

ORC Software Module for Performance Curve Calculation (PCS) Specifications

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This project addresses the problem of the absence of a single and unique way of calculating the implied wind and corrected times using a performance curve, being either one of the *standard* courses included in the certificate or constructed by given race leg data.

ORC will program a module to calculate PCS, which will be available to race management software manufacturers for free. There will be two versions of this module:

- The off-line version is a DLL, callable by any windows program.
- The on-line version is a web service, hosted in the ORC web-database server, to be used by internet-enabled applications using the http protocol.

The PCS module in both versions exchanges race data via xml, as described below.

The standard courses are *windward-leeward*, *olympic triangle*, *circular random*, *non-spinnaker* and *ocean course*.

Course Construction

The polars to be used are calculated directly for each leg, accounting for each leg length, magnetic direction and magnetic wind direction. In wind angles that range between the optimum angle to windward and the optimum downwind, the polar is interpolated with a *Lagrange interpolation* between any two contiguous available data. Inside the optimum angle the polar considered is VMG projected on the actual course: $VS=VMG/COS(TWA)$.

Tidal currents

For each leg a tidal current can be inserted, in speed and direction, with an effect on each leg length and wind angle.

Correction for Current

This functionality is not implemented yet

For each wind speed from 6 to 20 knots the allowances are corrected for the current speed and direction, to produce corrected allowances for all wind speeds. The procedure for each wind speed is as follows:

- Find the allowance "A" corresponding to the actual true wind direction "a" of the first leg of the course
- Calculate the yacht speed in knots as $V = 3600/A$
- Wind direction "a" and yacht speed V define the Provisional Boat Speed Vector
- Combine this Provisional Boat Speed Vector with the Current Speed Vector defined by current speed and direction, to find the Sailed Boat Speed Vector for the yacht

- Use the true wind angle "b" of the Sailed Boat Speed Vector to find the allowance "B"
- Since allowance "B" should be combined with the sailed distance, and not the course distance, "B" is multiplied with the ratio between the lengths of the Provisional Boat Speed Vector and the Sailed Boat Speed Vector to find the allowance "C".
- The allowance "C" is to be used for the actual course distance for the leg.

When the allowances of all legs have been calculated as described above, they are used to calculate the allowance for the entire course.

This procedure is a good approximation when the speed of the current is small as compared to the yacht speed. For very large current speeds any reasonably simple method will cause errors. It should also be remembered that if you enter a very large current speed opposite to the direction of the course, you may get the result that the yacht will never finish in low wind speeds, and that the calculation of corrected time cannot be performed.

The 7 performances vectors (which form the performance curve) used to determine the implied wind, are constructed for each individual yacht, so it is possible to account for the fact that a yacht may be fetching a mark, while another has to tack.

Alternatively, it is possible to use a **fixed wind speed** for each leg, common to the entire fleet. The module will calculate a single allowance for each leg using a cubic spline interpolation among the 7 performance vectors.

Performance Curve Solver

The 7 wind speed points being either one of the standard course, or calculated by the Course Construction method, are passed to the solver, which intercepts the **implied wind** value from the performance curve given, for a given average speed over the distance sailed, through a cubic spline method, the same that is used in several LPP and VPP calculations in the IMS. The implied wind values are limited to a minimum of 6 kts and a maximum of 20 kts, they are therefore not extrapolated beyond the range of calculations of the ORC VPP.

Scratch Boat Selection

It affects the absolute value of the corrected times, depending on the selection of a boat taken as a reference. At present the ORC PCS module selects the one with the least GPH. The scratch boat is assumed to have the corrected time equal to the elapsed time. To calculate corrected times for the rest of the fleet, a cubic spline interpolation is applied to the performance curve of the scratch boat to derive its allowance (secs/mile) for the implied wind calculated for each boat of the fleet:

$$CT_n = ET_{sb} - (A_n - A_{sb}) * D$$

CT_n : Corrected time

ET_{sb} : Scratch Boat elapsed time

A_n : Allowance

A_{sb} : Scratch Boat Allowance (equal to average speed)

D : Race distance

2015 update

The best implied wind (the one of the winning boat) is used to calculate corrected times. This is equal to applying the best implied wind as fixed wind speed to all legs. To calculate corrected times a cubic spline

interpolation is applied to the performance curve of each scratch boat to derive its allowance (A_n above) for this best implied wind.

