AILERON SPAN / APERT. ALETT. sa [%s]	22 AIL. MEAN CHORD / CORDA MEDIA AL. ca [m]	23 EMPENN. ARRAN. / SIST. IMPENN. FIG.7	24 STABILATOR SPAN / APERT. STABIL. bt [m]	25 STABILATOR AREA / SUP. STABILIZZ. st [m²]	26 STABILATOR AR / ALLUNG. STAB ARt [–]	27 STAB. MEAN CHORD / CORDA MEDIA STA. ct [m]	28 ELEVATOR CHORD / CORDA ELEVATORE ht [%ct]	29 ELEV. LEVER ARM / BRACCIO ELEV. A [m]	30 TAIL VOL. COEFF. / RAPP. VOLUMETR. TVC [–]	31 FIN HEIGHT / ALTEZZA DERIVA y [m]	32 TOTAL FIN AREA / SUP. TOT. DERIVA sv [m²]	33 FIN ASPEC. R. / ALLUNG. DERIVA ARv [–]	34 FIN MEAN CH. / CORDA M. DERIVA cv [m]	35 RUDDER CHORD / CORDA DIREZ. hv [%cv]	36 RUDDER L. ARM / BRACCIO DIR. B [m]	37 TAIL VOL. COEF. / RAPP. VOLUM. VVC [–]	38 SPOILERS ARR. / SIST. DIRUTT. FIG.15	39 AIR BRAKE SPAN / APERT. DIRUTT. sb [m]
GRP-S	LS 1 C	35	0.14	C	2.30	0.84	6.30	0.37	100	4.05	0.54	1.30	1.00	1.69	0.77	35	4.10	0.028	σC	0.93
GRP-S	STANDARD LIBELLE	39	0.10	B	2.50	1.16	5.39	0.46	21	3.65	0.66	1.19	0.78	1.82	0.66	40	3.59	0.019	C	1.20
GRP-S	FS 25	36	0.11	C	2.00	0.72	5.56	0.36	100	4.05	0.60	1.20	0.72	2.00	0.60	40	4.05	0.023	B	1.20
GRP-S	ASW 15 B	33	0.17	B	2.62	1.15	5.97	0.44	100	3.45	0.49	1.48	1.13	1.94	0.76	47	3.66	0.025	C	1.00
GRP-S	STANDARD CIRRUS	33	0.12	C	2.40	1.02	5.65	0.43	100	3.85	0.58	1.20	0.95	1.52	0.79	35	3.79	0.024	σC	1.20
GRP-S	D 38	35	0.17	C	2.30	1.00	5.29	0.43	100	4.27	0.53	1.25	0.92	1.98	0.63	40	4.29	0.021	σC	1.35
GRP-S	STANDARD JANTAR	32	0.11	C	2.60	1.35	5.01	0.52	29	3.92	0.45	1.35	1.10	1.66	0.81	42	3.98	0.027	C	1.33
GRP-S	LS 1f	35	0.14	C	2.20	0.98	4.94	0.45	25	3.95	0.61	1.15	0.90	1.47	0.78	35	3.99	0.025	σC	1.35
GRP-S	DG 100	35	0.17	C	2.30	1.00	5.29	0.43	100	4.29	0.53	1.24	0.92	1.67	0.74	50	4.29	0.024	σC	1.34
GRP-S	ASTIR CS	33	0.18	C	2.80	1.50	5.23	0.54	25	4.05	0.59	1.22	0.96	1.55	0.79	30	4.04	0.021	σC	1.21
GRP-S	HORNET	39	0.10	C	2.50	1.15	5.43	0.46	25	3.74	0.68	1.15	0.89	1.49	0.77	30	3.73	0.023	B	3.72
GRP-S	ASW 19	33	0.15	C	2.50	1.10	5.68	0.44	30	3.82	0.52	1.25	1.00	1.56	0.80	30	3.84	0.023	σC	1.20
GRP-15m	LIBELLE H-301	44	0.12	B	2.50	1.00	6.25	0.40	25	3.62	0.60	1.19	0.78	1.82	0.66	40	3.50	0.019	C	1.20
GRP-15m	PIK 20D	94	0.13	C	2.00	1.00	4.00	0.50	23	3.66	0.55	1.20	0.93	1.55	0.78	31	3.60	0.022	σC	1.20
GRP-15m	LS 3	95	0.16	C	2.20	0.89	5.44	0.40	25	3.95	0.48	1.32	1.00	1.74	0.76	35	3.90	0.025	σC	1.38
GRP-15m	MOSQUITO	45	0.11	C	2.50	1.15	5.43	0.46	25	3.88	0.70	1.40	0.90	2.18	0.64	30	3.90	0.024	B	3.20
GRP-15m	MINI NIMBUS	45	0.11	C	2.40	1.02	5.65	0.43	100	3.91	0.61	1.15	0.95	1.39	0.83	30	3.76	0.024	B	3.20
GRP-15m	DG 200	40	0.09	C	2.24	0.95	5.30	0.42	27	4.23	0.60	1.21	0.88	1.66	0.73	50	4.24	0.025	σC	1.46

TABLE 7.4.1

REMARKS NOTE

** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIU' CODA VERTICALE

* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIU' 90 KG

Group	Sailplane	1 FIRST FLIGHT / PRIMO VOLO	2 TAKE OFF WEIGHT * / PESO AL DECOLLO	3 MAX. TAKE OFF W. / PESO MAX. DECOLLO	4 WING WEIGHT / PESO ALA	5 FUSELAGE WEIGHT ** / PESO FUSOLIERA	6 STABILATOR WEIGHT / PESO STABILIZZATORE	7 BALLAST WATER / ZAVORRA ACQUA	8 OVERALL LENGTH / LUNGHEZZA F.T.	9 WING SPAN / APERTURA ALARE	10 ASPECT RATIO / ALLUNGAMENTO	11 WING AREA / SUPERFICIE ALARE	12 MIN. WING LOADING / CARICO ALARE MIN.	13 MAX. WING LOADING / CARICO ALARE MAX.	14 MEAN WING CHORD / CORDA MEDIA ALARE	15 ROOT WING CHORD / CORDA ALARE: RADICE	16 TIP WING CHORD / CORDA ALARE: ESTR.	17 WING PLANFORM / PIANTA ALARE	18 TAPER RATIO / RAPP. RASTRENAZ.	19 TAPER POINT / INIZIO RASTREM.	20 WING TWIST / SVERGOLAM. ALA
		YEAR	W	W'	Ww	Wf	Wt	Wb	L	b=2s	AR	S	W/S	W'/S	c	cr	ce	FIG.6	TR	yi	αw
		ANNO	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[m]	[m]	[–]	[m²]	[Kg/m²]	[Kg/m²]	[m]	[m]	[m]		[ce/cr]	[%s]	[°]
GRP-S	LS 1c	1967	293	312	107	91	5	–	7.20	15.0	23.1	9.74	30.1	32.0	0.65	0.85	0.32	DT	0.38	60	-2
GRP-S	STANDARD LIBELLE	1967	289	350	108	84	7	50	6.20	15.0	23.0	9.80	29.5	35.7	0.65	0.88	0.35	DT	0.40	58	-2.5
GRP-S	FS 25	1968	238	250	78	66	4	–	6.48	15.0	26.3	8.54	27.9	29.3	0.57	0.76	0.24	DT	0.32	74	0
GRP-S	ASW 15 B	1968	324	408	135	90	9	82	6.48	15.0	20.5	11.00	29.5	37.1	0.73	0.91	0.38	DT	0.42	59	-2
GRP-S	STANDARD CIRRUS	1969	302	390	110	95	7	60	6.35	15.0	22.4	10.04	30.1	38.8	0.67	0.92	0.35	DT	0.38	60	-0.75
GRP-S	D 38	1972	306	360	118	91	7	40	6.92	15.0	20.5	11.0	27.8	32.7	0.73	0.94	0.37	DT	0.40	60	-2.6
GRP-S	STANDARD JANTAR	1973	340	440	136	106	8	100	7.11	15.0	21.1	10.66	31.9	41.3	0.71	0.95	0.45	T	0.47	–	-3
GRP-S	LS 1f	1974	317	390	119	102	6	90	6.70	15.0	23.1	9.75	32.5	40.0	0.65	0.84	0.32	DT	0.38	60	-2
GRP-S	DG 100	1974	316	418	120	98	8	100	7.00	15.0	20.5	11.0	28.7	38.0	0.73	0.94	0.38	DT	0.40	60	-1.8
GRP-S	ASTIR CS	1974	342	450	138	105	9	100	6.47	15.0	18.1	12.4	27.6	36.3	0.83	1.00	0.45	DT	0.45	60	0
GRP-S	HORNET	1974	334	420	124	112	8	100	6.40	15.0	23.0	9.8	34.1	42.9	0.65	0.88	0.35	DT	0.40	58	-2.5
GRP-S	ASW 19	1975	344	408	140	104	10	120	6.80	15.0	20.5	11.0	31.3	37.1	0.73	0.91	0.38	DT	0.42	59	-2
GRP-15 m	LIBELLE H-301	1964	275	300	105	75	5	–	6.18	15.0	23.7	9.5	28.9	31.6	0.63	0.94	0.33	T	0.35	–	0
GRP-15 m	PIK 20 D	1973	338	450	140	102	6	140	6.45	15.0	22.5	10.0	33.8	45.0	0.67	0.90	0.36	DT	0.40	60	
GRP-15 m	LS 3	1976	370	472	158	115	7	150	6.86	15.0	21.4	10.5	35.2	45.0	0.70	0.97	0.46	T	0.47	–	–
GRP-15 m	MOSQUITO	1976	332	450	134	102	6	125	6.40	15.0	23.0	9.8	33.9	45.9	0.65	0.84	0.40	DT	0.48	47	0
GRP-15 m	MINI NIMBUS	1976	326	450	130	99	7	140	6.41	15.0	22.7	9.9	32.9	45.5	0.66	0.87	0.42	DT	0.48	47	0
GRP-15 m	DG 200	1976	331	450	126	108	7	110	7.00	15.0	22.5	10.0	33.1	45.0	0.67	0.84	0.33	DT	0.40	68	0

TABLE 7.5.2

GRP-15 = GLASS REINFORCED CONSTRUCTION 15 m CLASS
= COSTRUZIONE IN VETRORESINA CLASSE 15 m

WGV = VARIABLE GEOMETRY WING
= ALA A GEOMETRIA VARIAB.

