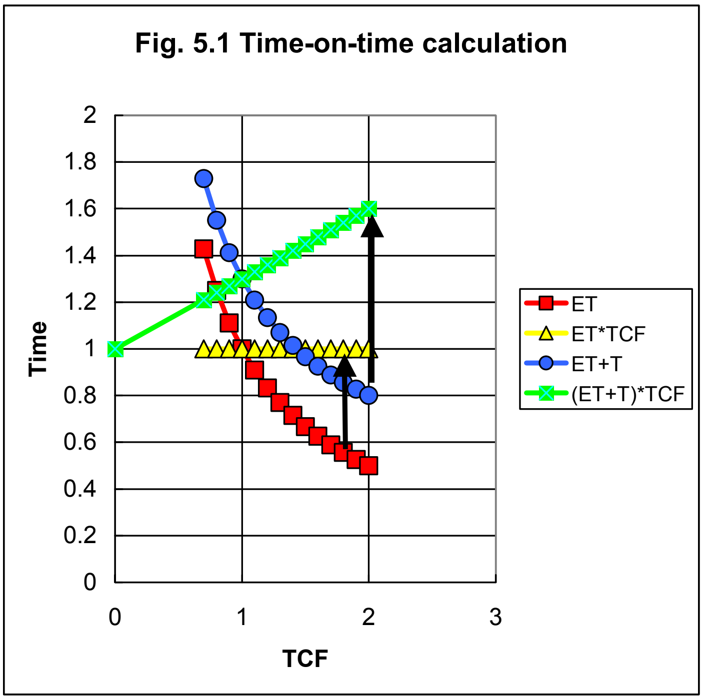
Chapter 5

5 Corrected time errors and IDEAL TIME calculation



In most cases the weather conditions are such that either the smallest or the largest boats in the class will be favoured by the weather. One typical example of such favouring is when there is a period of calm weather in the race and time-on-time scoring is used. Then

CT = (ET + T) * TCF = ET * TCF + T * TCF Eq 5.1

where T is the duration of the calm period.

The elapsed times are then ET + T (the blue curve in Figure 5.1) and the corrected time ET * TCF + T * TCF (the green line in Figure 5.1). Therefore the larger the TCF the more extra corrected time is added by the calm period, and the larger boats suffer more than the smaller ones.

An example of such a favouring of the smallest boats is given in Figure 5.2, illustrating the results from Toyota Truck Skagerak Cup in 1991. Here the red data illustrate the elapsed times, and the blue data illustrate the corrected times from a time-on-time calculation. The regression line through the corrected times shows that the smallest boat was favoured by 3 hours and 51 minutes and 35 seconds. The difference in LYS between the largest and smallest boat was dL = 0.23, and then we can calculate the calm time T as T = 231.58/0.23 = 1006.85 minutes = 16 hours and 47 minutes. This corresponds to 231.58*60/170=81.7 sec/NM. This bias equals the difference between an ILC 40 and a Farr 31, so there are no small biases we are dealing with. Actually, as you can see in Figure 5.2, in this race it would have been equally bad to score the race by putting corrected time equal to elapsed time, but then the results list would have been turned upside down, and the largest boat would have won. I participated in this race, and the calculated period of calm weather corresponds well with my experience from the race. Since I was racing the largest boat in the race and was scored second to last, in spite of the fact that we did not sail so badly, I started to study the different kinds of favouring of the larger or smaller boats. **I then found that in hardly any race the regression of corrected times was horizontal.** In

