# SCALING SAILPLANES
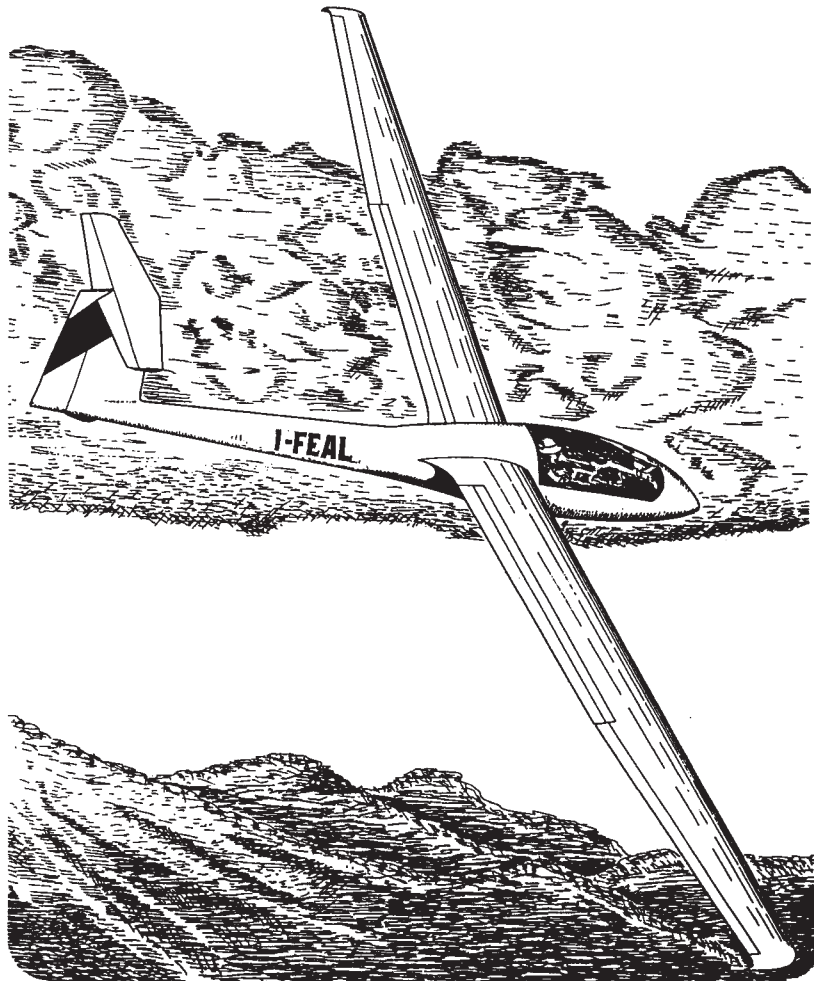


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# SCALING SAILPLANES

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).

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# 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 |

FIGURE 1

4
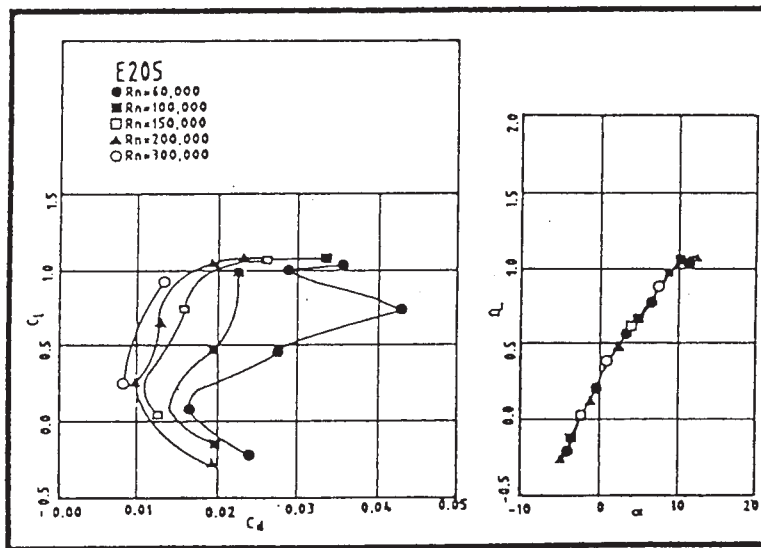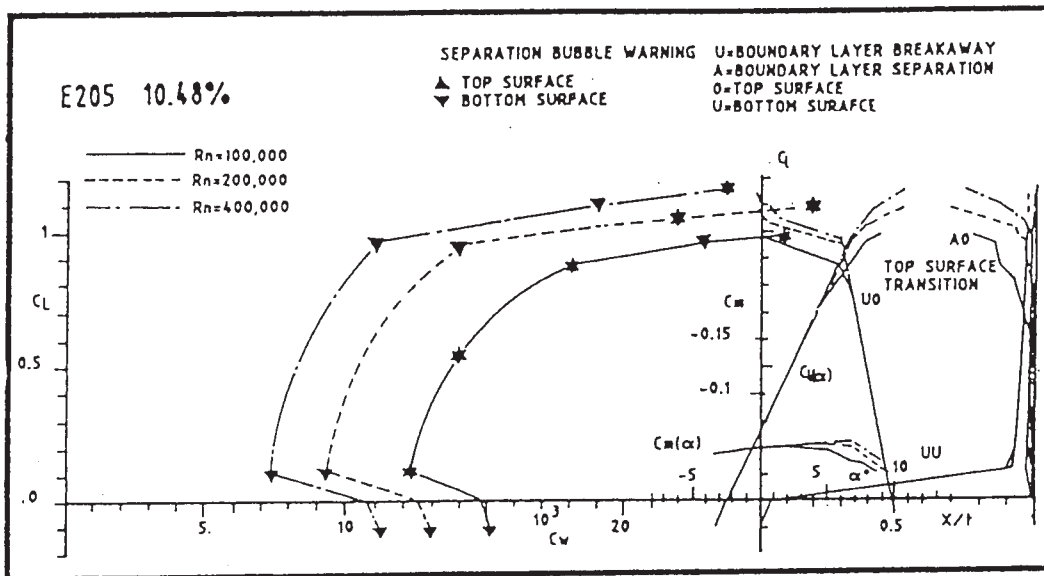
(More recently designed laminar sections maintain a laminar boundary layer for nearly the entire chord.)

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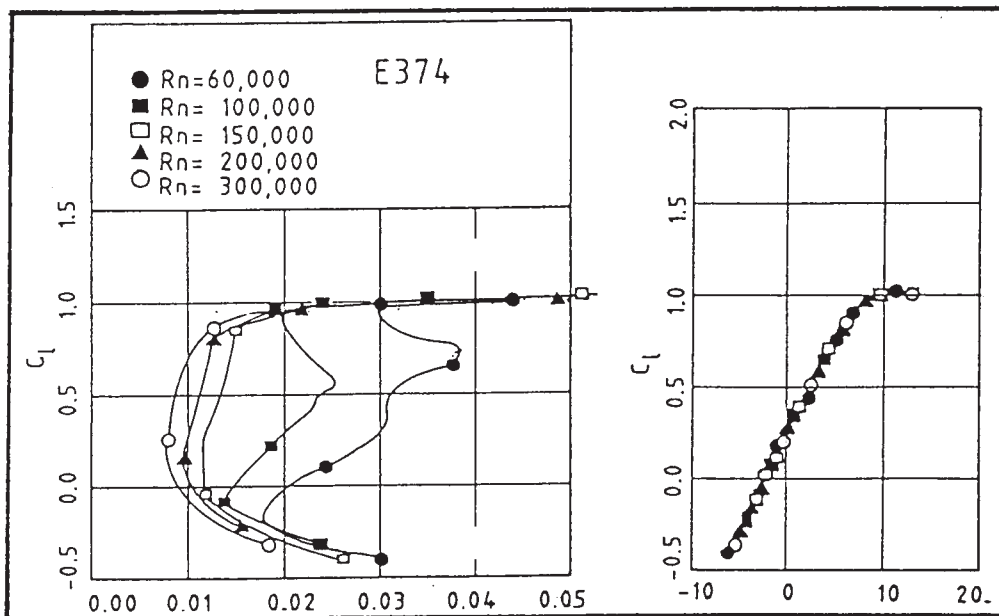
EXAMPLE: Let's assume that we intend to adopt the airfoil E 205 at an incidence equivalent to $C_L = 0.5$, at a Reynolds Number Re = 100,000.

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

$$E = \frac{C_L}{C_D} = \frac{0.5}{0.0137} = 36.5$$
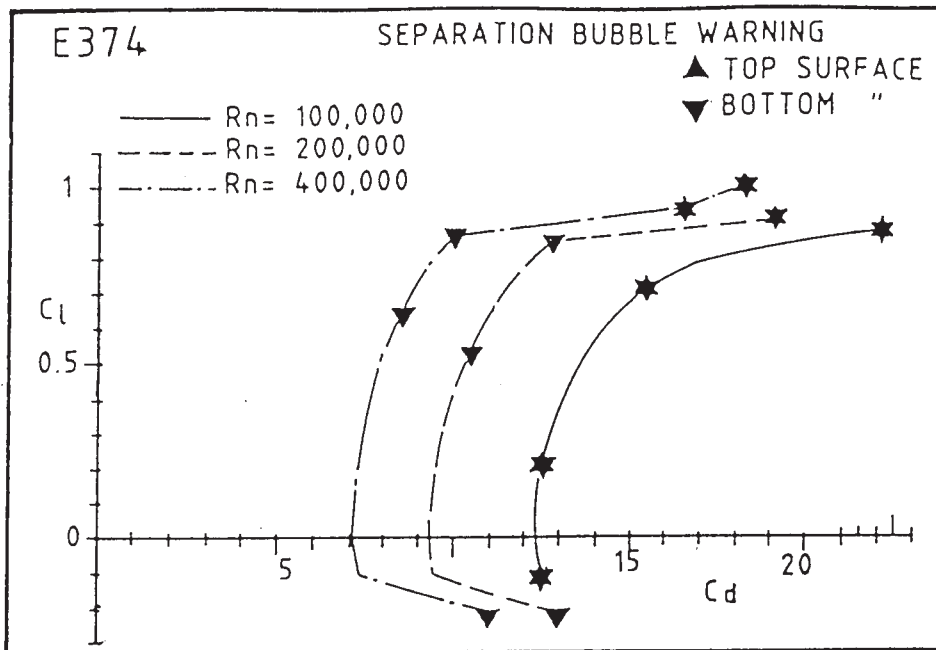
FIGURE 2

