"ULTRA-LIGHT" AND "LIGHT" SAILPLANES

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Introduction

The objective of flying by exploiting the air motions

(a) as long as possible
(b) as far as possible
(c) as fast as possible
(d) as often as possible
(e) as cheap as possible
(f) as free as possible

has been attempted and realized in different ways.

At the start of the sport of soaring the main goal was (a) (endurance), based on slope soaring and bungie launching.

When the possibility of thermal soaring was discovered and winch launching and aero-tow were introduced, the interest shifted towards (b) (cross-country distance), quickly followed by (c) (speed), the two objectives being intertwined.

The development of hang-gliders and paragliders, aimed at (e) (low cost) and (f) (freedom), started late but very successfully.

The development of powered sailplanes also aims at (f) (freedom), in particular: freedom from launching equipment and means of retrieving.

The development of "ultra light" and "light" sailplanes (the object of this paper) also aims at (e) (low cost) and (f) (freedom): freedom from expensive launching equipment, freedom from heavy bureaucracy (for instance, less demanding certification processes), freedom from the need of airfields.

The recent introduction of the "World Class" can be seen as a compromise between (a), (b), (c) and (e).

It is interesting to note that the objective (d), to soar as often as possible, i.e., the ability to exploit very weak soaring conditions, has received little attention so far.

1. A gap.

The objective of improving hang glider performance on one hand, and the effort to produce cheaper conventional sailplanes on the other hand, has produced a new breed of sailplanes which are often mentioned as "ultra-light" or "light" sailplanes.

Under this name, however, we find sailplanes that differ considerably in purpose, design and performance.

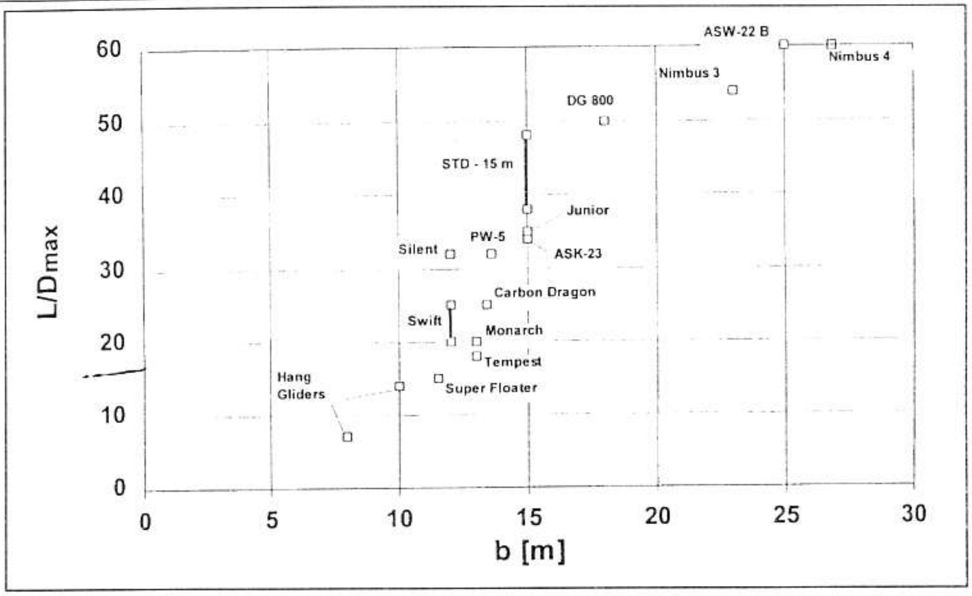

Figure 1.

For a couple of decades this development has taken place in America in a more significant and detectable way than in Europe.

The distinction made between "ultra-light" sailplanes and "light" sailplanes appears to be more clear cut in America, the former being more or less a development upwards of hang gliders (within the FAR 103 empty weight limit of 70 kg), the latter over that limit and sometimes approaching the features of a conventional sailplane.

The gap between hang gliders and conventional sailplanes and how the so-called "ultralight" and "light" sailplanes tend to fill this gap are shown in the plots of an index of performance, L/D_{max}, vs. wing span, b (Figure 1), empty weight, W_e (Figure 2), max. weight, W_{max} (Figure 3). Some of the types appearing in these plots are, more or less, high performance hang gliders *(Swift, Carbon Dragon,....)* although, due to weight increases in the development of the machine, the capability to be foot launched and/or foot landed has been lost in most cases.