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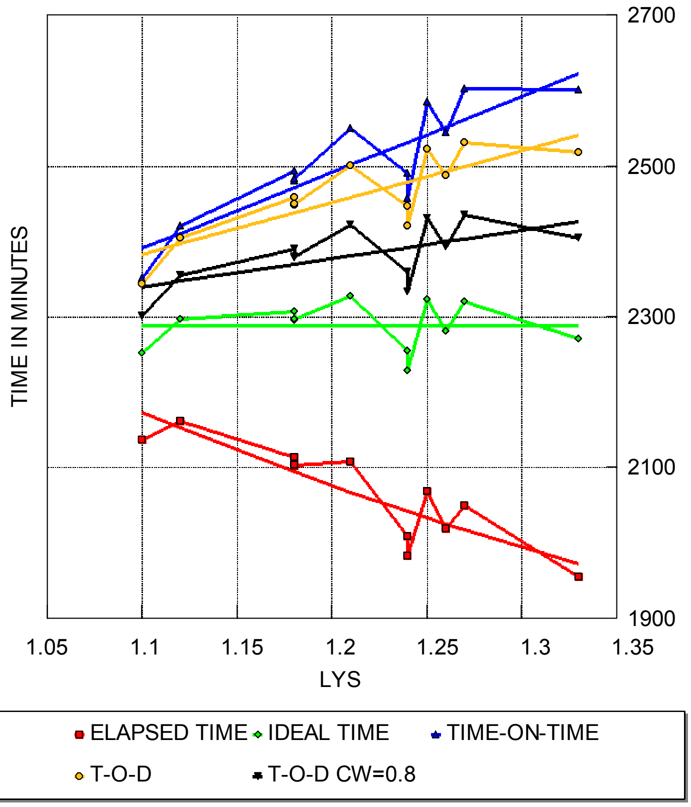
Fig. 5.2 Toyota Truck Skagerak Cup 1991



almost every race there is a heavy favouring of the largest or smallest boats. The most common reasons are:

1 A calm period favours the smallest boats in a time-on-time-calculation. Time-on-distance sometimes is a better method for this situation, since it is not affected by a calm period
2 Increasing wind speed generally favours the smallest boats, since they sail in stronger average wind.
3 Increasing wind speed from behind may favour the smallest boats, while increasing head winds may give a favouring of the largest boats.
4 Decreasing wind speed usually favours the largest boats, since they sail in stronger average wind speed. Sometimes the smallest boats do not even manage to finish, when the wind drops completely. Typically in evening races the wind drops and favours the largest boats. One way of compensating for this is to start the larger boats later than the smaller ones, and try to adjust the starting time so the smaller and larger boats finish at the same time.
5 The wind speed when the boats finish has a large influence on the results. Strong wind at the finish makes time differences smaller, and this favours the smallest boats. Light wind at the finish makes large time differences, and this favours the largest boats.

I then asked myself if there is a method to compensate for these unfair conditions, and calculate a corrected time, which will always give a horizontal regression of corrected time, when plotted against the handicapping number. What happens if we use time-on-distance on this race? LYS is very close to

LYS = 800/IMSGPH Eq 5.2

and we may therefore calculate

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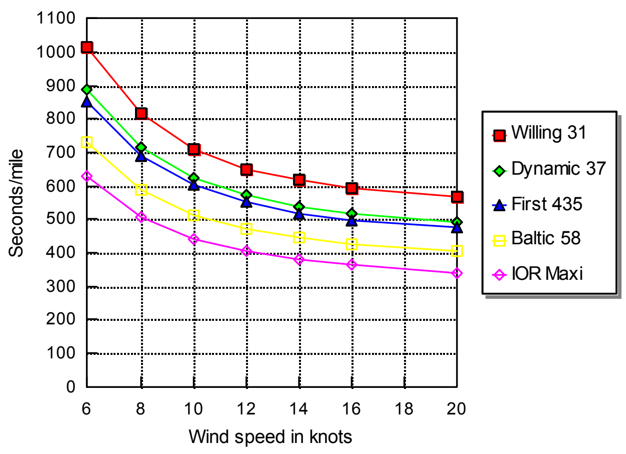
CT = ET - 800/L*NM + 800/L_1*NM Eq 5.3

Setting L_1 = 1 and NM = 170 gives

CT = ET - 800*170*(1/L-1). Eq 5.4

This result is shown in Figure 5.2 (orange curve) and Table 5.5. As you can see, in this case time-on-distance is about equally bad as time-on-time, even if time-on-distance is not affected by the calm period. One reason is that the wind speed for the period of the race when it was blowing was not average, but it was fairly heavy weather. **This illustrates that time-on-distance gives completely wrong results, if the calculation is not corrected for wind speed. There is a widely spread misunderstanding that time-on-distance can be used without such a correction. As soon as the wind speed is below or above the average wind speed for which the rating is valid, time-on-distance gives gross errors.**

Figure 5.3 Performance Curves for smaller and larger boats



Even if the wind speed is constant throughout the race, time-on-distance is wrong most of the time, while time-on-time is much more correct most of the time.

