WHY MICROLIFT SOARING ?

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1. Bits of history of soaring flight.

Gliders appeared long before sailplanes.
Whether the start of motorless flight is placed at Otto Lilienthal's or at the Wright brothers' successful attempts, it is a matter of gliding, not soaring flight. Theirs were gliders, not sailplanes – remarkable, fully controllable gliders.

As soon as the flight mechanics of these machines was understood, the exploitation of **slope soaring** for sustained motorless flight was straightforward. Wind flowing in the correct direction with respect to an adequate slope or ridge was the essential requirement.

It was learned soon by direct experience that turbulence with strong down-draughts developed behind the ridge, a dangerous area to be avoided. The standard technique was to fly along the ridge as far as sustained flight could be maintained, with gain of altitude if possible, then reverse the flight direction with a turn facing the wind, and so on.

The duration of the flight depended solely on the persistence of the favourable wind conditions, not to mention pilot's fatigue.

It didn't take long to discover that sometimes remarkably strong up-currents developed in zero wind conditions and even on flat terrain.

These conditions were related to sun radiation of the soil, producing different temperatures of the air mass in the close proximity of the ground, thereby resulting in atmospheric instability and thermal convection (the **thermals**).

At first, the variety of size, strength and shape of the thermals was not fully acknowledged. In order to enhance the glider capability to exploit thermals, it was believed that low wing loadings and good low speed performance were mandatory so that both rate of sink and circling radius could be kept as low as possible.

Further experience showed that thermals, in appropriate atmospheric conditions, continued and strengthened their upward movement inside the cumulus clouds (**cloud flying**), sometimes reaching the upper limit of the troposphere inside the top of the cumulus nimbus clouds. Much higher altitudes could thus be achieved. For safety reasons both pilot and glider had to be qualified for instrument flight, which was not always the case.

Alternating climbs to some altitude with glides till the next thermal permitted to cover distances in **cross-country** flights, more frequently occurring when sailplanes were designed for this type of flight, demanding for higher V_B (speed not to be exceeded in rough air) and V_{NE} (absolute speed limit). Increase of the wing loading was a consequence, whereas the circling radius was kept within reasonable values by the adoption of flaps, also beneficial for reducing the landing speed and run, as the occurrence of outlandings demanded for.

The development of low speed and high speed airbrakes was concurrent with the progress of this type of flight performance.

From distance to speed was the next step, being obvious that, given the available number of hours within a day of thermal activity, the increase of distance does go together with the increase of speed.

Phenomena related to the discontinuity of large air masses (cold fronts, sea-breeze fronts,…) are the source of up-currents often extending over great distances and moving with respect to the ground although relatively independent of the terrain characteristics. The exploitation of such fronts makes long distance flights possible, provided the sailplane is maintained in the area of up-rising air.

It was not until the early ‘30s that another atmospheric phenomenon drew the attention of sailplane pilots, always attempting to improve their performance not only in terms of endurance, distance and speed, but also of altitude. The oscillating path of air particles associated with a relatively strong air flow, occurring under particular conditions of the air mass and terrain, mountainous in most cases, may extend to high altitude, offering the sailplane the possibility of climbing to remarkable, sometimes stratospheric altitude.

The exploitation of these waves, called **standing waves** because of their stationary position with respect to the ground, often require climbing through “rotors”, huge, heavily turbulent vortices. The sailplane, therefore, must be designed for adequate strength in relation to gust loads, and equipped, as well as the pilot, for high altitude flight.

Moreover, the sailplane must be able to maintain its position in the ascending part of the wave, which may require a low rate of sink at high speed, hence, curiously enough, a relatively high wing loading.

2. Still much to learn.

The variety of soaring conditions associated with the different kinds of atmospheric motions is fascinating. In a historical perspective, slope soaring, thermalling, cross country techniques, frontal conditions, standing waves have enriched the soaring possibilities of motorless flight in a very impressive way, provided the appropriate tool, the sailplane, designed for the purpose, and the launching means are available.

