THE PERFORMANCE HANDICAP FORMULA EXPLAINED

In a second article, ACYC member Adam Tepper, who devised the performance handicap system we use, explains the handicap formula in detail…

As a follow up to my previous article, I have already been asked to explain the handicap formula in detail. The purpose of the handicap formula is to determine the average proportion of time that a boat lost a race compared with the winning boat. For that, we must understand how an average is calculated, and how a proportion is calculated and then tie these together.

Let's start by reviewing the formula for calculating a boat's handicap:

[Handicap] = (([Previous Handicap] * [Number of Starts]) + ([Fastest Actual Time in Previous Race] / [Boat's Actual Time in Previous Race])) / ([Number of Starts] + 1)

Calculating an average
We start with the basic formula for calculating an *average*, or more correctly an *arithmetic mean*. The arithmetic mean is equivalent to: $(x_1 + ... + x_n) / n$, where x are elements in the set of values we want to average, and n is the number of elements in the set.

A simple example, the average of 1, 2 and 3:

A = (1 + 2 + 3) / 3
Avg. = 6 / 3
Avg. = 2

Now, let's suppose we add another number to the set, 4, and recalculate the average:

Avg. = (1 + 2 + 3 + 4) / 4
Avg. = 10 / 4
Avg. = 2.5

The interesting thing about an average value is by definition, if each of the values in the set was the same as the calculated average, the result would be the same. Let's have a look at the first calculation again:

Avg. = (2 + 2 + 2) / 3
Avg. = 6 / 3
Avg. = 2

Note, the same result as the first calculation. This implies that as long as we know the previous average, and the number of elements in the set, we are free to discard the previous data elements from our formula when adding a new element to the set.

Therefore, the following are equivalent:
Avg. = $(x_1 + ... + x_n) / n$
Avg. = (([Original Average] * [Original Number of Elements in the Set]) + [New Element]) / [Current Number of Elements in the Set]

We know from our second example, that if we add 4 to the original set, the new average will be 2.5. Let's try that with our modified formula that doesn't require us to retain the original elements of the data set:

Avg. = ((2 * 3) + 4) / 4
Avg. = 10 / 4
Avg. = 2.5

Same result.

Calculating proportion
Now, for the purpose of a *performance handicap*, we want to determine the *average* *proportion* of time by which a boat lost the race. Proportionality is calculated by *y*/*x*.

A simple example, calculating the proportion between 1 and 2:
P = 1/2
P = 0.5

In other words, 1 is half of 2, which is obvious. If we take our original value of 1, and multiply it by the ratio of 0.5, we will get back to the number 2.

To give you an example more relative to sailing, we need to compare a boat's time with that of the fastest boat in the fleet. If the fastest boat in the fleet crossed the line in 30 minutes, and the boat in question crossed the line in 60 minutes, the ratio between those two values is:

P = [Fastest Actual Time in Previous Race] / [Boat's Actual Time in Previous Race]
P = 30/60
P = 0.5

This is the proportional amount by which the boat lost the race. So hypothetically, if the winning boat had no handicap, and this boat went into the race with a handicap of 0.5, the race would've been a draw - which is the ultimate goal of handicapping.

Bringing the two formulae together - calculating average proportion (handicap)
What we need to do next, is take the proportion of time by which a boat lost a race, and average that across all races.

Let's go back to our formula for the average:
Avg. = (([Original Average] * [Original Number of Elements in the Set]) + [New Element]) / [Current Number of Elements in the Set]

[New Element] = [Fastest Actual Time in Previous Race] / [Boat's Actual Time in Previous Race]

Therefore:
Avg. = (([Original Average] * [Original Number of Elements in the Set]) + ([Fastest Actual Time in Previous Race] / [Boat's Actual Time in Previous Race])) / [Current Number of Elements in the Set]

There's one final change we need to make to this formula in order to get the handicap value. Because each boat must start the first race with a handicap (either 1 or the handicap carried from the previous season), the number of elements in the set is always 1 more than the number of races.

So therefore, our formula becomes:
Avg. = (([Original Average] * [Number of Starts]) + ([Fastest Actual Time in Previous Race] / [Boat's Actual Time in Previous Race])) / [Number of Starts] + 1
Avg. = (([Previous Handicap] * [Number of Starts]) + ([Fastest Actual Time in Previous Race] / [Boat's Actual Time in Previous Race])) / [Number of Starts] + 1

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