Table 5.1 Wind speed correction factor CW for time-on-distance calculations

Wind speed in knots	6	8	10	12	14	16	20
CW	1.40	1.14	1.00	0.92	0.87	0.84	0.80
Eq 5.6	1.40	1.13	1.00	0.93	0.88	0.84	0.80

It is easy to understand why this is true. If you look at performance curves from IMS, like the ones in Figure 5.3, they vary a lot with wind speed, and the curves for smaller and larger boats are approximately proportional. Therefore the difference in seconds/mile between a large and a small boat is larger in light wind speeds than in strong wind speeds. A single handicapping number is valid only for average wind speeds. For light wind speeds the expected elapsed time to be subtracted from the actual elapsed time in a time-on-distance calculation should be larger, and for strong wind speeds it should be lower than for average conditions. Therefore the time differences between larger and smaller boats are underestimated in light wind speeds and overestimated in heavy wind speeds. This leads to a favouring of the

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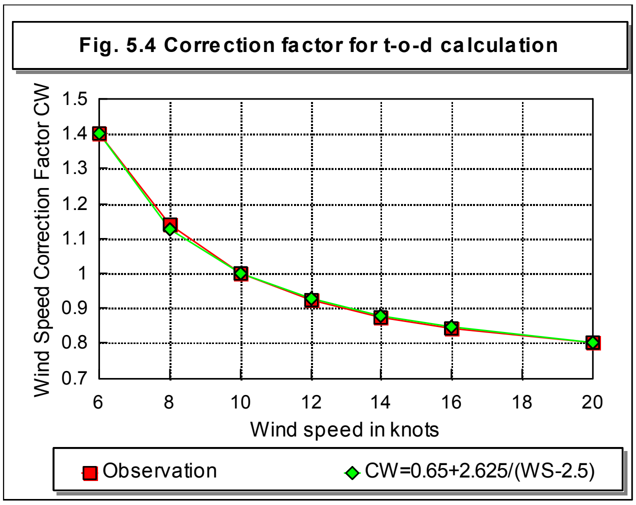

Fig. 5.4 Correction factor for t-o-d calculation

bigger boats in light winds and the smaller boats in strong winds. The latter case is illustrated in Figure 5.2 from Toyota Truck Skagerak Race 1991, when the wind was well above average in the period it was blowing.

It is very simple to make a good correction for wind speed when you use time-on-distance.

Table 5.1 and Figure 5.4 show a correction factor CW for wind speed derived from Circular Random Performance Curves from 100 IMS certificates. As you can see, CW varies quite a lot. In 6 knots wind TA should be multiplied by 1.40, and in 20 knots wind TA should be multiplied by 0.80. This means that differences between larger and smaller boats are about 40% larger in 6 knots wind, and about 20% lower in 20 knots wind, as compared to 10 knots wind. Obviously this leads to large biases if you do not take it into account. The time-on-distance formula then becomes

CT = ET - CW*TA + CW*RT. Eq 5.5

Generally speaking this is the only reasonable way of using time-on-distance, unless you use the more sophisticated IDEAL TIME method described below.

The following simple formula gives reasonably accurate values of CW. See Table 5.1 and Figure 5.4.

CW = 0.65 + 2.625/(WS - 2.5) Eq 5.6

Where WS is the wind speed in knots.

To demonstrate the errors introduced by time-on-distance with no wind speed correction, let us assume that two boats, an IMX-38 and an ILC 40, sail exactly as predicted by their Circular Random IMS Performance Curves. See Table 5.2. We use 10 knots wind speed to derive a single number TA for a