In no way can we say that the exploration of the atmosphere by soaring flight is an accomplished job. The complexity and variety of nature offers never ending challenges.

Other atmospheric phenomena are known as potentially usable for soaring flight, but have never been. Others may be still unknown.

Dynamic soaring, is practically one of those possibilities theoretically studied since many years in a variety of ways, but just entering the experimental stage in these recent years, thanks to the efforts of a few pilots/scientists like Gary Osoba in America [1], often inspired by the flight of stationary or migrating birds, or exploiting strong wind gradients over rough terrain. These efforts tend to exploit turbulence at both mesoscale and microscale levels, using different kinds of sailplanes which must be in any case strong enough and highly manoeuvrable in pitch, roll and yaw.

The **jet stream**, that gigantic river of high altitude high speed air flow at the border between troposphere and stratosphere, is reported to offer stretches of rising air along the discontinuities at its borderlines [2]. Couldn't a sailplane, possibly equipped with a pressurized cabin, provided the required altitude is attained, fly downwind along the jet stream at ground speeds unimaginable today? Balloons are doing something similar already.

Lift, weak and unsteady, associated with small scale turbulence, typically occurring within the atmospheric boundary layer, has been called **microlift** by the pilot who allegedly exploited it first [3].

3. Microlift.

In quite frequent meteorological situations, typically those developing into widespread thermal convection, it has been observed that the atmospheric boundary layer, usually extending from ground to a few hundred meters altitude, is animated by a lively form of microscale turbulence or eddying, with weak lift occasionally present, more or less rapidly transient.

This phenomenon is perceived by conventional sailplanes as occasional bumps of no use for gain of altitude. Their rate of sink is low enough but, due to the relatively large wing loading and span, their circling radius is excessive.

Hang gliders have a circling radius small enough to stay inside the mass of rising air, but their rate of sink is too high for gaining altitude.

Capped with a thermal inversion, the boundary layer can be thought of as a sort of laboratory where the conditions are set up for the mesoscale convection to develop upwards, involving air masses at higher altitude where traditional thermal soaring can later take place.

This complicated phenomenon at microscale level has caught the attention of a few meteorologists in the 1980s and 90s, some of them closely associated with soaring flight.

C.E. "Wally" Wallington [4] is particularly worthy being quoted. A few excerpts from his paper are particularly illuminating:

"We usually describe smaller-scale phenomena such as turbulence or eddying as random motion, and mesoscale features that we cannot explain are still sometimes viewed as anomalies super-imposed on a steadier more explainable flow. But the distinction between coherence and chaos is subjective. As analytical meteorology progresses, more elements of flow patterns have been shifted from the chaotic or anomalous class to the coherent, explainable category. Let us look at some of the pointers to discerning more of the small-scale coherence that we may be able to use at either the high-performance or lightweight ends of modern gliding technology."

“High-speed soaring is not the only path to fresh achievement. There is likely to be a growing body of lightweight-sailplane enthusiasts who, like the hang glider pilots, will also aim to stretch their horizons of achievement by learning and using the fine detail of wind and convection patterns appropriate to their end of the soaring spectrum.”

“Modern hang gliders, that can be soared in very narrow thermals and landed on very small patches of ground, may be used to explore the low-level structure more directly.”

“Advances in sailplane performance and pressure for greater achievements call for more detailed knowledge and understanding of patterns of lift and sink in a submesoscale range.”

These are prophetic words, also revealing a deep insight into the natural state of affairs.

Other contributions followed, not only related to soaring flight, of course. Being not a meteorologist I must acknowledge that my information cannot presume to be complete nor updated, not even 100% correct here and there. Anyway, reading of [5], [6] and [7], can provide useful insights in the typical meteorologists’ approach.

At about the same time as these studies appeared, microlift could be recognized, explored and exploited in flight.

4. Exploration and exploitation of microlift in flight.

As far as I know, it started in California in the late 70s and early 80s.