The performance and the weight of other types, downgraded versions of the conventional sailplanes *(Monarch, Tempest, Superfloater,....)* are strongly affected by the requirement of being designed for homebuilding.

Answers to a questionnaire promoted by the OSTIV Sailplane Development Panel in 1996 gave the results summarized in the table following this paper.

Far from being complete, this inquiry shows that some kinds of regulations relating to ultra-light sailplanes exist in the USA and Italy, a proposal (not known to the author whether already officially adopted) in Germany, where an empty weight limit of 70 (FAR 103), 80, 90 kg, respectively, is set for single seaters.

These limits appear to be more applicable to upgraded hang-gliders than to downgraded conventional sailplanes. In fact (Figure 2) only the *Swift* seems to comply with FAR 103, whereas the *Monarch, Superfloater, Tempest* and the latest versions of the *Carbon Dragon* do not.

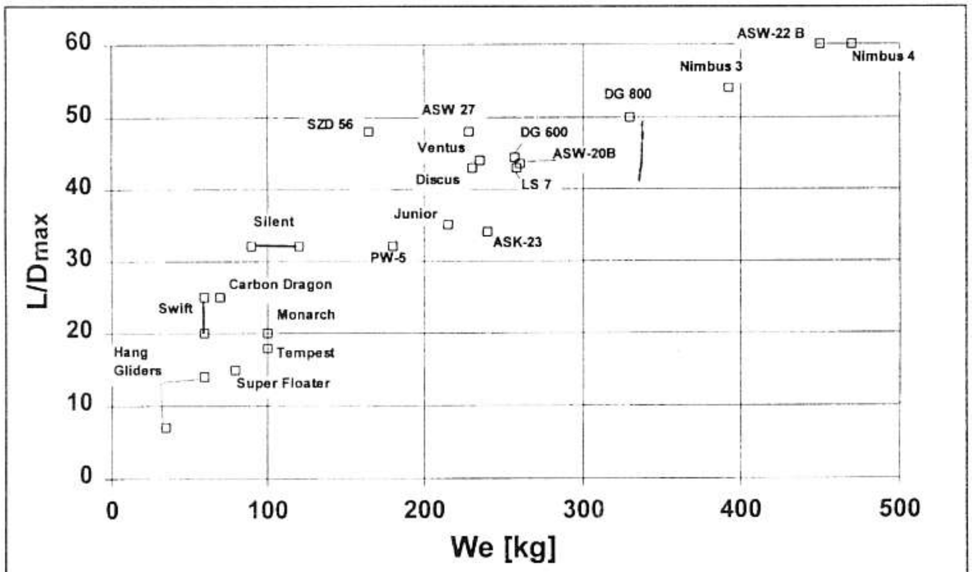

Figure 2.

It should be noted, therefore, that a new breed of gliders is emerging, for which speed or distance are not the top design priorities, but rather low cost, capability to exploit weak soaring conditions, recreational flight, suitability for construction from kits are.

The *Carbon Dragon is* perhaps the most representative type so far.

There is a high potential

of development with this class of sailplanes.

Let's have a closer look at some of them.

2. A brief review.

SWIFT (stands for Swept Wing with Inboard Flap Trim) [1] [2]

Path control by flaps. No weight shift. Control through elevons and ailerons. The empty weight of 50 kg is an early datum not including the pilot fairing and the emergency parachute.