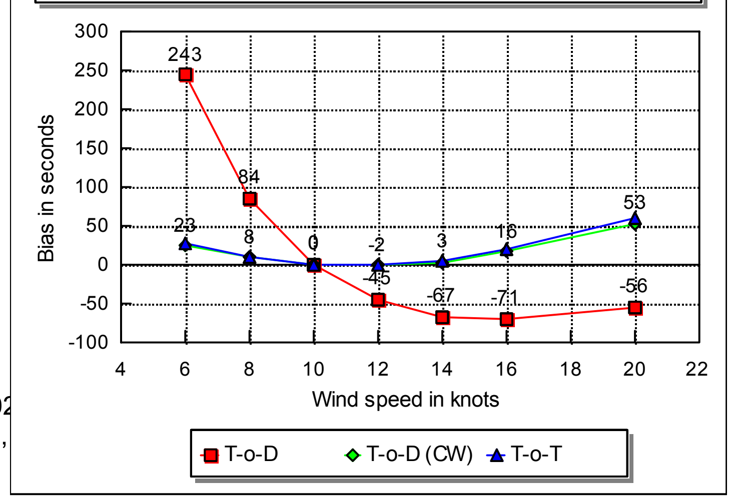

Figure 5.5 T-o-d favouring og largest boat
ILC-40 versus IMX-38

racecourse of 10 nautical miles. This gives TA = 5984 seconds for the IMX-38 and TA = 5434 seconds for the ILC 40. The elapsed times for 10 nautical miles are obtained by multiplying the Performance Curve numbers with 10, and the corrected time is here calculated as CT = ET - TA. As you can see in Table 5.2 and Figure 5.5, the corrected times then show large differences between the boats, in spite of the fact that they sail equally well. The largest boat is favoured by 243 seconds in 6 knots wind, and the smallest boat is favoured by 56 seconds in 20 knots wind. This is a quite unacceptable result. By applying the correction factor CW, the favouring of the largest boat in 6 knots wind is reduced to 23 seconds. In this particular case the largest boat is favoured with 53 seconds in 20 knots wind, but the favouring is obviously much more acceptable for most wind speeds after the application of CW.

Time-on-time has a wind speed correction built into it. Therefore time-on-time is clearly to be preferred before time-on-distance in most cases.

Table 5.2 and Figure 5.5 also show the corresponding time-on-time calculation, based on IMSTCF = 600/IMS. Not surprisingly time-on-time gives approximately the same result as time-on-distance with wind speed correction. The reason is that the performance curves of boats of different sizes are approximately proportional. If the performance curves are exactly proportional, the bias with time-on-time is zero for all wind speeds! There is only one condition when time-on-distance is better than time-on-time, and that is when there is a large part of the race with no wind. Then the smallest boats are favoured with a time-on-time calculation, as explained above.

Table 5.2 Typical bias of time-on-distance calculation

	Wind speed	6	8	10	12	14	16	20
IMX 38	PC	836.6	680.8	598.4	551.1	521.9	502.8	478.3
ILC 40	PC	757.3	617.4	543.4	500.6	473.6	454.9	428.9
10 Nautical Miles								
IMX 38	TA			5984				
ILC 40	TA			5434				
IMX 38	ET	8366	6808	5984	5511	5219	5028	4783
ILC 40	ET	7573	6174	5434	5006	4736	4549	4289
IMX 38	CT	2382	824	0	-473	-765	-956	-1201
ILC 40	CT	2139	740	0	-428	-698	-885	-1145
	Favouring of largest boat	243	84	0	-45	-67	-71	-56

Application of wind speed correction:

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IMX 38	CT(CW)	-10	-1	0	-3	-9	-13	-20
ILC 40	CT(CW)	-33	-9	0	-1	-11	-29	-73
	Favouring of largest boat	23	8	0	-2	3	16	53
Ratio of favouring with and without CW		0.10	0.05	1.00	-0.11	-0.31	-0.42	-0.60

Time-on-Time

IMX-38	TCF			1.003				
ILC-40	TCF			1.104				
IMX 38	CT	8388	6826	6000	5525	5232	5041	4795
ILC 40	CT	8361	6817	6000	5527	5229	5022	4735
	Favouring of largest boat	27	9	0	-2	4	19	60

The average favouring of 99 boats as compared to the IMX-38, is shown in Table 5.3. The IMX-38 is chosen as reference because it is an all round boat which sails about equally well in light and heavy weather.

Table 5.3 Favouring in seconds of 99 boats with and without application of CW

Wind speed	6	8	10	12	14	16	20
CW not applied:							
Average favouring, a	114	37	0	-18	-24	-28	-31
Standard deviation of a	224	80	1	46	73	87	100
CW applied:							
Average favouring, a(CW)	12	2	0	2	8	12	19
Standard deviation of a(CW)	108	42	1	28	46	57	69
Ratio a(CW)/a	0.10	0.05	NA	-0.11	-0.31	-0.42	-0.60