In a relatively rapid sequence of events, Jim Maupin, an experienced designer and skilled homebuilder, with the cooperation of a brilliant aerodynamicist, Ilv Culver, having probably in mind a big improvement of the foot launched hang glider (under FAR 103, limiting the empty mass to 70 kg), decided to design and build an ultralight sailplane which was called the *Carbon Dragon*.

<u>Main data of the Carbon Dragon prototype:</u>

b = 13,4 m (wing span)
A = 12,9 (wing aspect ratio)
S = 14 m2 (wing area)
W_e = 66 kg (empty mass)
W/S = 11,8 kg/m^2 (wing loading)
L/D_{max} = 25 (best glide ratio)
w_{min} = 0,51 m/s (min. rate of sink)
V_{NE} = 112 km/h (never exceed airspeed)
V_S = 32 km/h (stalling speed)
C_{Lmax} = 2 (max. lift coefficient - estimated)

Although originally intended as a hang glider, foot launching in nil wind conditions proved rather problematic. The Carbon Dragon is currently launched by auto-, winch-, aero-tow. The external appearance is that of a traditional sailplane, but with a very small wing loading and a very high max. lift coefficient of the wing. These are good choices, but they would not suffice if not accompanied by an excellent blend of stability and control, gentle stall in all conditions, no tendency to inadvertent spin, spontaneous recovery in any case – exactly what is wanted to fly safely at very low speed and altitude.

Dan Armstrong and Gary Osoba were among the first pilots to fly the machine. Armstrong was able to footlaunch. Osoba was able to fly hundreds of hours before and after buying the prototype. This gave him the possibility to establish a number of world records in the FAI Ultralight Class.

More important, to his amazement he was able to exploit those weak, narrow, often unsteady lift conditions which were denied to conventional sailplanes. He proposed the name **microlift** for the complicated atmospheric phenomenon as a whole.

Here his words, picked up at a lecture in Kansas City, 1999:

"I have had the privilege of exploring this area with growing reliability and effect for the past five years and will present logged flight data and in-flight video which demonstrates various useful techniques and some surprising results. Exciting among these is the exploitation of what I hypothesize as regions downwind of thermals which are inhabited by patterns of shed vortices and allow for the transfer of substantial amounts of energy from the atmosphere as well as a method of following the pattern into the next thermal for circling gains. Key in all of this is a relatively low ratio of glider virtual mass (which includes both the glider and the entrained airmass) to the atmospheric discontinuity."

And here, from an unpublished (as far as I know) paper of his [8]:

"***Microlift:*** *Small-scale, often stochastic, and previously non or under-utilized atmospheric discontinuities which, through the use of soaring craft and piloting techniques designed to exploit these, result in gains to the total energy of the aircraft. The term, as presently used can refer to both vertical and horizontal velocity differential and various combinations of these. With the exception of microlift climbing techniques in the inner core of thermals, these atmospheric events are distinct from the presently recognized macro forms of lift which have generally been utilized by soaring craft, e.g. organized thermals, orographic or ridge lift, convergence lines, and wave lift.*
Quite frequently, but not always, dynamic maneuvering (pilot induced manipulation of the relative gravity field through inertia) is required to deliver an increase of kinematic energy from an atmospheric discontinuity to the glider.
Natural soaring birds frequently and skilfully utilize these minor and fragmentary energy sources, often in long combinations, so that sustained soaring flight is possible without the usage of macro forms of lift. As such, the successful design and piloting of gliders capable of exploiting microlift represents a worthwhile endeavor and in many ways more fully emulates the flight dynamics naturally utilized by soaring creatures."

But now, listen to the pilot speaking to pilots about his microlift flights. A few excerpts of reference [9] give an idea of the superior level of soarability of a correctly designed ultralight glider:

"An auto-tow to 600'; contacting mild lift; working it until it gathers some steam; then….simply….fly away. ….Meanwhile, full scale gliders are both auto and aerotowing below me. The auto towed flights produce about 1000' of altitude, along with rapid landings. The aero-towed flights produce some thermalling and extended soaring for the better pilot/ship combinations but premature landings as the conditions are still working.

