Solving the Speed Run

How we broke through the 200kph barrier

Tijl Schmelzer & Bert Sen. Schmelzer

Preface

Just before Christmas 2014, I was preparing for our gliding trip to Kiripotib Flying Lodge in Namibia. I was updating the list of Belgian, Continental and World records with the newest record claims.

My eye had up till then been set on the "Koninginnenummer": the Open Class 3TP distance. My brother Bert and I had already broken this African record in 2012 in Morocco, but our claim was not ratified due to a silly bureaucratic reason. Because of our story, this bureaucratic process has since then been adjusted by the IGC/FAI, so our experience could not happen again.

However, in the last email of the IGC-mailing list, a new record claim for the free 3TP was just announced, with an impressive distance of 1349.4km, flown by Bostjan Pristavec and Klaus Seemann. This record would be hard to beat. The good news for us though, is that we would be allowed to fly their glider in Namibia: the beautiful EB28 Edition "7".

In this IGC-email, the last claim caught my attention. Laszlo Hegedus had one day before broken Makoto Ichikawa's standing African record on the Speed over a triangular course of 100km. He had improved the record from 171.83km/h to 192.69km/h.

I wondered: "What would be the theoretical maximum for this speed run?"

Tijl

100km FAI triangle

The 100km FAI triangle is the sprint discipline of the gliding athletics. It is very different from all other record categories: it is so simple, that you can optimize it so much that it can be completed almost perfectly according to the MacCready rules. Gliding tactics to deal with risk management are unimportant.

Additionally, all record categories allow for a max difference between start and finish altitude of 1000m. This bonus results in a significant boost in the average speed, as it can be used for a final glide which doesn't have to be "earned" by thermaling. In the 100km triangle, this represents a relatively large part of the flight, and thus has a much larger impact than on the larger triangles and out-and-return categories.

So, the 100km FAI triangle record can be defined as: One Perfect Climb, One Perfect Final Glide.

Its pureness makes it a very interesting theoretical and practical exercise.

However, it has to be said that a significant part of what constitutes gliding is excluded, and, as pilot's decision making skills play a minor role, you don't have to be a world champ to break this record. Much more important is planning, weather forecasting and task setting. And concentration during the execution, off course.

Above all, it's a lot of thrilling fun. The task only takes about half an hour, but this is time is very intense: you are incredibly focused, flying close to VNE, constantly looking at the clock and altimeter, and looking for the best line to get to the finishline as rapidly as possible. To me, it was almost as exciting as the final race of the World Gliding Championships in Rayskala last year.

The rules

The task has to be a triangle with a startpoint, 2 turnpoints and a finishpoint. Since it has to be a closed course, the start and finishpoint have to be the same.

The startline and finishline both are lines of 1km width (500m radius), and the TP sectors are 90 degree sectors with 3km radius.

Each leg has to be at least 28% of the total distance. This means that the largest leg is max 44% of the total distance.

And, finally, as mentioned above, the finish altitude cannot be lower than 1000m under the start altitude.

100km Speed records

Some pilots, amongst whom Hans-Werner Grosse, have lobbied in the past to split up all record categories between thermal and dynamic lift records. It is indeed true that you can't fly as fast, far or high in thermal conditions as in wave. Both are pretty much incomparable, so it's useless to point at the fantastic World Record of 289.4km/h flown in the lee wave of the Andes by Klaus Ohlmann. This is far above the limit possible with thermals.

Luckily for us in this case, there hasn't yet been found a good wave playground in Africa. The 100km speed triangle performance lies thus still within the realm of the thermal flights. And in the last few years, there has been a bit of a rush to knock off seconds of this task.

Overview of African Continental 100km Triangle Progress (Open Class Category):

Speed (km/h)	Time	Date	Pilot	Glider	Location
156.6	38:19	2012/05/31	Laszlo Hegedus	Nimbus 4T	Bitterwasser,NAM
169.8	35:20	2013/03/14	Uys Joncker	JS1C-21m	Tswalu, SA
171.83	34:55	2013/12/11	Makoto Ichikawa	Ventus 2cxm	Bitterwasser,NAM
175.58*	34:10	2014/12/12	Mauro Brunazzo	Quintus M	Bitterwasser,NAM
192.95*	31:08	2014/12/21	Laszlo Hegedus	EB28	Bitterwasser,NAM
205.89*	29:09	2014/01/06	Tijl & Bert Sen. Schmelzer	EB28 Edition	Kiripotib, NAM
Claims – Not yet ratified					*(Times are recalculated to 100km)*

The 200kph barrier

A barrier as artificial as the 1000km mark. However, not a single gliding record in thermal conditions has been completed beyond this boundary, and most likely not a single set task neither. And thus, to me, it made this challenge even more exciting. This would entail finishing within 30 minutes of crossing the startline.

But first, we had to analyze if it was even possible to break this barrier.

Some definitions

Before we start with the analysis, I would like to present you with a few definitions, which are common knowledge for pilots who are used to fly in areas with high cloudbases.

Indicated Air Speed (IAS): is the airspeed you read on your airspeed indicator.

True Air Speed (TAS): Since the air density and pressure decrease with altitude, less air molecules push on the membrane of the airspeed indicator. You are thus flying faster through the air, than airspeed indicates. True Air Speed compensates for this measurement error.