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 m/s | At / a Km/h | With Wing Loading Con Carico Alare Kg/m² | Best Glide Ratio Miglior Rapporto di Planata E | At / A Km/h | With Wing Loading Con Carico Alare Kg/m² | Max. Speed [VNE] Velocita' Max. 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).
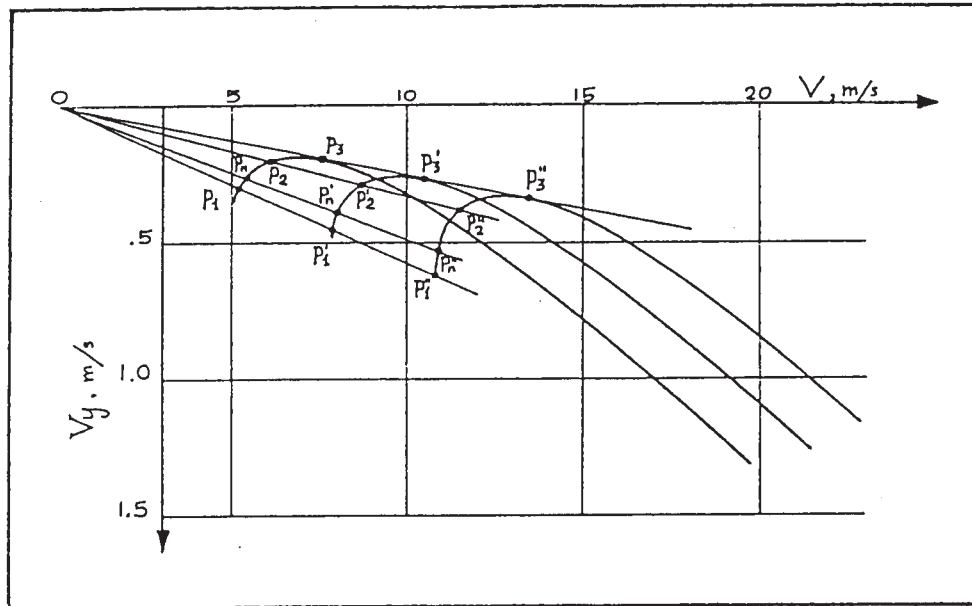
*Speed polars*
Polari odografiche

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 O (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, <u>divide</u> by the factors shown:*

*Per convertire valori in scala reale per applicarli a modelli costruiti secondo un rapporto di scala di F:1, <u>dividere</u> 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, <u>multiply</u> by the factors above.*

*Per convertire in scala reale i valori osservati o misurati relativi al modello, <u>moltiplicare</u> per i suddetti valori.*

# TABLE 6

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

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

| $\rho/\mu$ | 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

14

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

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

where

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

From a practical point of view, speed V, chord c, and $\rho/\mu$ (rho/mu) are multiplied by each other. The value of the ratio $\rho/\mu$ (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

$$E = C_L/C_D = D/H$$
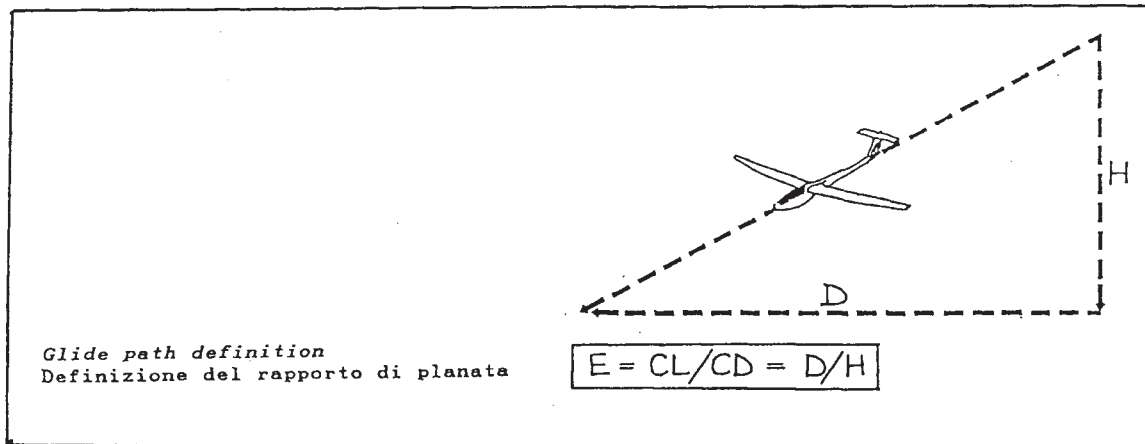
FIGURE 4

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.
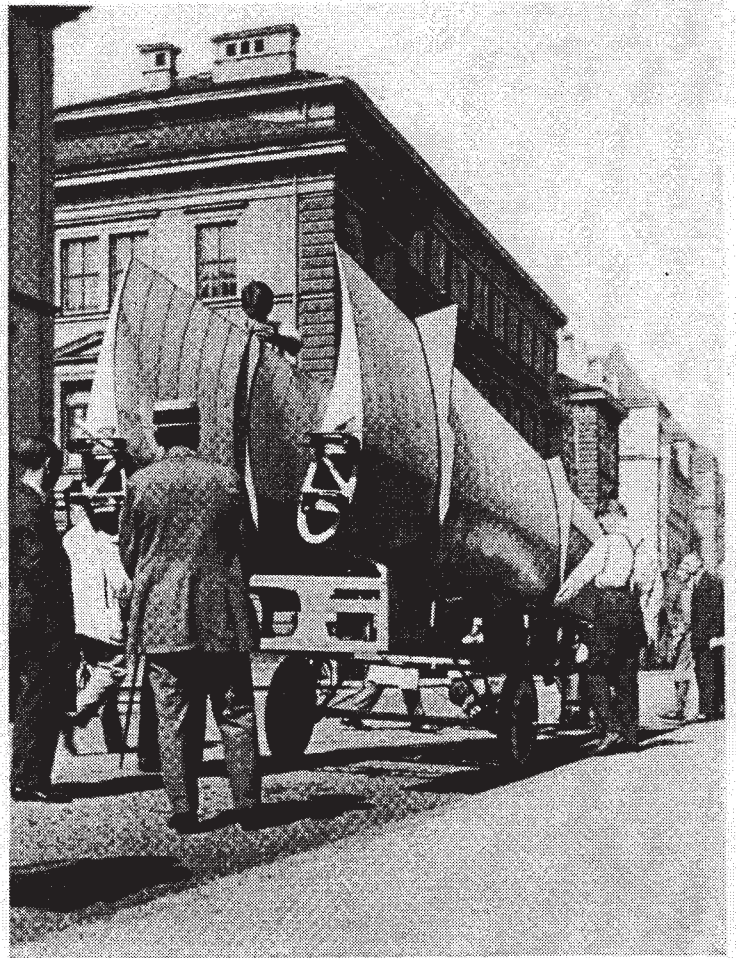
Photograph from Howard Siepen

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

NATIONAL GEOGRAPHIC, JUNE 1929

TABLE 7.1.2

Legend:

* = 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

Column groups: **W&C** = VAMPYR … SHK; **W&C-15 m** = FK 3 … VASAMA

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

## TABLE 7.1.1

REMARKS NOTE
** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIÙ CODA VERTICALE
* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIÙ 90 KG
✶ = METAL CONSTR. / COSTRUZ. METALLICA

Span groups: **WEC – 15 m** = MEISE, Ka 6 E, Ka 8 B, STANDARD AUSTRIA, SB 5B, FOKA 4, VASAMA. **WEC** = VAMPYR … FK 3.

