

---

# Determination of new Handicaps for Evaluation of Gliders in Club Class

Translation of:

Berechnung von neuen Handicap-Faktoren  
für die Wertung von Segelflugzeugen in der Club-Klasse

---

KAI ROHDE-BRANDENBURGER

Institute of Aerodynamics and Flow Technology

German Aerospace Center(DLR e.V.)

kai.rohde-brandenburger@dlr.de

2017

# Formula Symbols

<u>Symbol</u>	<u>Explanation</u>	<u>Unit</u>
$a$	updraft speed in thermal center	$m/s$
$a_{cent}$	centripetal acceleration	$m/s^2$
$b$	updraft gradient	$m/s/m^2$
$C_L$	lift coefficient	—
$C_D$	drag coefficient	—
$ED$	evaluation distance	$m$
$g$	earth acceleration	$\frac{m}{s^2}$
$H$	handicap factor	—
$H_{Spread}$	handicap factor with reduced spread	—
$L$	Lift	$N$
$\frac{L}{D}$	glide ratio	—
$m$	flight mass	$kg$
$n$	load factor	—
$part$	percentage of thermal or level flight of evaluation distance	—
$r$	radius	$m$
$S$	wing area	$m^2$
$t$	time	$s$
$V$	velocity	$\frac{km}{h}$
$V_g$	velocity at interthermal glide	$\frac{km}{h}$
$V_K$	airspeed in turn	$\frac{km}{h}$
$V_{K_{straight}}$	velocity on polar for calculation to circling velocity	$\frac{km}{h}$
$V_C$	cross-country speed in weather model	$\frac{km}{h}$
$V_{C,WL}$	cross-country speed in weathermodel multiplied with wing loading factor	$\frac{km}{h}$
$V_{climb}$	achieved rate of climb in thermal	$\frac{m}{s}$
$V_{Gl}$	velocity at sink rate 0.8m/s	$\frac{km}{h}$
$V_S$	sink rate	$\frac{m}{s}$
$V_{S_0}$	Stall speed or minimum controllable airspeed	$\frac{m}{s}$
$V_{S,min}$	velocity at minimum sink rate	$\frac{km}{h}$
$V_{S,WL}$	sink rate with new calculated wingloading	$\frac{m}{s}$
$V_{S,K}$	calculated sink rate while thermaling	$\frac{m}{s}$
$V_{S,K,straight}$	sink rate at $V_{K_{straight}}$	$\frac{m}{s}$
$V_{thermal}$	thermal updraft speed	$\frac{m}{s}$
$V_{WL}$	velocity with new calculated wingloading	$\frac{km}{h}$
$W$	Drag	$N$
$WL$	wingloading	$\frac{kg}{m^2}$
$\rho$	air density	$\frac{kg}{m^3}$
$\phi$	bank angle	$degree$

# Abbreviation

<u>Abbreviations</u>	<u>Meaning</u>
Akaflieg	Akademische Fliegergruppe, academic oriented student organization, dedicated to the design, construction and flying of aircraft, especially sailplanes (from [5])
DMSt	Deutsche Meisterschaft im Streckenflug, German decentralised gliding competition
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V., German Aerospace Center
EM	European Championship
FAI	Federation Aeronautique Internationale, international air sports federation
idaflieg	Interessengemeinschaft Deutscher Akademischer Fliegergruppen e.V., Umbrella Organization for the German Akafliegs (from [5])
OLC	Online Contest, decentralised online competition for gliding

# Contents

<b>Formula Symbols</b>	<b>i</b>
<b>Abbreviation</b>	<b>iii</b>
<b>1 Introduction and Motivation</b>	<b>1</b>
<b>2 Modelling of Thermals</b>	<b>2</b>
<b>3 Determination of cross-country speed</b>	<b>5</b>
3.1 Polars from Flight Performance Measurements . . . . .	5
3.2 Influence of Wingloading to Flight Performance . . . . .	5
3.3 Decrease of Handicap Spread . . . . .	7
3.4 Calculation Method . . . . .	8
3.4.1 Thermal Calculation . . . . .	8
3.4.2 Cruising Speed Calculation . . . . .	10
3.4.3 Level Flight Calculation . . . . .	10
3.4.4 Cross-Country Speed Calculation . . . . .	10
<b>4 New Handicap Factors</b>	<b>12</b>
4.1 Comparison of Old and New Handicap Factors . . . . .	12
4.2 Adjustment of Handicap Factors in the Future . . . . .	13
<b>5 Influence to Competition Results</b>	<b>14</b>
5.1 EM Rieti 2015 . . . . .	14
<b>6 Summary</b>	<b>15</b>
<b>Annex</b>	<b>18</b>

# 1 Introduction and Motivation

The experience in competitions over the last decades led to the fact that certain aircraft were preferred by the pilots, because some aircrafts are given an advantage in the actual handicap system. The current registrations to championships and the results show a quite clear picture. In order to revert to the original character of this class, the handicap factors would have to be changed and adjusted. In addition, efforts should be made to focus the calculation of handicap factors on more modern aircraft. The idea of a separation of the actual club class was rejected. In order to be able to evaluate all of the aircrafts in competitions, handicap factors were introduced which include the performance of the aircraft. The current handicap factors are almost identical to the DMSt index list calculated in [1] for decentralized competitions and therefore refer to a relatively untypical weather model for central competitions. The motivation of this development is a fairer evaluation of all aircrafts and thus also the use of more modern and usually also safer aircrafts for competitions. The weather model for the calculation of the factors was adapted to competition values. In addition, all current wingloadings and flight weights were included in this new calculation, which is why no aircraft has the same handicap factor for different masses. The spreading of the handicap factors was then reduced by a factor in order to continue using the current scoring system and the evaluation software at competitions.

## 2 Modelling of Thermals

The thermal model was adapted based on the previous models by Horstmann, Quast and Ronig. For this purpose, the amount and trend of the thermal strength was adjusted following the consideration of the valuation of flights in the German Championship in Zwickau 2015. The percentage of thermal types and level flight without sinking on the overall route were also adjusted. As a result, the average climb speed is increased and the resultant calculated cross-country speeds are faster. This makes use of areas of the measured polar, which lies in a higher speed range than before.

