

World Robotic Sailing Championship 2016

Viana do Castelo, Portugal – 5 - 10 September 2016

Notice of race and competition rules

V2.1 - 29 August 2016

1. Introduction

The World Robotic Sailing Championship 2016 will be organized in Viana do Castelo, Portugal, from September 5th to September 9th. The World Robotic Sailing Championship will be followed by the International Robotic Sailing Conference that will be held on September 10th (Saturday) in the Rowing Center of Viana do Castelo.

The organizing committee invites teams from any organization, including private individuals, schools, colleges, universities and companies, to enter the competition. Each team competes with one boat and the team members can be shared among different teams. The championship will be organized by 4 contests, each one tentatively allocated to a single day. The first day (September 5th) will be reserved for the setup of the teams and free trials in the WRSC race area.

2. Classes

The World Robotic Sailing Championship is open to boats propelled entirely by wind. The boats must use only the energy of the wind as the propulsion force (and, indirectly, also the wave energy). Besides the more traditional soft or rigid sailing rigs, the wind energy may also be used to power a propeller or a paddle-wheel driven by a wind turbine. The coupling between the wind turbine and the propeller may be done either by mechanical or electrical means, providing that it is not possible to use any kind of energy stored on board to drive the propeller. The participants must be able to clearly demonstrate this to the Race Committee.

The boats may use any type of hull (mono or multi) and any type of rig, with one or more soft or rigid sails. The beam of multi-hulls should not exceed their LOA and the maximum draft of any boat should be limited to 2 m. Hydrofoils are allowed, although these appendages cannot be installed or removed manually to configure one boat for the different challenges.

The two classes considered in WRSC 2016 are:

Micro-sailboats (MS)

Small autonomous sailboats up to 1.5 m LOA and weighting no more than 100 kg.

Sailboats (S)

Autonomous sailboats which do not fit in the micro-sailboats category, up to 4 meters LOA and weighting no more than 300 kg.

3. Liability and Safety

All sailing robots must be controllable by a designated human helmsman throughout all events. The responsibility for avoiding any collision, damage or personal injuries will rest solely with the respective teams. The organizers will not assume any liability with respect to third party damages, personal injuries or environmental contamination resulting from any activity of a team participating in the WRSC. All teams are responsible for their own safety during the event and the decision to participate or not in the competitions is of the exclusive responsibility of the team members.

Each team will nominate a person of contact (POC) that will be requested to sign a term of responsibility where she/he assumes all the responsibility of any damage, injury or environmental contamination that will result from any activity of her/his team, including the operation of their autonomous sailboat.

All sailing boats will be under the supervision of a motor boat provided by the organization. At least one person per team is guaranteed a seat in a motor boat, and a motor boat will be shared by no more than two teams at the same time. All people on board of a motor boat must follow the safety instructions of the driver and must provide their own personal floatation device which must be worn at all times while on the water. The safety crews reserve the right to manage the fleet of support boats, and can refuse access to the support boats, in certain circumstances. Similarly, any team member entering the pontoons must follow the safety instructions of the shore crew and the marina personnel. The organization reserves the right to refuse access to restricted areas of the marina.

For safety reasons, the race area will be confined to a region of the river delimited by 4 marks. At least two support boats will monitor the borders of this region to prevent any participant boat of navigating beyond this area. Figure 1 shows approximately the area requested for WRSC that may be subject to last minute adjustments.



Figure 1 - The approximate race area reserved for WRSC.

4. Collisions and Right of Way

Autonomous boats have right of way over manually controlled boats. In the event of a potential collision, then COLREGs rules must be followed (for example, a boat on a starboard tack has right of way, etc). However, all competitors must take appropriate actions to avoid collisions and having right of way is not an acceptable excuse for allowing a collision to take place.

5. Scoring

The WRSC is organized with 4 contests scheduled for each day of the event: fleet race, station keeping, area scanning and obstacle avoidance. The scoring for each contest will be based on automatic tracked data to establish a ranking (1st to Nth position) that will measure the relative ability to accomplish each task. A sailboat that decides not participating in a contest, or not being able to fulfil the minimum objectives defined for each one, will be given a ranking equal to the number of sailboats registered in its category plus 1. Whenever possible the results will be posted in the Race Office at the end of each day.

Each challenge will give a prize for the first and second places in each class and the absolute winner of the World Robotic Sailing Championship will be declared the team/sailboat with the lowest sum of the rankings obtained in each competition.