Groundspeed: True Air Speed + Windspeed

In higher altitudes the altitude effect becomes noticeable quickly: the difference between IAS and TAS increases with the square root of the air density.

$$IAS = TAS \sqrt{\frac{\rho}{\rho 0}}$$

With ρ being the density of the air in which the glider is flying, and $\rho 0$ the air density in the International Standard Atmosphere (15°C, 1013.25hPa = 1.225kg/m3).

Since temperature in Namibia is not very cold at cloudbase (mostly above freezing temperature), it is also reasonable to ignore temperature effects in our calculations. The above formula can thus be changed to a, for us easier to use, formula:

$$IAS = TAS \sqrt{\frac{Air\ Pressure}{Std.Pressure}}$$

With Std. Pressure being 1013.25 hPa

It is also reasonable to use the ICAO standard atmosphere (a standardized scale of how pressure changes with altitude) for calculations. An approximation for the ICAO standard atmosphere is given by the following formula:

$$Air\ Pressure = (1/100)\left(\frac{(Altitude(m) - 44330.8)}{4946.54}\right)^{1/0.1902632} hPa$$

For example, using these formula's, an IAS of 200km/h at 5000m (540hPa), would be equal to a TAS of 273.96km/h.

The importance of these definitions will be shown later on.

Quick analysis of Laszlo Hegedus' Record Claim flight

So, this analysis started with taking a closer look at the best performance up till then. Laszlo Hegedus is a member of the Hungarian National team, and has competed in many WGC's. He holds the World Record of the Speed over triangular course of 1250km at 151.1km/h. (Bitterwasser, NAM on Nimbus 4t) This is currently one of only two open class world record NOT flown in wave!

During his 100km record flight, he made two attempts, and in the final one he flew a speed of 192.95km/h.

The vital statistics on this run, with my short comments:

Statistic	Value	Unit	Comment
Task Length	119.3	km	Why longer than 100km?
Legs	32.0%-37.6%-30.4%		Doesn't look optimal.
Cloudbase	5073	m	
Start Alt.	4875	m	
Finish Alt.	4078	m	
Alt. Difference	797	m	203 meter left over.
# of Climbs	1		Good
Climb Rate	4.8	m/s	Very powerful!
Alt. Gain	600	m	Low
Time In Climb	02:06		Very low
Total Distance	125.1	km	
Detours	5.8	km	
Detours	4.86%		Low for normal flight, rather average high for 100km speed
Mean L/D	88		Very high
Total Avg. Groundspeed	215	km/h	Too low
Total Avg. IAS	172	km/h	Too low
Rising Avg. GS	184	km/h	About right
Rising Avg. IAS	151	km/h	About right
Sinking Avg. GS	232	km/h	Way too low
Sinking Avg. IAS	183	km/h	Way too low

My main conclusions from this flight, is that it is very good, but not perfect. The climb rate and mean glide ratio are extremely high. However, the glidespeed in sinking air is too low speed (as I will show in the MacCready calculations). Furthermore, the finish was too high.

So there is still room for improvement.

Optimization

The EB28 Edition

All gliding optimization calculations start with the polar of the glider at hand.

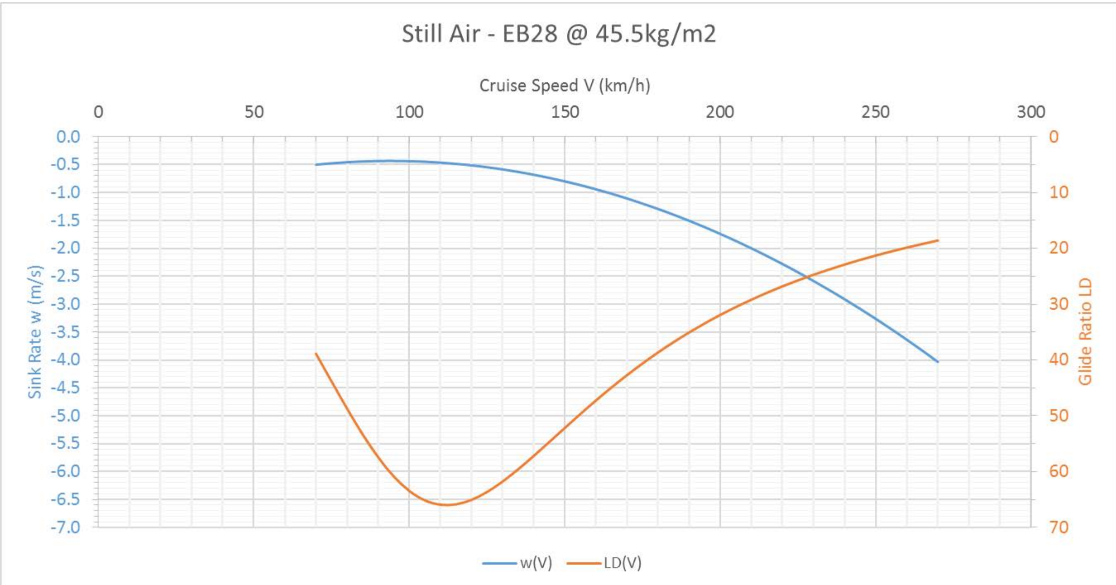
The quadratic approximated sink polar is defined as:

$$w = a\,V^2 + b\,V + c$$

With V the airspeed (km/h), and w the corresponding sinkspeed (m/s). By dividing airspeed V by sinkspeed w, we get the glide (LD) polar.