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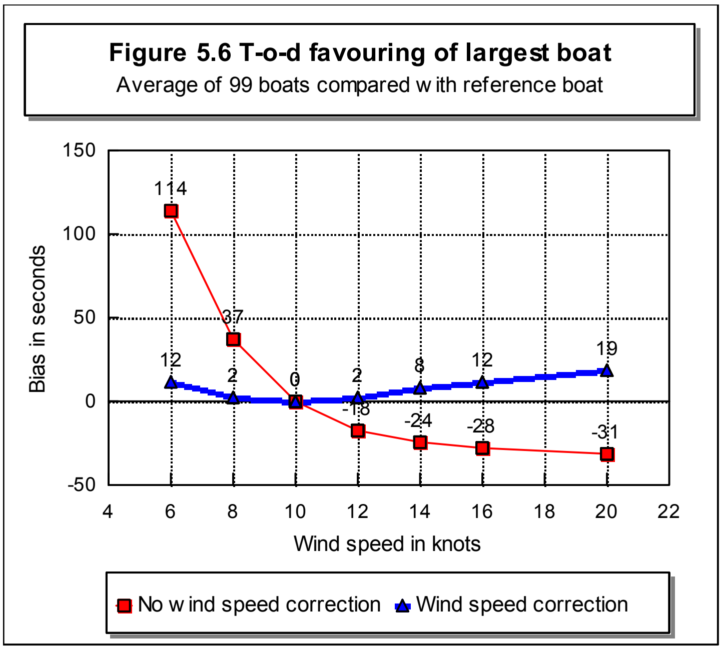

Figure 5.6 T-o-d favouring of largest boat
Average of 99 boats compared with reference boat

Table 5.3 and Figure 5.6 show that the average favouring for 99 boats as compared to the reference boat IMX-38 is considerably reduced by the application of CW. Table 5.3 also shows that there is a fairly large spread of results. This is due to the fact that heavy and light wind boats come out differently, and that the shapes of the performance curves are slightly different. The standard deviation is also considerably reduced by the application of CW.

When CW is applied, you have to consider what type of time-on-distance rating you are dealing with. You have to adjust the rating to a true seconds/mile number, corresponding to the real speed of the boat. By applying the relationships in Table 8.6, we get the time allowances to be used for the different systems, as shown in Table 5.4.

Table 5.4 Time-on-distance single number ratings to be used with CW for different systems

System	T-o-D rating	Comment
IMS	IMSGPH	No correction
PHRF	PHRF + 550	PHRF's own definition. Average conditions
DH	DH + 160	Adjusted to IMSGPH level
HN	HNSM + 683	HN's own definition
HN	552.6/HNt-o-t	Adjusted to IMSGPH level
PN	PN/1.338	Adjusted to IMSGPH level
LYS	800/LYS	Adjusted to IMSGPH level
IR2000	646/IR2000	Adjusted to IMSGPH level

Let us now test CW on Toyota Truck Skagerak Cup. We assume that the wind speed was 20 knots, and we get

$$CT = ET - 0.8*800*170*(1/L - 1) \qquad \text{Eq 5.6}$$

As shown in Table 5.5 and Figure 5.2 (black curve), this is better, but not adequate either in this case. This leads to the conclusion that there was also a wind variation during the race.

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So we may have a number of complicated wind conditions and variations during a race:
- Wind speed that is not average
- Wind speed that varies during the race as explained above.

Is there a method to handle all this? If you use time-on-distance, the corrected time may be calculated as

CT = ET - TA + RT. Eq 5.7

The time allowance TA may be adjusted to take the varying weather conditions into account, and we introduce a factor F for this purpose:

TA = F/TCF Eq 5.8

and

$RT = F/TCF_1$ Eq 5.9

where TCF_1 is the TCF of the reference boat. We then get

$IDEAL\ TIME = ET - F/TCF + F/TCF_1$ Eq 5.10

It can be shown that if you calculate F as

F = (A*B/n - D)/(A*C/n - n) Eq 5.11

where

A = SUM(TCF) Eq 5.12
B = SUM(ET) Eq 5.13
C = SUM(1/TCF) Eq 5.14
D = SUM(ET*TCF) Eq 5.15
n = number of finishing boats,

the regression of IDEAL TIME will always be horizontal when plotted against the TCF rating. The following Table 5.5 shows this calculation for Toyota Truck Skagerak Race 1991, and Figure 5.2 illustrates these results (green curve).