AS = AEROBATIC SAILPLANES
= ALIANTI ACROBATICI

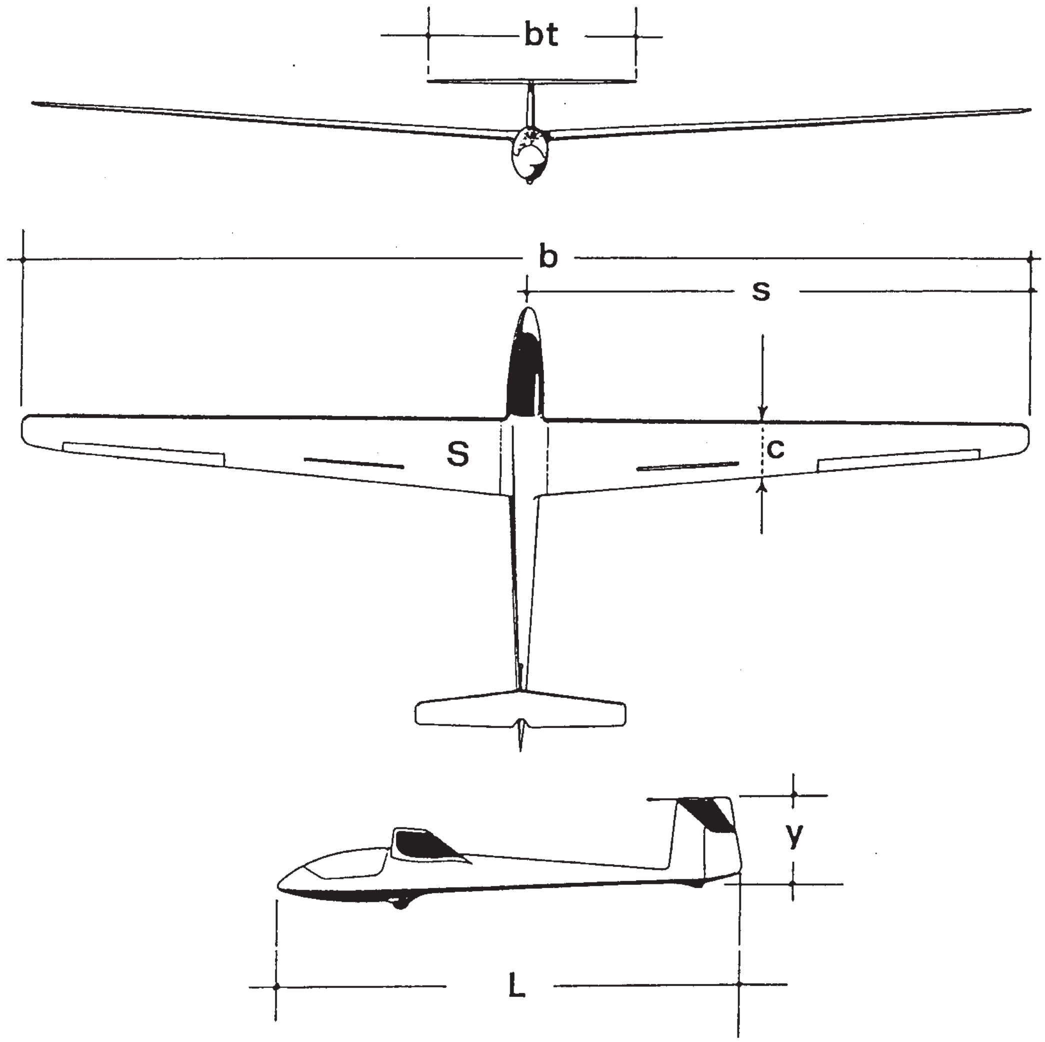
		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
		AILERON SPAN APERT. ALETT.	AIL. MEAN CHORD CORDA MEDIA AL.	EMPENN. ARRAN. SIST. IMPENN.	STABILATOR SPAN APERT. STABIL.	STABILATOR AREA SUP. STABILIZZ.	STABILATOR AR ALLUNG. STAB	STAB. MEAN CHORD CORDA MEDIA STA.	ELEVATOR CHORD CORDA ELEVATORE	ELEV. LEVER ARM BRACCIO ELEV.	TAIL VOL. COEFF. RAPP. VOLUMETR.	FIN HEIGHT ALTEZZA DERIVA	TOTAL FIN AREA SUP. TOT. DERIVA	FIN ASPEC. R. ALLUNG. DERIVA	FIN MEAN CH. CORDA M. DERIVA	RUDDER CHORD CORDA DIREZ.	RUDDER L. ARM BRACCIO DIR.	TAIL VOL. COEF. RAPP. VOLUM.	SPOILERS ARR. SIST. DIRUTT.	AIR BRAKE SPAN APERT. DIRUTT.
		sa	ca	FIG. 7	bt	st	ARt	ct	ht	A	TVC	y	sv	ARv	cv	hv	B	VVC	FIG. 15	sb
		[% s]	[m]		[m]	[m²]	[–]	[m]	[% ct]	[m]	[–]	[m]	[m²]	[–]	[m]	[% cv]	[m]	[–]		[m]
GRP – 15 m	ASW 20	36	0.09	C	2.20	1.00	4.85	0.45	32	3.89	0.53	1.25	1.00	1.57	0.80	30	3.88	0.024	σ C	1.40
	SPEED ASTIR	47	0.13	C	3.00	1.44	6.25	0.48	28	3.87	0.64	1.09	0.98	1.21	0.90	30	3.75	0.022	σ C	1.50
VGW	AN 66 C			B																
	SIGMA			C	2.59	1.12	5.99	0.43				1.83	1.44	2.33	0.79					
	SB 11	41	0.14	C	2.70	1.24	5.88	0.46	100	4.55 / 4.50	0.76 / 0.51	1.27	1.17	1.38	0.92	40	4.45 / 4.40	0.033 / 0.028	σ C	1.20
	MÜ 27																			
AS	LO 100	56	0.24	B	2.70	1.00	7.29	0.37	42	3.24	0.27	1.10	0.78	1.55	0.71	63	3.74	0.027	B	2.30
	B 4	37	0.19	C	3.08	1.71	5.56	0.55	33	3.83	0.50	1.32	1.22	1.70	0.85	34	3.38	0.020	C	1.31
	SALTO	43	0.10	D	2.14	1.09	4.20	0.51	38	3.61	0.73	0.91	0.46	3.60	0.51	38	3.61	0.028	B	1.30

TABLE 7.5.1

Group	REMARKS / NOTE	❶ FIRST FLIGHT / PRIMO VOLO	❷ TAKE OFF WEIGHT * / PESO AL DECOLLO	❸ MAX. TAKE OFF W. / PESO MAX. DECOLLO	❹ WING WEIGHT / PESO ALA	❺ FUSELAGE WEIGHT ** / PESO FUSOLIERA	❻ STABILATOR WEIGHT / PESO STABILIZZATORE	❼ BALLAST WATER / ZAVORRA ACQUA	❽ OVERALL LENGTH / LUNGHEZZA F.T.	❾ WING SPAN / APERTURA ALARE	❿ ASPECT RATIO / ALLUNGAMENTO	⓫ WING AREA / SUPERFICIE ALARE	⓬ MIN. WING LOADING / CARICO ALARE MIN.	⓭ MAX. WING LOADING / CARICO ALARE MAX.	⓮ MEAN WING CHORD / CORDA MEDIA ALARE	⓯ ROOT WING CHORD / CORDA ALARE: RADICE	⓰ TIP WING CHORD / CORDA ALARE: ESTR.	⓱ WING PLANFORM / PIANTA ALARE	⓲ TAPER RATIO / RAPP. RASTREMAZ.	⓳ TAPER POINT / INIZIO RASTREM.	⓴ WING TWIST / SVERGOLAM. ALA
		YEAR	W	W'	Ww	Wf	Wt	Wb	L	b=2s	AR	S	W/S	W'/S	c	cr	ce		TR	yi	αw
		ANNO	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[Kg]	[m]	[m]	[–]	[m²]	[Kg/m²]	[Kg/m²]	[m]	[m]	[m]	FIG.6	[ce/cr]	[%s]	[°]
GRP – 15 m	ASW 20	1977	335	454	134	102	9	120	6.82	15.0	21.4	10.5	31.9	43.3	0.70	0.70	0.30	DT	0.43	63	0
GRP – 15 m	SPEED ASTIR	1978	365	515	134	119	11	140	6.68	15.0	19.6	11.47	31.8	44.9	0.76	1.03	0.50	T	0.49	–	0
VGW	AN 66 C	1973	510	650	300			120	8.10	23.0	33.8 27.6	16.0 19.2	31.9 26.2	40.6 33.9	0.74 0.84			RT			
VGW	SIGMA	1971	697	703					8.81	21.0	36.2 26.8	12.2 16.5	57.1 42.2	57.6 42.6	0.58 0.79			RT		35	
VGW	SB 11	1978	360	470	169	95	6	100	7.40	15.0	21.3 17.0	10.36 13.2	34.1 27.3	44.5 35.0	0.70 0.88	0.80 1.00	0.32 0.40	RT	0.40	60	0
VGW	MÜ 27	1979							10.30	22.0	27.5 20.2	17.6 23.9									
AS	Lo 100	1952	258	265	80	80	8	–	6.15	10.0	9.2	10.9	23.7	24.3	1.09	1.30	0.56	RT	0.43	30	-3
AS	B 4	1966	314	350	121	93	10		6.57	15.0	16.1	14.0	22.4	25.0	0.93	1.07	0.43	RT	0.40	59	0
AS	SALTO	1970	259	270	86	75	8		5.90	13.6	21.5	8.6	30.1	31.4	0.63	0.86	0.36	DT	0.42		-2

** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIU' CODA VERTICALE

* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIU' 90 KG



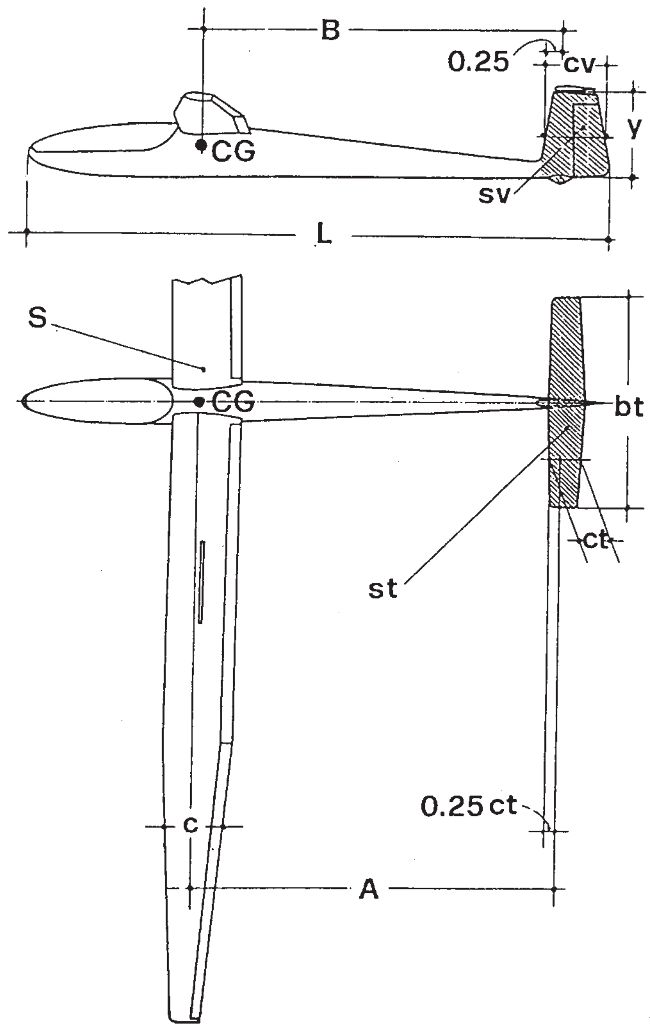
$$S = b * c$$

$$AR = b/c = b^2/S$$

Basic sailplane's parameters
Parametri basilari dell'aliante

S = b*c = *Wing area* / Superficie alare
b = *2s* = *Wing span* / Apertura alare
L = *Overall length* / Lunghezza totale
bt= *Stabilator span* / Apertura stabilizzatore
c = *Wing mean chord* / Corda media alare
y = *Fin height* / Altezza deriva
AR= *b/c* = *B^2/S* = *Aspect ratio* / Allungamento

FIGURE 5



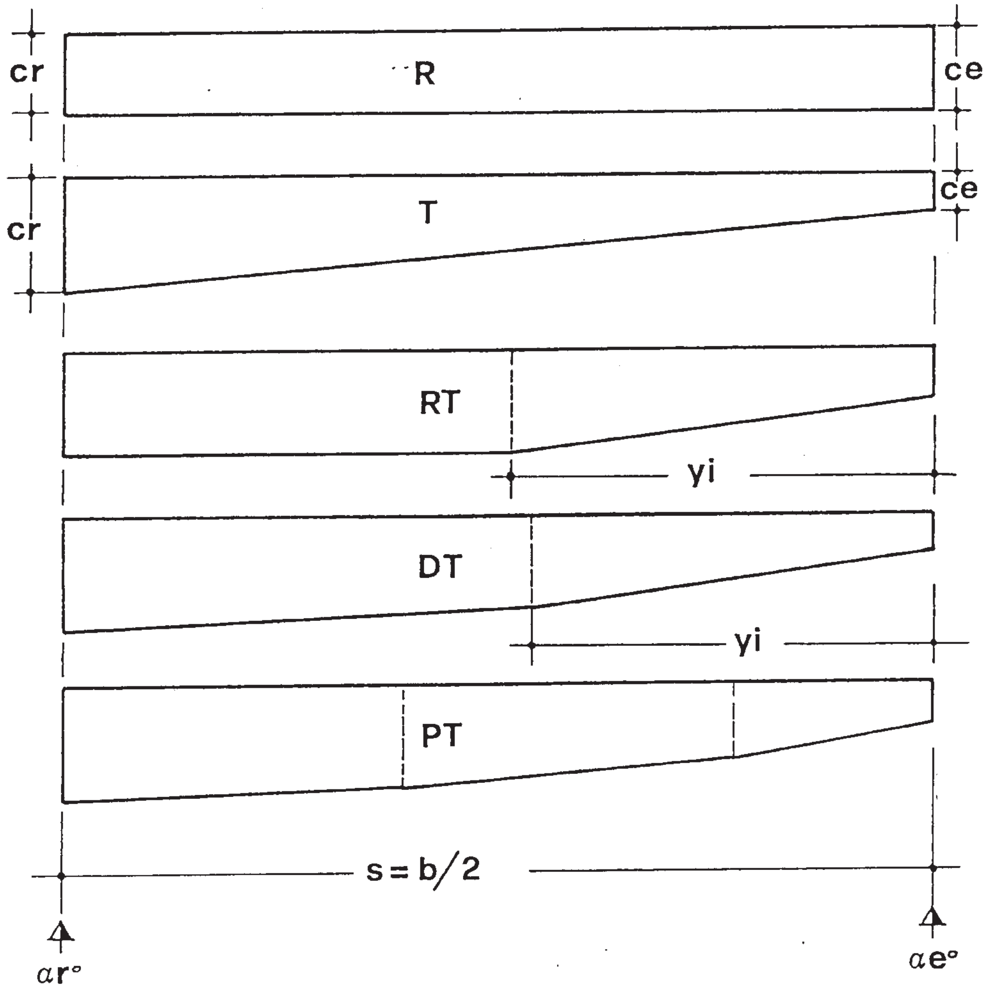
$$TVC = \frac{st * A}{S * c}$$

$$VVC = \frac{B * sv}{S * b}$$

Tail volume coefficients
Rapporti volumetrici di coda

S = *Wing area* / Superficie alare
A = *Stabilator* arm / Braccio di leva stabilizzatore
B = *Rudder arm* / Braccio di leva direzionale
st= *Stabilator area* / Superficie stabilizzatore
sv= *Vertical tail area* / Superficie deriva
ct= *Stabilator mean chord* / Corda media stabilizzatore
cv= *Vertical tail mean chord* /Corda media deriva

FIGURE 6



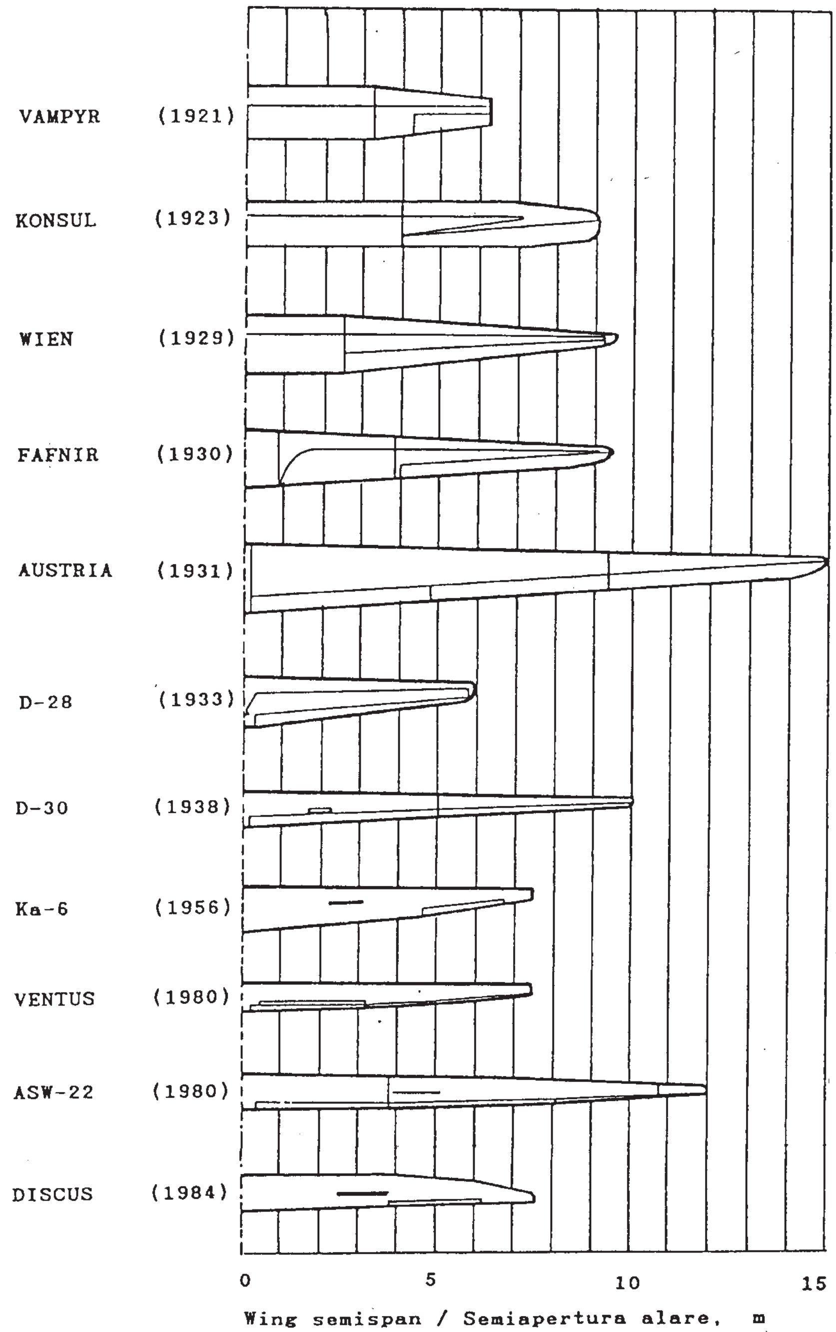
$$TR = ce/cr$$

$$\alpha w° = \alpha r° - \alpha e°$$

Wing planforms: style PT is just the "Schuemann" or TNT (Dornier) wing, if turned upside down
Piante alari: PT, capovolta, e' la cosiddetta ala "Schuemann" o TNT (Dornier)

R = *Rectangular* / Rettangolare
T = *Tapered* / Rastremata
Rt= *Rectangular-tapered* / Rettangolare rastremata
TT= *Double tapered* / Doppia rastremazione
PT= *Multi-tapered* / Rastremazione multipla