2018 update

After an AGM decision in November 2017, the individual boat's implied wind or the best implied wind can be used for corrected time calculation. A setting has been added to the xml race representation (see XML description below).

Interaction

The PCS module accepts input and returns results via xml.

The DLL contains a function which accepts as parameter the name of the xml file containing the input. This function returns zero when successfully executed, an error number otherwise. The results (implied winds & corrected times) are written in the original xml file.

The web service accepts the xml input via an http POST message. Likewise, it returns the original xml with the results embedded. In case of error, the error code is returned as an attribute of the xml document element.

Date-time values are represented in the ISO-8601 format: YYYY-MM-DD"T"hh:mm:ss

example: 2013-02-13T13:33:44

The dot (".") is the decimal separator.

The xml is encoded in *UTF-8*.

XML Description

Example

```
<?xml version="1.0" standalone="yes"?>
<race start="2012-08-13T13:00:00" distance="0" type="0" useboatiw="0">
  <legs>
    <leg distance="5.1" course="34" windDirection="124" windSpeed="0" currentDirection="5" currentSpeed="2"/>
    <leg distance="2.53" course="24" windDirection="124" windSpeed="0" currentDirection="5" currentSpeed="2"/>
    <leg distance="33" course="24" windDirection="100" windSpeed="0" currentDirection="5" currentSpeed="2"/>
  </legs>
  <boats>
    <boat finish="2012-08-13T23:01:22" impliedWind="12.34567" correctedTime="00:03:55:34" rms="..."/>
    <boat finish="2012-08-14T01:00:02" impliedWind="11.33673" correctedTime="00:04:25:34" rms="..."/>
    <boat finish="2012-08-13T22:15:34" impliedWind="12.64567" correctedTime="00:03:59:01" rms="..."/>
  </boats>
</race>
```

The document element <race> attributes:

start	start time of the race
type	0 = constructed course 1 = windward – leeward 2 = ocean course 3 = olympic triangle 4 = circular random 5 = non spinnaker

distance Meaningful only when type <> 0, otherwise ignored.

useboatiw 0 = use the best achieved implied wind (fixed wind) to calculate corrected times (default)
1 = use individual boat's implied wind (variable wind) to calculate corrected times

The <legs> node need to be present only when race type equals zero (constructed course) and must contain one or more <leg> elements.

<leg> attributes:

distance leg distance

course course sailed (rhumbline bearing)

windDirection true wind direction (bearing)

windSpeed optional true wind speed, used for fixed wind speed course construction only (*)

predefinedCourse optional code for using predefined time allowances as follows: [Sunday, February 22, 2015]

0 : Calculate allowances from TWA (default)

1 : Use Windward - Leeward

2 : Use Ocean Course

3 : Use Olympic Triangle

4 : Circular Random

5 : Use Non-Spinnaker

currentDirection optional current direction (**)

currentSpeed optional current speed (**)

(*) If windSpeed is <> 0 for any leg, the race is assumed to be "fixed wind speed" therefore all legs must have windSpeed<>0. If windSpeed is not found or is equal to zero it defaults to 6 kts. For windSpeeds < 6 or > 20, 6 and 20 kts are used respectively.

(**) currently ignored - not implemented

The <boats> node is mandatory and must contain one or more <boat> elements.

<boat> attributes:

finish time the boat finished

rms the fixed length data line as contained in the rms file for this boat (see attached file for example)

impliedWind the implied wind as calculated by the PCS module (***) - **output**

correctedTime the corrected time as calculated by the PCS module – **output**

correctedSeconds the corrected time as calculated by the PCS module *in seconds* – **output**

constructedCourseVector when type=0, the 7-wind speeds vector calculated according to leg data– **output**

warning contains a message when the curve is not monotonic – **output**

Any additional (user defined) attributes or nodes in the xml input are maintained. The PCS module only adds (or replaces if they already exist) the following attributes in the <boat> nodes:

impliedWind, correctedTime, correctedSeconds, constructedCourseVector, warning.

For instance, the user might add boat identification data (yach name, sailno etc) which will be maintained in the returned xml document.

*(***) When fixed wind speed is set, the impliedWind is equal to the weight average of leg wind speeds, using the leg distance as weight.*