6. Tracking

Although the tracking devices developed by ENSTA Bretagne will be used again in WRSC2016, the competing boats should be able to provide the organization the basic tracking data recorded from their own global navigation satellite system (e.g. GPS). As the scoring process will be based on the course done by each boat, it will be preferable to use the actual position data processed by the boat's navigation system to prevent possible deviations resulting from the different location data produced by the trackers and the boat's navigation system.

The tracking data to be provided by each boat should include a timestamp and the lat/lon coordinates, with not less than one track point per second. This data must be provided in one of the following formats:

- A CSV (comma-separated values) text file with three decimal integer numbers per line representing “`hhmmssdd, Lat*107, Lon*107`” (hhmmssdd represents the hour, minute, second and day of the month). For example, the entry “`14233407, 416887091, -88259850`” means 14h23m34s of day 7 (of September - note the month is not logged), lat=41.6887091° (north) and lon = -8.8259850° (west)); 9h of recording will need approximately 1MByte of data.
- The same format as above but using 3 digits for the field representing the seconds, where the third digit (rightmost) represents the decimal part of seconds. For example, the record “`142334807, 416887091, -88259850`” means 14h23m34.8s of day 7 of September, lat=41.6887091° (north) and lon = -8.8259850° (west)).
- A CSV (comma-separated values) text file with three decimal integer numbers per line representing “`GPS_milliseconds-of-the-week, Lat*107, Lon*107`”, where the field “`GPS_milliseconds-of-the-week`” represents the number of milliseconds since the 00h00m of last Sunday. For example, the entry “`317009123, 416887091, -88259850`” means 16h03m29.123s of Wednesday (day 3), lat=41.6887091° (north) and lon = -8.8259850° (west));
- For any of the 3 formats referred above: a binary file with 12-byte records representing the three 32-bit signed integers (in two's complement), in little-endian or big-endian byte order (the team has to specify which little- or big-endian format is used). This format will require approximately 388 KByte of data for logging 9h.

7. Wind and time limits

The competitions will run only with a minimum sustained wind speed of 6 knots (approx. 3m/s) and a maximum gust wind speed of 20 knots. The time limits indicated in the detailed description of each challenge may be adjusted according to the actual wind conditions observed in the course area.

8. Measurement units

Lat/Lon: degrees in decimals, e.g. 60.3456° (chart datum: WGS-84)

Distance: meters

Angles: degrees

9. Competitions

WRSC will be organized with 4 competitions, in a similar way to the previous WRSC editions. Two course areas may be set in different regions, using smaller courses for the micro-sailboat class and larger regions for the sailboat class. The precise locations will be defined only a few days before the event, according to the regional short-term weather forecast. The next sections detail the rules for each of the competitions:

9.1 Fleet race

All boats will sail together around a trapezoidal course with legs ranging between 100m and 700m. Figure 2 shows a possible location and format of course for the fleet race. The two classes will compete separately, with a shorter course for the micro-sailboat class.

Scoring

If a boat succeeds completing the whole course, it will be scored by its arrival order. If not, boats will be scored according to the number of marks reached in the correct order and the order of arrival to that mark. As usual in previous WRSC, the start procedure will be done manually, either by having the boats under manual control and switching to automatic control at the start sign, or by holding the boat behind the start line and releasing it at the start signal. If the weather conditions are favorable, up to two fleet races will be done for each class, summing the resulting individual scoring. A mark/buoy is considered reached if at least one track point is recorded within a radius of 5m around the position of the (virtual) buoy.

Remote control is allowed during the course exclusively to avoid imminent collisions and only for the boat with no right of way. Alternatively, a collision may also be prevented by holding manually the boat with no right of way, but ensuring that its position and heading is maintained until the risk of collision has passed. In the case a boat gets entangled with a buoy or any other floating debris (seaweed, lines, fishing nets, etc) it can be assisted manually, as long as no advantage is given to the boat.

Minimum objective

To be considered for the scoring, a sailboat must complete at least the first leg, from the start line to the first buoy.

Time limit

The time limit for this race will be set to a maximum of 60 mins.



Figure 2 - Fleet race: example of race course

9.2 Station keeping

The station keeping (or *virtual anchoring*) contest will be set in a different manner of the previous editions, to better evaluate the ability of the robotic sailboats to perform a virtual anchoring task. Only a single waypoint P will be set for this competition (see figure 3). The sailing boats will have to keep navigating as close as possible to that waypoint during 5 minutes after entering a circle with a radius $R=20m$ around that waypoint.