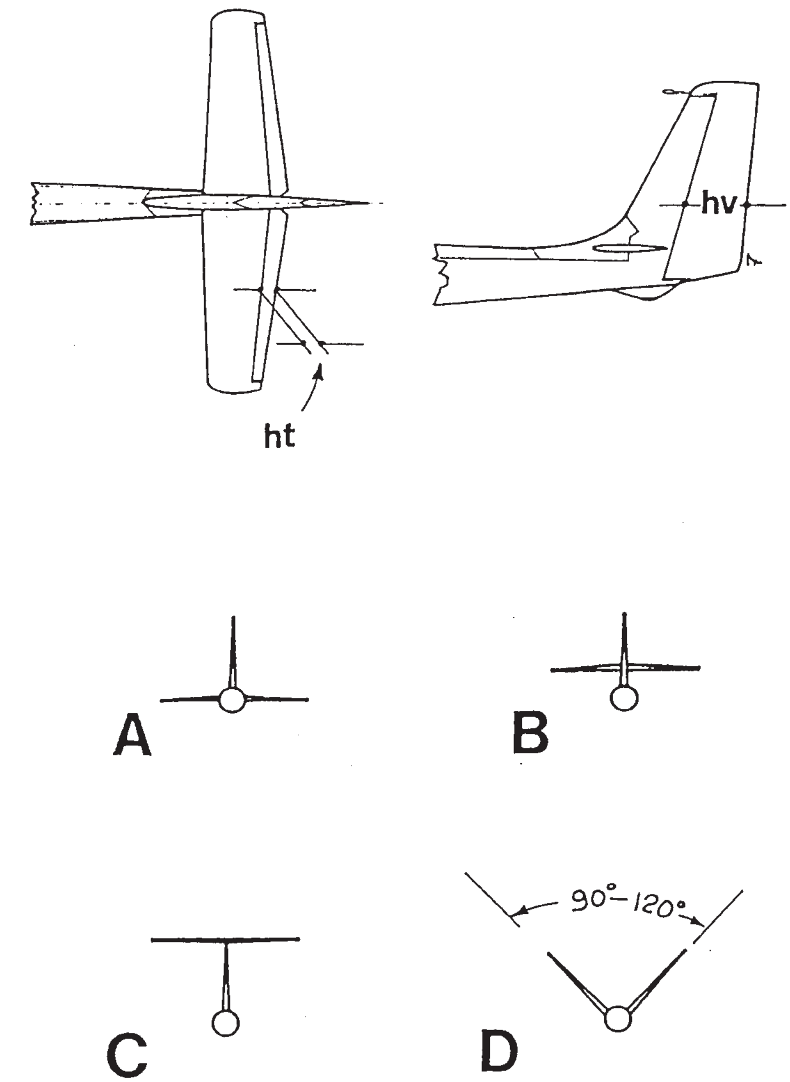
FIGURE 7-A



Evolution of sailplane wing planforms
Evoluzione della pianta alare degli alianti

FIG.6-B

FIGURE 7-B



Tailplanes
Impennaggi

A = *Conventional* / Convenzionale
B = *Cross* / A croce
C = *T-tail* / A T
D = *V-tail* / A V
ht= *Elevator chord* / Corda elevatore
hv= *Rudder chord* / corda direzionale

FIGURE 8

The ratio TVC — as it appears in any aerodynamics textbook — is one the fundamental parameters which define the static longitudinal stability. The ratio TVC is given by the relation

$$TVC = \left[\frac{st}{S}\right] \bullet \left[\frac{A}{c}\right]$$

where

st = stabilator area
A = wing-stabilator lever arm
S = wing area
c = wing mean chord

Similarly, the tail volume coefficient, VVC (vertical), is one of the parameters which define the static directional stability of any aerodyne, whether flying model or aeroplane.

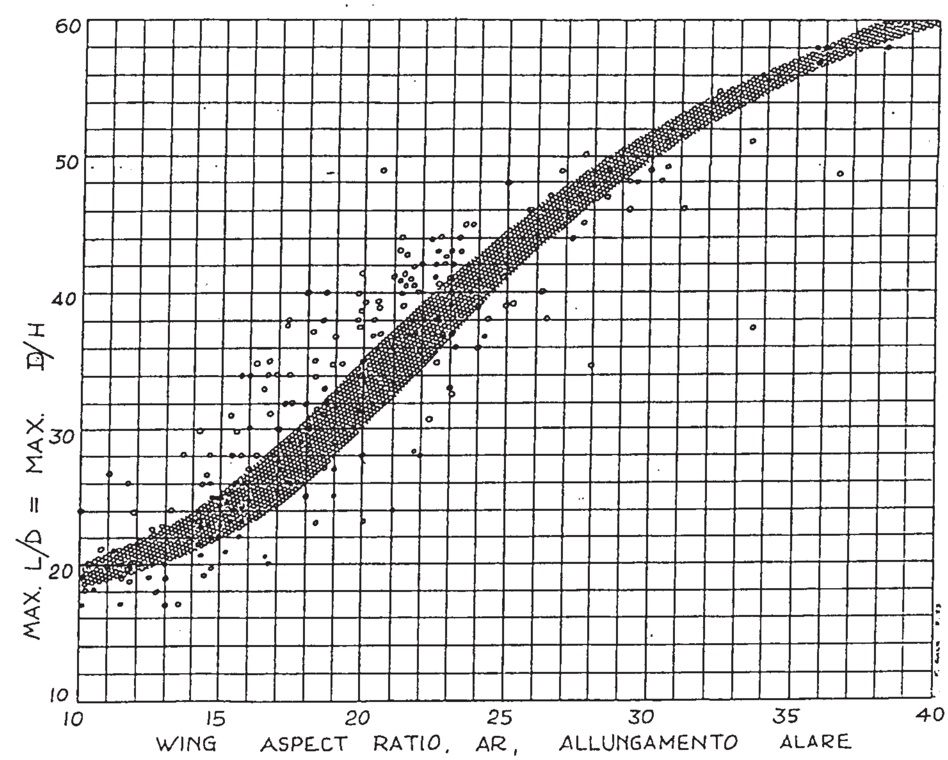
The ratio VVC is given by the relation

$$VVC = \left[\frac{sv}{S}\right] \bullet \left[\frac{B}{b}\right]$$

where

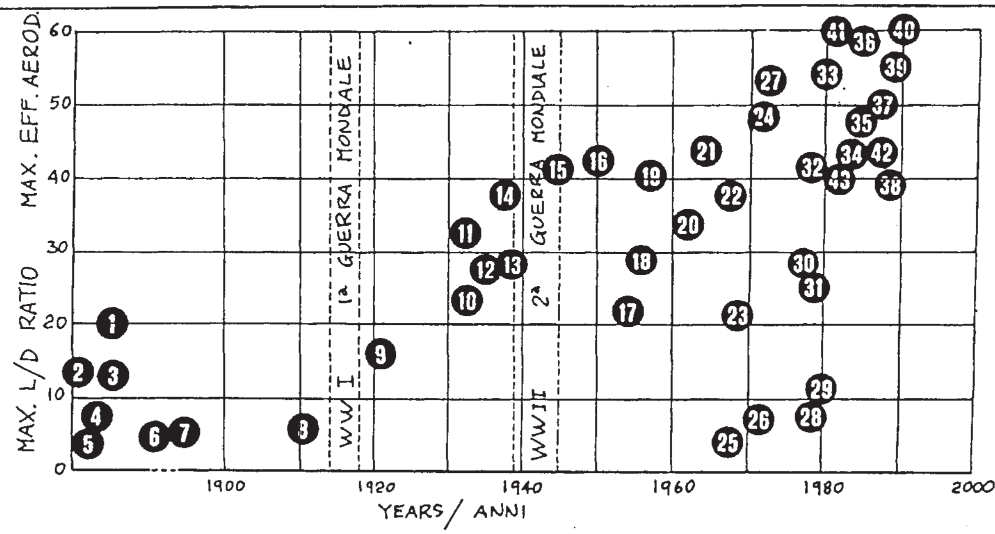
B = wing-vertical tail lever arm
sv = vertical tail area
S = wing area
b = wing span

These ratios, or tail volume coefficients as they are also named, TVC (horizontal) and VVC (vertical), are often referred to as indices of static stability in aeromodeling publications. As a matter of fact, they are part of the formulae which define the pitching moment coefficient and the yawing moment coefficient, respectively. See, for instance, Reference 2.



Lift/drag ratios vs. Aspect Ratio, AR
Efficienza secondo l'allungamento, AR

FIGURE 9-A



1. ALBATROSS
2. PTENARODON
3. VULTURE
4. BAT
5. ZANONIA MACROCARPA SEED
6. MONTGOMERY PILCHER
7. LILIENTHAL
8. WRIGHT
9. VAMPYR
10. D-28
11. AUSTRIA
12. MINIMOA
13. WEIHE
14. D-30
15. HORTEN VI
16. RJ-5
17. I-26 A
18. Ka-6
19. PHOENIX
20. FOKA 4
21. D-36
22. ASW 15
23. I-26 E
24. ASW 17
25. ROGALLO WING
26. QUICKSILVER
27. SB-10
28. DRAGONFLY
29. MITCHELL WING
30. MONERAI
31. WOODSTOCK
32. ASW 20
33. NIMBUS 3
34. DISCUS
35. VENTUS b
36. NIMBUS 3 b
37. DG 600
38. TWIN ASTIR III
39. LS-5
40. NIMBUS 4
41. ASW 22 B
42. SZD 55-1
43. SB-12

Efficiency improvement over the years
Miglioramento dell'efficienza nel corso degli anni

FIGURE 9-B

The construction technique of some vintage and contemporary soarers may offer interesting hints for aeromodelling applications. However, a detailed analysis, aimed at locating specific details for potential use in flying models, is beyond the scope and the limits of this simple digest.

In order to realize an intrinsically "good" radioguided sailplane, an old golden rule suggests the ballast added in the nose so the center of gravity, CG, is at the right point, must not exceed 10% of the total weight. If this does not happen, there is something wrong, either in the design or in the construction.

For instance, if the ballast is more than 200 g in a radioguided glider having a total weight of 2000 g, the fuselage might be too short ahead of the wing, or the lever arm between the wing and the empennages is too long, or the empennages are too heavy.

In the case of scale reproductions of full size sailplanes, the above problem is magnified because of the different percentage bearing of the "payload." While the pilot is the sailplane's payload, the radio gear (receiver, servos, and battery) is the payload of a radioguided sailplane.