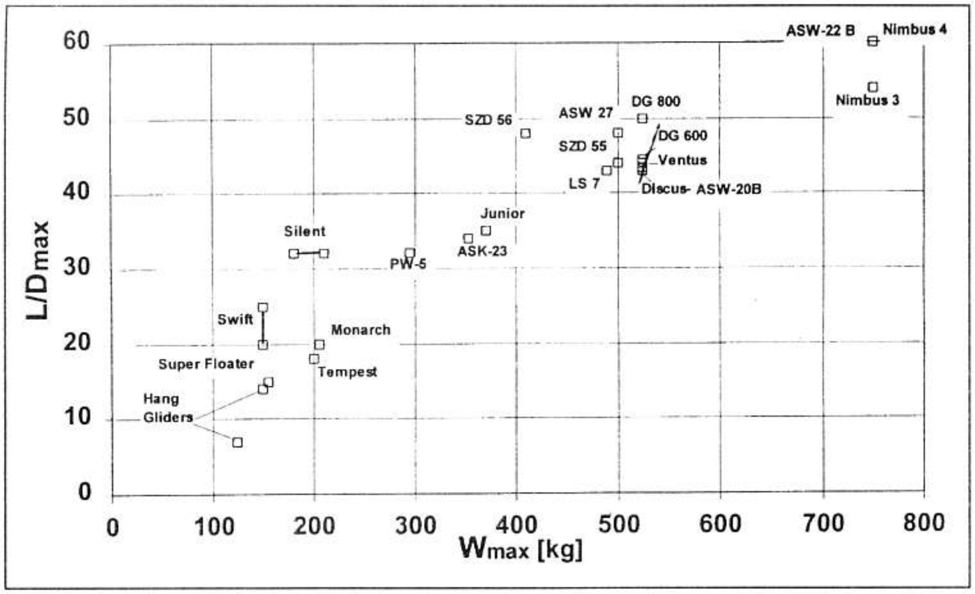

Figure 3.

SPECIFICATIONS

- Wings made up of composite materials : skin in sandwich kevlar/epoxy, spar in carbon epoxy laminated under vacuum
- Cage in cromoly steel (4130) and aluminium 2017 anodised.
- Controls are driven by push pull tubes and ballrods, bellcrank on bearings
- Wing span : 11,9 m 39 ft
- Wing area : 12,5 m² 135 sq. ft
- Aspect ratio : 11.3 : 1
- Weight 50 kg 115 lbs
- Maximum L/D ratio with pilot fairing 25 without fairing 20
- L/D at 100 km/h (60 mph) 15
- Minimum sink rate 0,7 m/s 135 fpm
- Vne 115 km/h 72 mph
- Rated load + 6 g/-4 g
- The SWIFT is delivered with a landing gear (wheel and skate), a harness, a pneumatic parachute and a speedmeter.
- A mandatory two days training program is included in the purchase price of each SWIFT

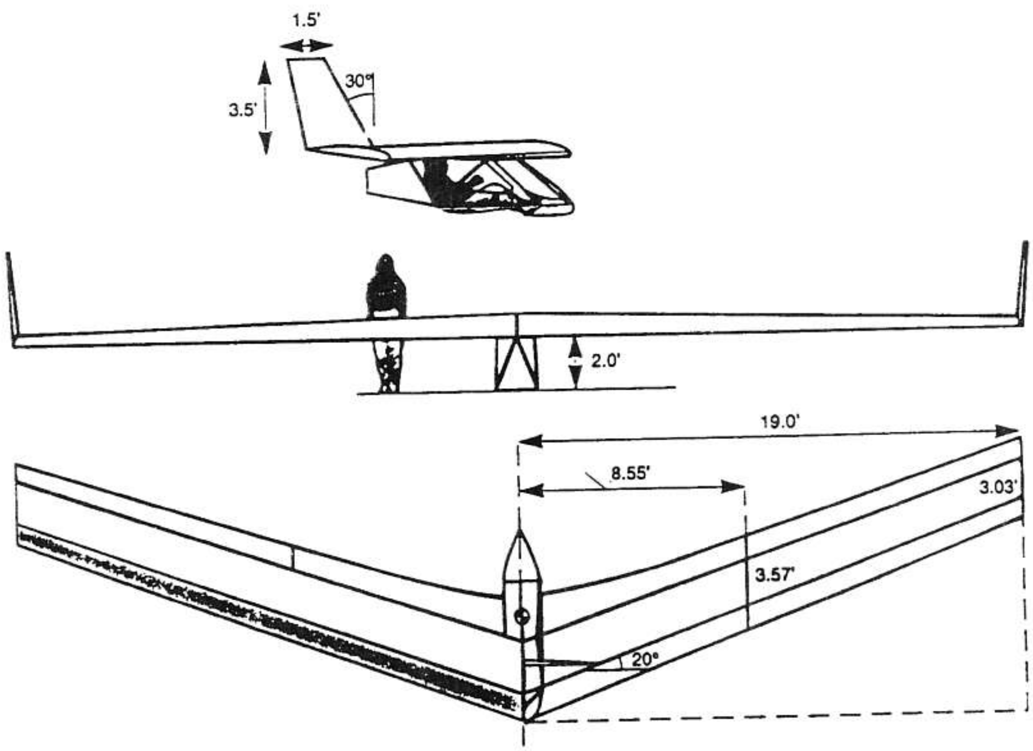

Figure 4.