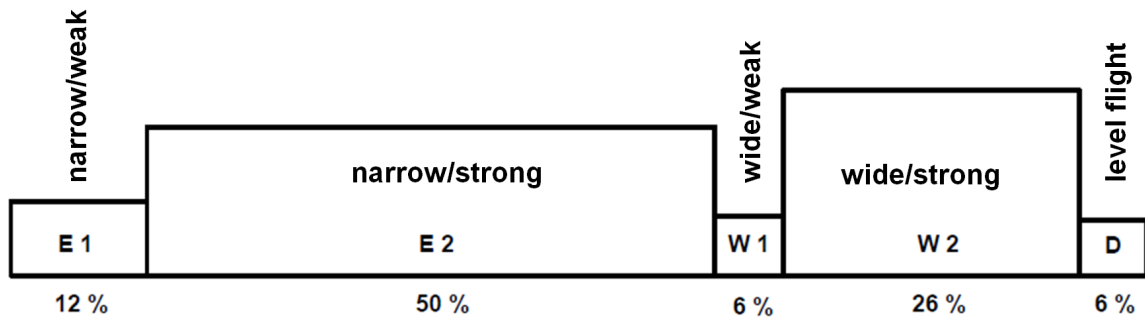


Fig. 2.1: Parts of the evaluation distance in the weather model ref. Ronig [1]

The new weather model calculates the course of the updraft velocity in the Thermal with a quadratic approach instead of an linear approach so far. In addition, thermals with weak and very narrow updrafts are removed. The old weather model simulates a DMSt cross-

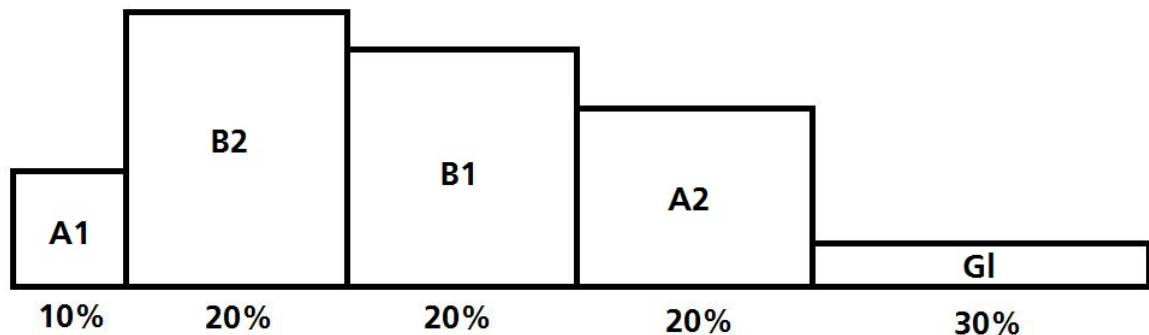


Fig. 2.2: Parts of the evaluation distance in the new weather model

country flight over a whole day, with weak thermals in the beginning, strong thermals

coefficients	Thermal A1	Thermal A2	Thermal B1	Thermal B2	GL	Unit
a	2.5	3.5	4.95	5.95	-	[m/s]
b	-0.00005	-0.00008	-0.00009	-0.0001	-	[m/s/m <sup>2</sup> ]
Part	10	20	20	20	30	[percent]

Table 2.1: Thermal data of the new weather model

coefficients	Thermal E1	Thermal E2	Thermal W1	Thermal W2	GL	Unit
a	3.5	4.2	2.0	4.0	-	[m/s]
b	-0.023	-0.02	-0.0042	-0.01	-	[m/s/m]
Part	12	50	6	26	6	[percent]

Table 2.2: Thermal data of weather model ref. Ronig [1]

over midday, and weak but wide thermals for the final approach. The new weather model simulates a competition day, with good thermals at task start, strong thermals over the day and even at final glide.

The course of the updraft velocity in the thermals over the thermal radius is calculated with the linear approach:

$$w_{A(r)} = a + r * b \quad (2.0.1)$$

With the new quadratic approach changes this formula to:

$$w_{A(r)} = a + r^2 * b \quad (2.0.2)$$

The values for calculating the updraft in the individual thermals are shown in the tables.

The course of the updraft over the radius for all used thermals is shown in figure 2.1, to allow a comparison of the new model to the DMSt model.