| # | Parameter (EN / IT) | Sym | Unit | VAMPYR | FAFNIR | GRUNAU BABY IIb | MINIMOA | WEIHE 50 | HKS I | HKS III | ZUGVOGEL III | ZEFIR | SHK | FK 3 ✶ | MEISE | Ka 6 E | Ka 8 B | STANDARD AUSTRIA | SB 5B | FOKA 4 | VASAMA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | FIRST FLIGHT / PRIMO VOLO | ANNO | YEAR | 1921 | 1930 | 1933 | 1935 | 1938 | 1953 | 1955 | 1957 | 1958 | 1965 | 1968 | 1939 | 1955 | 1958 | 1958 | 1959 | 1960 | 1961 |
| 2 | TAKE OFF WEIGHT / PESO AL DECOLLO * | $W$ | [Kg] | 210 | 290 | 239 | 340 | 335 | 540 | 389 | 335 | 385 | 350 | 364 | 250 | 281 | 281 | 298 | 293 | 335 | 303 |
| 3 | MAX. TAKE OFF W. / PESO MAX. DECOLLO | $W'$ | [Kg] | 210 | 315 | 250 | 350 | 335 | 588 | 410 | 365 | 415 | 370 | 400 | 255 | 300 | 310 | 323 | 300 | 385 | 300 |
| 4 | WING WEIGHT / PESO ALA | $W_w$ | [Kg] | – | – | 85 | 145 | 140 | 250 | 173 | 150 | 185 | 164 | 152 | 82 | 116 | 110 | 122 | 122 | 130 | 124 |
| 5 | FUSELAGE WEIGHT / PESO FUSOLIERA ** | $W_f$ | [Kg] | – | – | 57 | 95 | 93 | 183 | 109 | 88 | 103 | 87 | 113 | 71 | 69 | 74 | 78 | 69 | 107 | 83 |
| 6 | STABILATOR WEIGHT / PESO STABILIZZATORE | $W_t$ | [Kg] | – | – | 7 | 10 | 12 | 17 | 17 | 7 | 7 | 11 | 9 | 7 | 6 | 7 | 8 | 12 | 8 | 6 |
| 7 | BALLAST WATER / ZAVORRA ACQUA | $W_b$ | [Kg] | – | – | – | – | – | – | 75 | – | – | – | 50 | – | – | – | – | – | – | – |
| 8 | OVERALL LENGTH / LUNGHEZZA F.T. | $L$ | [m] | 5.00 | 7.76 | 6.05 | 7.00 | 8.14 | 8.30 | 7.16 | 7.10 | 7.07 | 6.30 | 7.22 | 7.27 | 6.70 | 7.00 | 6.20 | 6.50 | 7.00 | 5.97 |
| 9 | WING SPAN / APERTURA ALARE | $b{=}2s$ | [m] | 12.6 | 19.0 | 13.6 | 17.0 | 18.0 | 19.0 | 17.2 | 17.0 | 17.0 | 17.0 | 17.4 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| 10 | ASPECT RATIO / ALLUNGAMENTO | AR | [–] | 10.0 | 20.0 | 13.0 | 15.2 | 17.7 | 20.3 | 20.8 | 20.1 | 20.6 | 19.7 | 21.9 | 15.0 | 18.1 | 16.5 | 16.7 | 17.3 | 18.5 | 19.1 |
| 11 | WING AREA / SUPERFICIE ALARE | $S$ | [m²] | 16.0 | 18.6 | 14.2 | 19.0 | 18.34 | 17.79 | 14.23 | 14.37 | 14.0 | 14.65 | 13.8 | 15.0 | 12.4 | 14.5 | 13.5 | 13.0 | 12.16 | 11.75 |
| 12 | MIN. WING LOADING / CARICO ALARE MIN. | $W/S$ | [Kg/m²] | 13.1 | 15.6 | 16.8 | 17.9 | 18.3 | 30.4 | 27.3 | 23.3 | 27.5 | 23.9 | 26.4 | 16.7 | 22.7 | 19.4 | 22.1 | 22.5 | 27.5 | 25.8 |
| 13 | MAX. WING LOADING / CARICO ALARE MAX. | $W'/S$ | [Kg/m²] | 13.1 | 16.9 | 17.6 | 18.4 | 18.3 | 33.1 | 28.8 | 25.4 | 29.6 | 25.3 | 29.0 | 17.0 | 24.2 | 21.4 | 23.9 | 23.1 | 31.7 | 26.5 |
| 14 | MEAN WING CHORD / CORDA MEDIA ALARE | $\bar{c}$ | [m] | 1.27 | 0.98 | 1.04 | 1.12 | 1.02 | 0.94 | 0.83 | 0.85 | 0.82 | 0.86 | 0.79 | 1.00 | 0.83 | 0.97 | 0.90 | 0.87 | 0.81 | 0.78 |
| 15 | ROOT WING CHORD / CORDA ALARE: RADICE | $c_r$ | [m] | 1.35 | 1.63 | 1.18 | 1.30 | 1.56 | 1.23 | 1.27 | 1.16 | 0.96 | 1.20 | 0.87 | 1.45 | 1.17 | 1.30 | 1.20 | 1.00 | 1.22 | 1.08 |
| 16 | TIP WING CHORD / CORDA ALARE: ESTR. | $c_e$ | [m] | 0.76 | 0.41 | 0.49 | 0.75 | 0.43 | 0.54 | 0.38 | 0.34 | 0.51 | 0.30 | 0.37 | 0.55 | 0.49 | 0.60 | 0.56 | 0.38 | 0.40 | 0.37 |
| 17 | WING PLANFORM / PIANTA ALARE | FIG.6 |  | RT | RT | RT | T | T | T | DT | T | T | DT | T | T | DT | T | DT | RT | T | DT |
| 18 | TAPER RATIO / RAPP. RASTREMAZ. | TR | [$c_e/c_r$] | 0.56 | 0.27 | 0.42 | 0.58 | 0.28 | 0.44 | 0.47 | 0.33 | 0.56 | 0.43 | 0.34 | 0.38 | 0.37 | 0.38 | 0.50 | 0.56 | 0.31 | 0.37 |
| 19 | TAPER POINT / INIZIO RASTREM. | $y_i$ | [%s] | – | 0.54 | 0.53 | 0.58 | – | 0.52 | – | 0.56 | – | – | – | – | 0.61 | 0.60 | 0.54 | – | – | 0.62 |
| 20 | WING TWIST / SVERGOLAM. ALA | $\alpha_w$ | [°] | – | -3.5 | -2 | -6.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 | -4 | -1.5 | 0 | 0 | 0 | 0 |

## TABLE 7.2.2

Legend:

WEC-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

| Glider | ㉑ da [%b] AILERON SPAN | ㉒ ca [m] AIL. MEAN CHORD | ㉓ EMPENN. ARRAN. (FIG.7) | ㉔ bt [m] STABILATOR SPAN | ㉕ St [m²] STABILATOR AREA | ㉖ ARt STABILATOR AR | ㉗ ct [m] STAB. MEAN CHORD | ㉘ ht [%ct] ELEVATOR CHORD | ㉙ A [m] ELEV. LEVER ARM | ㉚ TVC TAIL VOL. COEFF. | ㉛ y [m] FIN HEIGHT | ㉜ Sv [m²] TOTAL FIN AREA | ㉝ ARv FIN ASPEC. R. | ㉞ cv [m] FIN MEAN CH. | ㉟ hv [%cv] RUDDER CHORD | ㊱ B [m] RUDDER L. ARM | ㊲ VVC TAIL VOL. COEF. | ㊳ SPOILERS ARR. (FIG.15) | ㊴ db [m] AIR BRAKE SPAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STANDARD ELFE | 32 | 0.18 | A | 2.90 | 1.45 | 5.80 | 0.50 | 100 | 4.27 | 0.54 | 1.43 | 1.05 | 1.94 | 0.74 | 40 | 4.33 | 0.025 | A | 1.11 |
| PHÖNIX T | 29 | 0.12 | C | 3.20 | 1.55 | 6.61 | 0.48 | 35 | 4.04 | 0.66 | 0.95 | 1.21 | 0.75 | 1.27 | 58 | 4.35 | 0.022 | | |
| SB 6 | 28 | 0.13 | B | 2.60 | 1.20 | 5.63 | 0.46 | 100 | 4.47 | 0.54 | 1.50 | 1.27 | 1.77 | 0.85 | 40 | 4.51 | 0.034 | C | |
| 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 | |
| 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 | |
| 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 | |
| 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 | 0.020 | C | |
| CIRRUS B | 37 | 0.15 | B | 2.50 | 1.05 | 5.95 | 0.42 | 28 | 4.16 | 0.49 | 1.20 | 1.15 | 1.90 | 0.78 | 45 | 4.30 | 0.022 | C | |
| PHOEBUS C | 32 | 0.16 | C | 3.20 | 1.56 | 6.56 | 0.49 | 100 | 4.24 | 0.57 | 1.48 | 1.16 | 1.24 | 0.97 | 49 | 4.28 | 0.024 | C | |
| 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 | |
| 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 | 0.019 | C | |
| 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 | 4.65 | 0.018 | C | |
| 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 | 4.46 | 0.019 | C | |
| 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 | 4.45 | 0.016 | FIG.15 | |
| 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 | | 0.019 | | |
| 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 | 0.016 | Bσu | |
| 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 | 0.021 | Bσu | |
| 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 / 0.035 | A | |

## TABLE 7.2.1

Remarks / Note:
** = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIÙ CODA VERTICALE
* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIÙ 90 KG

Groups: W&C‑15m (STANDARD ELFE, PHÖNIX T) · GRP‑F (SB 6 … FS 29)

| Aircraft | ① YEAR / ANNO | ② W [Kg] * | ③ W' [Kg] | ④ Ww [Kg] | ⑤ Wf [Kg] ** | ⑥ Wt [Kg] | ⑦ Wb [Kg] | ⑧ L [m] | ⑨ b=2s [m] | ⑩ AR | ⑪ S [m²] | ⑫ W/S [Kg/m²] | ⑬ W'/S [Kg/m²] | ⑭ c̄ [m] | ⑮ cr [m] | ⑯ ce [m] | ⑰ Planform (FIG.6) | ⑱ TR [ce/cr] | ⑲ yi [%] | ⑳ αw [°] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| PHÖNIX T | 1957 | 269 | 300 | 96 | 75 | 8 | – | 6.90 | 16.0 | 18.7 | 14.36 | 18.7 | 20.9 | 0.81 | 1.25 | 0.53 | RT | 0.42 | 0.57 | -2 |
| SB 6 | 1961 | 350 | 350 | 145 | 119 | 6 | – | 7.50 | 18.0 | 26.9 | 12.66 | 26.9 | 26.9 | 0.72 | 0.90 | 0.41 | DT | – | – | 0 |
| SB 7B | 1962 | 390 | 390 | 181 | 112 | 7 | – | 7.08 | 17.0 | 30.8 | 12.66 | 30.8 | 30.8 | 0.74 | 0.92 | 0.37 | RT | 0.36 | 0.41 | |
| BS 1 | 1962 | 425 | 500 | 192 | 134 | 9 | – | 7.58 | 18.0 | 22.8 | 14.20 | 35.2 | 35.2 | 0.79 | 0.99 | 0.40 | DT | 0.41 | 0.56 | 0 |
| 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 |
| ASW 12 | 1965 | 409 | 430 | 194 | 117 | 8 | 100 | 7.35 | 18.3 | 25.8 | 13.00 | 31.5 | 33.1 | 0.71 | 0.76 | 0.26 | DT | 0.34 | 0.59 | -3 |
| CIRRUS B | 1967 | 366 | 400 | 165 | 104 | 7 | – | 7.20 | 17.7 | 24.9 | 12.60 | 29.0 | 31.7 | 0.71 | 0.87 | 0.35 | T | 0.40 | 0.58 | -2 |
| PHOEBUS C | 1967 | 333 | 459 | 176 | 85 | 6 | – | 6.98 | 17.0 | 20.6 | 14.06 | 23.7 | 32.6 | 0.83 | 1.21 | 0.37 | DT | 0.31 | – | |
| SB 8 | 1967 | 301 | 334 | 129 | 76 | 6 | – | 7.70 | 18.0 | 23.0 | 14.10 | 21.3 | 23.7 | 0.78 | 0.93 | 0.36 | RT | 0.37 | – | |
| DIAMANT 18 | 1967 | 385 | 440 | 182 | 105 | 8 | – | 7.72 | 18.0 | 22.7 | 14.28 | 27.0 | 30.8 | 0.79 | 0.97 | 0.45 | DT | 0.46 | 0.62 | -3 |
| 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 |
| SB 9 | 1969 | 415 | 421 | 218 | 100 | 6 | 100 | 7.50 | 22.0 | 31.3 | 15.48 | 26.8 | 27.2 | 0.70 | 0.97 | 0.25 | DT | 0.36 | 0.51 | -1.5 |
| NIMBUS II | 1969 | 446 | 580 | 230 | 120 | 7 | 150 | 7.50 | 20.3 | 28.6 | 14.4 | 31.0 | 40.2 | 0.71 | 0.97 | 0.40 | DT | 0.41 | 0.57 | 0 |
| 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 | |
| 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 |
| 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 | 0.29 | DT | 0.80 / 0.30 | 0.30 / 0.67 | -1.5 |
| 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 | 0.40 / 0.49 | RT | 0.40 | 0.54 / 0.68 | -1.5 |

Column symbols / descriptions:
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. RASTREMAZ.
⑲ TAPER POINT / INIZIO RASTREM.
⑳ WING TWIST / SVERGOLAM. ALA