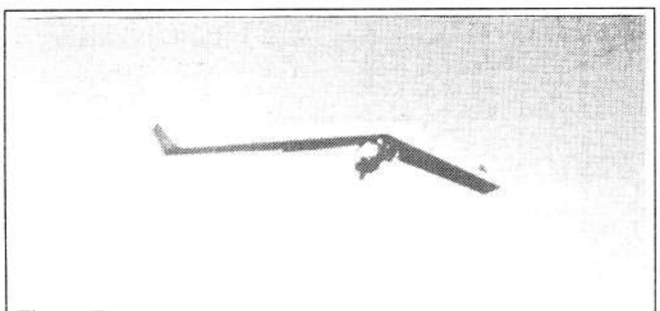

Figure 5.

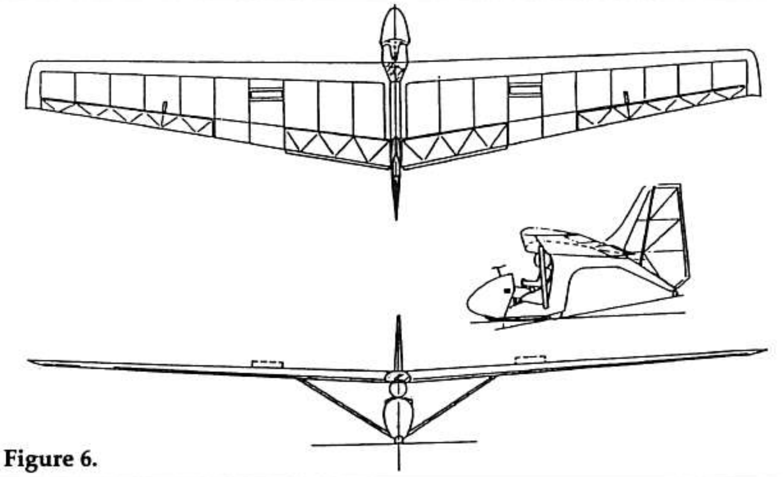

Figure 6.

MONARCH [3]

Main data:

- $b = 13$ m (wing span)
- $A = 9.5$ (wing aspect ratio)
- $W_e = 100$ kg
- $W_{max} = 204$ kg
- $w_{min} = 0.81$ m/s at 48 km/h
- $L/D_{max} = 20$ at 64 km/h

(Figure 6)
(Figure 7)

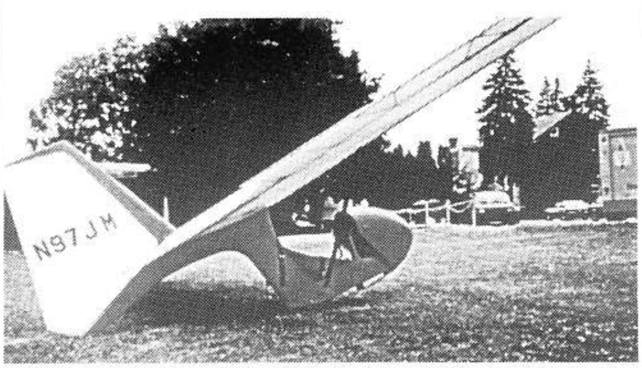

Figure 7.

3. Exploitation of "micro lift"

The objectives of low cost of both the machine and its operation, the possibility of homebuilding from plans or kits, naturally led to small, light and simple sailplanes.

The combination of a low wing loading (W/S) and a high C_{LMAX} (see the *Carbon Dragon,* in particular) produces a low sinking speed and a small circling radius.

Perhaps in a somewhat serendipitous way, it was discovered that some of these light sailplanes are able to exploit weak air motions, in particular at low altitudes, which are out of reach of both hang-gliders and conventional sailplanes [5] [6] [7].

As underlined by Bruce Carmichael [9], the most powerful parameter that affects the minimum sinking speed (W_{min}) is the so-called "span squared loading," i.e., gross weight (W) divided by the square of the wing span (b), W/b^2.

The value W/b^2 for typical standard class sailplanes ranges from 1.61 to 2.14 (weight in kg and span in m). A diagram of W/b^2 versus wing span presented by Carmichael [9] (Figure 13) clearly shows the powerful effect of wing span when associated to low weight as in the case of human powered aircraft. However it also shows how well placed the very light *Carbon Dragon is,* notwithstanding the small span.