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Table 5.5 Toyota Truck Skagerak Race 1991

F = (A*B/n - D)/(A*C/n - n)
NM = 170 Nautical Miles
n = 12 finishing boats

F = 1270.58 LYS*Minutes
f = 448.44 LYS*Sek/NM
L_1 = 1.00 = Reference LYS number

	TCF	Elapsed Time			Time-on-Time		Time-on-Distance				IDEAL TIME	
Boat	LYS	ET		1/L	L*ET		CW = 1		CW = 0.8		ET-F/L+F/L1	
		Minutes	Place		LYS*Min	Place		Place		Place	Minutes	Place
N 3396	1.10	2137.13	11	0.9091	2350.85	1	2343.19	1	2301.98	1	2252.64	2
N 419	1.12	2161.57	12	0.8929	2420.95	2	2404.42	2	2355.85	3	2297.70	7
N 6262	1.18	2102.43	7	0.8475	2480.87	4	2459.28	7	2390.13	7	2307.33	9
N 1994	1.18	2104.12	8	0.8475	2482.86	5	2448.20	5	2379.04	5	2296.25	6
N 4998	1.18	2113.52	10	0.8475	2493.95	7	2449.88	6	2380.73	6	2297.93	8
N 6988	1.21	2107.67	9	0.8264	2550.28	9	2501.06	9	2422.38	10	2328.18	12
N 7313	1.24	1982.12	2	0.8065	2457.82	3	2447.23	4	2359.48	4	2254.43	3
N 7241	1.24	2008.52	3	0.8065	2490.56	6	2420.83	3	2333.08	2	2228.03	1
N 7059	1.25	2068.72	6	0.8000	2585.9	10	2522.05	11	2431.38	11	2322.83	11
N 7777	1.26	2019.42	4	0.7937	2544.47	8	2487.14	8	2393.60	8	2281.60	5
N 6478	1.27	2049.82	5	0.7874	2603.27	12	2531.71	12	2435.33	12	2319.94	10
N 7888	1.33	1955.50	1	0.7519	2600.82	11	2517.91	10	2405.42	9	2270.76	4
	A =	B =		C =	D =							
	14.56	24810.54		9.9169	30062.6							

The Factor F is simply tilting the curve of time versus handicapping number. The slope of this curve is a linear function of F. The factor F = 0 gives CT = ET, and F calculated from the IDEAL TIME formula always gives a horizontal curve of time versus handicapping number.

It is necessary to plot the times versus handicapping number, in order to understand how the different scoring calculations really work, and how terribly wrong the usual time-on-time and time-on-distance calculations are most of the time. I strongly recommend that you plot your races in the way it is illustrated here in Figure 5.2. You will find that most races are heavily biased. I have plotted quite a number of races, and the conclusions are:

- Hardly any usual time-on-time or time-on-distance calculation is fair. Most calculations are favouring either the largest or the smallest boats
- Never use classes with large differences in handicapping numbers within the class
- Time-on-time is best in most cases
- Don't use time-on-time when there is a calm period
- Never use time-on-distance without wind speed correction
- Use IDEAL TIME calculation if you want to compensate for all biases.

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The use of IDEAL TIME requires:

1. If you want IDEAL TIME to be significantly better than the conventional methods, the number of boats should not be below a minimum number, dependent on the difference in handicapping number between the largest and smallest boats:

$n > 0.07/(dL)^2$ Eq 5.16

Where dL is the difference between the largest and smallest LYS number. We don't use IDEAL TIME for n<7. For other handicapping numbers the conversion formulas in chapter 8 may be used to find the corresponding formulas for minimum number of boats.

2. The handicapping numbers should be fairly evenly distributed between the largest and smallest ones.

The problem with IDEAL TIME calculations in races is that it is not easy to know how you are doing on the racecourse, and not easy to understand the calculation. My experience is that most people prefer to know how they are doing according to simple and unfair methods of calculation, rather than not knowing how they are doing according to a more complicated but fair calculation. Therefore the IDEAL TIME calculation is more ideal for statistical purposes. See chapter 6.

IMS and ORC Club take care of the differences in wind speed, and compensate for the different performances of heavy and light weather boats, provided that you take full advantage of these systems. **But IMS and ORC Club do not correct for calm periods or other variations of wind speed and direction during the race**. From this point of view IMS and ORC Club are equally wrong as any time-on-distance or time-on-time calculations from single handicapping numbers, which require constant wind speed in order to give correct results. The IDEAL TIME method may also be used for IMS and ORC Club, but many people would consider this to be too complicated. On the other hand most sailors have no understanding at all of what is going on inside the race management computer, when you are rating and scoring IMS or ORC Club, so you could make it slightly more complicated and much more fair by using IDEAL TIME.

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