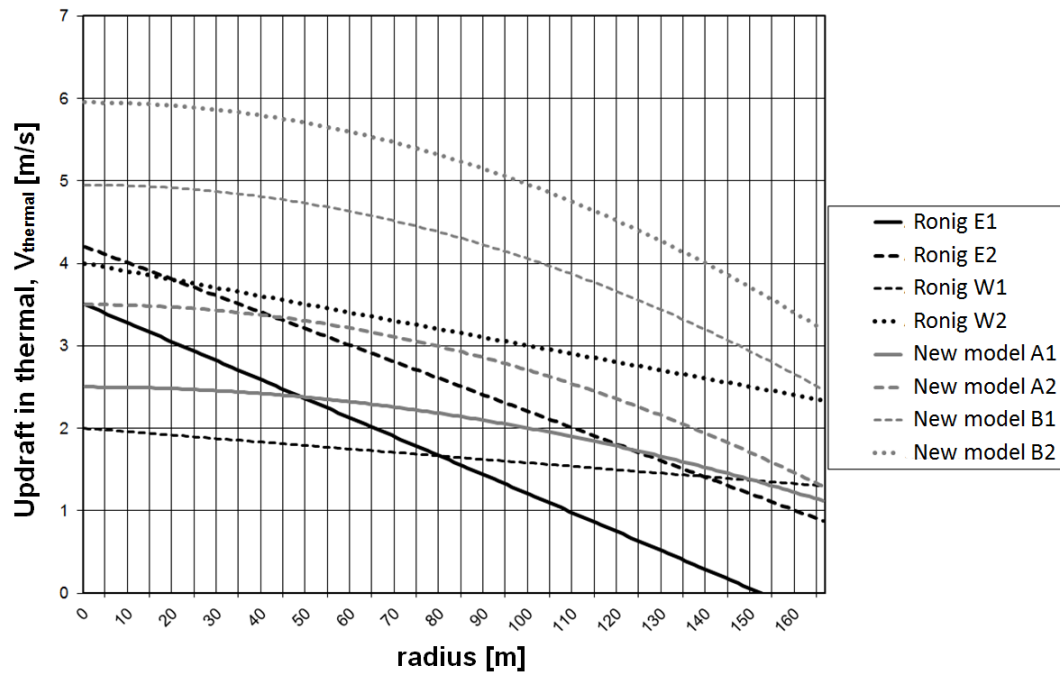


Fig. 2.3: Thermal profiles of both weather models

## 3 Determination of cross-country speed

While calculating the averaged cross country speed with this methods, everybody should be aware that this is a theoretical value. It shall be assumed, that the pilot is flying optimal, the circling polar is identic with the calculation from the straight flight polar, the modelling of the thermals is correct and that there is no horizontal wind. This is an often used approach to calculate new sailplane designs and to show the influence of those designs without the influence of the pilot. Approaches from across europe, which make use of the IGC-files, can only be done with a lot of flights and statistic methods. That is an interesting approach, and should be observed in the future.

Further possibilities, like the integration of the handling characteristics and the correct measurement of the circling polar are current research topics. Furthermore this is a pure thermal model, without the influence of waves and ridge lifts. It is only an attempt to include an averaged weather model. There will always be competition days with so less thermal updrafts, that some gliders can still climb and some gliders have to land or the highest glide ratio makes the result. The fair consideration of those sporadic cases is not possible in a handicapped class and should be considered by the competition director.

### 3.1 Polars from Flight Performance Measurements

For those calculations, the performance of the sailplane must be known. The performance in this case is plottet as a speed polar. This has the biggest influence in the theoretical model. Because those values are hard to calculate, and the values from the manufacturer are to good in most cases, which would lead to unfair handicaps, the measured polars of the DLR/idaflieg are used. With considerable effort, the flight performance of the majority of sailplanes was measured and catalogued over the last decades, started at 1961. Sailplanes, which are not measured yet, will be sorted into the list by experience of known sailplanes and expertise. Normally those values are not to far out, but they will be adjusted after measurement data is available.

### 3.2 Influence of Wingloading to Flight Performance

The wing loading has decisive influence to the flight performance. Because the wing area is constant at flight for nearly all sailplanes, the only factor is the take off weight, if water ballast is prohibited. Different pilot weights and ballast can change this weight. Over the last decades the mass of some old sailplanes increased, which led to an increase of the allowed mass. This was not taken into account for the present handicap list, so some sailplanes still have their old handicap factor for a take off mass of 330kg, but are allowed to fly at 361kg.

$$V_{WL_{new}} = \sqrt{\frac{WL_{new}}{WL_{old}}} * V_{WL_{alt}} \quad (3.2.1)$$

$$V_{S,WL_{new}} = \sqrt{\frac{WL_{new}}{WL_{old}}} * V_{S,WL_{old}} \quad (3.2.2)$$

In figure 3.1 the shift of the polar for the measured speed polar of the ASW19B from 1980 is shown. In this example, the flight performance was recalculated from the measured wingloading of 32kg/m\*m to the maximum wingloading of 41kg/m\*m. In club class the maximum wing loading of each glider is limited by the reference weight in [8]. Figure 3.1 only shows the maximum effect for the ASW19B.

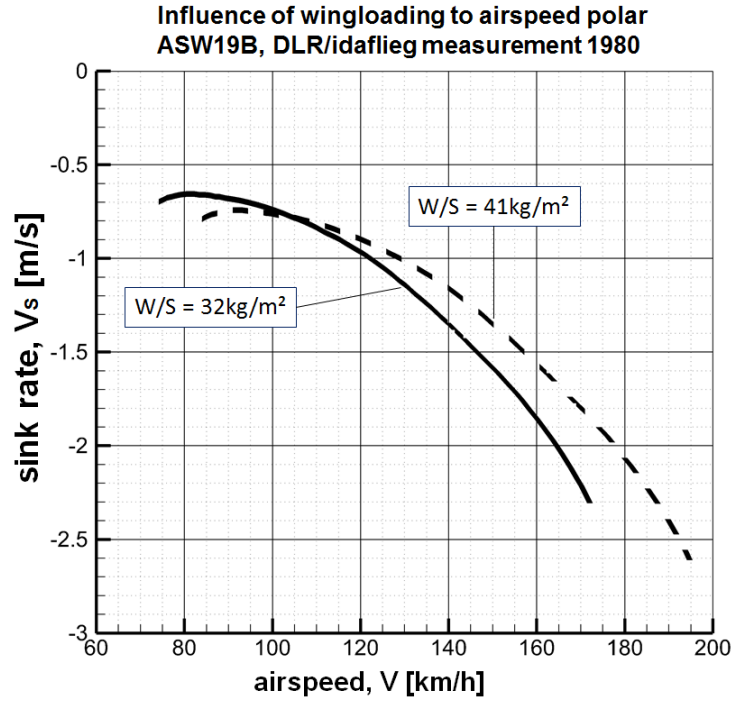


Fig. 3.1: Effect of wing loading on airspeed polar

The previous calculation by the formula above took this into account, however the glide ratio in the old calculation stayed constant for all wing loadings, just shifted to faster or slower speeds. With this calculation method, there is no big advantage in cross country speeds at higher wing loading with water ballast, even at fast thermal updrafts. This contradicts with the experience in competitions. To calculate this positive effect, a measurement of a cirrus at different wingloadings was evaluated. The factor, which was calculated from this evaluation, influences the cross country speed if the wingloading varies from the wingloading at measurement. This effect of increasing the flight performance with higher wing loadings is mentioned in [5], but not taken into account by the old calculation.

$$WL_{factor} = 1.00409 * \frac{WL_{new} - WL_{old}}{10 \frac{kg}{m^2}} \quad (3.2.3)$$

$$V_{C,WL} = WL_{factor} * V_C \quad (3.2.4)$$

This increases the cross country speed with changed wingloading per 10kg/m<sup>2</sup> variance from measurement wing loading with 0.41%. The value is selected intentional small, because every sailplane with a unequal airfoil reacts to this reynolds number caused change different. The influence is not that big, because at club class all gliders are very near to their measured wingloading. The biggest influence would have the Cirrus, because he varies most from his old measured wing loading, but the new measured polar with higher wing loading is used to calculate the new cross country speed.