# TABLE 7.3.2

TWS = TWIN SEAT SAILPLANES = ALIANTI BIPOSTO

\* = METAL CONSTRUCTION = COSTRUZ. METALLICA

| TWS | ㉑ AILERON SPAN / APERT. ALETT. aa [%] | 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. db [m] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| GOEVIER | 61 | 0.34 | A | 3.18 | 2.64 | 3.83 | 0.83 | 42 | 4.26 | 0.46 | 1.74 | 1.72 | 0.99 | 0.86 | 64 | 4.64 | 0.028 | C | 0.90 |
| 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 |
| BERGFALKE II/55 | 46 | 0.26 | A | 2.80 | 2.00 | 3.92 | 0.71 | 46 | 4.11 | 0.43 | 1.11 | 1.09 | 1.48 | 0.86 | 77 | 4.87 | 0.018 | C | 1.10 |
| 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 |
| Ka 7 | 37 | 0.27 | A | 3.00 | 2.55 | 3.53 | 0.85 | 42 | 4.40 | 0.58 | 1.45 | 1.34 | 1.57 | 0.92 | 56 | 4.74 | 0.024 | C | 1.47 |
| BLANIK \* | 42 | 0.34 | A | 3.45 | 2.66 | 4.47 | 0.77 | 42 | 4.43 | 0.59 | 1.53 | 1.61 | 1.46 | 1.05 | 58 | 4.95 | 0.024 | B | |
| 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[b] | 1.20 |
| CALIF | 28 | 0.18 | C | 3.15 | 1.70 | 5.84 | 0.54 | 20 | 5.08 | 0.68 | 1.95 | 1.34 | 1.74 | 0.83 | 47 | 4.92 | 0.022 | C | 1.47 |
| ASK 13 | 37 | 0.27 | A | 3.00 | 2.55 | 3.53 | 0.85 | 42 | | | 1.45 | 1.21 | 1.84 | 0.69 | 57 | 5.05 | 0.020 | C | |
| LSD-ORNITH | | 0.15 | C | 2.30 | 0.84 | 6.30 | 0.37 | 100 | | | 1.30 | 1.20 | 1.41 | 0.92 | | | | C | |
| 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[a] | 1.21 |
| 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[b] | 1.40 |
| GLOBETROTTER | | | C | 2.75 | 1.47 | 5.14 | 0.53 | | | | 1.20 | 1.00 | 1.44 | 0.83 | | | | C[c] | 1.21 |
| B-12 | 37 | 0.15 | B | 3.28 | 1.44 | 7.47 | 0.44 | | | | 1.79 | 1.46 | 2.19 | 0.82 | | | | C[d] | 1.21 |
| SFH 34 | | | C | | | | | | | | | | | | 40 | | 0.045 | C | 1.40 |
| ASK 21 | | | C | | | | | 25 | | | | | | | | | | 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 | | C | 1.51 |

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## TABLE 7.3.1

REMARKS / NOTE

** = FUSELAGE PLUS VERTICAL TAIL PLUS 90 KG = FUSOLIERA PIU' CODA VERTICALE PIU' 90 KG

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

* = METAL CONSTRUCTION = COSTRUZ. METALLICA

← TWS →

| | ① FIRST FLIGHT / PRIMO VOLO (YEAR/ANNO) | ② W [Kg] TAKE OFF WEIGHT* / PESO AL DECOLLO | ③ W' [Kg] MAX. TAKE OFF W. / PESO MAX. DECOLLO | ④ Ww [Kg] WING WEIGHT / PESO ALA | ⑤ Wf [Kg] FUSELAGE WEIGHT** / PESO FUSOLIERA | ⑥ Wt [Kg] STABILATOR WEIGHT / PESO STABILIZZATORE | ⑦ Wb [Kg] BALLAST WATER / ZAVORRA ACQUA | ⑧ L [m] OVERALL LENGTH / LUNGHEZZA F.T. | ⑨ b [m] WING SPAN / APERTURA ALARE | ⑩ AR [-] ASPECT RATIO / ALLUNGAMENTO | ⑪ S [m²] WING AREA / SUPERFICIE ALARE | ⑫ W/S [Kg/m²] MIN. WING LOADING / CARICO ALARE MIN. | ⑬ W'/S [Kg/m²] MAX. WING LOADING / CARICO ALARE MAX. | ⑭ c [m] MEAN WING CHORD / CORDA MEDIA ALARE | ⑮ ct [m] ROOT WING CHORD / CORDA ALARE : RADICE | ⑯ ce [m] TIP WING CHORD / CORDA ALARE : ESTR. | ⑰ WING PLANFORM / PIANTA ALARE (FIG.6) | ⑱ TR [ce/ct] TAPER RATIO / RAPP. RASTREMAZ. | ⑲ yi [%] TAPER POINT / INIZIO RASTREM. | ⑳ αw [°] WING TWIST / SVERGOLAM. ALA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | – | – |
| GOEVIER | 1938 | 325 | 410 | 122 | 102 | 10 | – | 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 | 100 | 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 | – | 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 | T | 0.40 | 0.59 | 0 |
| TWIN ASTIR | 1976 | 495 | 650 | 194 | 196 | 15 | 100 | 7.66 | 17.50 | 17.1 | 17.90 | 27.7 | 36.3 | 0.91 | 1.30 | 0.66 | T | 0.51 | 0.58 | 0 |
| GLOBETROTTER | 1977 | 498 | 600 | | | | | 8.10 | 17.00 | 18.1 | 15.72 | 31.7 | 35.1 | | | 0.51 | DT | 0.40 | 0.59 | 0 |
| B-12 | 1977 | 492 | 582 | | | | | 8.67 | 18.20 | 20.0 | 16.60 | 29.6 | 35.5 | 1.05 | 1.30 | 0.66 | DT | 0.51 | 0.59 | 0 |
| SFH 34 | 1978 | 390 | 490 | | | | | 7.50 | 15.80 | 17.0 | 14.80 | 26.4 | 33.1 | 1.06 | 1.30 | 0.48 | DT | 0.40 | | |
| ASK 21 | 1979 | 440 | 550 | | | | | 8.35 | 17.00 | 16.1 | 17.95 | 24.5 | 30.6 | 0.87 | | | T | | | |
| PHOEBUS B1 | 1964 | 314 | 350 | | | | | 6.98 | 15.0 | 17.2 | 13.11 | 24.0 | 26.7 | 1.21 | 1.21 | | DT | | | |

# 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.

| Group | Model | (21) AILERON SPAN APERT. ALETT. $\Delta a$ [%] | (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. $\Delta t$ [m²] | (26) STABILATOR AR ALLUNG. STAB $AR_t$ [-] | (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 $\Delta v$ [m²] | (33) FIN ASPEC.R. ALLUNG. DERIVA $AR_v$ [-] | (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. $\Delta b$ [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 | C | 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 | 0.72 | 2.00 | 0.60 | 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 | 0.78 | 1.82 | 0.66 | 40 | 3.66 | 0.023 | B | 1.00 |
| 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 | 3.79 | 0.025 | C | 1.20 |
| GRP-S | STANDARD CIRRUS | 33 | 0.12 | C | 2.40 | 1.02 | 5.29 | 0.43 | 100 | 3.85 | 0.58 | 1.25 | 0.95 | 1.52 | 0.63 | 40 | 3.79 | 0.024 | °C | 1.20 |
| GRP-S | D 38 | 35 | 0.17 | C | 2.30 | 1.00 | 5.01 | 0.43 | 100 | 4.27 | 0.53 | 1.25 | 0.92 | 1.98 | 0.81 | 40 | 4.29 | 0.021 | °C | 1.35 |
| GRP-S | STANDARD JANTAR | 32 | 0.11 | C | 2.60 | 1.35 | 4.94 | 0.45 | 29 | 3.92 | 0.45 | 1.35 | 0.90 | 1.47 | 0.66 | 42 | 3.98 | 0.027 | C | 1.33 |
| GRP-S | LS 1f | 35 | 0.14 | C | 2.20 | 0.98 | 5.29 | 0.45 | 25 | 3.95 | 0.61 | 1.15 | 0.92 | 1.10 | 0.78 | 35 | 3.99 | 0.025 | °C | 1.35 |
| GRP-S | DG 100 | 35 | 0.17 | C | 2.30 | 1.00 | 5.23 | 0.43 | 100 | 4.05 | 0.53 | 1.24 | 0.91 | 1.67 | 0.74 | 50 | 4.04 | 0.024 | °C | 1.34 |
| GRP-S | ASTIR CS | 33 | 0.18 | C | 2.80 | 1.50 | 5.43 | 0.54 | 25 | 4.05 | 0.59 | 1.22 | 0.96 | 1.55 | 0.79 | 42 | 3.98 | 0.027 | °C | 1.21 |
| GRP-S | HORNET | 39 | 0.10 | C | 2.50 | 1.15 | 5.68 | 0.46 | 25 | 3.82 | 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 | 5.43 | 0.46 | 30 | 3.74 | 0.52 | 1.25 | 1.00 | 1.56 | 0.80 | 30 | 3.84 | 0.023 | °C | 1.20 |
| GRP-S | LIBELLE H-301 | 44 | 0.12 | B | 2.50 | 1.00 | 6.25 | 0.44 | 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 | °C | 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 | °C | 1.38 |
| GRP-15m | MOSQUITO | 45 | 0.11 | C | 2.50 | 1.15 | 5.43 | 0.46 | 25 | 3.88 | 0.70 | 1.40 | 0.89 | 2.18 | 0.64 | 30 | 3.90 | 0.024 | B | 1.20 |
| 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 | °C | 1.46 |

## TABLE 7.4.1

**Legend:**
- `**` = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIÙ CODA VERTICALE
- `*` = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIÙ 90 KG