The a, b and c coefficients are inherent to each glider and wingloading, and the one used for the EB28 edition at min. weight are a = -0.00011616 , b = 0.02182417 , c = -1.4585725

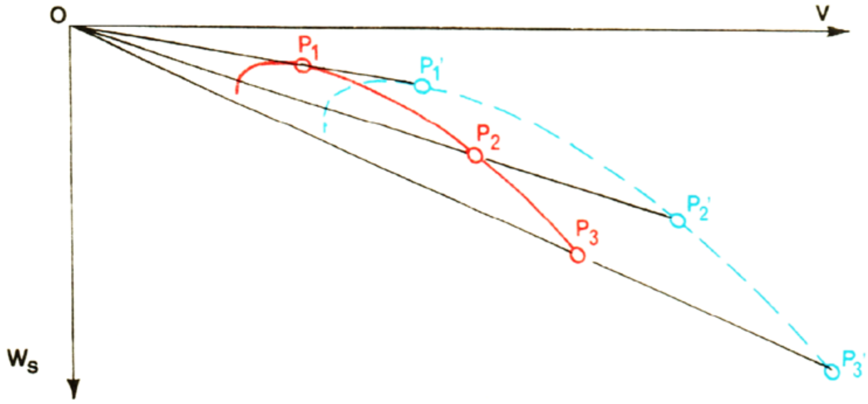
Note that a, b and c values are different from your flight computer or analysis software values, because of different units used in these formulas. They still represent the same polar.



This sink and glide ratio polar seem to be a bit optimistic at low speeds (max LD 65.5), however, I think it is realistic in the speed range that matters for this flight (150km/h – 250km/h IAS).

The effect of waterballast

Off course, weight of the glider affects the polar. If we increase or decrease the weight, for instance by adding water ballast, the polar will change. Because of the underlying aerodynamical physics, this change can be very well approximated by scaling the original sink polar around the origin.



The scaling factor W is:

$$W = \sqrt{\frac{Weight\ New}{Weight\ Original}}$$

For the a, b and c coefficients of the sinkpolar the effect is:

$$a' = \frac{a}{W}$$

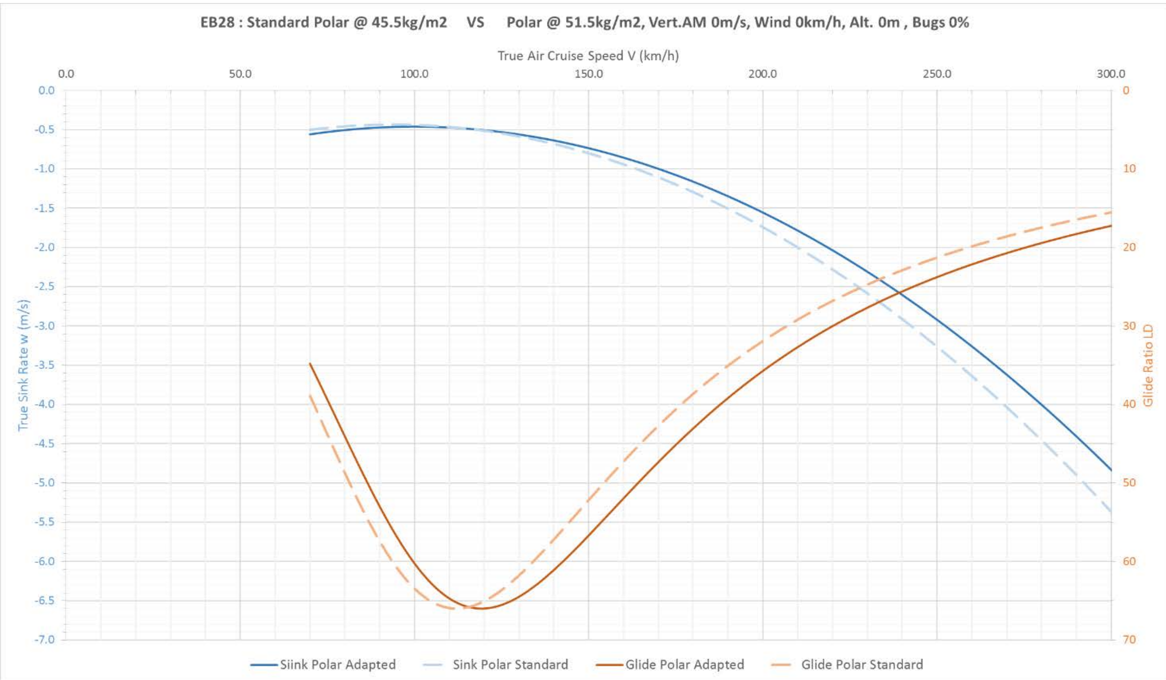
$$b' = b$$

$$c' = Wc$$

If you inquire the effects of this formula, you find that a weight increase does not affect the glide ratio of a glider, it just increases the airspeed at which the best glide ratio can be found. In reality, a weight increase does in fact increase the glide ratio slightly due to flying at higher Reynolds numbers. This, rather small, effect is thus neglected in all glide computers and optimization programs.