As a rule, the payload is situated ahead of the wing on both full size gliders and model gliders. It easily represents 20% to 30% of the total sailplane weight; in well designed and well built model gliders, thanks to the use of miniaturized receivers and servos, it seldom exceeds 10% of the all-up weight.

Let's examine again the Minimoa sailplane which we are supposing is to be reproduced in 1:5 scale. Realistically we assume the scale model will weigh 4 Kg, instead of the theoretical 2.8 Kg given by the "true scale" formula in FIGURE 10 (page 38). We assume also that the following conditions are verified on both the full size aircraft and the scale model:

1) The center of gravity, CG, is situated at 30% of the wing chord;

2) The weight of the discrete components (wing, fuselage, plus vertical tail) have the same percentage bearing;

3) The center of gravity of each discrete component is situated at the same point.

By applying the "true scale" rules of TABLE 5 (page 14), the following partial weights are obtained.

Component	Symbol	% of total weight	Original	Model
Wing	GI	58	145	2.118
Fuselage plus vertical tail	G2	38	95	1.392
Stabilator	G3	4	10	0.140
Total empty weight	W — G4	100	250	3.650
Payload	G4		100	0.350
Total take-off weight	W		350	4.000

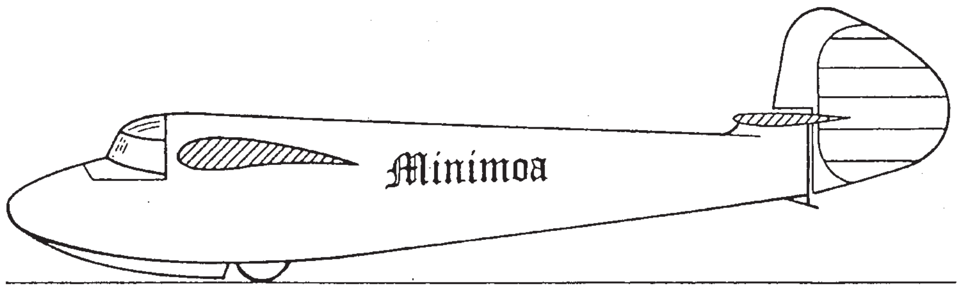
At this point, let's calculate the moment of every partial weight about a vertical line. For ease of reasoning, we choose the vertical straight line y-y on which the center of gravity, CG, is located. See FIGURE 11 (page 39).

On the right side of such a line the following moments can be computed:

G2 • b2 = 95 • 0.8 = 74.1
G3 • b3 = 4 • 4.25 = <u>17.0</u>
Total = 91.1 Kg • m

On the left side, the following moments are found:

G1 • b1 = 145 • 0.18 = 26.1
G4 • b4 = 100 • 0.65 = <u>65.0</u>
Total = 91.1 Kg • m

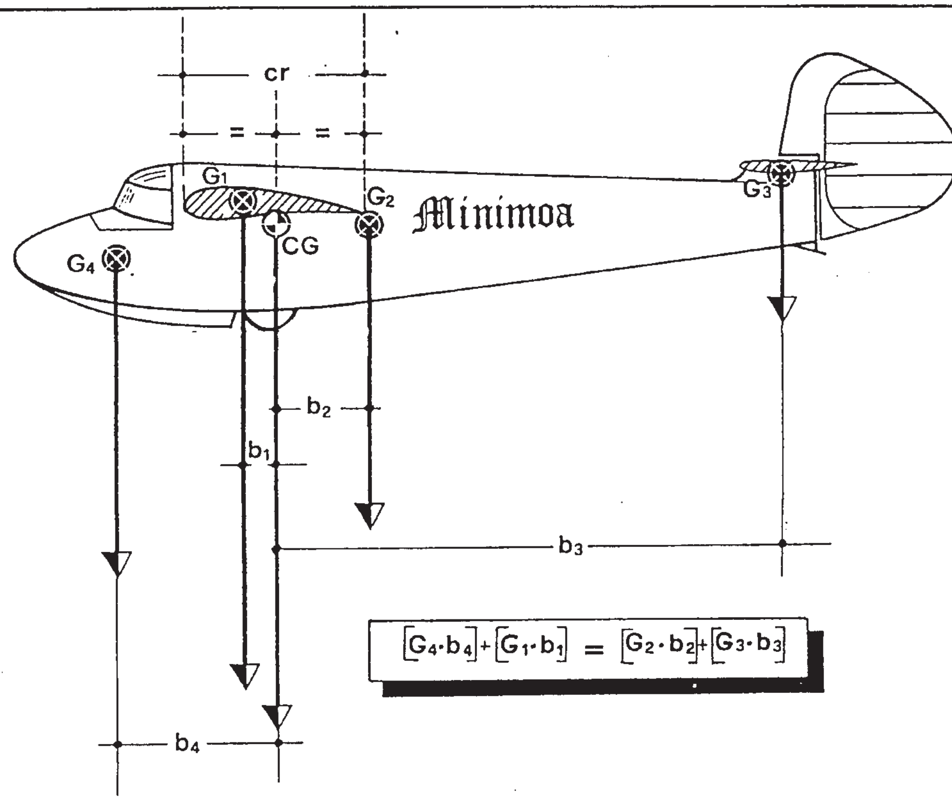


		FULL SIZE / ORIGINALE	1:5 SCALE MODEL / MODELLO IN SCALA 1:5
b	[m]	17.00	3.40
S	[m²]	19.00	0.76
st	[m²]	1.98	0.079
A	[m]	4.13	0.82
sv	[m²]	1.20	0.048
B	[m]	5.40	1.08
c	[m]	1.12	0.224
W	[Kg]	350	4.00 → 5.65 *
TVC	[-]	0.38	0.38
VVC	[-]	0.02	0.02
W/S	[Kg/m²]	18.42	5.26 → 7.43 *

* = BALLAST ADDED / AGGIUNTA ZAVORRA

A scale reduction example
Esempio di riduzione in scala

FIGURE 10



$$[G_4 \cdot b_4] + [G_1 \cdot b_1] = [G_2 \cdot b_2] + [G_3 \cdot b_3]$$

G1= Ww G2= Wf G3= Wt	SEE TABULATION 7 VEDERE TABELLA 7

		FULL SCALE / ORIGINALE	MODEL / MODELLO
		WEIGHTS / PESI, Kg	
G1	WING / ALA	145	2.118
G2	FUSELAGE + VERT. TAIL / FUSOLIERA + IMPENNAGGIO	95	1.392
G3	STABILATOR / STABILIZZATORE	10	0.140
W-90 Kg =	EMPTY WEIGHT / PESO A VUOTO	250	3.650

		LEVER ARMS / BRACCI DI LEVA m	
b1	G1 LEVER ARM / BRACCIO DI LEVA DI G1	0.18	0.036
b2	G2 LEVER ARM / BRACCIO DI LEVA DI G2	0.79	0.246
b3	G3 LEVER ARM / BRACCIO DI LEVA DI G3	4.05	0.810

G4	PAYLOAD / "CARICO PAGANTE"	KG	100	0.350
b4	G4 LEVER ARM / BRACCIO DI LEVA DI G4	m	0.65	0.13 → 0.28

Example of balance calculations
Esempio di calcolo per bilanciamento

FIGURE 11

As a result, the Minimoa sailplane is perfectly balanced with the pilot on board. The situation is quite different in the case of the 1:5 scale reproduction. On the right side of the y-y line the following moments are acting:

$$G2 \bullet b2 = 1.392 \bullet 0.246 = 0.472$$
$$G3 \bullet b3 = 0.140 \bullet 0.81 = \underline{0.113}$$
$$\text{Total} = 0.585\ \text{Kg} \bullet \text{m}$$

On the left side the following is found:

$$G1 \bullet b1 = 2.118 \bullet 0.036 = 0.0762$$
$$G4 \bullet b4 = 0.350 \bullet 0.13 = \underline{0.0455}$$
$$\text{Total} = 0.1217\ \text{Kg} \bullet \text{m}$$

As a consequence, the scale reproduction of the Minimoa is totally unbalanced. Some ballast must be added in the nose in order to bring the center of gravity, CG, to the right location.

Question: How much ballast? If the additional ballast is placed at the point G4, where the radio gear is installed, the required quantity would be

$$\text{ballast} = [0.5850 - 0.1217]/0.13 = 0.4633/0.13 = 3.56\ \text{Kg}$$

This almost doubles the weight of the model! Therefore (in order to maximize the moment about such a point), one tries to place the ballast ahead of the center of gravity, CG, as far as possible. In our example, placing the ballast at about 0.28 m ahead of the center of gravity seems to be a possible solution. By doing so, the quantity required becomes

$$[0.5850 - 0.1217]/0.28 = 1.65\ \text{Kg}$$

Luckily, as far as flying models are concerned, keen builders do much better than the above theoretical example. For instance, Nunzio Pompele, an aeromodeler hailing from Milan Italy, has built a 1:3.95 scale Minimoa, obtaining the following characteristics:

$$b = 4.30,\ S = 1.18\ \text{m},\ c = 0.28\ \text{m},\ W = 5.10\ \text{kg},\ W/S = 4.32\ \text{Kg/m}^2$$

Discrete weights are as follows:

wing	2.000
stabilator	0.124
fuselage with vertical empennage	2.178
radio gear	0.400
ballast	0.400

It can be seen that the distribution of the partial weights of the scale model is quite different than the original Minimoa. Most probably the positions of the discrete centers of gravity G1, G2, G3, and G4 are different, allowing the model to be balanced by adding only 400 g of lead. In this R/C scale model by Nunzio Pompele the center of gravity, CG, is situated at 50% of the root chord, cr. This corresponds to about 33% of the mean wing chord, c, exactly as for the original Minimoa sailplane.

This model, which has been mentioned here as a good example of scale reproduction, also fulfils the previously mentioned golden rule, according to which ballast should not exceed 10% of the total weight. Additionally, the wing loading is lower than the value assessed with the "true scale" rule. A fundamental lesson is to be learned from this simple arithmetical exercise: The weight of the rear part of the fuselage, behind the centre of gravity, must be as low as possible.

Needless to say, such a requirement determines the choice of the construction technique, since every gram of extra weight in the tail requires roughly five grams of additional ballast in the nose.
Ideally, the traditional wood (balsa and ply) construction with ribs, formers, stringers, and light covering, is to be preferred for scale models of vintage sailplanes.