Column groups: **GRP-15 m** = DG 200, MINI NIMBUS, MOSQUITO, LS 3, PIK 20 D, LIBELLE H-301 — **GRP-5** = ASW 19, HORNET, ASTIR CS, DG 100, LS 1f, STANDARD JANTAR, D 38, STANDARD CIRRUS, ASW 15 B, FS 25, STANDARD LIBELLE, LS 1c

| # | Parameter (EN / IT) | Sym | Units | DG 200 | MINI NIMBUS | MOSQUITO | LS 3 | PIK 20 D | LIBELLE H-301 | ASW 19 | HORNET | ASTIR CS | DG 100 | LS 1f | STANDARD JANTAR | D 38 | STANDARD CIRRUS | ASW 15 B | FS 25 | STANDARD LIBELLE | LS 1c |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ① | FIRST FLIGHT / PRIMO VOLO | ANNO | | 1976 | 1976 | 1976 | 1976 | 1973 | 1964 | 1975 | 1974 | 1974 | 1974 | 1974 | 1973 | 1972 | 1969 | 1968 | 1968 | 1967 | 1967 |
| ② | TAKE OFF WEIGHT / PESO AL DECOLLO * | W | [Kg] | 331 | 326 | 352 | 370 | 338 | 275 | 344 | 334 | 342 | 316 | 317 | 340 | 306 | 302 | 324 | 238 | 289 | 293 |
| ③ | MAX.TAKE OFF W. / PESO MAX. DECOLLO | W' | [Kg] | 450 | 450 | 450 | 472 | 450 | 300 | 408 | 420 | 450 | 418 | 390 | 440 | 360 | 390 | 408 | 250 | 350 | 312 |
| ④ | WING WEIGHT / PESO ALA | Ww | [Kg] | 126 | 130 | 134 | 158 | 140 | 105 | 140 | 124 | 138 | 120 | 119 | 136 | 118 | 110 | 135 | 78 | 108 | 107 |
| ⑤ | FUSELAGE WEIGHT / PESO FUSOLIERA ** | Wf | [Kg] | 108 | 99 | 102 | 115 | 102 | 75 | 104 | 112 | 105 | 98 | 102 | 106 | 91 | 95 | 90 | 66 | 84 | 91 |
| ⑥ | STABILATOR WEIGHT / PESO STABILIZZATORE | Wt | [Kg] | 7 | 7 | 6 | 7 | 6 | 5 | 10 | 8 | 9 | 8 | 6 | 8 | 8 | 7 | 9 | 4 | 7 | 5 |
| ⑦ | BALLAST WATER / ZAVORRA ACQUA | Wb | [Kg] | 110 | 140 | 125 | 150 | 140 | — | 120 | 100 | 100 | 100 | 90 | 100 | 40 | 60 | 82 | — | 50 | — |
| ⑧ | OVERALL LENGTH / LUNGHEZZA F.T. | L | [m] | 7.00 | 6.41 | 6.40 | 6.86 | 6.45 | 6.18 | 6.80 | 6.40 | 6.47 | 7.00 | 6.70 | 7.11 | 6.92 | 6.35 | 6.48 | 6.48 | 6.20 | 7.20 |
| ⑨ | WING SPAN / APERTURA ALARE | $b=2s$ | [m] | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| ⑩ | ASPECT RATIO / ALLUNGAMENTO | AR | [-] | 22.5 | 22.7 | 23.0 | 21.4 | 22.5 | 23.7 | 20.5 | 23.0 | 23.0 | 20.5 | 23.1 | 21.1 | 20.5 | 22.4 | 20.5 | 26.3 | 23.0 | 23.1 |
| ⑪ | WING AREA / SUPERFICIE ALARE | S | [m²] | 10.0 | 9.9 | 9.8 | 10.5 | 10.0 | 9.5 | 11.0 | 9.8 | 12.4 | 11.0 | 9.75 | 10.66 | 11.0 | 10.04 | 11.00 | 8.54 | 9.80 | 9.74 |
| ⑫ | MIN. WING LOADING / CARICO ALARE MIN. | W/S | [Kg/m²] | 33.1 | 32.9 | 33.9 | 35.2 | 33.8 | 28.9 | 31.3 | 34.1 | 27.6 | 28.7 | 32.5 | 31.9 | 27.8 | 30.1 | 29.5 | 27.9 | 29.5 | 30.1 |
| ⑬ | MAX. WING LOADING / CARICO ALARE MAX. | W'/S | [Kg/m²] | 45.0 | 45.5 | 45.9 | 45.0 | 45.0 | 31.6 | 37.1 | 42.9 | 36.3 | 38.0 | 40.0 | 41.3 | 32.7 | 38.8 | 37.1 | 29.3 | 35.7 | 32.0 |
| ⑭ | MEAN WING CHORD / CORDA MEDIA ALARE | c | [m] | 0.67 | 0.66 | 0.65 | 0.70 | 0.67 | 0.63 | 0.73 | 0.65 | 0.83 | 0.73 | 0.65 | 0.71 | 0.73 | 0.67 | 0.73 | 0.57 | 0.65 | 0.65 |
| ⑮ | ROOT WING CHORD / CORDA ALARE: RADICE | cr | [m] | 0.84 | 0.87 | 0.84 | 0.97 | 0.90 | 0.94 | 0.91 | 0.88 | 1.00 | 0.94 | 0.84 | 0.95 | 0.94 | 0.92 | 0.91 | 0.76 | 0.88 | 0.85 |
| ⑯ | TIP WING CHORD / CORDA ALARE: ESTR. | ce | [m] | 0.35 | 0.42 | 0.40 | 0.46 | 0.36 | 0.33 | 0.38 | 0.35 | 0.45 | 0.38 | 0.32 | 0.45 | 0.37 | 0.35 | 0.38 | 0.24 | 0.35 | 0.32 |
| ⑰ | WING PLANFORM / PIANTA ALARE | FIG.6 | | DT | DT | DT | T | DT | T | DT | DT | DT | DT | T | DT | DT | DT | DT | DT | DT | DT |
| ⑱ | TAPER RATIO / RAPP. RASTRENAZ. | TR | [ce/cr] | 0.40 | 0.48 | 0.48 | 0.47 | 0.40 | 0.35 | 0.42 | 0.40 | 0.45 | 0.40 | 0.38 | 0.47 | 0.40 | 0.38 | 0.42 | 0.32 | 0.40 | 0.38 |
| ⑲ | TAPER POINT / INIZIO RASTREM. | yi | [%] | 68 | 47 | 47 | — | 60 | — | 59 | 58 | 60 | 60 | 60 | — | 60 | 58 | 59 | 74 | 58 | 60 |
| ⑳ | WING TWIST / SVERGOLAM. ALA | αw | [°] | 0 | 0 | 0 | -1 | 0 | — | -2 | -2.5 | -1.8 | 0 | 0 | -3 | -2.6 | -0.75 | -2 | -2.5 | -2 | -2 |

# TABLE 7.5.2

**← AS →|← VGW →|← GRP – 15 m →**

GRP-15 = GLASS REINFORCED CONSTRUCTION 15 M CLASS = VETRORESINA CLASSE 15M

WGV = VARIABLE GEOMETRY WING = ALA A GEOMETRIA VARIAB.

AS = AEROBATIC SAILPLANES = ALIANTI ACROBATICI

| No. | Description | Symbol | Units | GRP-15m ASW 20 | SPEED ASTIR | VGW AN 66 C | SIGMA | SB 11 | MÜ 27 | AS LO 100 | B 4 | SALTO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | AILERON SPAN / APERT. ALETT. | da ca. | [%] | 36 | 47 | | | 41 | | 56 | 37 | 43 |
| 22 | AIL. MEAN CHORD / CORDA MEDIA AL. | | [m] | 0.09 | 0.13 | | | 0.14 | | 0.24 | 0.19 | 0.10 |
| 23 | EMPENN. ARRAN. / SIST. IMPENN. | | FIG.7 | C | C | B | C | C | | B | C | D |
| 24 | STABILATOR SPAN / APERT. STABIL. | bt | [m] | 2.20 | 3.00 | | 2.59 | 2.70 | | 2.70 | 3.08 | 2.14 |
| 25 | STABILATOR AREA / SUP. STABILIZZ. | St | [m²] | 1.00 | 1.44 | | 1.12 | 1.24 | | 1.00 | 1.71 | 1.09 |
| 26 | STABILATOR AR / ALLUNG. STAB | ARt | [-] | 4.85 | 6.25 | | 5.99 | 5.88 | | 7.29 | 5.56 | 4.20 |
| 27 | STAB. MEAN CHORD / CORDA MEDIA STA. | ct | [m] | 0.45 | 0.48 | | 0.43 | 0.46 | | 0.37 | 0.55 | 0.51 |
| 28 | ELEVATOR CHORD / CORDA ELEVATORE | ht | [%ct] | 32 | 28 | | | 100 | | 42 | 33 | 38 |
| 29 | ELEV. LEVER ARM / BRACCIO ELEV. | A | [m] | 3.89 | 3.87 | | | 4.55/4.50 | | 3.24 | 3.83 | 3.61 |
| 30 | TAIL VOL. COEFF / RAPP. VOLUMETR. | TVC | [-] | 0.53 | 0.64 | | | 0.76/0.51 | | 0.27 | 0.50 | 0.73 |
| 31 | FIN HEIGHT / ALTEZZA DERIVA | y | [m] | 1.25 | 1.09 | | 1.83 | 1.27 | | 1.10 | 1.32 | 0.91 |
| 32 | TOTAL FIN AREA / SUP. TOT. DERIVA | Sv | [m²] | 1.00 | 0.98 | | 1.44 | 1.17 | | 0.78 | 1.22 | 0.46 |
| 33 | FIN ASPEC. R. / ALLUNG. DERIVA | ARv | [-] | 1.57 | 1.21 | | 2.33 | 1.38 | | 1.55 | 1.70 | 3.60 |
| 34 | FIN MEAN CH. / CORDA M. DERIVA | cv | [m] | 0.80 | 0.90 | | 0.79 | 0.92 | | 0.71 | 0.85 | 0.51 |
| 35 | RUDDER CHORD / CORDA DIREZ. | hv | [%cv] | 30 | 30 | | | 40 | | 63 | 34 | 38 |
| 36 | RUDDER L. ARM / BRACCIO DIR. | B | [m] | 3.88 | 3.75 | | | 4.45/4.40 | | 3.74 | 3.38 | 3.61 |
| 37 | TAIL VOL. COEF. / RAPP. VOLUM. | VVC | [-] | 0.024 | 0.022 | | | 0.033/0.028 | | 0.027 | 0.020 | 0.028 |
| 38 | SPOILERS ARR. / SIST. DIRUTT. | σ | FIG.15 | C | C | | C | C | | B | C | B |
| 39 | AIR BRAKE SPAN / APERT. DIRUTT. | Jb | [m] | 1.40 | 1.50 | | | 1.20 | | 2.30 | 1.31 | 1.30 |