An hour here, an hour and a half there. Some a little longer. One excellent pilot lands out, unable to return in a 15 meter racer.
I watch it all, from many thousands of feet higher than they venture. Having topped out about 8000' AGL, I move around cross-country in several different directions, flying a high lift band about 1000' thick. ...I watch as the others finally give up and start the process of breaking down. Some are sliding their gliders into sleek, shiny trailers. Others are wheeling them into hangars, ready for the next day. They hang around and talk. They fiddle with adjustments, perform a little work. Talk some more. I wonder if I remember that I'm up here....maybe not. Then, as the sun begins to sink, they all begin to head home. I've been sinking slowly as well, along with the sun. We're companions now, with the others gone. It's warmer down here and very smooth. It feels wonderful. Although weak, the cycles are still workable so I go on for a while. In between climbs , knowing that the 4 plus hours has been enough for today...it won't matter if I lose it now and have to land. But I don't lose it. It just keeps happening. Once again I have to decide to quit. To fly down through it, mild as it is, and land within a wing span of the hangar before the sun is completely gone."

Another article by Gary Osoba, *"More on Microlift Techniques"* [3], which I recommend reading in its full length, gives an impressive overall picture of microlift soaring. A few excerpts:

"These gliders are designed to maximize soarability. Racing around with high speed efficiency, although respected, is not the top design priority. They stay up when nothing else can. They launch way early, sometimes hours before conventional sailplanes are soaring. And they land way late, after using every little bit of lift there is to find. The result is dramatically longer average flight times. And consequently, a significantly reduced number of takeoffs, tows and landings per unit of soaring time.
When it does come time to return to earth, the number of landing sites is much greater than for conventional sailplanes. Not only can these gliders utilize microlift, but they can perform what we may term microlandings."

"If I contact lift above 200' during the auto tow, I release early and fly away. If I take the full tow to 800' or so, it usually takes a few hundred feet to find a small thermal and then begin the afternoon's trek in that fashion."

"The Carbon Dragon uses about 20' – 25' of vertical altitude in a coordinated 360 degree turn, enjoys a full stall recovery in about the same and a spin recovery in about 60' or 70' (if you can entice it to even enter one in the first place). So what kind of net effect can be expected from using 500' micropatterns for landing instead of the standard 1000' footer? The sum, in this case, is dramatically greater than the parts. Very dramatically so. It's not as if the extra 500' on a day with 5000' thermal tops gives you 10% more time to contact another thermal. And that consequently, on the average, you'll avoid 10% of the unwanted landings. Getting 10% more air time. No, the dynamics of micrometeorology enter the picture and the whole formula begins to change. For here, within 500' or so of the surface, the magic of microlift phenomena is truly alive. It's a vibrant, and give birth to a microsave when absolutely you need one!
For the sailplane pilot who feels that nothing useful can be negotiated at these low altitudes, think at all the times you scratched, and hunted, and struggled to stay up….only to commit to a premature landing. And sure enough, well into final, there's the lift….too low to do anything with. But high enough to play havoc with your final glide path. It's not

that you missed it earlier… flew around it….it's just that you weren't low enough yet. That's right, low enough.
I've spoken with many experienced hang glider pilots who know what I am talking about. From time to time, they have benefited from the phenomenon. They just don't yet possess the performance levels to reliably exploit this near-earth soaring environment."

"On any given day where convection is working as a result of solar heating, every likely thermal producing source can provide you with a save, whether it's cycling or not. Basically, every time. I see this because it's been my experience in the Carbon Dragon over dozens and dozens of instances. Now, if it is too early in the day, it's not going to work. If it's at the end of the day, it may not work. If the sun has shut down….it won't be reliable. Otherwise it's there for you."