Sinking speed may also be correlated with W/b^2 [9]:

$$W_{min} = 0.17 + 0.25\ W/b^2\ (m/s)$$

where W in the above formula is expressed in kg and b

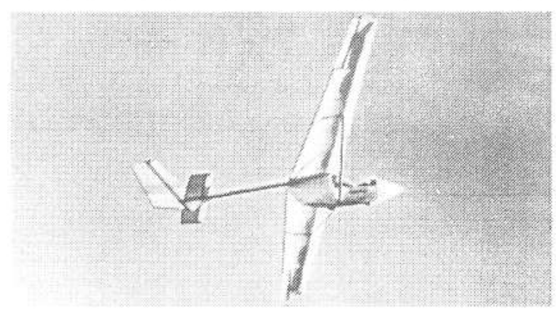

Figure 8.

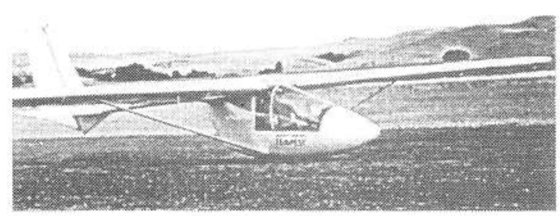

Figure 9.

TEMPEST [4]

	Main data:
	$b = 13$ m
	$A = 12$
(Figure 8)	$V_{NE} = 120$ km/h
	$V_s = 42$ km/h
(Figure 9)	$W_{min} = 0.86$ m/s
	$W_e = 100$ kg
	$W_{max} = 200$ kg

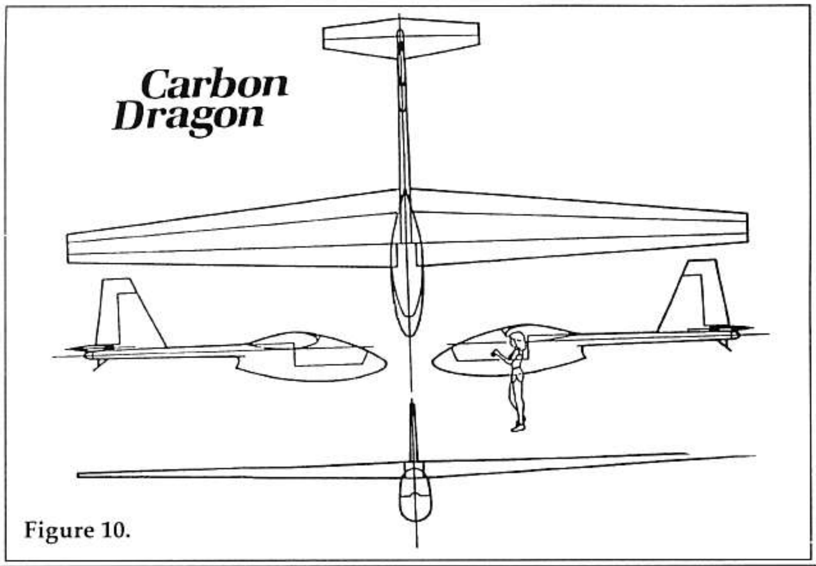

Figure 10.

CARBON DRAGON [5] [6] [7] [8]

Main data:
$b = 13.4$ m
$A = 12.9$
$S = 14 m^2$
$We = 66$ kg
$W_{max} = 152 = 66 + 86$ kg
$W/S_{max} = 11.8 kg/m^2$
$L/D_{max} = 25$
$w_{min} = 0.51$ m/s
$V_{NE} = 112$ km/h
$V_s = 32$ km/h
$C_{LMAX} = 2$ (estimated)

(Figure 10)
(Figure 11)

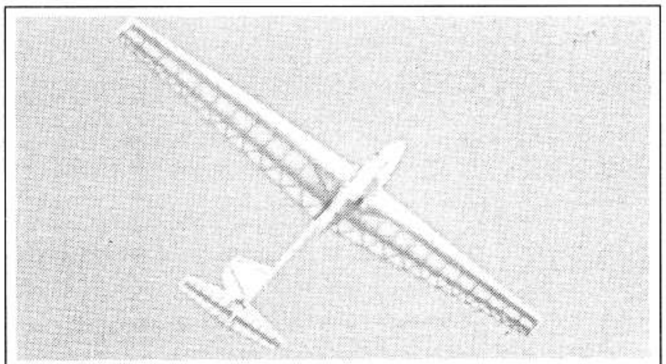

Figure 11.

in meters. Carmichael's diagram w_{min} vs. W/b^2 (Figure 14) shows how the Carbon Dragon fits between conventional sailplanes (powered and not) and the human powered aircraft.