TABLE 7.5.1

REMARKS NOTE

\* = EMPTY WEIGHT PLUS 90 KG / PESO A VUOTO PIÙ 90 KG

\*\* = FUSELAGE PLUS VERTICAL TAIL / FUSOLIERA PIÙ CODA VERTICALE

| # | Parameter | GRP – 15 m | | | | | VGW | | AS | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | ASW 20 | SPEED ASTIR | AN 66 C | SIGMA | SB 11 | MÜ 27 | Lo 100 | B 4 | SALTO |
| ① | FIRST FLIGHT / PRIMO VOLO — YEAR (ANNO) | 1977 | 1978 | 1973 | 1971 | 1978 | 1979 | 1952 | 1966 | 1970 |
| ② | TAKE OFF WEIGHT / PESO AL DECOLLO — $W$ [Kg] \* | 335 | 365 | 510 | 697 | 360 | | 258 | 314 | 259 |
| ③ | MAX. TAKE OFF W. / PESO MAX. DECOLLO — $W'$ [Kg] | 454 | 515 | 650 | 703 | 470 | | 265 | 350 | 270 |
| ④ | WING WEIGHT / PESO ALA — $W_w$ [Kg] | 102 | 134 | 300 | | 169 | | 80 | 121 | 86 |
| ⑤ | FUSELAGE WEIGHT / PESO FUSOLIERA \*\* — $W_p$ [Kg] | 102 | 119 | | | 95 | 80 | 80 | 93 | 75 |
| ⑥ | STABILATOR WEIGHT / PESO STABILIZZATORE — $W_t$ [Kg] | 9 | 11 | | | 6 | | 8 | 10 | 8 |
| ⑦ | BALLAST WATER / ZAVORRA ACQUA — $W_b$ [Kg] | 120 | 140 | 120 | | | 100 | − | | |
| ⑧ | OVERALL LENGTH / LUNGHEZZA F.T. — $L$ [m] | 6.82 | 6.68 | 8.10 | 8.81 | 7.40 | 10.30 | 6.15 | 6.57 | 5.90 |
| ⑨ | WING SPAN / APERTURA ALARE — $b=2s$ [m] | 15.0 | 15.0 | 23.0 | 21.0 | 15.0 | 22.0 | 10.0 | 15.0 | 13.6 |
| ⑩ | ASPECT RATIO / ALLUNGAMENTO — $AR$ [–] | 21.4 | 19.6 | 33.8 / 27.6 | 36.2 / 26.8 | 21.3 / 17.0 | 27.5 / 20.2 / 23.9 | 9.2 | 16.1 | 21.5 |
| ⑪ | WING AREA / SUPERFICIE ALARE — $S$ [m²] | 10.5 | 11.47 | 16.0 / 19.2 | 12.2 / 16.5 | 10.56 / 13.2 | 17.6 / 23.9 | 10.9 | 14.0 | 8.6 |
| ⑫ | MIN. WING LOADING / CARICO ALARE MIN. — $W/S$ [Kg/m²] | 31.9 | 31.8 | 26.2 / 31.9 | 57.1 / 42.2 | 34.1 / 27.3 | | 23.7 | 22.4 | 30.1 |
| ⑬ | MAX. WING LOADING / CARICO ALARE MAX. — $W'/S$ [Kg/m²] | 43.3 | 44.9 | 33.9 / 40.6 | 57.6 / 42.6 | 44.5 / 35.0 | | 24.3 | 25.0 | 31.4 |
| ⑭ | MEAN WING CHORD / CORDA MEDIA ALARE — $\bar{c}$ [m] | 0.70 | 0.76 | 0.74 | 0.58 / 0.79 | 0.70 / 0.88 | 0.80 / 1.00 | 1.09 | 0.93 | 0.63 |
| ⑮ | ROOT WING CHORD / CORDA ALARE: RADICE — $c_r$ [m] | 0.70 | 0.74 | | 0.70 | 1.00 | 1.00 | 1.30 | 1.07 | 0.86 |
| ⑯ | TIP WING CHORD / CORDA ALARE: ESTR. — $c_e$ [m] | 0.30 | 0.50 | | 0.32 | 0.40 | 0.40 | 0.56 | 0.43 | 0.36 |
| ⑰ | WING PLANFORM / PIANTA ALARE — FIG.6 | DT | T | RT | RT | | RT | RT | RT | DT |
| ⑱ | TAPER RATIO / RAPP. RASTREMAZ. — $TR$ [$c_e/c_r$] | 0.43 | 0.49 | | | | 0.40 | 0.43 | 0.40 | 0.42 |
| ⑲ | TAPER POINT / INIZIO RASTREM. — $y_i$ [%] | 63 | − | 35 | | | 60 | 30 | 59 | |
| ⑳ | WING TWIST / SVERGOLAM. ALA — $\alpha_w$ [°] | 0 | 0 | | | | 0 | −3 | 0 | −2 |

$$S = b*c$$

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

*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

$$TR = ce/cr \qquad \alpha w° = \alpha r° - \alpha e°$$

*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

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

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

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

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

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

FIGURE 9-B

35
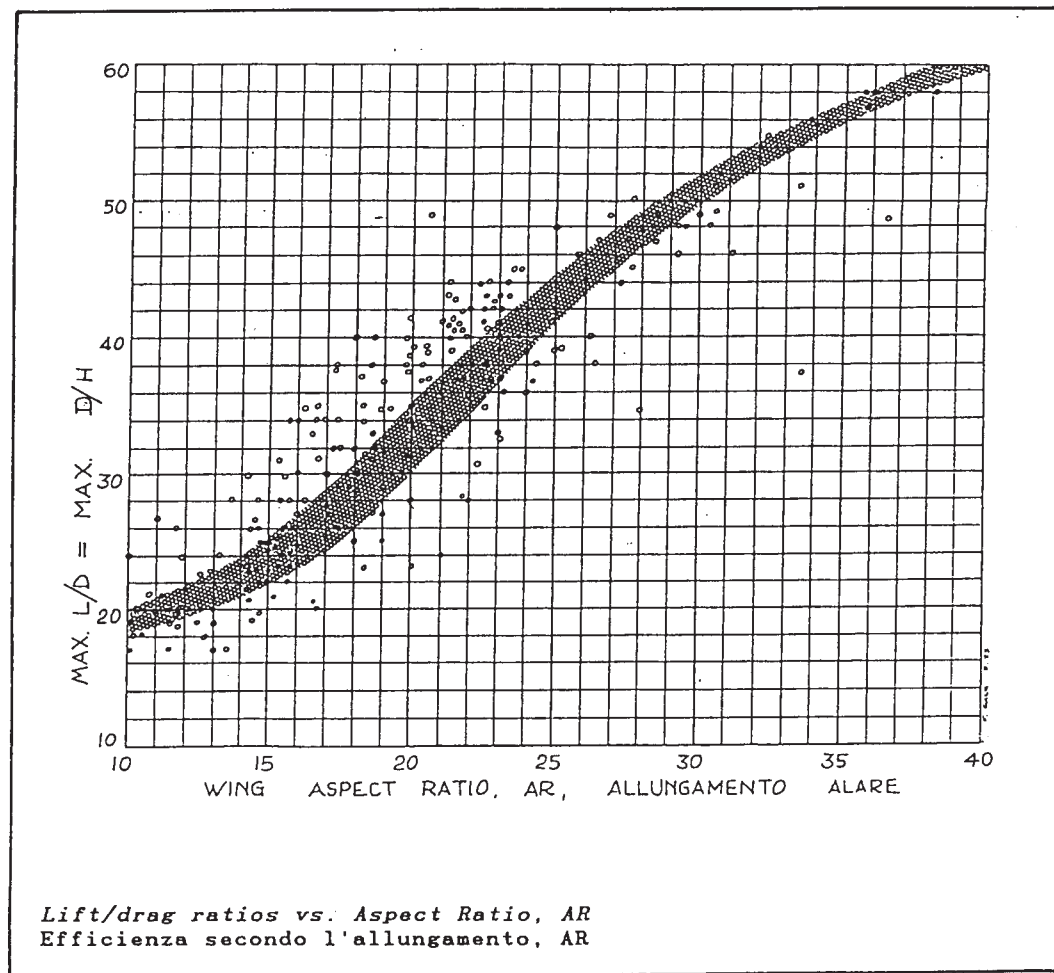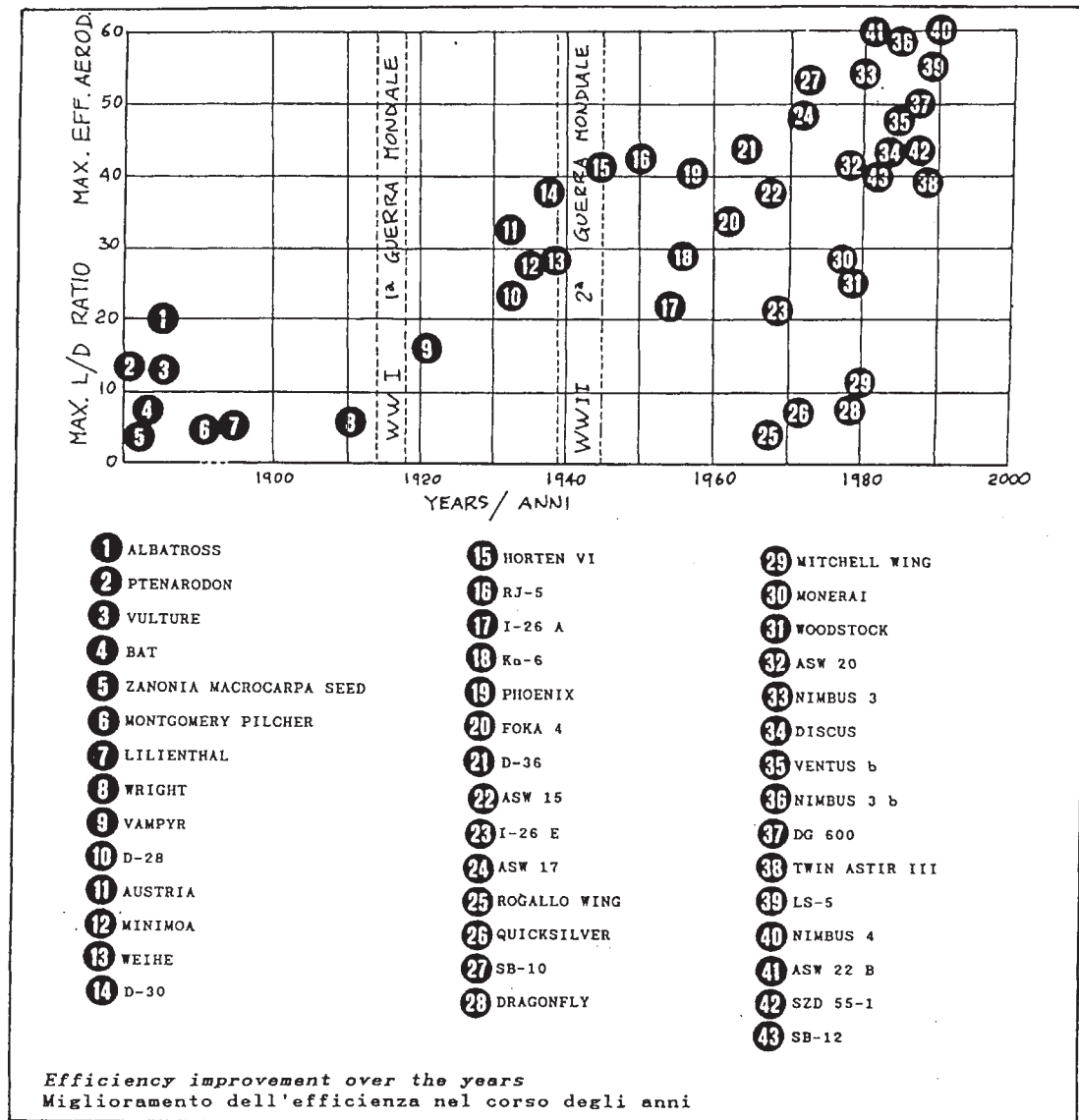
The construction technique of some vintage and contemporary soarers may offer interesting hints for aeromodelling applications. However, a detailed analysis, aimed at locating specific details for potential use in flying models, is beyond the scope and the limits of this simple digest.