"Without a doubt, there is usable lift to be used down here, in close proximity of the earth. Capturing its potential requires a combination of the right equipment and the right techniques. Of course, nothing presented herein should be construed as a contradiction of the old soaring adage 'Get high and stay high!' Something which is accomplished with ease in gliders like the Carbon Dragon. For example, at the time of this writing, my most recent flight in weak spring conditions lasted 7 hours. The thermals only averaged 2 knots. Even so, other than using microlift techniques to climb away from the 600' auto tow, I spent the entire flight within 1500' of the 4500' cloudbase. But when everything else has failed you, and you haven't yet resigned yourself to landing, nap-of- the-earth microlift may prove to be your answer."

"Hopefully there's something here which will prove useful to you whether you fly a hang glider, a standard class sailplane, or a Nimbus 4. And, I hope it gives impetus to those interested in exploring the emerging field of ultralight and light sailplanes.
Whether it's the excellent soarability, the increased number of usable landing fields, the efficiency of micropatterns, or the reliability of a nap-of-the-earth save, this class has much to offer. In case you haven't already guessed it, I'm thoroughly enjoying myself in it!"

It seems to me that these articles (and several in addition – see, for instance [10] [11]) demonstrate that with microlift we are in front of a complex of atmospheric phenomena which, in addition to those reviewed in the first paragraph of this paper, offer a new domain and new opportunities to soaring flight.

5. **Promotion of microlift exploration and exploitation to a larger extent.**

As in each of the atmospheric conditions exploited for soaring flight, also microlift requires that the basic tool, the sailplane, be designed and equipped accordingly.
In this case, the microlift sailplane, under some respects, can be seen as a step backwards to early times, when it was erroneously believed that the exploitation of thermals required a low wing loading. Of course this is only partially true. Most probably none of those old light sailplanes would have been able to exploit microlift efficiently.

Now, as far as I know, the number of microlift sailplane types actually flying here and there in the world is limited to the Carbon Dragon, the German ULF-1 and a few of other prototypes. A particularly interesting prototype (still undergoing flight testing successfully) is the Swiss Archeopteryx [13] . None of these is available or is intended for production in a completed form so far.

The number of Carbon Dragons completed by single homebuilders is roughly estimated to be around 40, over 400 sets of drawings sold. But it can be higher considering the tendency of homebuilders to be isolated in their activity without reporting anywhere. The number of flying ULF-1 is known to be about 30.

These small numbers do not reflect a lack of interest for this type of glider. They are rather due to the difficulty and cost for getting one. The difficulty and cost, on their turn, are due to the complexity of the structure, the non-availability of kits, the limited number of home builders of adequate skill.

6. The role of OSTIV and FAI.

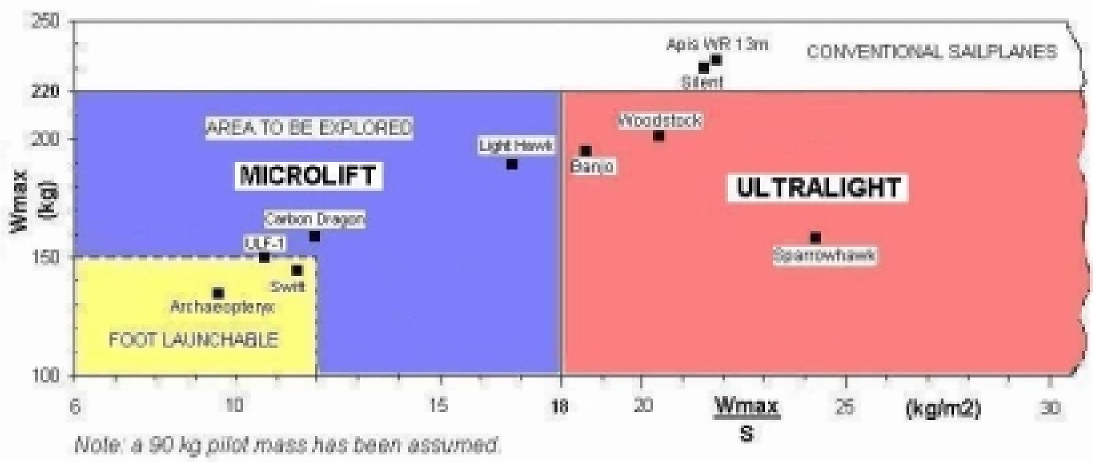
International bodies of high reputation, OSTIV and FAI-IGC, combining their respective competence, are on the way to do something to accelerate the development of microlift soaring.