Evaluating the ability of the sailplane to exploit "micro lift" w_{min} is not everything, of course. The circling radius is an even more important parameter and is strongly dependent on wing loading W/S and C_{LMAX}. Maneuverability at high angle of attack, safe stalling and more, are of paramount importance. According to flight reports [5] [6], all these qualities seem to be possessed by the *Carbon Dragon.*

Another interesting design is under development in the USA namely, the *Ciba Hawk.* According to data kindly provided by Bruce Carmichael and from [8], it is "intended as the next step beyond the *Carbon Dragon* for exploiting micro lift." The main specification data are: $b = 15$ m, $A = 19.2$, $W_e = 68$ kg (probably optimistic!), $W_{max} = 159$ kg, $W/S = 13.6 kg/m^2$, $W/b^2 = 0.144 lbs/ft^2$, $L/D_{max} = 35.4$, $w_{min} = 0.42$ m/s and wing $C_{LMAX} = 2.2$!

It will be interesting to see the performance of this ultra-light sailplane. It demonstrates the rising interest in the USA for the exploitation of weak conditions in contrast to the long established tendency of high speed flying, the *floaters* against the *racers!*

Another claim for low sink aimed at exploiting weak conditions comes from von der Kreek [10].

Here, the importance of a relatively larger span is emphasized and a high wing loading is tolerated. The calculated sinking speed does appear to be very low (below 0.5 m/s). The circling radius, however, appears to be too large for micro lift exploitation.

4. **Airworthiness Requirements: Yes or No?**

The information available to the author on existing regulations or requirements in various countries is very limited and unofficial.

Looking again at the table at the beginning of the paper, ultra-light sailplanes exist only in a few countries. Of course, hang gliders have been kept out of the picture.

As already stated, the USA, Italy and possibly Germany have set an empty weight limit of 70 (FAR 103), 80 and 90 kg, respectively, for single seaters.

Bruce Carmichael notes: "We are still governed by Part 103 with a maximum empty glider weight of 155 lbs if we wish the freedom from government regulation enjoyed by the hang gliders. Efforts have been made to increase this without success."

JAA has a clear standing (Figure 15): JAR-22 is not applicable to ultra-lights. Not too bad: could you imagine JAR-22 applied to a *Carbon Dragon* or to a *Ciba Hawk?* The empty weight of the glider would rise to such values that micro-lift exploitation would be impossible!

In the actual situation, therefore, a void also exists from this standpoint between hang gliders and conventional sailplanes, i.e., between full freedom and heavy restraints.

If an expansion is wanted for these attractive "light" sailplanes beyond the boundaries of home building and of "experimental" categories and the like, one way

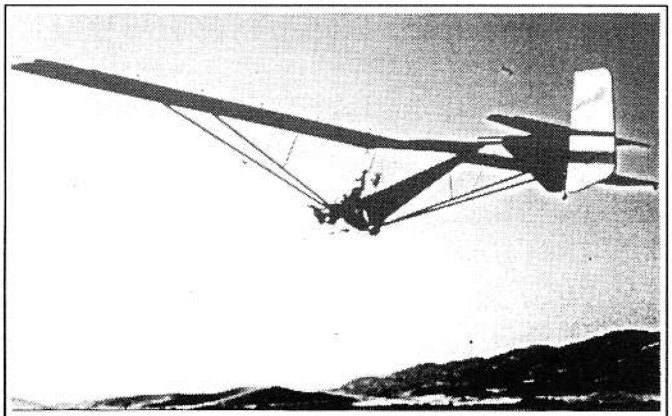

Figure 12.

SUPER FLOATER [4]

Main data: $b = 11.6$ m
$A = 8.44$
(Figure 12) $S = 15.6\ m^2$
$W_e = 81$ kg
$W_{max} = 181$ kg
$W/S_{max} = 11.6 kg/m^2$
$V_{NE} = 96$ km/h
$V_s = 37$ km/h
$L/D_{max} = 15$?
$w_{min} = 0.91$ m/s

to go about it could possibly be to promote sensible reasonable regulations.

Who does not see a danger there? When you opt for regulations you know where you start but not where you will get to. The loss of a certain degree of freedom could certainly be a price to pay.

From the safety point of view it is hard to deny that the applicable airworthiness standards should not be the individual choice of any designer or homebuilder or user, more so if the aircraft is intended for series production.
At least basic commonly agreed guidelines should be available as advisory material.