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:

$$G2 \bullet b2 = 95 \bullet 0.8 \ = 74.1$$
$$G3 \bullet b3 = \ 4 \bullet 4.25 = \underline{17.0}$$
$$\text{Total} = 91.1 \ \text{Kg} \bullet \text{m}$$

On the left side, the following moments are found:

$$G1 \bullet b1 = 145 \bullet 0.18 = 26.1$$
$$G4 \bullet b4 = 100 \bullet 0.65 = \underline{65.0}$$
$$\text{Total} = 91.1 \ \text{Kg} \bullet \text{m}$$

37
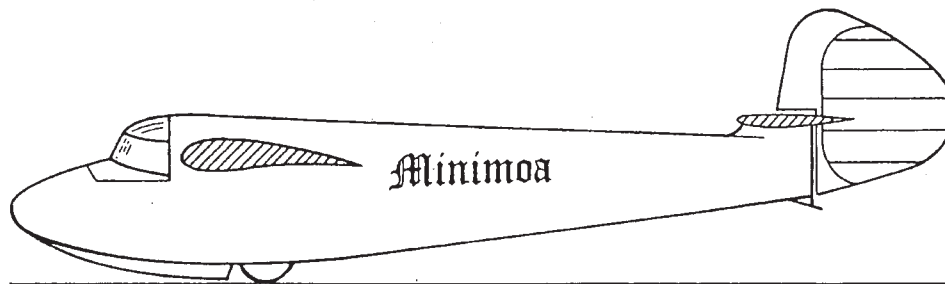
| | | FULL SIZE | 1:5 SCALE MODEL |
|---|---|---|---|
| | | ORIGINALE | MODELLO IN SCALA 1:5 |
| b | [m] | 17.00 | 3.40 |
| S | [m²] | 19.00 | 0.76 |
| st | [m²] | 1.98 | 0.079 |
| A | [m] | 4.13 | 0.82 |
| sv | [m²] | 1.20 | 0.048 |
| B | [m] | 5.40 | 1.08 |
| c | [m] | 1.12 | 0.224 |
| W | [Kg] | 350 | 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

Figure content:

cr

G1    G2    **Minimoa**    G3

CG

G4

$b_2$

$b_1$

$b_3$

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

$b_4$

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

|  |  |  | 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:

$$G2 \bullet b2 = 1.392 \bullet 0.246 = 0.472$$
$$G3 \bullet b3 = 0.140 \bullet 0.81 \phantom{0} = \underline{0.113}$$
$$\text{Total} = 0.585 \text{ Kg} \bullet \text{m}$$

On the left side the following is found:

$$G1 \bullet b1 = 2.118 \bullet 0.036 = 0.0762$$
$$G4 \bullet b4 = 0.350 \bullet 0.13 \phantom{0} = \underline{0.0455}$$
$$\text{Total} = 0.1217 \text{ Kg} \bullet \text{m}$$

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.
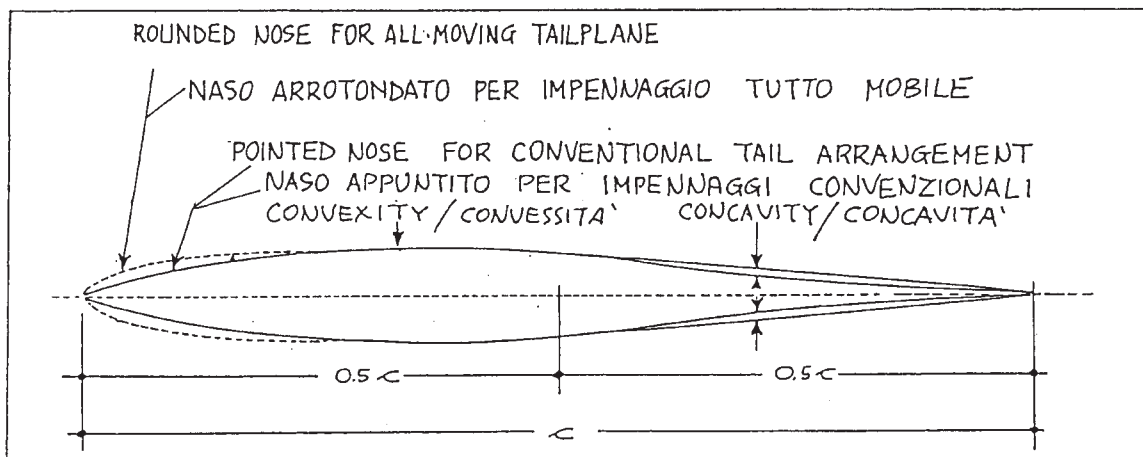
In the best case, such thickness is constant along the whole length, while, according to the science of structures, it should be larger where

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.



ROUNDED NOSE FOR ALL·MOVING TAILPLANE

NASO ARROTONDATO PER IMPENNAGGIO TUTTO MOBILE

POINTED NOSE FOR CONVENTIONAL TAIL ARRANGEMENT
NASO APPUNTITO PER IMPENNAGGI CONVENZIONALI
CONVEXITY/CONVESSITA`        CONCAVITY/CONCAVITA`

0.5 c        0.5 c

c

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

FIGURE 12

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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.
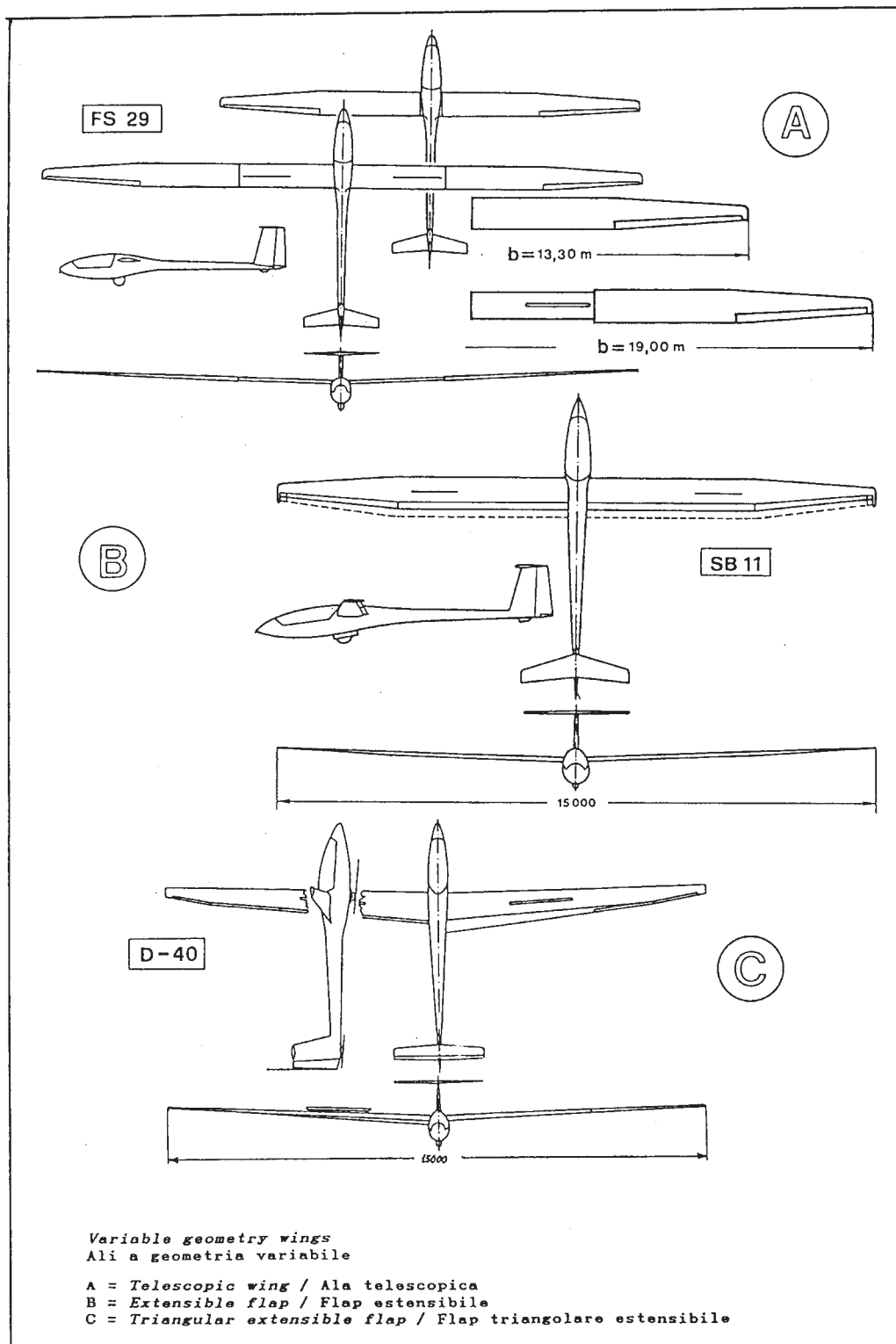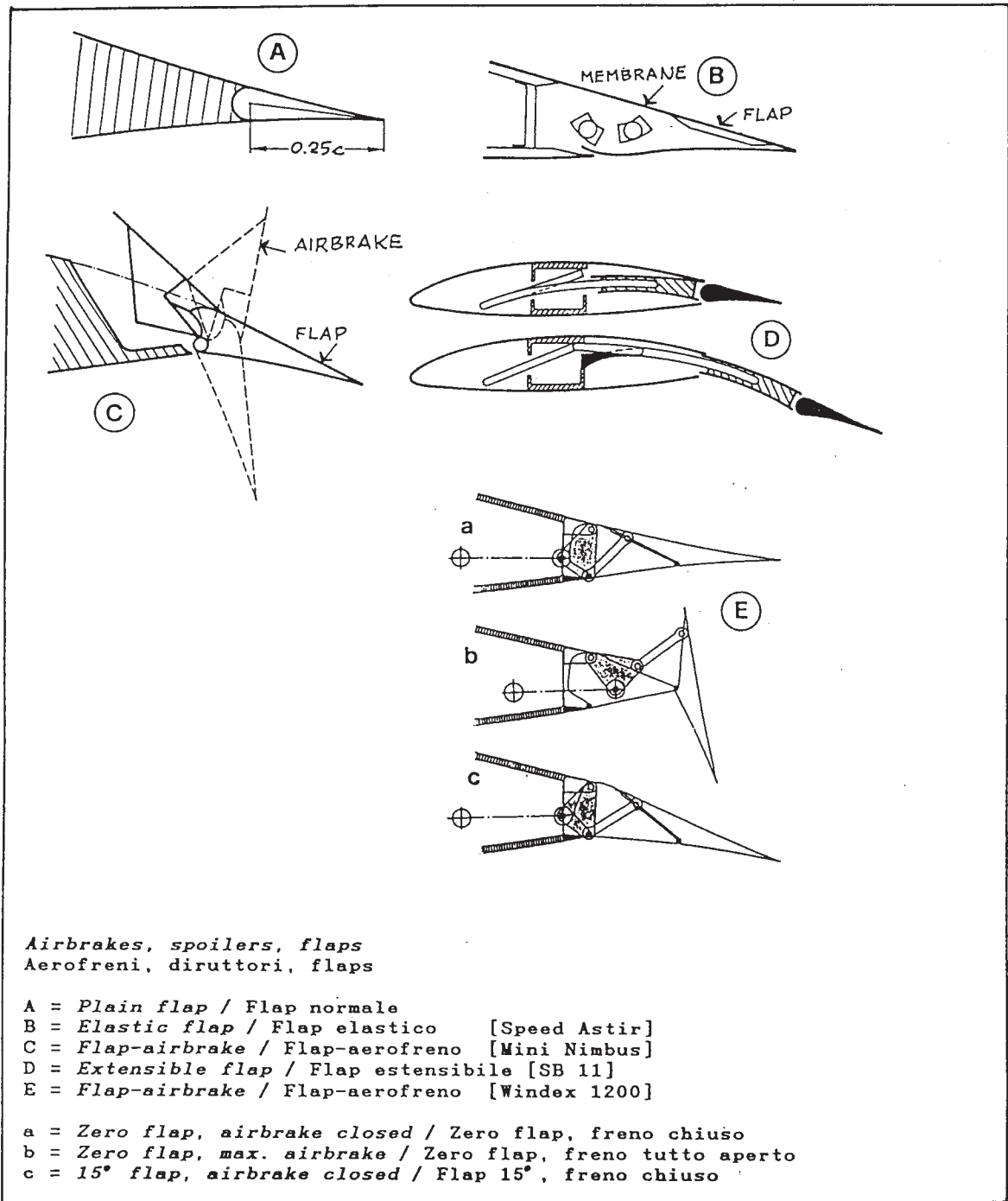
FS 29