On March 1st, 2003, at the annual IGC meeting, the OSTIV proposed definition for the MICROLIFT SAILPLANE has been presented to IGC. If introduced in the FAI Sporting Code, Sec.3, this definition would co-exist with that of the ULTRALIGHT SAILPLANE or, in the FAI terminology, ULTRALIGHT GLIDER, which would remain unchanged:

ULTRALIGHT GLIDER:
A glider with a maximum take off mass not exceeding 220 kg.

MICROLIFT GLIDER:
A glider with a maximum take off mass not exceeding 220 kg and a maximum wing loading not exceeding 18 kg/m^2.

The respective domains of the two classes are clearly shown in the figure.



A step further was suggested by OSTIV in its official document [12]. If a new class of Microlift Gliders were created by IGC an advantage would be immediate: the Microlift Gliders would have a chance for records, which is presently denied to them. Indeed, the only possibility they have is for distance and speed records within the Ultralight class, which is nonsense.

A preliminary vote at the IGC plenum expressed a large majority in favour of these proposals. In application of the so called “one-year rule”, next year there could be a deciding vote.

But much more would be achieved than the records. The recognition by FAI would give the microlift sailplane an official standing and would produce a positive fallout on new designs taking advantage of the freedom of choice given by the domain, where the combination of empty masses up to 130 kg and wing loadings up to 18 kg/m^2 could be the tentative choice of a designer.

True enough, this is not the case of a class being created on the basis of an objective situation of a large number of sailplanes of similar basic design existing already. On the contrary, one would start with a small number of sailplanes fitting in at the beginning, with the expectation of a large increase of their number.

Considering that flying the microlift is flying atmospheric phenomena still largely unknown, soaring with sailplanes specifically designed for this would create once more the conditions for scientific research. Isn’t gliding within FAI the only air sport having, through OSTIV, technical and scientific cooperation and support?

7. Hints for a better interaction with the media.

From the sporting point of view there is another aspect worth mentioning: attempts are on the way within IGC for the introduction of new types of gliding competitions which could appeal to the general public. The very recent *Grand Prix de France* (22-28 June 2003) seems to be a successful example.

It seems to me that microlift soaring might offer something of that kind. A limited area so that spectators can see any glider flying over it, but not speed and/or distance taken into account for the scoring: the integral of altitude vs. time instead. A ceiling should be set, which could be at a few hundreds meters AGL or more than one thousand, according to the prevailing meteorological conditions. Also a time limit should be set. At the end, the winner would be the pilot achieving the maximum total gain, i.e. the maximum value of the integral.

The GNSS systems available today should be able to record the necessary data in a relatively easy way.

I must acknowledge that this is a last minute idea (July 2003), the details of which have not been studied at all. If it does not work, please do not blame me too much. It would be great if it stimulates better ones.

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SOME ADDITIONAL REMARKS CONCERNING MICROLIFT SOARING

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Although microlift sailplanes are designed and optimized for use in the low atmospheric boundary layer, their use is certainly not restricted to that. If the atmospheric conditions permit they can climb out of this boundary layer and continue their flight by using thermals and other upcurrents just like conventional sailplanes do. Their climbing performance when circling in thermals will even be superior to that of any conventional sailplane. Their gliding performance however is inferior. As a result their cross-country performance in atmospheric conditions in which conventional sailplanes successfully can fly, is less. But they might very well still be able to fly cross-country when conditions have weakened below the level that present sailplanes can stay up.