The adoption of airworthiness requirements named *Lufttuchtigkeitsforderungen fue Gleitflugzeuge, LFG,* is under consideration in Germany. Proposed by Hans Grannemann [11] they are intended as being applicable to single-seaters up to 90 kg empty weight and two-seaters up to 135 kg (Figure 16).

These requirements are laid down in a similar way to JAR-22 but, of course, they are much less demanding. For instance, limit load factors are +4, -2 instead of +5.3, -2.65 (cat.U). V_{Dmin} is given as 2/3 of that specified by JAR-22 at equal C_{Dmin} and W/S.

It is not clear to the author if such requirements should be a matter of concern for the German Aero Club or for the German airworthiness authority, LBA.

This is a delicate and controversial matter to be taken, however, into serious consideration.

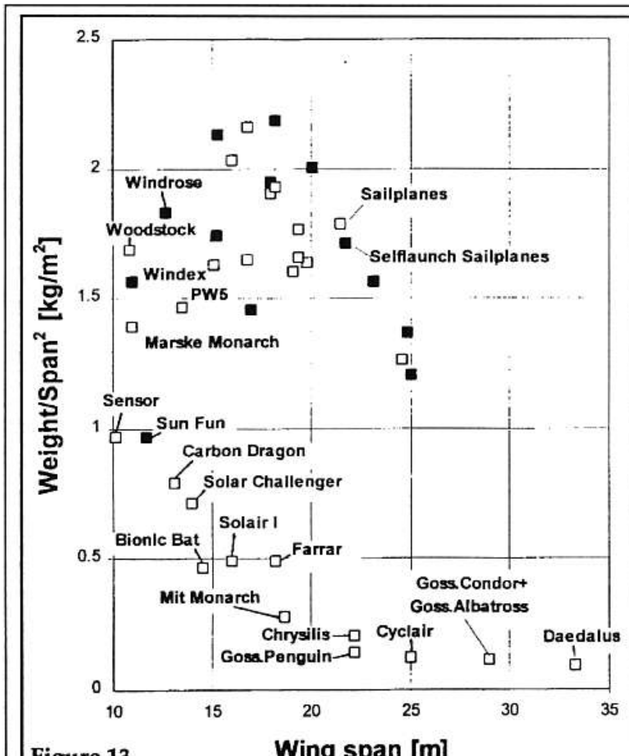

Figure 13.

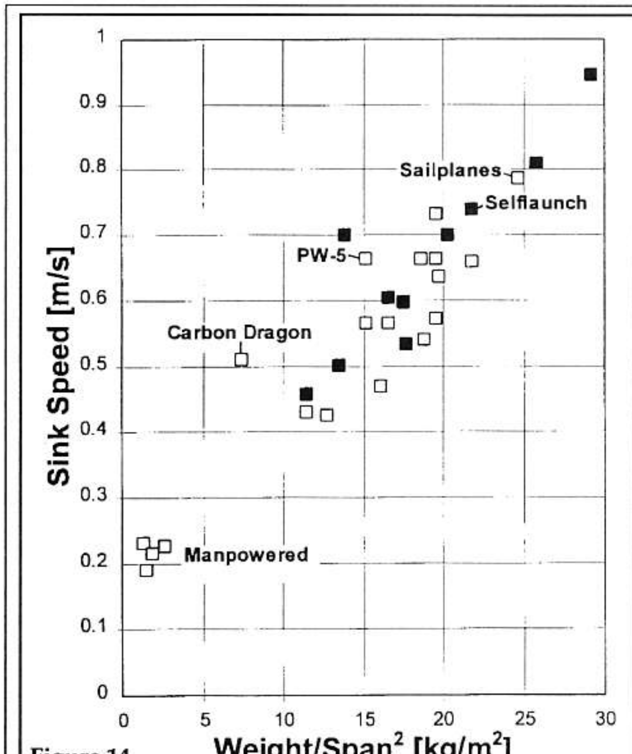

Figure 14.

(NPA 22A-60)
ACJ 22.1(a)
Add a new ACJ below JAR 22.1(a)
as follows:-

[ACJ 22.1(a) (Interpretative Material)

JAR-22 is not applicable to aeroplanes classified as hang-gliders and ultralights or microlights. The definitions of these aeroplanes differ from country to country. However, hang-gliders can be broadly defined as sailplanes that can take off and land by using the pilot's muscular energy and potential energy.