### 3.3 Decrease of Handicap Spread

The spread of the calculated cross country speeds is higher than before, due to the new thermal models with higher climb rates and the resulting higher interthermal speeds. In this calculation, every glider is calculated for it's own. The effect of many gliders with different performance flying the same task can just be estimated. It is supposed, that a slower glider is faster and a faster glider is slower on the task, if both planes are flying together in a competition. This problem is caused by the big difference in performance in this handicapped class. To take this effect into account, a factor was created to decrease the spread to values lower than before.

To get a plausible handicap value, the value calculated the old way. After that the square

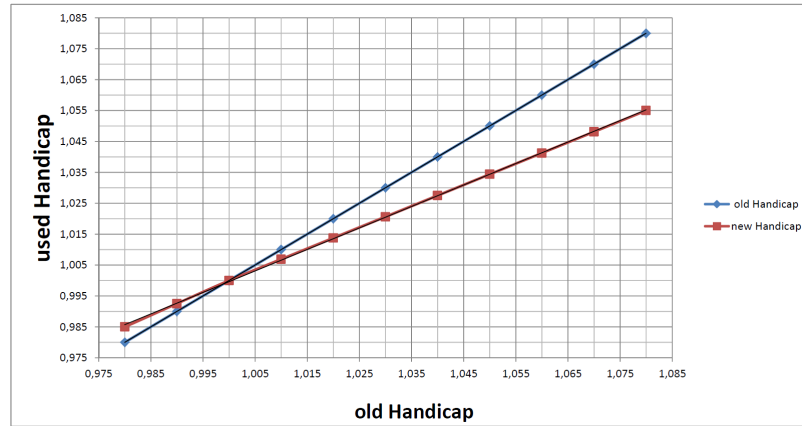


Fig. 3.2: Comparison of old and new spread in handicap system

root is calculated, which decreases the spread of the handicap to nearly 70% of the old spread.

$$H = \frac{V_{C,WL,X}}{V_{C,WL,ASW19}} \quad (3.3.1)$$

$$H_{spread} = \sqrt{H} \quad (3.3.2)$$

With this formula, the spread of the handicap is reduced consistant over all gliders.

### 3.4 Calculation Method

The cross country speed is calculated for each thermal part in the weather model. The climb speed for each thermal is calculated and with that value the McCready speed is determined. Therefore the measured polar of the glider is used, calculated to the wing-loading at reference weight according to Reichmann.

It is an iterative calculation, due to the real course of the sinkspeed polar. For a speed a

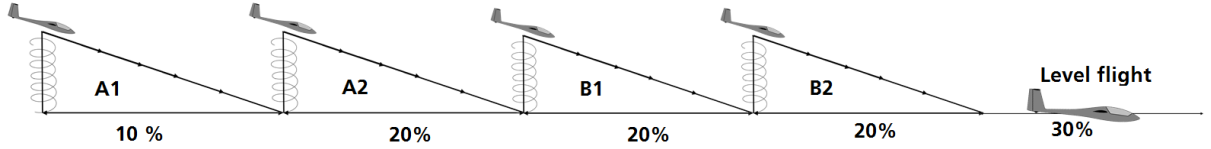


Fig. 3.3: Parts in the weather model

little lower than minimum sinking, the optimal bank angle in each thermal for best climb performance is determined. Then the cruising speed according to McCready is determined. With the sinkspeed polar, the climb speed in each thermal and the corresponding cruising speed, the cross country speed for each thermal part in the weather model can be calculated. The time needed for each part in the weather model can be summed up with the time for the straight level flight and results in the averaged cross country speed for this glider.

#### 3.4.1 Thermal Calculation

All four thermal parts are calculated the same way. The velocity while thermaling is determined according to the speed polar. The speed polar is calculated to actual wing-loading. The minimum velocity and the velocity at minimum sink rate are determined. The velocity on the polar for flying in the thermal is calculated with the following formula:

$$V_{K_{straight}} = \frac{(V_{S,0} + 2 * V_{S,min})}{3} \quad (3.4.1)$$

The sinking speed at the speed for flying in the thermal is determined from the straight flight polar:

$$V_{S_{K_{straight}}} = V_S(V_{K_{straight}}) \quad (3.4.2)$$

The speed polar can be calculated to the coefficient polar:

$$C_{L_K} = \frac{m * g}{\frac{\rho}{2} V_{K_{straight}}^2 * S} \quad (3.4.3)$$

$$C_{D_K} = \frac{C_{L_K}}{\frac{L}{D_K}} = \frac{C_{L_K}}{\frac{V_{K_{straight}}}{V_{S,K_{straight}}}} \quad (3.4.4)$$

The thermal updraft speed at radius  $r$  is calculated as follows:

$$V_{thermal}(r) = a + r * b^2 \quad (3.4.5)$$

The radius while circling depends on the bank angle. The speed for flying in the thermal at the straight flight polar is calculated to the circling speed, which is higher because of the higher wingloading due to radial acceleration while circling, depending on bank angle. For this the coefficients are used and the lift coefficient can be calculated to the circling speed, shown in [5]:

$$V_K(\phi) = \sqrt{\frac{2W}{\rho S} \frac{1}{C_{L_K} \cos \phi}} \quad (3.4.6)$$

According to the lift coefficient, the drag coefficient can be used to calculate the sinking speed while circling, shown in [5]:

$$V_{S,K}(\phi) = \sqrt{\frac{2W}{\rho S} \frac{C_{D_K}}{C_{L_K}^3 \cos \phi^{3/2}}} \quad (3.4.7)$$

The relation of the bank angle and the circling radius is as follows:

$$\phi = \arctan \frac{V_K^2}{g * r} \quad (3.4.8)$$

From this calculation into coefficients and the relation of bank angle and circling radius, the sinking speed while circling and the thermal updraft speed are depending on the radius. Now the optimal climb speed can be iterative calculated.

$$V_{climb}(r) = V_{thermal}(r) + V_{S,K}(r) \quad (3.4.9)$$

The optimal bank angle is calculated, which gives the best climb speed for the local thermal updraft and the corresponding sinking speed.