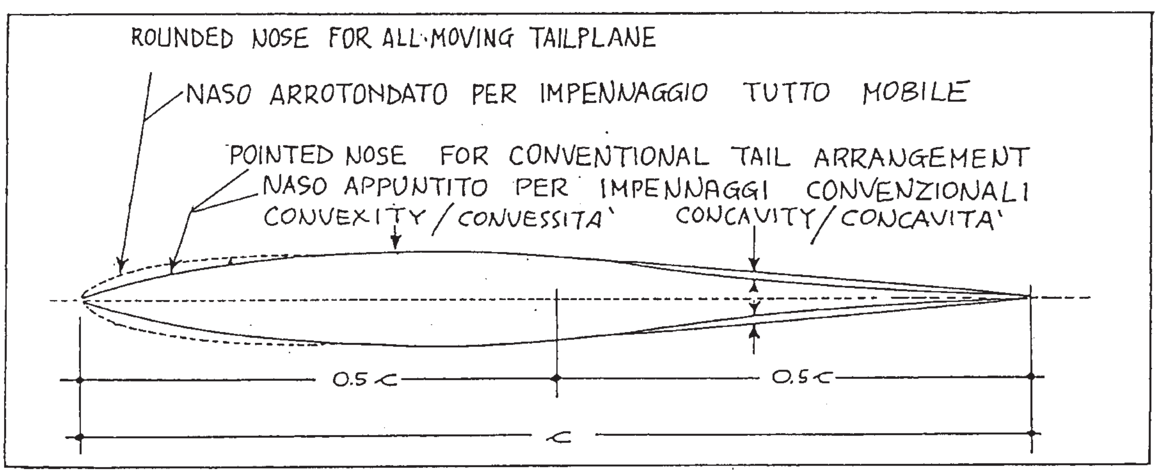
Often, a fiberglass monocoque construction is preferred as far as the fuselage is concerned, due to its higher impact resistance, since landings of flying models are sometimes rather hectic. However, monocoque fuselages of flying models are usually too heavy in the tail because of the fiberglass thickness.

In the best case, such thickness is constant along the whole length, while, according to the science of structures, it should be larger where the fuselage exhibits the largest cross section. Let's not forget that any extra material at the tail must be balanced by added ballast in the nose!

The logical suggestion that can be derived from the above reasonings is to realize a fuselage with a long nose ahead of the wing in order to minimize the addition of ballast. Of course, this suggestion can be followed only for radioguided gliders which are not true scale reproductions of full size sailplanes.

As logically expected, the previously mentioned tail volume coefficients don't change when the aircraft is scaled down, as appears from the example of FIGURE 10 (page 38). However, sometimes it may happen that the horizontal tail coefficient, TVC, is too small. Therefore the static longitudinal stability is inadequate, particularly at low speed.

The simplest remedy is to increase by 10% to 15% the area of the horizontal tail, st, but this bends the competition rules for radioguided scale sailplanes. Alternatively, one can use a "biconcave" airfoil, such as the example of FIGURE 12 (below). Airfoils of this type are quite common in contemporary competition sailplanes, but practically unknown among model builders.



Example of "bi-concave" airfoil
Esempio di profilo "biconcavo"

FIGURE 12

These airfoils are characterized by a substantial moment coefficient, even with small angles of deflection. Their stabilizing action is substantially larger than that produced by conventional symmetrical airfoils, such as the well known and used NACA 0009, NACA 0006, etc.

Variable geometry wings have been the subject of experimentation in full size sailplanes — this in order to fulfil various requirements related to thermal flight, turns, and speed. The same requirements apply also to radioguided sailplanes.

There are various solutions to the variable geometry problem of increasing the lifting area and reducing the wing loading:

A) Increase the wing span. The airfoil and the maximum lift coefficient do not change. Only the aspect ratio, AR, and the wing area, S, increase.

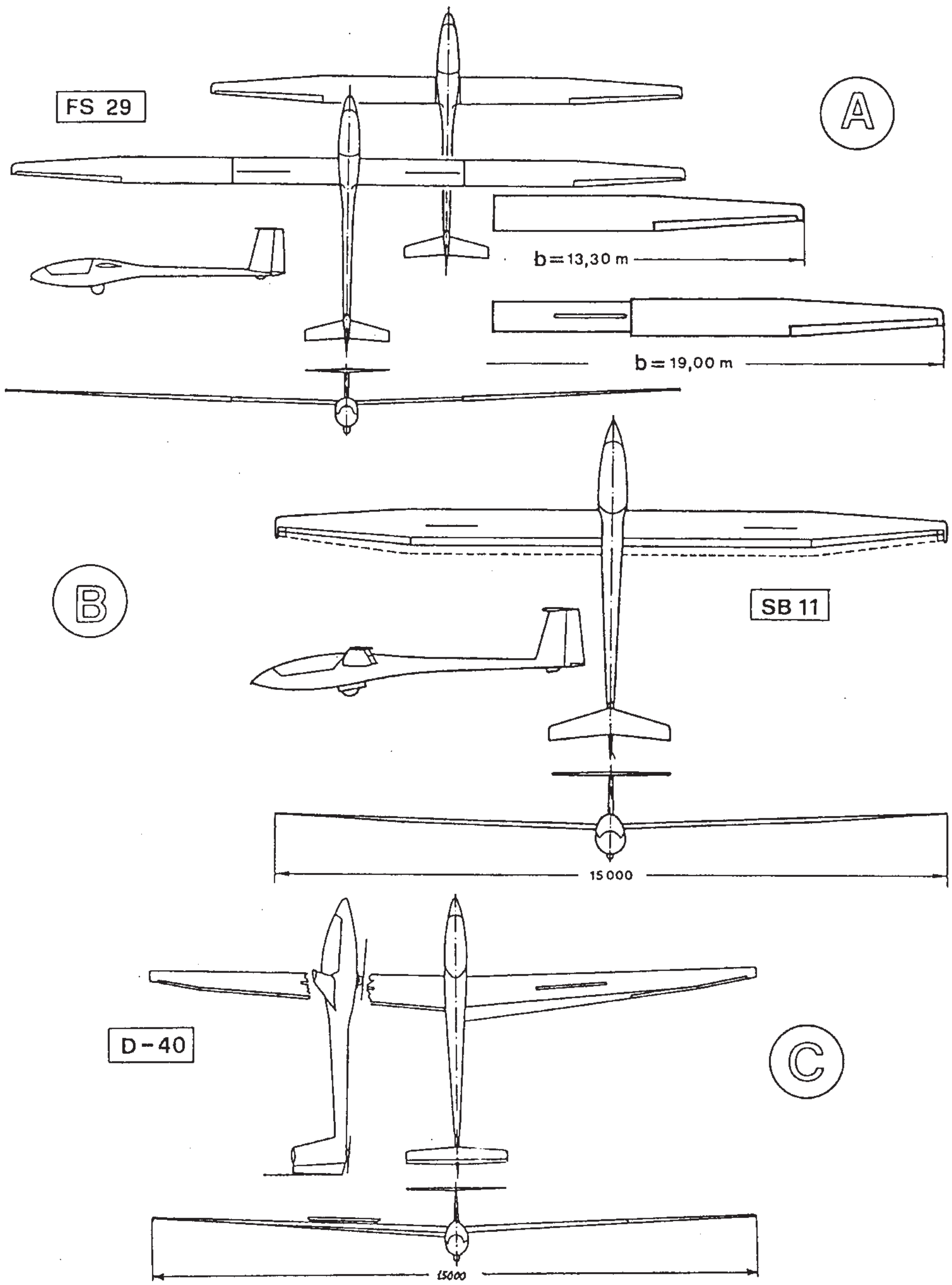
This has been done with the fs-29, a sailplane built by Akaflieg Stuttgart. It has a telescopic wing, as shown in FIGURE 13-A (page 44). Apart from the extreme complication of this construction, which cannot be easily duplicated in aeromodeling, the major problem of this solution is the quantity of energy required to slide in and out the telescopic wing. The resulting operation is too slow to be practicable.

B) Increase the wing chord. In this respect, two systems have been tried:

1) a sliding flap at the trailing edge, which extends along the full wing span, as in the case of the SB-1, Milomei M-2, and Sigma sailplane. See FIGURE 13-B (page 44) and FIGURE 14-D (page 45).

2) a triangular flap, which extends out of a great portion of the trailing edge. This system has been tried out on the D-40 sailplane built by Akaflieg Darmstadt. See FIGURE I3-C (page 44).

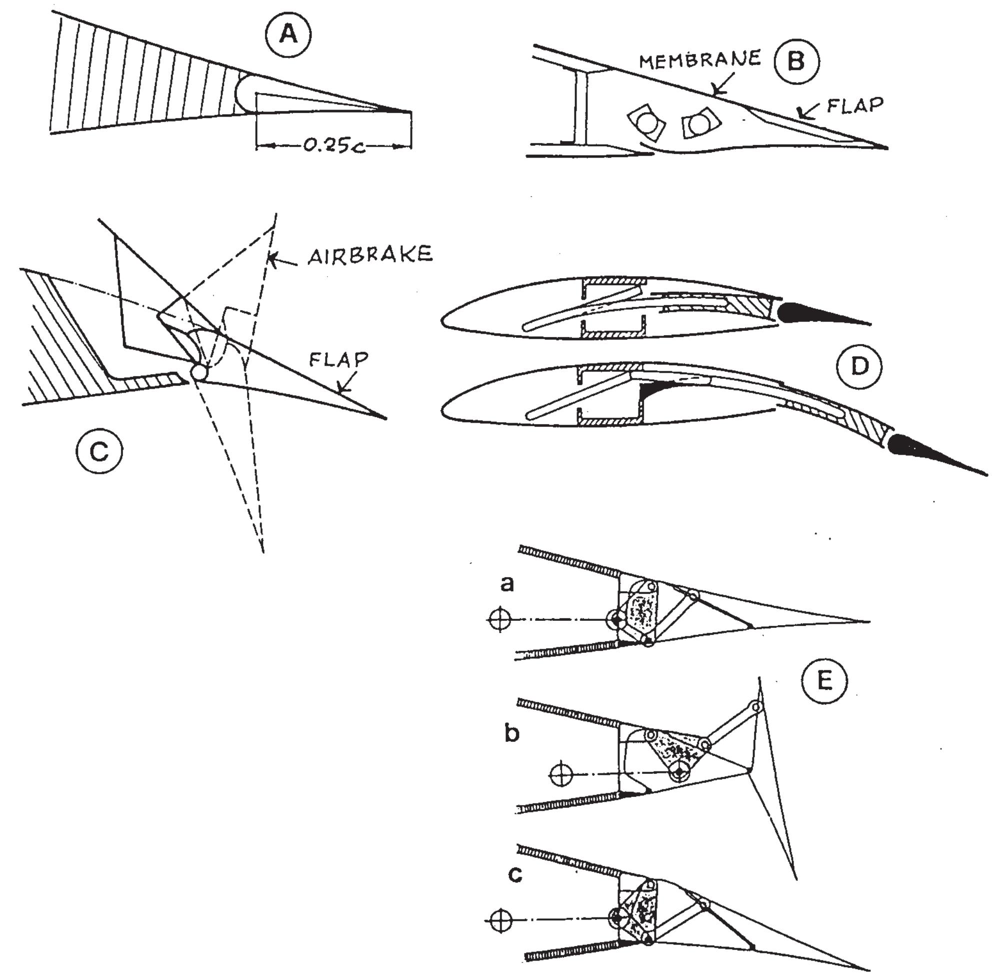
This system increases the lifting area and the induced drag as well, since the aspect ratio, AR, is reduced. Eventually the aerodynamic efficiency, $E = C_L/C_D$, is slightly spoiled, while both the wing loading W/S and the sink speed, V_y, are reduced.