Off course, since minimum sink will be higher (and at a higher speed), climbrates in thermals will suffer a bit.

For the 100km speed run, which can only be flown in fantastic conditions, a glider cannot be heavy enough. We will thus need to fly the EB28 at 850kg, with a wingloading of 51.5kg/m2. The resulting polar can be found in the following figure.



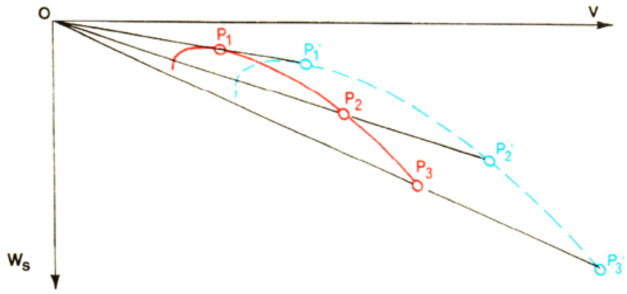
The altitude effect

Altitude not only has a tremendous effect on the IAS measurement, but also on the real sinkpolar and glide polar.

At higher altitude, less air molecules are available to carry the plane. This means the sink speed of the glider will increase with altitude.

But also, there are less air molecules to hold the glider back. Drag is thus reduced as well, making it easier to fly faster.

The net impact of both sink and forward speed can be expressed exactly in the same way as adding waterballast to the glider: it is a scaling of the sink polar around the origin.

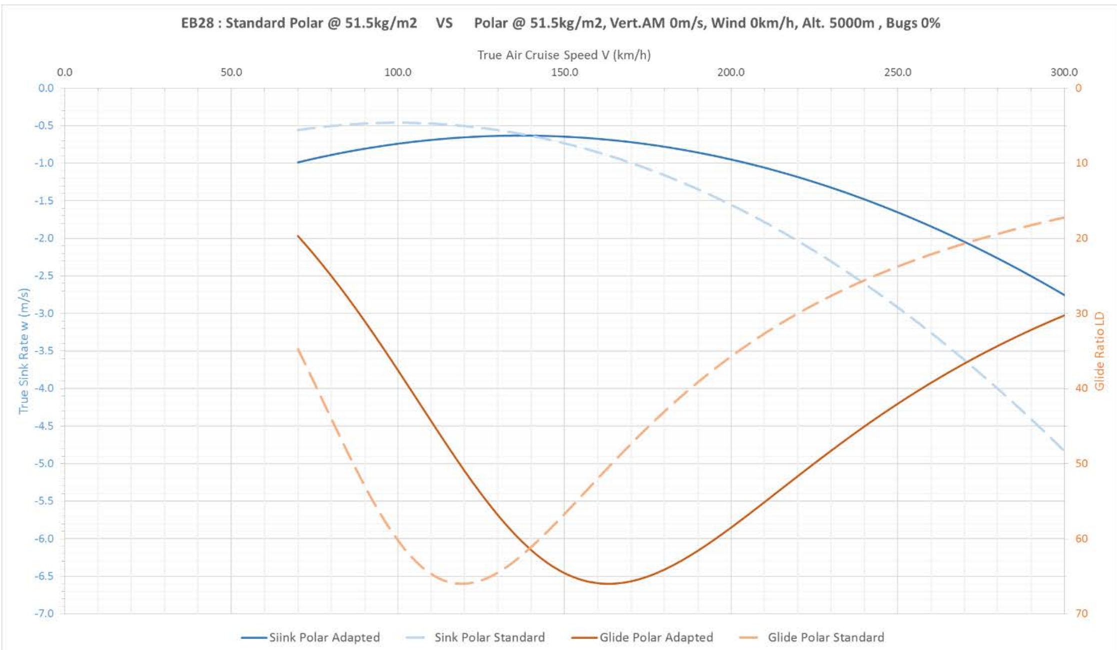


The scaling factor P you are already familiar with:

$$P = \sqrt{\frac{Air\ Pressure}{Std.\ Pressure}}$$

This again ignores secondary temperature effects. And the formula also ignores the small increase in glide ratio in altitude due to the higher Reynolds numbers.

So this altitude effect, a part from the great climb rates, is one of the main reasons people fly so fast in Namibia. As a comparison: the polar of an EB28 at 5000m at 51.5kg/m2 (850kg) corresponds to an EB28 at sea level at 97kg/m2 (1600kg)!



Something else that is important related to the altitude effect: How does the redline change with altitude?

This is an engineering question, which is much more difficult to answer in general. It has to do with the damping effects on flutter of the airmass and many other factors. Normally, the manufacturer of the glider includes a table with the change of max IAS with altitude. For the EB28 Edition, the max IAS decreases from 285km/h at sea level to 245km/h at 5000m. This corresponds with an increase of TAS to 335.6km/h!

For the yellow line, such a table is not commonly available, so common sense prevails. I would not fly at IAS 245km/h in 5000m trough a 5m/s thermal.

So, the question becomes: How does the altitude effect affect MacCready rules and Speed To Fly?

You know that, when you increase waterballast, your Speed To Fly for a certain MacCready Value increases as well. That's why you have to always put in the right wingloading into your flightcomputer.