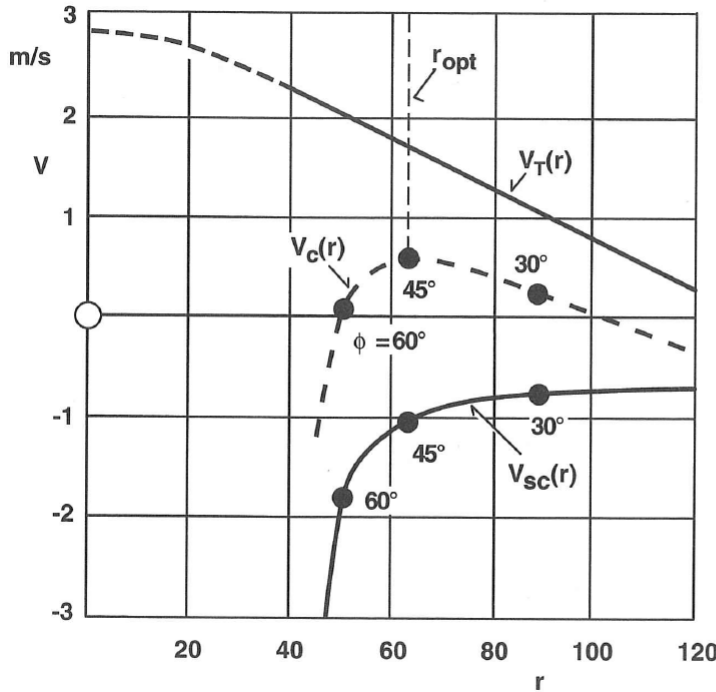


Fig. 88: Rate of climb vs. turn radius for ASW-19 in type A1 thermal.

$V_T$  thermal strength  
 $V_{sc}$  sink rate in turn  
 $V_c$  net rate of climb  
 $V_c(r) = V_T(r) - V_{sc}(r)$

Fig. 3.4: Rate of climb vs. turn radius and bank angle for ASW19, ref. Thomas [5]

This is the optimal climb speed at the given wingloading in this thermal part and is used to calculate the McCready cruising speed in the next chapter.

### 3.4.2 Cruising Speed Calculation

The calculation of the cruising speed is based on climb speed for the respective thermal. As a restriction, only 80 percent of the optimal climb speed is used to calculate the cruising speed. This is well discussed in [1] and corresponds with experience. The so calculated cruising speeds are at reasonable values lower than 200km/h.

The solution is calculated, based on the graphic method given at [7], p.270. The measured polar is calculated to the actual wingloading and the tangent is determined. The tangent point gives the cruising speed depending to the calculated climb speed.

With this climb speed, the time can be calculated, which is needed for the part of the track. The lost altitude, corresponding on the sink speed at cruising speed, is used to calculate the time, needed at circling with the climb speed, to get the altitude back.

$$t_{thermal} = \frac{\frac{part * ED}{\frac{L}{D}g}}{V_{climb}} \quad (3.4.10)$$

The crusing speed is calculated for 80% of the optimal climb speed in the thermal according to McCready. With this crusing speed and the percentage of the track, the time to fly this part of the track is calculated:

$$t_{cruising} = \frac{part * ED}{V_g} \quad (3.4.11)$$

This calculation of time is done for each thermal and respective part of the track and the sum is representing the time, needed for the thermal parts of the weather model:

$$t_X = t_{climb,X} + t_{cruise,X} \quad (3.4.12)$$

### 3.4.3 Level Flight Calculation

The straight level flight was implemented from S. Ronig in [1]. This is representing the final glide and longer straight flights without circling, like cloudstreets or at convergence lines. This straight level flight is defined to low speeds, no gain in altitude and the updraft at level flight is 0.8m/s. Because of this definition, the speed on the sink speed polar is used, which gives 0.8m/s sink speed. despite the higher cruising speeds in this weather model, this part represents speeds near to the best glide ratio. In formulas, the speed on the speed polar at 0.8m/s sink speed and the respective part of the track gives the time, needed to fly this part.

$$V_{Gl} = V_S(0.8m/s) \quad (3.4.13)$$

$$t_{Gl} = \frac{part_{Gl} * ED}{V_{Gl}} \quad (3.4.14)$$

### 3.4.4 Cross-Country Speed Calculation

To calculate the averaged cross country speed, the time of all parts is summed up. The total distance of the track is divided by the sum of time to get the averaged cross country speed:

$$V_C = \frac{ED}{t_{A1} + t_{A2} + t_{B1} + t_{B2} + t_{GL}} \quad (3.4.15)$$

To take the wingloading effect from chapter 3.2 into account, the averaged cross country speed is multiplied with the factor from 3.2. For example, the averaged cross country speed of the ASW19B is multiplied with the WL-Factor of 1.0037181. Therfor the result is a cross country speed of 96.89km/h with the values in the table:

Thermal	A1	A2	B1	B2	GL	Unit
Climb rate	1.21	2.0	3.39	4.33	0.8	[m/s]
Circling radius	85.75	79.41	77.97	76.73	-	[m]
Bank angle	36.09	39.5	40.38	41.17	-	[degree]
Crusing speed	125.47	134.1	159.1	168.1	106.7	[km/h]
Flight time	26.68	42.96	34.54	31.65	50.62	[minutes]

For comparison only, the values of the ASW24 with a averaged cross country speed of 106.28km/h and a WL-Factor of 1.014315:

Thermal	A1	A2	B1	B2	GL	Unit
Climb rate	1.234	2.01	3.39	4.33	0.8	[m/s]
Circling radius	89.51	83.22	81.79	80.58	-	[m]
Bank angle	38.15	41.64	42.53	43.33	-	[degree]
Crusing speed	124.0	161.65	180.04	186.22	116.465	[km/h]
flight time	25.22	39.41	31.72	29.08	46.37	[minutes]



## 4 New Handicap Factors

The calculations in the previous chapters were carried out for all gliders in the clubclass. A few gliders without measured polars were implemented in the handicap list by hand. To find out which gliders are meant, the measured gliders are marked in the list. The calculated handicap factor is normed to the ASW19/B, wherefore the handicap factor of the ASW19/B is 1.00.

