SMSA PHRF TOT Handicapping and Scoring
Fall and Spring Frostbite Race Series

Sections:

- **-Introduction**
- **-PHRF System (TOT vs. TOD)**
- **-Example Calculation**
- **-Determining Relative Position in TOT Races**
- **-Problems with PHRF in "Non-average" conditions**

Introduction:
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(Disclaimer) No handicapping system is totally fair. However, we have chosen these somewhat imperfect ones while we continue to struggle for an unrealistic goal of perfection.

In the past we have struggled with ways to improve on the less than perfect PHRF scoring approach. As a single number handicapping system PHRF makes a set of assumptions about the fleet and our environment to establish a handicap for each boat. The primary assumptions are: 1) that a rated boat is in bristol racing condition with a clean bottom, new sails and an experienced crew, 2) that the race course is primarily Windward/Leward, and 3) conditions are "average". The approach assumes that the boat is crewed by a very competent crew and with a boat in excellent condition. Thus, if one does not maintain their boat (sails, hardware, bottom, etc.) well and exert a significant effort in crew training, it will be somewhat difficult to consistently finish high in a PHRF race series.

Our implementation of TOT will not correct this situation, however, it is an attempt to address the environment and course aspects of our racing.

This document will attempt to describe our implementation of the PHRF TOT system for the Fall and Spring Frostbite Race series. The PHRF TOD systems will be described in General SIs for 2017.

PHRF System (TOT vs. TOD):
There are two ways to handicap races using the PHRF handicaps: Time on Time (TOT) and Time on Distance (TOD). In the TOD calculation, the corrected time is directly related to the distance (i.e. only distance is used in the calculation). On the other hand, in TOT the corrected time is proportional to the distance (i.e. distance is not used directly in the calculation). We will use TOT for our Spring and Fall Frostbite Series and TOD for most of the other races on the calendar this year. See the specific SIs for an event to confirm the scoring system to be used.

The majority of races in North America employ TOD calculations. However, recent studies by US Sailing and others have suggested that TOT may be a better choice in some environments. It is very important in TOD racing that the RC has an accurate measure of course length, in TOT scoring it is not necessary to determine the exact course length. For short races or where the course distance is unknown TOT may be the best solution.

The PHRF TOT attempts to correct for inequities of changes in wind velocity and direction. Unfortunately, it is not as easy to determine your relative position in a race with TOT versus TOD.

Example Calculation:
To sort through the TOT calculations, I thought it would be useful to include some calculations using some typical boats in our fleet. In Table 1, I have listed numbers for an unrealistic race in which everyone finished the race at the same time for illustrative purposes. I picked 4500 seconds for the length of the race because this is close to the average race length for the first boat crossing the finish line. A 4500 second race is 1 hour and 15 minutes, about average for our Wednesday night and Frostbite races

The winner is determined by the corrected time which is calculated by multiplying the TCF (time correction factor) of each boat times its actual time. The TCF for each boat is calculated using the following equation.

$$\mathbf{TCF = A / (B + PHRF)}$$

The value for the B constant in the denominator, B + PHRF, is chosen such that combined number is approximately equal to the seconds it should take for a boat to sail a nautical mile.

The TCF values we will use for events in 2017 (and the associated conditions) are:

B Factor	When Used
520	Heavy Air
560	Medium – Average race
620	Light /Medium
650	Light air and/or reaching

For most of our races a TCF of 560 will probably be used. I would encourage the PRO for a race to consider other values based on course and conditions. At the end of the year we will evaluate the results.

The A value is picked such that the average boat in the fleet would have a "nice" looking number of TCF ≅ 1. The commonly accepted value for the constant A is 650. The value of constant A will not affect the relative finishing order of boats, but the value of constant B can affect that order.

Thus, we arrive at the TCF equation employed in our time corrections:

TCF = 650 / (560 + PHRF)

The corrected time is calculated by multiplying the boats actual finish time by the boats TCF:

Corrected time = actual time x TCF

The boat with the lowest corrected time wins the race. In our example in Table 1 in which all boats finish at the same time, the boat will win that has the highest PHRF. For the boat with the lowest PHRF to have won, it would have to have finished 1113 (18 min 33 sec) seconds faster. A fairly large number for a race that lasts around 4500 seconds (75 minutes). Using results from one of last year's Wednesday Night Races, this is not an unusual gap for our fleet.

Table 1 - 4500 second Race results

Boat	PHRF	Racer's Time	TCF (Average)	Corrected Time	Delta to 1st
Blue Boat Home	231	4500	0.822	3698	0
Shamal	174	4500	0.886	3985	287
Arctic Tern	168	4500	0.893	4018	320
Easy Button	159	4500	0.904	4068	370
Wicked Good	132	4500	0.939	4227	529
Jray	120	4500	0.956	4301	604
The Doghouse	111	4500	0.969	4359	661
Supra	90	4500	1.000	4500	802
Pursuit	60	4500	1.048	4718	1020
Bad Cat	48	4500	1.069	4811	1113

The calculations for the PHRF TOT races are somewhat cumbersome. However, we employ a very sophisticated Excel spreadsheet for calculating the results which makes the process manageable with a laptop computer at the dock.