Since the altitude effect on the polar is similar to the addition of waterballast, you might deduce that you should also fly faster in higher altitude for the same MC setting. And in fact, such is the case. However, we are talking in terms TAS, not IAS!

A following explanation can be often heard or even found in textbooks: "Quite neatly, the altitude effect on Speed To Fly, and the altitude effect on the difference between IAS and TAS cancel each other out. So we can use the IAS measurement for the Speed To Fly as calculated for sea level. This makes it easy, so we just can keep our STF steady looking at the airspeed indicator, while descending during a glide."

However, this is not true! The following tables shows the optimal speed to fly in IAS and TAS in 4 altitudes (0m, 3000m, 4000m, 5000m) for a MacCready Value of 4.5m/s, in still air, and with vertical airmass movement (+3m/s, +2m/s, +1m/s, +0.5m/s, 0m/s, -0.5m/s, -1m/s, -2m/s, -3m/s):

Optimal Speed To Fly EB28Edition@51.5kg/m2

IAS **MC4.5**

	0m	**3000m**	**4000m**	**5000m**
3.0	167	160	158	156
2.0	193	182	179	176
1.0	215	202	198	194
0.5	225	211	207	202
Still Air	235	220	215	210
-0.5	245	229	223	218
-1.0	254	237	231	226
-2.0	272	252	246	240
-3.0	288	267	260	254

TAS **MC4.5**

	0m	**3000m**	**4000m**	**5000m**
3.0	167	192	202	213
2.0	193	219	230	241
1.0	215	243	254	266
0.5	225	254	265	277
Still Air	235	265	276	288
-0.5	245	275	286	299
-1.0	254	285	297	309
-2.0	272	303	316	329
-3.0	288	321	334	347

Although modern flight computers could in theory incorporate this, most if not all currently still ignore this secondary effect, as it is not really that important for the vast majority of our performances. In the case of the perfect 100km speed run, it is.

From the table you can see, that STF based on IAS decreases with altitude. Based on TAS it, off course, increases with altitude.

Interestingly, in 5000m with MC4.5, even if you fly through a decent thermal of 2.0m/s during your glide, while your IAS should not go below 176km/h, your TAS should not go below 241km/h! This means that you have to keep your speed up, even while crossing decent climbs. In reality, this is even more pronounced, since dynamic transition losses are not accounted for in these formulas. Thus: don't pull too much while crossing climbs.

Additionally, there is also the issue that the same IAS-TAS difference because of altitude can also be found in certain variometer types. Some vario's show not the real climb and sink rates. And this has an effect on correct MC Value setting. I'd like to refer to Reichmann's Streckensegelflug for more information on that. Most modern common electric vario's do measure true climb and sink rates.

How does this all translate into cross country average speeds?

If we look at the case where there is no vertical airmass movement, the following tables give the summation for Sea level and 4000m:

Sea level	**Climbrate**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**m/s**
	STF TAS = IAS	204	215	225	235	245	254	263	**km/h**
	Sinkspeed True	-1.65	-1.91	-2.18	-2.47	-2.76	-3.06	-3.36	**m/s**
	LD	34.4	31.3	28.7	26.5	24.7	23.1	21.7	
True XC	**Alt.Loss**	-2905	-3195	-3484	-3770	-4053	-4331	-4605	**m**
	TimeToClimb	16.1	15.2	14.5	14.0	13.5	13.1	12.8	**min**
	TimeToCruise	29.4	27.9	26.6	25.5	24.5	23.6	22.8	**min**
	TotalTime	45.5	43.1	41.1	39.5	38.0	36.7	35.6	**min**
	XCSpeed	131.8	139.2	145.9	152.1	157.9	163.3	168.5	**km/h**
With 1000m diff.	**Alt.Loss**	-1905	-2195	-2484	-2770	-3053	-3331	-3605	**m**
Start-Finish	**TimeToClimb**	10.6	10.5	10.4	10.3	10.2	10.1	10.0	**min**
	TotalTime	40.0	38.4	37.0	35.7	34.7	33.7	32.8	**min**
	Avg. Speed	150.1	156.5	162.3	167.8	173.1	178.0	182.8	**km/h**

4000m	**Climbrate**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**m/s**
	STF TAS	242	254	265	276	286	297	306	**km/h**
	STF IAS	189	198	207	215	223	231	239	**km/h**
	Sinkspeed True	-1.70	-1.94	-2.19	-2.45	-2.73	-3.01	-3.29	**m/s**
	LD	39.6	36.4	33.6	31.2	29.2	27.4	25.8	
True XC	**Alt.Loss**	-2523	-2748	-2975	-3201	-3427	-3650	-3872	**m**
	TimeToClimb	14.0	13.1	12.4	11.9	11.4	11.1	10.8	**min**
	TimeToCruise	24.8	23.6	22.6	21.7	20.9	20.2	19.6	**min**
	TotalTime	38.8	36.7	35.0	33.6	32.4	31.3	30.3	**min**
	XCSpeed	154.6	163.4	171.3	178.6	185.4	191.7	197.7	**km/h**
With 1000m diff.	**Alt.Loss**	-1523	-1748	-1975	-2201	-2427	-2650	-2872	**m**
Start-Finish	**TimeToClimb**	8.5	8.3	8.2	8.2	8.1	8.0	8.0	**min**
	TotalTime	33.3	32.0	30.9	29.9	29.0	28.3	27.6	**min**
	Avg. Speed	180.4	187.7	194.5	200.7	206.7	212.3	217.6	**km/h**

Now this is uplifting news! According to this, with a realistic 4.5m/s climb rate, and an average altitude of 4000m during the flight, an average speed of 200.7 km/h should be possible. Even without cloudstreeting and energy lines!