### 4.1 Comparison of Old and New Handicap Factors

The new handicap factors with the used values are shown in the following list.

new Handicap	Glider Type	Flaps	Max. mass of non lifting Parts [kg]	Wing area [m <sup>2</sup> ]	Reference Mass [kg]	WL [kg/m <sup>2</sup> ]	Old Handicap	measured polar
1,055	ASW20 15m	f	235	10,5	372	35,4	1,08	x
1,05	ASW24		245	10	365	36,5	1,07	x
1,045	Discus a,b,CS		240	10,58	372	34,7	1,07	x
1,045	Mosquito, B	f	240	9,86	368	37,3	1,07	x
1,045	LS3 , a	f	230	10,5	367	35	1,07	x
1,04	DG200 15m	f	250	10	380	38	1,07	x
1,04	Mini Nimbus	f	240	9,86	368	37,3	1,07	x
1,04	Genesis 2		241	11,15	366	32,8	1,07	-
1,04	Speed Astir II, IIb	f	260	11,47	400	34,9	1,06	x
1,03	LS7		235	9,8	353	36	1,06	x
1,025	Glasflügel 304, B, HPH 304 CZ 15m	f	240	9,9	369	37,3	1,07	x
1,025	PIK 20 A	f	250	10	380	38	1,03	x
1,025	LS4, a, b		230	10,5	356	33,9	1,04	x
1,02	PIK 20 B	f	240	10	370	37	1,03	x
1,02	SZD 55-1		248	9,6	363	37,8	1,06	x
1,02	CB-15 CRYSTAL		240	9,77	350	35,8	1,05	-
1,02	SZD 59 ACRO		248	9,6	363	37,8	1,02	-
1,02	H301 Libelle	f	200	9,8	315	32,1	1,02	x
1,02	HPH 304 C		240	9,9	359	36,3	1,04	x
1,015	DG300 Elan		246	10,27	369	35,9	1,04	x
1,015	PEGASE 101 A,B,C,D,P,AP		225-235	10,5	361	34,4	1,03	x
1,015	PIK 20 D	f	225	10	355	35,5	1,03	-
1,01	Jantar Std. 3		245	10,66	373	35	1,01	x
1,01	SZD-48-3M		240	10,9	360	33	1,01	-
1,01	SZD-48-3MI		240	10,66	365	34,2	1,01	-
1,005	Jantar Std. 2, 2M		245	10,66	373	35	1,01	x
1,005	Std. Cirrus B 16m		220-233	10,36	350	33,8	1,02	x
1,005	Hornet C		225	9,8	343	35	1	x
1,005	LS 1f, LS 1f(45)		230	9,75	347	35,6	1,01	x
1	ASW19 , B		225-230	11	362	32,9	1,01	x
1	DG 100, G, Elan, G		265	11	385	35	1	x
1	Jantar Std.		236	10,66	364	34,1	1	x
1	Std. Cirrus, CS11-75, G		220-240	10,04	361	36	1	x
0,995	ASW 15, B		220	11	352	32	0,98	x
0,99	LS 1 0,a,b,c,d		212	9,74	312	32	0,98	x
0,985	Std. Libelle , 201B, 202, 203		210	9,8	328	33,5	0,98	x

Fig. 4.1: List of new and old handicap factors

Every glider, which has a measured polar, was calculated. A change in position compared

to the previous list can have following reasons:

- Different behaviour in the new weather model
- Calculation and shift of the polare due to actual wingloading or reference weight
- New measurement data
- Repositioned due to missing measurement data

For this calculation, the past values for adjustments by deviations of masses or due to addition of winglets prescribed in [8] are the same. For addition of Winglets 0.005 will be added to the handicap factor. For deviations from reference mass, 0.005 per 10kg will be added to the handicap factor, and it will be reduced by 0.004 per 10kg if the takeoff mass is less than reference weight.

For the exact wording please refer to [8].

## 4.2 Adjustment of Handicap Factors in the Future

The issue, that gliders are preferred because of their handicap factor given, should be avoided in the future.

No handicap factor can be completely fair. For this reason, the handicap factor should be reviewed and adjusted based on competition results and pilot statements. It should be noted, that this should only be applied to avoid having a special type of aircraft dominate the clubclass.

## 5 Influence to Competition Results

To show the influence of the new handicap factors at competition and to avoid unintended or unsportsmanlike effects, a complete competition was recalculated with the new handicap factors. It should be noted, that this is a theoretical calculation. The results at competitions are strongly influenced by psychological effects, especially the top positions are flying in a tactic way due to their position. This calculation is only used to examine the effects to competitions due to a change of the handicap factors.

### 5.1 EM Rieti 2015

The influence of the new handicap factors is relatively low. The positions are not changed very much. As might be expected, due to the reduced spread of the handicap factors the score difference from first to last position is reduced. Especially the more modern planes get more points, but they are not totally advantaged. The first places are changed, but the score difference between them is still very low.