Flying microlift sailplanes at altitudes of less than 1000ft can be more exciting than flying at usual altitudes far higher.. The surface of the earth with its undulations, waters, trees and vegetation, different landscapes and man-made structures is much nearer and far better visible with all its interesting details. Closer to the ground also the sense of speed is stronger than at greater altitudes. Comparable with soaring close to mountain slopes or ridges. The perception of controlled movement close to the surface greatly adds excitement to this kind of soaring, less experienced at greater altitudes.

On the other hand people on the ground also will have an increased perception of sailplanes at very low altitudes. This may fascinate them and inspire their imagination, but it might also annoy others due to feelings of danger or fear for intrusion of their privacy. Therefore safe and socially acceptable procedures for overflying populated areas are important. The sheer fact that these microlift sailplanes mostly fly at very low altitudes makes them very visible for the public on the ground. Unusual flight handling and also accidents probably will be much more conspicuous for people on the ground and may have negative consequences for the public perception of soaring.
On the other hand this increased conspicuity for people on the ground offers new opportunities to make soaring as a sportive event more attractive for the public. In combination with the capability to make very short landings it can open up the possibility of active participation by microlift sailplanes in public festivities for instance with flight and landing in a sport stadium, on a soccerfield or at a town square.

We should be aware of all new opportunities this new family of microlift sailplanes can offer and we should try to exploit them. Let us not make the mistake of appreciating them with our conventional judgement regarding speeds, distances, altitudes etc. Their advantage and reason for existence is their performance capability.in the low atmospheric boundary layer; i.e., at low altitudes. That should be exploited. But if just the fun of flying there in conditions of very weak lift is not sufficient, competition for microlift sailplanes can be introduced. But competition flying which stimulates and rewards their special capabilities in a positive way. Here are opportunities to make a soaring contest also more attractive for people on the ground if one takes care to dimension the contest area such as to keep the competing sailplanes within visible range for the public so that their performances can actually be seen and compared.

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Just as an example some ideas concerning possible tasks and different kinds of microlift sailplane contests:

"Time Limited Altitude Valuation"
Time spent at different altitudes during a specified period is weighed and valued. The lower the altitude, the higher the weighing factor. This task can further be confined to a specified area around the location where the public is, with a landing back at that site.

"Rounds Around the Public"
Distance flown around an assigned area (where the public is) within a given time is valued according to the number of circuits around this area. The number of circuits is important to enhance short distances to the central area in order to be visible to the public. This task could be flown for instance with two to four sailplanes at the same time flying against each other.
Similar contests already have been flown in the past with 15m sailplanes in Luchon, France.

"Weighed Duration"
Duration of the flight is valued in relation to the time of the day, by setting higher weighing factors for early "pre-convection hours" and late "post-convection hours".

"Weighed Altitude Gain"
The overall altitude gain during a fixed time is valued, with a weighing factor for the altitude inversely proportional to the altitude below a set maximum altitude.

In these different examples the scoring can easily be put in mathematical terms.

To those pilots having a low appreciation for these new microlift sailplanes I would point out that these are not just another group of simple cheap gliders meant for pilots with low ambitions. These are not cheap toys for old boys. Some of the newest and most promising designs like the *Archaeopteryx* have characteristics not matched by any of our existing sailplanes, no matter their price. Even among the best and most expensive sailplanes gathered here at the world competitions in Leszno you will not find a single one capable of carrying a useful load more than 2.5 times its empty weight. Neither is there any glider around here which offers a minimum flying speed at maximum weight which is less than 25% of its maximum safe speed. If one of these gliders just would have one of these capabilities, it probably would easily win the competition here.

Last but not least: We should not hamper the development of this new family of microlift sailplanes by overregulation. Instead we should stimulate their development by offering them good guidance based on our experience and knowledge of conventional soaring in addition to their own experience with low altitude phenomena and operations.

We should be aware that these new sailplanes could make soaring more attractive for many more people either pilots or spectators and thus could put a halt to the worldwide stagnation over the last years in the number of glider pilots.

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