Also, notice that the average speed bonus of the 1000m altitude difference between start and finish is about 20km/h. So, people thinking the 100km triangle is just a simple final glide, and nothing to it, are wrong. Beating the 200km/h barrier, still means flying above 180km/h true average XC speed, albeit over a relatively short distance!

Unfortunately, some things are not taken into account:

- Detours: in a normal flight, you fly 5-10% more km than the task distance because the optimal line is very rarely straight on course. In the 100km speed run, each % detour, results in a bit more than a 2km/h speed loss. A realistic value lies between 2.5-5%, so 5-10km/h speed loss.

- You lose speed while cornering around the turning points. First you have to slow down and speed up again, which results in dynamic losses as well as deviating from optimal STF. And, secondly, you have to fly a bit (about 250m) beyond the turnpoint. To be certain to have a log fix within the turnpoint sector. I estimate the losses to be ca 1.5km/h per turnpoint, so 3km/h in total. This part can be included in the detours.

- The pilot, nor the glider is perfect. At these high speeds, small imperfections (deviations from optimal STF, time to center climb, slipping, not using total 1000m buffer,…), cause significant losses in average speed. It is hard to estimate exactly how much, but I think it should be in the range of 5-10km/h.

Adding these three losses together we come to a realistic max speed on the 100km triangle of 13-25km/h.

This reduces the attainable record speed to 175-188km/h with a realistic 4.5m/s climb, and 187-199km/h with a fantastic 5.5m/s climb.

Luckily, there are some pieces of the puzzle left in the bag.

Dynamic pull

There is no max limit to the startspeed, and no min limit to the finishspeed. You could thus start at VNE, and finish with stall speed. In a normal flight, this is quite unimportant, but, in the 100km task, it can be vital!

In a real situation, you would start at 4500m with IAS 235km/h (TAS 311km/h), and finish in 3500m with IAS 110km/h (TAS 137km/h). You would off course pull up a bit from IAS 235km/h to ca IAS 215km/h just after the start, and from IAS 215km/h to IAS 100km/h just before the finish. But for simplicity, it is easier to see it as one pull-up.

How does speed convert to altitude? Ignoring second order air resistance effects, the physics are quite simple by equating kinetic and potential energy:

$$E\,\frac{m\,V^2}{2} = mgh$$

With m mass, V True Air Speed in m/s, dimensionless E dynamic transition efficiency, g gravitational constant 9.8m3/(kg.s2) , and h altitude in m.

Since the efficiency of a single transition in a glider is rather efficient, we can arbitrarily put this at 90%. This value is likely a bit too conservative.

Since the mass can be scrapped from both sides, this becomes:

$$\Delta h = E\,\frac{V0^2 - V^2}{2g}$$

with V0 the original speed in m/s, and Δh the change in altitude.

Filling in the above speeds of 311km/h and 137km/h, gives us a Δh of 300m.

Off course, it is impossible to do and time this maneuver perfectly, so let’s round it down to 200m. The following table shows the effect on the average speed:

4000m	Climbrate	3	3.5	4	4.5	5	5.5	6	m/s
	STF TAS	242	254	265	276	286	297	306	km/h
	STF IAS	189	198	207	215	223	231	239	km/h
	Sinkspeed True	-1.70	-1.94	-2.19	-2.45	-2.73	-3.01	-3.29	m/s
	LD	39.6	36.4	33.6	31.2	29.2	27.4	25.8	
True XC	Alt.Loss	-2523	-2748	-2975	-3201	-3427	-3650	-3872	m
	TimeToClimb	14.0	13.1	12.4	11.9	11.4	11.1	10.8	min
	TimeToCruise	24.8	23.6	22.6	21.7	20.9	20.2	19.6	min
	TotalTime	38.8	36.7	35.0	33.6	32.4	31.3	30.3	min
	XCSpeed	154.6	163.4	171.3	178.6	185.4	191.7	197.7	km/h
With 1000m diff.	Alt.Loss	-1523	-1748	-1975	-2201	-2427	-2650	-2872	m
Start-Finish	TimeToClimb	8.5	8.3	8.2	8.2	8.1	8.0	8.0	min
	TotalTime	33.3	32.0	30.9	29.9	29.0	28.3	27.6	min
	Avg. Speed	180.4	187.7	194.5	200.7	206.7	212.3	217.6	km/h
With 1000m diff.	Alt.Loss	-1323	-1548	-1775	-2001	-2227	-2450	-2672	m
Start-Finish	TimeToClimb	7.4	7.4	7.4	7.4	7.4	7.4	7.4	min
and Pull-Up	TotalTime	32.1	31.0	30.0	29.1	28.4	27.7	27.0	min
	Avg. Speed	186.7	193.5	199.9	205.8	211.5	216.9	222.1	km/h

The Pull-up gives us thus an additional 5km/h bonus. We are now nearing the possibility of the 200km/h barrier, but only with a 5.5m/s climb.