Ⓐ

b = 13,30 m

b = 19,00 m

Ⓑ

SB 11

15000

D-40

Ⓒ

15000

*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

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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

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

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

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

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:

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

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

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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
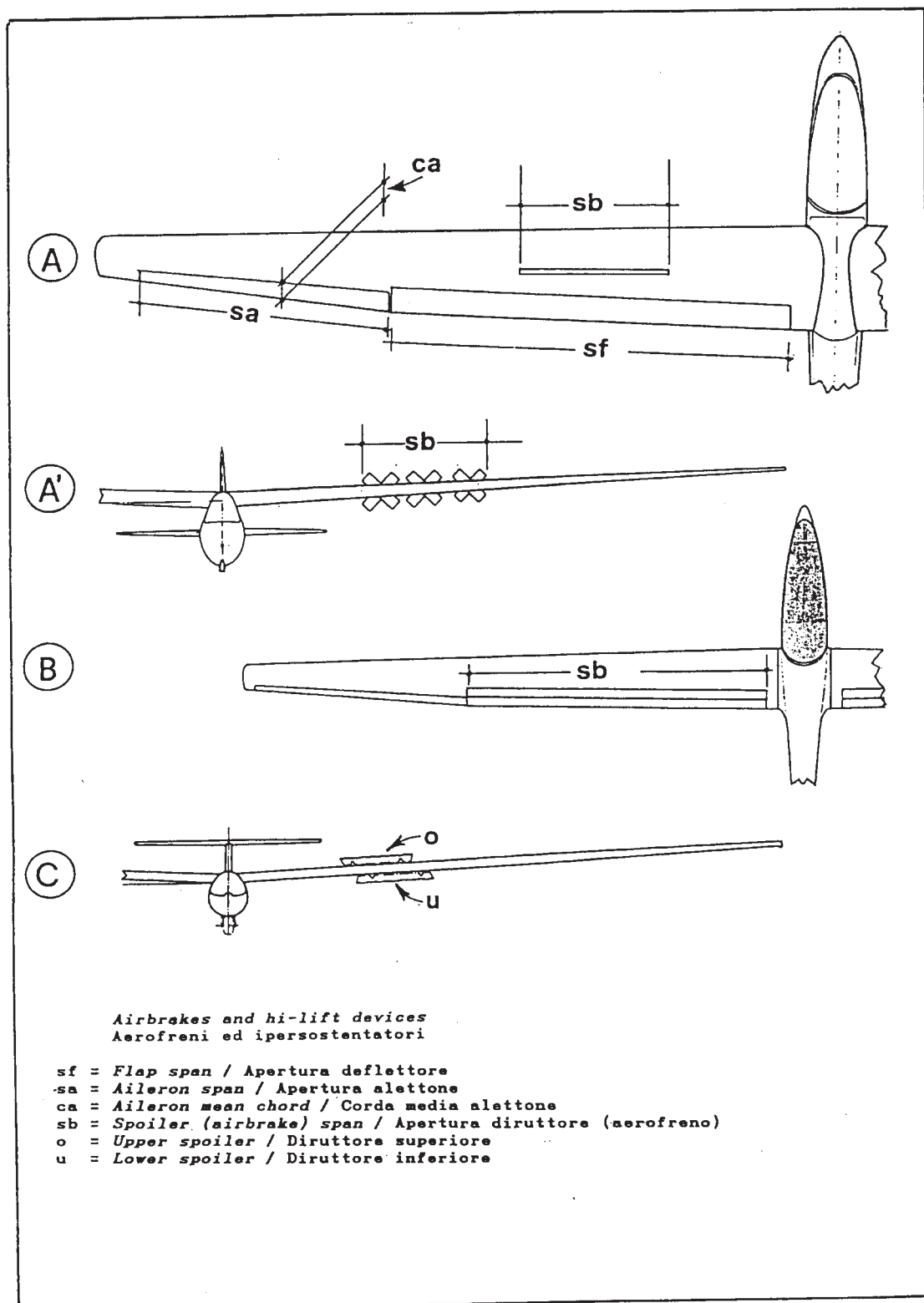u  = Lower spoiler / Diruttore inferiore

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
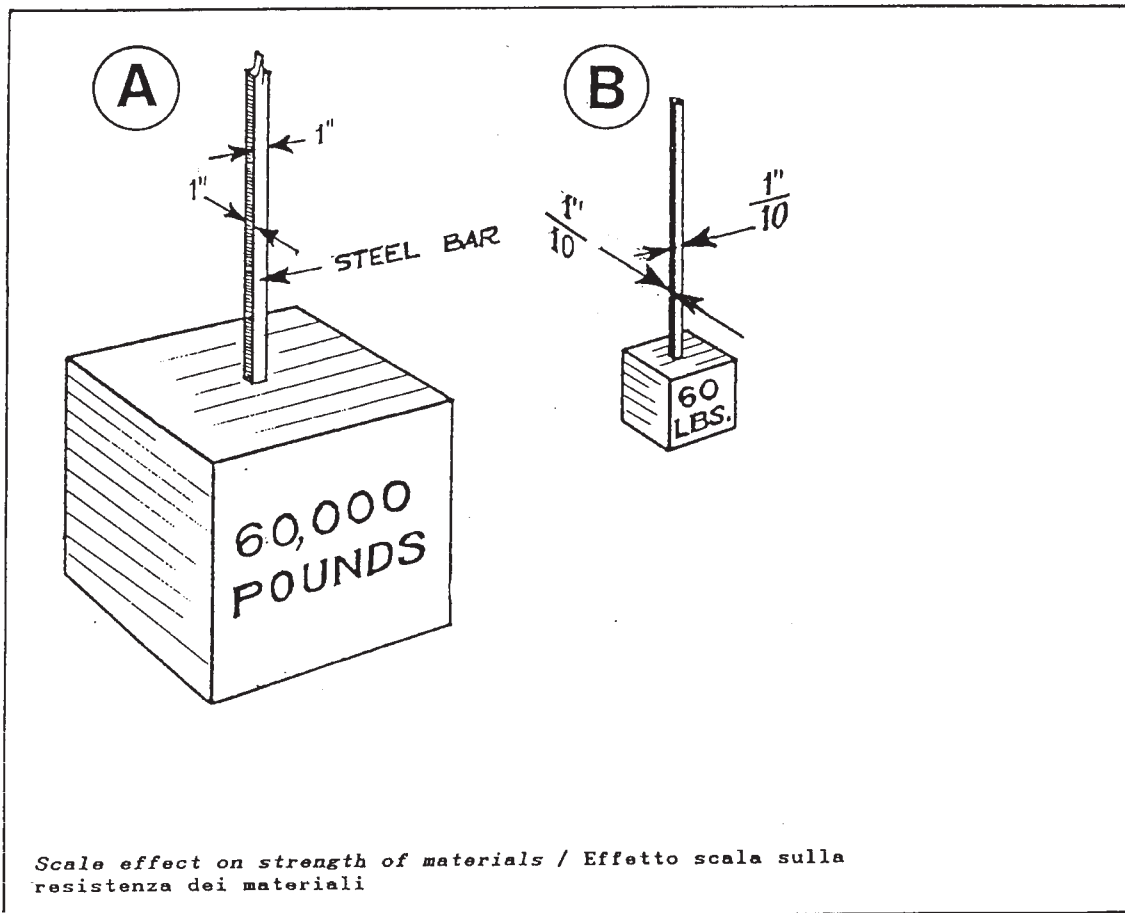


Scale effect on strength of materials / Effetto scala sulla resistenza dei materiali

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