Variable geometry wings
Ali a geometria variabile

A = *Telescopic wing* / Ala telescopica
B = *Extensible flap* / Flap estensibile
C = *Triangular extensible flap* / Flap triangolare estensibile

FIGURE 13



Airbrakes, spoilers, flaps
Aerofreni, diruttori, flaps

A = *Plain flap* / Flap normale
B = *Elastic flap* / Flap elastico [Speed Astir]
C = *Flap-airbrake* / Flap-aerofreno [Mini Nimbus]
D = *Extensible flap* / Flap estensibile [SB 11]
E = *Flap-airbrake* / Flap-aerofreno [Windex 1200]

a = *Zero flap, airbrake closed* / Zero flap, freno chiuso
b = *Zero flap, max. airbrake* / Zero flap, freno tutto aperto
c = *15° flap, airbrake closed* / Flap 15°, freno chiuso

FIGURE 14

In this respect, there is no point in repeating here detailed considerations and reasonings which appear in every textbook of aerodynamics. Let's only remember that the sink speed, V_y, of every glider, whether flying model or full size, is determined by the relation

$$V_y = 4 \bullet \sqrt{\left[\frac{W}{S}\right] \bullet \left[\frac{C_D^2}{C_L^3}\right]}$$

where

V_y = sink speed, m/s
W = weight, Kg
S = lifting area, m^2
C_D = drag coefficient of the complete sailplane,
C_L = lift coefficient of the complete sailplane.

It is worth noting that the coefficients C_D and C_L are referring to the complete sailplane and not to the wing airfoil.

EXAMPLE: $S = 0.76\ m^2$, $W = 2.8$ Kg, $C_D = 0.06$, $C_L = 0.8$

The sink speed, in m/s, becomes

$$V_y = 4 \bullet \sqrt{\left[\frac{2.8}{0.76}\right] \bullet \left[\frac{0.06}{0.8}\right]} = 0.64$$

If one adds some ballast, in order to trim the craft, both the wing loading, W/S, and the sink speed, V_y, increase. In this respect, the following formula applies:

$$V_y' = V_y \bullet \left[\frac{W'}{W}\right]$$

The tighter the turn radius, while soaring in a thermal, the stronger is the requirement for an increased wing area.

The above mentioned variable geometry systems, apart from the complexity of construction, show also some operational drawbacks. For instance, when flaps are fully deployed, ailerons are no more effective.

As a matter of fact, the yaw moment coefficient and the roll moment coefficient are proportional to the lift coefficient squared, so the yaw moment coefficient is magnified when flaps are deployed. As a consequence, a larger rudder must be installed to compensate for the inadequate response of the ailerons.

Additionally, the increased lift coefficient, C_L, due to the deflection of the trailing edge flaps, has a negative side effect. The point of maximum camber is moved rearwards, thus requiring a stronger correction by means of the elevator. This notwithstanding, the system with a triangular trailing edge flap, shown in FIGURE 13-C (page 44) can be easily adapted to flying models.

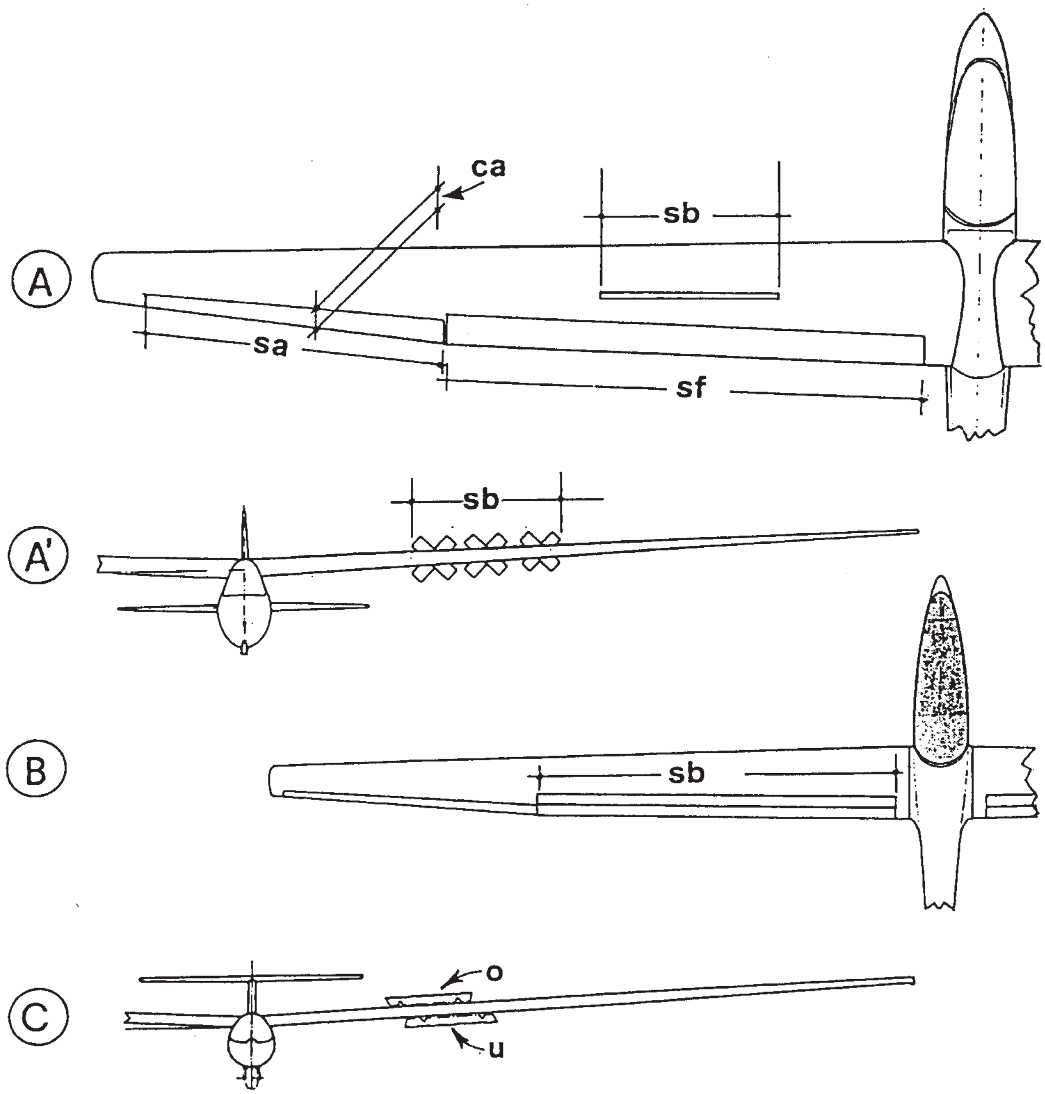
Air brakes are commonly used in order not to exceed the ultimate velocity (V_{NE}). Beyond this limit, structures can deform beyond the possibility of recovery. Several types of air brakes are described in the aeronautical literature. See, for instance, those described in Reference 19.

As far as sailplanes are concerned, whether full size or flying model, air brakes can be placed into one of two types:

(a) those mounted on the top and/or on the bottom of the wing, usually near the point of maximum thickness;

(b) those mounted at the wing trailing edge.

Spoilers of the type (a) were the first to be mounted on sailplanes. See FIGURE 15 (page 48). Air brakes of this type spoil the air flow over the wing surfaces, thus causing a great drag which hinders the speed. However, their most remarkable effect is the steepening of the glide path. Generally speaking, the speed reduction which these air brakes can produce on flying models is marginal. The only sizing criterium available to model builders is their span, sb, as shown in FIGURE 15 (page 48).



Airbrakes and hi-lift devices
Aerofreni ed ipersostentatori

sf = *Flap span* / Apertura deflettore
sa = *Aileron span* / Apertura alettone
ca = *Aileron mean chord* / Corda media alettone
sb = *Spoiler (airbrake) span* / Apertura diruttore (aerofreno)
o = *Upper spoiler* / Diruttore superiore
u = *Lower spoiler* / Diruttore inferiore

FIGURE 15

A plain flap and a spoiler are incorporated in air brakes of the (b) type. FIGURE 14-C (page 45) and FIGURE 14-E (page 45) depict two such systems installed on full size gliders.

This air braking system effectively reduces the flying speed, since it increases both drag and lift. Systems of this type, adequately simplified, have been successfully installed on radioguided gliders, although their construction complexity prevents a wider usage.

TABLE 8 (page 50) lists the complete technical specifications of the Polish glider SZD-42 Jantar 2 "Amber" This information can be used as a guide when sizing air brakes and flaps.

Two items, which could be related to the "dynamic similitude" principle, are seldom taken into consideration, when it comes to flying models: speed and strength of materials. Even for the so called "speed classes" (for both radioguided and control line models), scoring is based on the time spent to cover a given course or a number of laps, never on the relative (even approximate) speed. As a result, aeromodelers are usually in almost complete darkness when it comes to reasonings about the real speed of their models.