Cloudstreeting

Luckily, there are cloudstreets and energylines. This will be the final piece of the puzzle to the 100km record. But also the hardest to put into a model.

Energylines shift the sink polar upwards, with its upward velocity. This means that your glide ratio will improve tremendously. The longer, and the better the patches of rising air, the more we can boost our average speed. So, what does a realistic Cloudstreet look like?

For this we would need a general distribution of vertical airmass movement along the track. My preferred method for this, would be using actual flight data of a good flight. However, to extract the airmass movement from an IGC-file, a dynamic model would be needed, and I am not aware of such software currently existing.

Generally, I would split up the data in rising and sinking parts, and regard both of these parts as two separate homogenous blocks. The parameters could then be extracted from SeeYou.

However, SeeYou’s paramaters are not derived from a dynamic model, and as such, netto climb and sink rates are exaggerated due to “Knuppeltermik”. In moderate European circumstances on a 300km+ flight, this is not a big issue. For the purposes presented here, the skew in the data becomes very large.

In this case, I thus prefer to see the whole airmass as one homogenous entity. The vertical movement is then derived from comparing the actual average sinkrate during the total glide, to the sinkrate connected to the actual average glidespeed as derived from the theoretical EB28 polar in the average altitude.

In this way, the effect of dynamic transitions is eliminated. The model thus becomes a bit less accurate, but more robust. In reality, one would fly slower than the model STF in rising parts, and faster than the STF in sinking parts. In reality, the glide angle, and the final average task speed would both be a bit (a few km/h) higher. This is important keep in mind looking at the following pages.

To find realistic values, we can use the values of Laszlo Hegedus’ record flight:

Alt. Loss in Glide	-1414	m
Time Glide	1982	sec
Average Sinkrate	-0.71	m/s
Average Glidespeed TAS	215	km/h
Polar Sinkrate for that TAS	-1.17	m/s
Netto Avg. Airmass movement	**0.46**	m/s

Analysis and optimization of the 192.95km Record Claim

The actual performance

Putting all data in the simple model delivers a resulting time (37:20) and speed of 191.7km/h very close to the actual record claim (37:05) and 192.95km/h.

From previous experience with using this simple model, this accuracy is not uncommon, since it is fitted to the polar.

Also the glide ratio from the model (84) and reality (88) are very close, as well as the climb height in thermals (691m vs 600m).

So, now that the model works, and since we have a real life scenario, we can start optimizing.

Taskparameters			
	Taskdistance	119.3	km
	Total Distance	125.1	km
	De-tours	4.86%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	803	m
	Climbrate	4.76	m/s
	Netto cloud streeting climb	0.46	m/s

Calculations			
Thermalling	Average netto climb	5.56	m/s
Glide	GlideSpeed TAS	215	km/h
	GlideSpeed IAS	162	km/h
	Sinkspeed True	-0.71	m/s
	Time Glide	34.9	min
	Altitude loss	-1494	m
	Time Climb	5.2	min
Finalglide	Time not climb	-2.8	min

Output		
timeclimb	2.4	min
Altclimb	691	m
timeglide	34.9	min
LD	84	
Total time	**37:20**	**min:sec**
Average Speed	**191.7**	**km/h**

Flying the perfect MacCready Speed To Fly

The first, and most important part is the perfection of STF. The main improvement would be changing the average glidespeed from 215km/h TAS to the optimal STF of 278km/h TAS (210 km/h IAS). The result of doing only this, would lead to an average speed of 204.8km/h!

However, glide ratio decreases to 41, and required altitude to climb to 2264m, which could not be done using a single thermal (see discussion between 1 and multiple thermals later on)!

Keep in mind, that this a hindsight optimization. And hindsight is 20/20.

Taskparameters			
	Taskdistance	119.3	km
	Total Distance	125.1	km
	De-tours	4.86%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	803	m
	Climbrate	4.76	m/s
	Netto cloud streeting climb	0.46	m/s

Calculations			
Thermalling	Average netto climb	5.56	m/s
Glide	GlideSpeed TAS	278	km/h
	GlideSpeed IAS	210	km/h
	Sinkspeed True	-1.89	m/s
	Time Glide	27.0	min
	Altitude loss	-3067	m
	Time Climb	10.7	min
Finalglide	Time not climb	-2.8	min

Output		
timeclimb	7.9	min
Altclimb	2264	m
timeglide	27.0	min
LD	41	
Total time	**34:57**	**min:sec**
Average Speed	**204.8**	**km/h**

Watching the red line

If we use a bit more conservative glidespeed of TAS 260km/h (IAS 196 km/h), and glidespeed), the average speed would still have been 203.9km/h, but Glide ratio would be a healthy 48, and required altitude to climb in the thermal 1738m.