Ultralights or microlights can be described as very low-energy aeroplanes, as some of their main characteristics are strictly limited. The following criteria are often used (alone or in combination): stalling speed, weight to surface ratio, maximum take-off weight, maximum empty weight, fuel quantity, number of seats.

In addition, both hang-gliders and ultralights/microlights are usually not type-certificated, and JAR-22 prescribes minimum standards for the issue of type certificates. This latter interpretation could also apply to aeroplanes having restricted certificate of airworthiness - JAR-22 is not applicable to such aeroplanes.]

Figure 15.

5. Is FAI concerned?

Certainly it is!

The FAI structure tries to cover all air sports. This is not easy in an ever changing scenario.

When a new air sport or a new way of doing a given air sport appears, the problem arises whether a new Commission should be set up or an existing Commission be given the task of dealing with the new activity.

When IGC was asked: "do you think that glider aerobatics belongs to you?", the motivated answer was "no," and glider aerobatics was assigned to the FAI Aerobatics Commission.

When, not many years ago, IGC was asked: "do you think that motorgliders are of your concern?", the motivated answer was "yes", and a Motorgliding Subcommittee was created within IGC.

Now, what about "ultra-light" and "light" sailplanes? Do the former belong to the Hang gliding Commission, and do the latter belong to IGC? This has not been decided so far.

The introduction of such ultralight as the *Swift and* the *Carbon Dragon* among hang-gliders would mean to give up two very peculiar features of hang-gliders: to be foot launchable and landable and to be controlled by C.G. shift.

The introduction of "light" sailplanes among conventional sailplanes, by far the main concern of IGC, would probably meet with scarce interest and competence of the IGC delegates, most of them being strongly interested in *racers* and, presumably, much less or not at all in *floaters*.

What about the FAI Homebuilt Aircraft Commission? In this case the concern would be limited to homebuilt aircraft.

Maybe an ad hoc Commission would be a better solution. Who knows?

What really matters is that the potential value of these new emerging sailplanes is understood, appreciated and action should be taken.

Our American friends are well on the way. The country where hang-gliding was born as a modern air sport, is also the country where the pioneering activity of these new developments is taking place. There, the idea of establishing a new "Light Sailplane Class" has already been launched [12].

Through its prestige and the competence of its specialized Commissions, by orientating towards the achievement of records, badges and competitions, the FAI has great power to promote and develop air sports.

The opportunity to rejuvenate the sport of soaring

Lufttüchtigkeitsforderungen für Gleitflugzeuge

(LFG)

Fassung vom November 1994

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Abschnitt E - (entfallen)

Abschnitt F - Ausrüstung

Abschnitt G - Betriebsgrenzen und Angaben

Anhang G - Führerraum Hinweisschilder

Anhang H - Handbuchvorlage

Entwurf

Figure 16.

ULTRALIGHT GLIDERS (March 1996)

Country	1. Do U/L gliders exist and fly in your country?	2. If yes, are they designed or built in your country?	3. Do regulations or reqs. relating to U/L gliders exist in your country? If yes: weight (W)? speed (V)? operating limitations?
1. Australia	YES	imported	NO
2. Austria	NO	-	NO
3. Czech Rep.	NO	-	NO
4. Finland	NO	-	NO
5. France	under construction (*Carbon Dragon*)	imported (plans)	NO
6. Germany	YES	mostly amateur constructions	YES: Airworthiness Reqs. LFG, Nov.1994 Wempty: single 90 kg, double 135 kg V = 50 km/h
7. Italy	YES (one model: *Silent*)	designed and built in Italy	YES: Government law n.106, 25.03.85 Wempty: single 80 kg, double 100 kg Operating limitations: 500 ft ground etc.
8. Poland	YES	a prototype designed and built in Poland, home-built units	NO
9. Switzerland	NO	-	NO
10. UK (Ann Welch)	YES (one or two built but not flying now)	designed and built in UK	NO
11. USA	YES	designed and built in USA	YES: FAR 103 (operating limitations) Only single seaters allowed Wempty=155 lbs = 70 kg

Table

through proper action in this field of "ultra-light" and "light" sailplanes, should neither be missed nor delayed.

Acknowledgments

The author is most indebted to Bruce Carmichael and Dan Armstrong, not only for providing a wealth of data relating to American "ultra-light" and "light" sailplanes, but also for the useful hints and ideas which have enriched this paper.

The author is also grateful to Hans Grannemann for providing precious information on airworthiness initiatives under way in Germany.

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