Determining Relative Position in TOT Races:

As I mentioned previously, it is not as straight forward to calculate your relative position in a TOT race versus a TOD race. In Table 2, I have created a hypothetical "Corrected Time 600 sec (10 min)" race.

Table 2 - 600 second Race results

Boat	PHRF	Racer's Time	TCF (Avg)	Corrected (Avg)	Delta to 1st (Avg)	TCF (Low)	Corrected (Low)	Delta to 1st (Low)	TCF (High)	Corrected (High)	Delta to 1st (High)
Blue Boat Home	231	600	0.822	493	0	0.866	519	0	0.764	458	0
Shamal	174	600	0.886	531	38	0.937	562	43	0.819	491	33
Arctic Tern	168	600	0.893	536	43	0.945	567	48	0.825	495	37
Easy Button	159	600	0.904	542	49	0.957	574	55	0.834	501	42
Wicked Good	132	600	0.939	564	71	0.997	598	79	0.864	519	60
Jray	120	600	0.956	574	80	1.016	609	90	0.878	527	69
The Doghouse	111	600	0.969	581	88	1.030	618	99	0.889	534	75
Supra	90	600	1.000	600	107	1.066	639	120	0.915	549	91
Pursuit	60	600	1.048	629	136	1.121	672	153	0.956	574	115
Bad Cat	48	600	1.069	641	148	1.144	687	167	0.973	584	126

Thus, if Bad Cat had a keen interest in beating Pursuit (just a hypothetical situation), it would need to be ahead 12 seconds (641-629 sec) for every 10 minutes in the race with an Average TCF. Thus as Bad Cat approached the finish line in a 1 hour race, they will need to be ahead by >72 seconds (12 sec x 6). Still not a trivial calculation, but if you know who you want to beat and the difference in time for a 10 minute period, one can estimate if you are ahead during the race or if you won at the end of a race. Notice that with a High TCF the calculation would be >60 seconds.

Problems with PHRF TOT in "Non-average" Conditions:
I would describe "average" racing conditions as 10 to 12kts of wind and a course with a good balance of Windward/Leward conditions. This will always be open to judgement calls but the RC should make their best call. The choice of a TCF for a given event when conditions are NOT average can minimize the advantages that some boats have over others in the fleet. Factors to be considered and the impact on scoring are: Wind strength and variability, course layout, and boat characteristics.

First a discussion about how the PRHF rating is meant to work. The current PHRF ratings assume a boat with a 0 PHRF rating will take about 650 seconds to complete a mile under average conditions on a W/L course. This should mean an average VMG for that boat would be 5.54kts. You could convert a given boat's PHRF rating to a predicted VMG and then compare the boats performance over a known race course. This exercise would provide an evaluation of the course against the assumed PHRF norm. If we displayed our fleet in terms of assumed optimal TOD VMG it would look like table 4.

Table 4 - Predicted VMG - TOD

Boat	PHRF	ToD Est. Seconds/ mile	% of Zero Boat	TOD VMG
Blue Boat Home	231	881	136%	4.09
Shamal	174	824	127%	4.37
Arctic Tern	168	818	126%	4.40
Easy Button	159	809	124%	4.45
Wicked Good	132	782	120%	4.60
Jray	120	770	118%	4.68
The Doghouse	111	761	117%	4.73
Supra	90	740	114%	4.86
Pursuit	60	710	109%	5.07
Bad Cat	48	698	107%	5.16
Zero Boat	0	650	100%	5.54

Calculating VMG for TOT is not an easy exercise. We can use past results for our fleet to see that in some instances boats can exceed the optimal TOD estimated VMG. Table 5 is an attempt at demonstrating the impact of TOT on the predicted VMG for a boat.

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Table 5 - Predicted VMG - TOT

Boat	PHRF	TOD VMG	TOT VMG - TCF=650	TOT VMG - TCF=620	TOT VMG - TCF=560	TOT VMG - TCF=520
Blue Boat Home	231	4.09	3.01	3.121	3.358	3.537
Shamal	174	4.37	3.45	3.577	3.869	4.092
Arctic Tern	168	4.40	3.50	3.630	3.929	4.158
Easy Button	159	4.45	3.58	3.713	4.023	4.260
Wicked Good	132	4.60	3.83	3.979	4.324	4.589
Jray	120	4.68	3.95	4.107	4.469	4.748
The Doghouse	111	4.73	4.04	4.206	4.583	4.873
Supra	90	4.86	4.27	4.454	4.865	5.184
Pursuit	60	5.07	4.64	4.847	5.316	5.682
Bad Cat	48	5.16	4.80	5.019	5.514	5.902
Zero Boat	0	5.54	5.54	5.806	6.429	6.923
VMG Range		1.45	2.52	2.69	3.07	3.39
		26%	46%	46%	48%	49%

The impact can be quite large. This is probably desirable in short races, however, in longer races it could present problems. As discussed in the opening, PHRF is not a perfect handicapping system. PHRF TOT can be useful in leveling the playing field for short races with non-average conditions. At the end of this season we should have enough data points to evaluate this approach and make some recommendations for scoring “Non-average” PHRF race conditions.

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