The only exception to this generalized practice is the Schneider Trophy Re-enactment, held at Lake Havasu, Arizona (USA), every year. Here scale reproductions of the floatplane racers, which competed for the full scale Schneider Trophy Races (1912 - 1931) are required to cover a given course at "scale speed."

As far as radioguided sailplanes are concerned, there are four speed values of interest to the keen model builder:

(a) Speed at the best glide angle, V_e, that is, when the maximum aerodynamic efficiency (C_L/C_D) is achieved;

(b) Lowest sink speed, V_y;

(c) Stalling speed, V_s,

(d) Maximum speed, never to be exceeded, V_{NE}.

TABLE 8

SZD-42 JANTAR 2 - "AMBER"

Complete Specifications / Specifiche Complete

Wing span / Apertura alare...........................	b	m	20.5
Wing root chord / Corda alare alla radice............	cr	m	0.90
Wing tip chord / Corda alare alla radice.............	ce	m	0.395
Wing mean chord / Corda media alare..................	c	m	0.731
Wing aspect ratio / Allungamento alare	AR	-	29.2
Length overall / Lunghezza fuori tutto	L	m	7.11
Stabilator span / Apertura stabilizzatore	bt	m	2.60
Height over tail / Altezza alla deriva	y	m	1.76
Wing area / Superficie alare	S	m	14.25
Ailerons area (total) / Superficie alettoni (totale).	aa	m	1.15
T.E. flaps area (total) / Superficie flaps B.U.......	fa	m	1.38
Spoilers area (total) / Superficie diruttori (totale)	ba	m	0.69
Fin area / Superficie deriva fissa		m	0.72
Rudder area / Superficie direzionale		m	0.48
Tailplane area / Superficie piano orizzontale........	st	m	1.35
Elevator area / Superficie elevatore		m	0.38
Empty weight / Peso a vuoto	We	Kg	343
Max. take off weight / Peso massimo al decollo [**]..	W'	Kg	593
Max. take off weight / Peso massimo al decollo [*]...	W	Kg	463
Max. wing loading / Carico alare massimo [**]........	W'/S	Kg/m	41.6
Max. wing loading / Carico alare massimo [*].........	W/S	Kg/m	32.5
Best glide ratio / Miglior rapp. di planata.[**].....	1:47	@ 102	Km/h
Best glide ratio / Miglior rapp. di planata.[*]......	1:46	@ 88	Km/h
Min. sink speed / Minima vel. di caduta .[**].....m/s	0.54	@ 87	Km/h
Min. sink speed / Minima vel. di caduta .[*]......m/s	0.46	@ 75	Km/h
Stalling speed / Velocita' di stallo .[**]..........		80	Km/h
Stalling speed / Velocita' di stallo .[*]...........		65	Km/h
Max.speed (smooth air) / Vel.max. (aria calma).[**]..		165	Km/h
Max.speed (rough air) / Vel.max. (aria pertur.).[**].		140	Km/h
Max.speed (smooth air) / Vel.max. (aria calma).[*]...		250	Km/h
Max.speed (rough air) / Vel.max. (aria pertur.).[*]..		160	Km/h
Max.aero-tow speed / Vel.max. di traino.............		140	Km/h
G-limits / Limiti di carico .[**]..................	g	+4	-1.5
G-limits / limiti di carico .[*]...................	g	+5.3	-2.65

[**] = *With (water) ballast* / Con zavorra (acqua)
[*] = *Without (water) ballast* / Senza zavorra (acqua)

A look at the speed polar of any sailplane, no matter whether full size or scale model, tells us immediately that V_e (best glide ratio velocity) and V (at which V_y is minimum) are well apart. The former is always larger than the latter. For instance, in the case of the SZD-42 Jantar 2 "Amber," the best glide angle is achieved at 88 Km/h, while the minimum sink speed is obtained at 75 Km/h. See TABLE 8 (page 50).

From time to time, aeromodeling literature has shown examples of builders who embarked themselves in simple or sophisticated endeavors to measure glide angles and flight speeds of their models. Unfortunately, this practice is far from being widespread. Anyhow, let's proceed with a hypothetical example of "scale speed" calculations. Our guinea pig is again the Minimoa sailplane of FIGURE 10 (page 38). By applying the "true scale" rules of TABLE 5 (page 14), one gets:

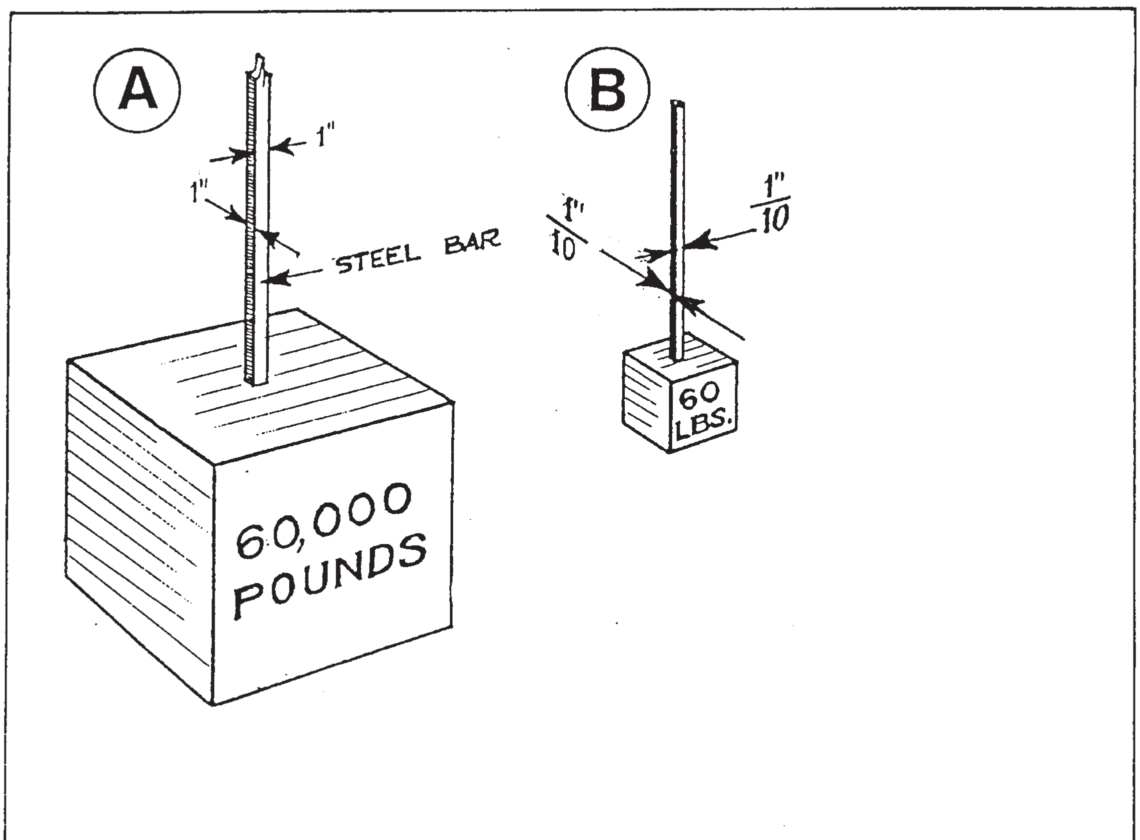
Symbol	Explanation	Unit	Full scale	1:5 model
V_e	(best glide)	Km/h	70	31.3
V_y	(best sink)	m/s	0.70	0.31
V at V_y	(for best V_y)	Km/h	60	26.8
V_{NE}	(V_{NE})	Km/h	200	89.5

The only speed which is not realistically attainable is the sink speed, V_y, 0.31 m/s (1 ft/s). This value has been and still is the midsummer night's dream of every serious free-flighter. Chances are extremely slim for any radioguided sailplane to achieve this performance.

In our quest to achieve complete "dynamic similitude," we find another area where Mother Nature refuses to cooperate with us. This is the strength of materials, which is related to internal forces (molecular forces) which are not reduced at all on scaled down components of any kind. As a result, the material is relatively much stronger with respect to the stresses it must withstand.

Although surprising at first glance, this result can be easily explained with a working example. A large steel cube weighing 60,000 pounds is suspended, like a stationary pendulum, by means of a steel bar with one inch square cross section. Let's assume that the breaking strength of the steel bar is just one ounce more than 60,000 pounds per square inch. In other words, it is stressed right up to within one ounce of its ultimate (breaking) load. See FIGURE 16-A (below). The additional weight of even a small slice of pizza, placed on the cube, would cause the bar to break and the cube to fall.

Now look at the model of the cube-bar system in FIGURE 16-B (below), which has been constructed to 1/10 scale. The sketch has not been



Scale effect on strength of materials / Effetto scala sulla resistenza dei materiali

FIGURE 16

drawn to such a high scale ratio. The model bar, of course, has a cross section of 1/10" by 1/10", that is 1/100 square inches. The unit tensile strength of the steel bar of the model is still 60,000 pounds per square inch. Therefore the ultimate breaking strength of the model bar is 1/100 of 60,000 pounds, that is, 600 pounds. However, the weight of the model cube is 1/10 x 1/10 x 1/10 x 60,000 lbs., that is 60 pounds! The bar in the model could therefore support ten times the weight of the cube.

This is equivalent to a relative increase in the strength of the bar by a 10 to 1 ratio — the same scale ratio to which the model was constructed. Lesson to be learned here: The strength of materials in any scaled down model always undergoes a relative increase by the ratio of the scale factor, indicated by F in TABLE 5 (page 14).

This explains why it is possible to build flying models of balsa wood, which would be totally unsuitable for a full scale aerodyne. This is also the reason for the apparent herculean strength of some insects, ants for instance, which easily carry many times their own weight and can withstand severe mistreatment. An ant can fall from a tall building without any damage at all! Its “F” value is enormously high compared to the structural strength of a human!

All of the above may sound like a kind of academic exercise, but it could be food for thought for keen modelers, particularly for those who claim the structures of their R/C sailplane are built to scale.

Ferdinando Galè

Published by B2Streamlines
P.O. Box 975
Olalla WA 98359 USA
<http://www.b2streamlines.com>