Taskparameters			
	Taskdistance	119.3	km
	Total Distance	125.1	km
	De-tours	4.86%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	803	m
	Climbrate	4.76	m/s
	Netto cloud streeting climb	0.46	m/s

Output		
timeclimb	6.2	min
Altclimb	1783	m
timeglide	28.9	min
LD	48	
Total time	**35:07**	**min:sec**
Average Speed	**203.9**	**km/h**

Calculations			
Thermalling	Average netto climb	5.56	m/s
Glide	GlideSpeed TAS	260	km/h
	GlideSpeed IAS	196	km/h
	Sinkspeed True	-1.49	m/s
	Time Glide	28.9	min
	Altitude loss	-2586	m
	Time Climb	9.1	min
Finalglide	Time not climb	-2.8	min

Using the whole 1000m buffer and Pulling-Up before the finishline

Now, if we optimize this further, by using up 950m of the 1000m altitude difference, instead of the 803m used, and additionally adding the 200m of the pull-up before the finishline, we can increase the average speed further to 211.2km/h.

Taskparameters			
	Taskdistance	119.3	km
	Total Distance	125.1	km
	De-tours	4.86%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	1150	m
	Climbrate	4.76	m/s
	Netto cloud streeting climb	0.46	m/s

Calculations			
Thermalling	Average netto climb	5.56	m/s
Glide	GlideSpeed TAS	260	km/h
	GlideSpeed IAS	196	km/h
	Sinkspeed True	-1.49	m/s
	Time Glide	28.9	min
	Altitude loss	-2586	m
	Time Climb	9.1	min
Finalglide	Time not climb	-4.0	min

Output		
timeclimb	5.0	min
Altclimb	1436	m
timeglide	28.9	min
LD	48	
Total time	**33:54**	**min:sec**
Average Speed	**211.2**	**km/h**

Why fly more than necessary?

A next step, is reducing the task distance from 119.3km to 101km. This improves the average speed already to 215.9km/h!

And now, the altitude needed to climb is reduced to a very manageable 1038m, possible to do in a single climb!

This flight would thus have been possible in these circumstances (however, we would have needed to start 300 meter lower, but, this discussion will follow later).

Taskparameters			
	Taskdistance	101	km
	Total Distance	105.9	km
	De-tours	4.83%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	1150	m
	Climbrate	4.76	m/s
	Netto cloud streeting climb	0.46	m/s

Output		
timeclimb	3.6	min
Altclimb	1038	m
timeglide	24.4	min
LD	48	
Total time	**28:04**	**min:sec**
Average Speed	**215.9**	**km/h**

Calculations			
Thermalling	Average netto climb	5.56	m/s
Glide	GlideSpeed TAS	260	km/h
	GlideSpeed IAS	196	km/h
	Sinkspeed True	-1.49	m/s
	Time Glide	24.4	min
	Altitude loss	-2188	m
	Time Climb	7.7	min
Finalglide	Time not climb	-4.0	min

Perfect weather

The 192.95km/h record claim was flown in very good, but not perfect weather. What would be the ultimate weather for the 100km speed triangle?

This question is off course impossible to answer 100% correctly, but we can make a good realistic guess, by increasing the Climbrate from 4.76m/s to a fantastic but possible climb of 5.5m/s, and additionally increasing the Netto cloud streeting climb rate from 0.46 to 0.75m/s.

At the same time, we decrease the detours to 3.5%.

In this case, the max attainable average speed increases to 236.3km/h, and I think this should be pretty close to the theoretical max record speed in thermal conditions on the EB28 Edition.

However, this would be extremely difficult to do in reality!

Taskparameters			
	Taskdistance	101	km
	Total Distance	104.5	km
	De-tours	3.50%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	1150	m
	Climbrate	5.50	m/s
	Netto cloud streeting climb	0.75	m/s

Calculations			
Thermalling	Average netto climb	6.30	m/s
Glide	GlideSpeed TAS	287	km/h
	GlideSpeed IAS	217	km/h
	Sinkspeed True	-1.84	m/s
	Time Glide	21.8	min
	Altitude loss	-2410	m
	Time Climb	7.3	min
Finalglide	Time not climb	-3.5	min

Output		
timeclimb	3.8	min
Altclimb	1260	m
timeglide	21.8	min
LD	43	
Total time	**25:38**	**min:sec**
Average Speed	**236.3**	**km/h**

Flying an EB29 with 25.3m span @ 61.7kg/m2

What if we would switch gliders to the single seater EB29, with short wingspan at the higher max take-off weight of 900kg?

With a roughly estimated decrease in climb rate of 0.1m/s compared to the lighter EB28 edition, the max average speed in perfect weather would increase to an incredible 258.5km/h!

To reach this speed, however, one would need to fly beyond the red line in sink.

Taskparameters			
	Taskdistance	101	km
	Total Distance	104.5	km
	De-tours	3.50%	
	Average Altitude	4500	m
	Altitude Effect Factor	1.32	
	Start-Finish Alt Difference	1150	m
	Climbrate	5.40	m/s
	Netto cloud streeting climb	0.75	m/s

Output		
timeclimb	3.7	min
Altclimb	1197	m
timeglide	19.8	min
LD	45	
Total time	**23:27**	**min:sec**
Average Speed	**258.5**	**km/h**

Calculations			
Thermalling	Average netto climb	6.30	m/s
Glide	GlideSpeed TAS	318	km/h
	GlideSpeed IAS	240	km/h
	Sinkspeed True	-1.98	m/s
	Time Glide	19.8	min
	Altitude loss	-2347	m
	Time Climb	7.2	min
Finalglide	Time not climb	-3.5	min