			Handicap		Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 8		Day 9		Day 10		Overall		Points	Position
			new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	Delta	new
1	D.	Std. Cirrus	1	1	885	893	884	910	880	889	904	919	786	789	572	571	1000	1000	667	668	703	702	7281	7341	-60	2
2	L.	Std. Cirrus	1	1	883	890	877	903	887	896	922	937	789	793	574	573	942	943	664	664	704	703	7241	7302	-61	3
3	K.	LS1f	1,005	1,01	887	887	907	925	908	908	892	898	900	896	595	575	896	873	691	686	615	608	7292	7256	36	1
4	D.	Std. Libelle	0,99	0,99	923	931	796	820	912	922	985	1000	994	998	558	560	742	759	573	573	554	554	7037	7117	-80	4
5	G.	Std. Cirrus	1	1	869	877	847	873	962	971	814	828	844	847	601	600	964	937	678	678	448	447	7027	7058	-31	5
6	S.	Pik20A	1,025	1,03	1000	1000	861	878	1000	1000	969	975	552	549	531	521	891	865	533	530	672	665	7009	6983	26	6
7	S.	ASW15b	0,995	0,98	810	841	717	766	904	943	818	859	853	878	572	585	806	852	646	661	550	571	6676	6956	-280	7
8	Z.	Std. Cirrus	1	1	889	897	931	958	935	945	946	961	763	766	574	573	331	331	702	702	595	595	6666	6728	-62	9
9	N.	Cirrus G	1	1	841	848	888	914	957	957	848	853	854	858	550	550	530	530	681	681	525	525	6674	6716	-42	8
10	M.	Std. Cirrus	1	1	889	897	970	998	909	918	930	945	806	809	553	553	515	515	372	366	695	695	6640	6696	-56	10
11	J.	H301	1,02	1,02	781	788	681	704	939	948	786	800	784	787	548	544	835	855	646	647	514	514	6514	6587	-73	11
12	K.	Std. Libelle	0,99	0,99	337	334	656	678	806	815	875	890	996	1000	591	586	878	850	479	479	692	692	6310	6324	-14	12
13	S.	Std. Cirrus CS	1	1	890	898	886	912	714	723	942	957	291	288	601	601	452	452	675	676	808	808	6259	6315	-56	15
14	U.	Std. Cirrus	1	1	883	891	921	947	792	801	864	878	277	274	567	554	928	888	240	237	806	806	6278	6276	2	13
15	M.	LS4	1,025	1,04	321	313	1000	1000	993	974	964	951	1000	981	565	530	707	703	299	290	429	411	6278	6153	125	13
16	B.	LS4	1,025	1,04	804	790	813	813	763	746	940	928	666	651	473	458	899	853	298	289	610	589	6267	6117	150	14
17	D.	ASW19b	1	1,01	843	835	720	727	774	765	1000	996	698	688	542	537	318	315	297	290	654	639	5846	5792	54	16
18	S.	LS1f	1,01	1,02	859	852	355	350	927	898	849	845	274	269	516	504	845	821	683	673	586	566	5894	5778	116	17
19	R.	ASW19b	1	1,01	335	328	643	650	815	806	860	856	974	962	594	575	450	446	493	486	663	648	5827	5757	70	18
20	P.	LS7	1,03	1,06	810	775	734	711	996	949	0	0	235	226	524	492	315	307	241	231	687	644	4543	4335	208	19

Fig. 5.1: Recalculation of competition results at Rieti 2015

## 6 Summary

A new weather model is presented and explained. Die previous weather model simulates the weather on a daylong flight in a decentralised competition like the DMSt or OLC classic. Due to that, the weather model was changed and adjusted to a good competition day. The modelling of the thermals was changed to a quadratic function for more realistic thermal profiles, because of optimization problems ref. to [6].

To adjust the actual handicap factors in the clubclass, a new list was calculated with the new weather model. Care was taken on the actual allowed reference mass in [8] and the influence of wingloading to performance. The previous calculation of the actual handicap factors was not done at reference weight. A wingloading factor was introduced, to take the performance change into account due to wingloading and the corresponding reynolds-number effect.

The new calculated handicap-factors were standardised to the ASW19/B. Due to the higher climb rates in the thermals, the spread of the handicaps was reduced by a factor. The spread of the new handicap factors is smaller than with the old handicap factors.

To show the influence of the new handicap factors to competition results, a competition was recalculated. The new results show, that more modern glider get more points than before, but the positions are not completely changed. The incentive, to fly competitions with more modern gliders should be provided with those new handicap factors.

# List of Figures

2.1	Parts of the evaluation distance in the weather model ref. Ronig [1] . . . .	2
2.2	Parts of the evaluation distance in the new weather model . . . . .	2
2.3	Thermal profiles of both weather models . . . . .	4
3.1	Effect of wing loading on airspeed polar . . . . .	6
3.2	Comparison of old and new spread in handicap system . . . . .	7
3.3	Parts in the weather model . . . . .	8
3.4	Rate of climb vs. turn radius and bank angle for ASW19, ref. Thomas [5] .	9
4.1	List of new and old handicap factors . . . . .	12
5.1	Recalculation of competition results at Rieti 2015 . . . . .	14

## List of Tables

2.1	Thermal data of the new weather model . . . . .	3
2.2	Thermal data of weather model ref. Ronig [1] . . . . .	3

# Annex

new Handicap	Glider Type	Flaps	Max. mass of non lifting Parts [kg]	Wing area [m²]	Reference Mass [kg]	WL [kg/m²]	Old Handicap	measured polar
1,055	ASW20 15m	f	235	10,5	372	35,4	1,08	x
1,05	ASW24		245	10	365	36,5	1,07	x
1,045	Discus a,b,CS		240	10,58	372	34,7	1,07	x
1,045	Mosquito ,B	f	240	9,86	368	37,3	1,07	x
1,045	LS3 , a	f	230	10,5	367	35	1,07	x
1,04	DG200 15m	f	250	10	380	38	1,07	x
1,04	Mini Nimbus	f	240	9,86	368	37,3	1,07	x
1,04	Genesis 2		241	11,15	366	32,8	1,07	-
1,04	Speed Astir II,IIb	f	260	11,47	400	34,9	1,06	x
1,03	LS7		235	9,8	353	36	1,06	x
1,025	Glasflügel 304, B, HPH 304 CZ 15m	f	240	9,9	369	37,3	1,07	x
								-
1,025	PIK 20 A	f	250	10	380	38	1,03	x
1,025	LS4, a, b		230	10,5	356	33,9	1,04	x
1,02	PIK 20 B	f	240	10	370	37	1,03	x
1,02	SZD 55-1		248	9,6	363	37,8	1,06	x
1,02	CB-15 CRYSTAL		240	9,77	350	35,8	1,05	-
1,02	SZD 59 ACRO		248	9,6	363	37,8	1,02	-
1,02	H301 Libelle	f	200	9,8	315	32,1	1,02	x
1,02	HPH 304 C		240	9,9	359	36,3	1,04	x
1,015	DG300 Elan		246	10,27	369	35,9	1,04	x
1,015	PEGASE 101 A,B,C,D,P,AP		225-235	10,5	361	34,4	1,03	x
1,015	PIK 20 D	f	225	10	355	35,5	1,03	-
1,01	Jantar Std. 3		245	10,66	373	35	1,01	x
1,01	SZD-48-3M		240	10,9	360	33	1,01	-
1,01	SZD-48-3MI		240	10,66	365	34,2	1,01	-
1,005	Jantar Std. 2, 2M		245	10,66	373	35	1,01	x
1,005	Std. Cirrus B 16m		220-233	10,36	350	33,8	1,02	x
1,005	Hornet C		225	9,8	343	35	1	x
1,005	LS 1f, LS 1f(45)		230	9,75	347	35,6	1,01	x
1	ASW19 , B		225-230	11	362	32,9	1,01	x
1	DG 100, G, Elan, G		265	11	385	35	1	x
1	Jantar Std.		236	10,66	364	34,1	1	x
1	Std. Cirrus, CS11-75, G		220-240	10,04	361	36	1	x
0,995	ASW 15, B		220	11	352	32	0,98	x
0,99	LS 1 0,a,b,c,d		212	9,74	312	32	0,98	x
0,985	Std. Libelle , 201B, 202, 203		210	9,8	328	33,5	0,98	x

			Handicap		Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 8		Day 9		Day 10		Overall		Points	Position
	Name	Glider	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	new	old	Delta	new
1 D.	Std. Cirrus		1	1	885	893	884	910	880	889	904	919	786	789	572	571	1000	1000	667	668	703	702	7281	7341	-60	2
2 L.	Std. Cirrus		1	1	883	890	877	903	887	896	922	937	789	793	574	573	942	943	664	664	704	703	7241	7302	-61	3
3 K.	LS1f		1,005	1,01	887	887	907	925	908	908	892	898	900	896	595	575	896	873	691	686	615	608	7292	7256	36	1
4 D.	Std. Libelle		0,99	0,99	923	931	796	820	912	922	985	1000	994	998	558	560	742	759	573	573	554	554	7037	7117	-80	4
5 G.	Std. Cirrus		1	1	869	877	847	873	962	971	814	828	844	847	601	600	964	937	678	678	448	447	7027	7058	-31	5
6 S.	Pik20A		1,025	1,03	1000	1000	861	878	1000	1000	969	975	552	549	531	521	891	865	533	530	672	665	7009	6983	26	6
7 S.	ASW15b		0,995	0,98	810	841	717	766	904	943	818	859	853	878	572	585	806	852	646	661	550	571	6676	6956	-280	7
8 Z.	Std. Cirrus		1	1	889	897	931	958	935	945	946	961	763	766	574	573	331	331	702	702	595	595	6666	6728	-62	9
9 N.	Cirrus G		1	1	841	848	888	914	957	957	848	853	854	858	550	550	530	530	681	681	525	525	6674	6716	-42	8
10 M.	Std. Cirrus		1	1	889	897	970	998	909	918	930	945	806	809	553	553	515	515	372	366	695	695	6640	6696	-56	10
11 J.	H301		1,02	1,02	781	788	681	704	939	948	786	800	784	787	548	544	835	855	646	647	514	514	6514	6587	-73	11
12 K.	Std. Libelle		0,99	0,99	337	334	656	678	806	815	875	890	996	1000	591	586	878	850	479	479	692	692	6310	6324	-14	12
13 S.	Std. Cirrus CS		1	1	890	898	886	912	714	723	942	957	291	288	601	601	452	452	675	676	808	808	6259	6315	-56	15
14 U.	Std. Cirrus		1	1	883	891	921	947	792	801	864	878	277	274	567	554	928	888	240	237	806	806	6278	6276	2	13
15 M.	LS4		1,025	1,04	321	313	1000	1000	993	974	964	951	1000	981	565	530	707	703	299	290	429	411	6278	6153	125	13
16 B.	LS4		1,025	1,04	804	790	813	813	763	746	940	928	666	651	473	458	899	853	298	289	610	589	6267	6117	150	14
17 D.	ASW19b		1	1,01	843	835	720	727	774	765	1000	996	698	688	542	537	318	315	297	290	654	639	5846	5792	54	16
18 S.	LS1f		1,01	1,02	859	852	355	350	927	898	849	845	274	269	516	504	845	821	683	673	586	566	5894	5778	116	17
19 R.	ASW19b		1	1,01	335	328	643	650	815	806	860	856	974	962	594	575	450	446	493	486	663	648	5827	5757	70	18
20 P.	LS7		1,03	1,06	810	775	734	711	996	949	0	0	235	226	524	492	315	307	241	231	687	644	4543	4335	208	19



# Bibliography

- [1] Ronig, Stefan (1995). Überarbeitung des Indexsystems für Segelflugzeuge zur Verbesserung der Chancengleichheit auf Wettbewerben mit unterschiedlicher Leistungsfähigkeit  
*Studienarbeit, Inst. f. Entwurfsaerodynamik, DLR Braunschweig.*
- [2] Horstmann, Karl-Heinz (1976). Neue Modellaufwindverteilungen und ihr Einfluss auf die Auslegung von Segelflugzeugen  
*Vortrag-OSTIV-Congress 1976 Räyskälä (Finnland), Institut für Aerodynamik , DFVLR Braunschweig .*
- [3] Quast, Armin (1977). Mittlere Reisegeschwindigkeit vermessener Segelflugzeuge unter gleichzeitiger Berücksichtigung von vier Modellaufwindverteilungen  
*Akademische Fliegergruppe Braunschweig e.V..*
- [5] Thomas, Fred (1984). Grundlagen für den Entwurf von Segelflugzeugen  
*Lehrbuch, Motorbuch Verlag Stuttgart*
- [6] Rohde-Brandenburger, Kai (2011). Einfluss der Optimierungsgrundlage auf das Wingletdesign am Beispiel des Segelflugzeuges SB 15  
*Studienarbeit, Inst. f. Aerodynamik und Strömungstechnik, DLR Braunschweig.*
- [7] Kassera, Winfried (2011). Flug ohne Motor  
*Lehrbuch, Motorbuch Verlag, Stuttgart*
- [8] FAI (2016). IGC Procedures for Handicapped Classes  
*FAI, Class D (gliders)*