Scoring

An individual score will be calculated as the minimum radius R_{min} centered in another point P_c that contains 95% of the points logged (by the boat or the by the tracking devices), normalized to the length overall (LOA) of the boat (R_{min}/LOA). To account for the GPS error, P_c will be considered instead of P , where P_c is obtained as the average of the coordinates of all the points registered during the 5 minutes after entering the circle with a radius $R=20m$ (green dots in figure 3). To be qualified in this contest, the point P_c must be inside the red circle, regardless of the positions of the points recorded during the 5 minute period.

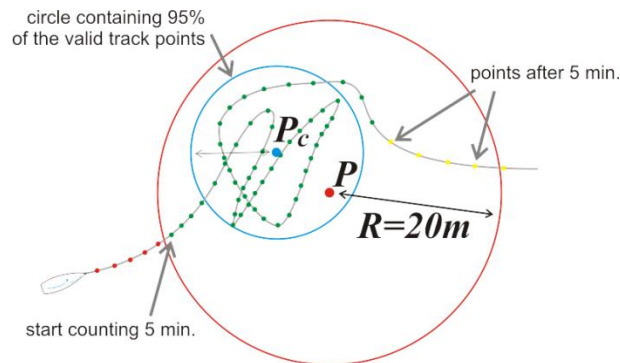


Figure 3 - Scoring procedure for the station keeping contest.

Figure 3 illustrates this procedure. The sailboat track is considered during 5 minutes after entering the red circle (20m radius, centered in the reference waypoint P); the average of the coordinates of all recorded track points during the 5 mins (green dots) gives point P_c ; the score is calculated with the radius of the blue circle centered in P_c that contains 95% of the valid track points. The contest starts by releasing the sailing boat at least 40m away from the reference waypoint P . Depending on the weather conditions, a maximum of 3 attempts may be done by each sailboat and the best score among the three attempts will be used to build the final ranking for this challenge.

Minimum objective

To be scored in this contest the sailing boat must stay within the $R=20m$ circle (red circle) during the first minute after entering it; also, the final point P_c must be inside that red circle.

Time limit

The total time limit for this contest is 10 minutes: after the start signal, boats will have 5 minutes to enter the red circle and then more 5 minutes to complete the challenge.

9.3 Area scanning

The objective of the area scanning contest is to measure the ability of the sailboats to perform a navigation path suitable to sample a closed region. The course area will be divided in 20m x 20m squares and the objective is to visit as many squares as possible, within the maximum allowed time. A square is considered visited if at least one track point is registered within that square.

The challenge starts when the sailboat enters the start line and finishes when the sailboat crosses the finish line, before exhausting the maximum time allowed for this challenge (30 mins). Boats will be ranked by counting first the number of squares visited and then

comparing the percentage of the track points that are within the course area, delimited by the blue line in figure 4. The boats not crossing the start line will be classified DNS (*did not start*) and assigned a ranking position equal to the number of boats registered in that class plus one. The boats that start the course but do not succeed to cross the finish line within the maximum time will be scored DNF (*did not finish*) and assigned a ranking equal to the number of registered boats in his class.

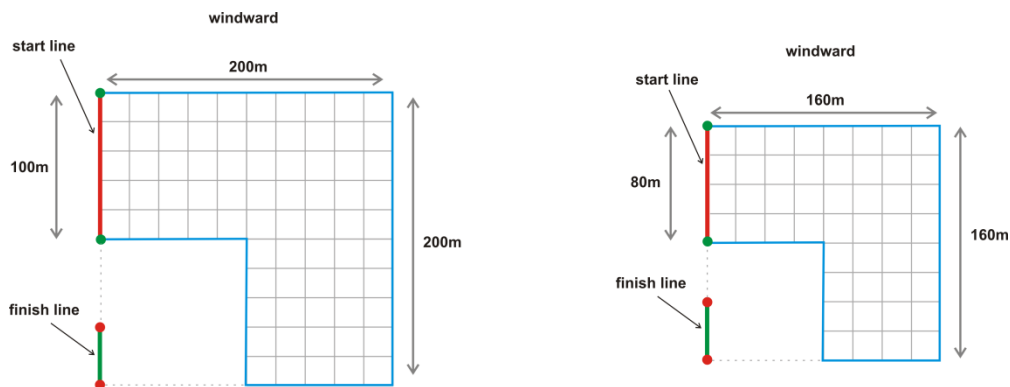


Figure 4 - Courses for the area scanning contest (class “S” on the left, class “MS” on the right).

The course area will be set as a “L” shape region composed by 75 squares, arranged as a 200m x 100m rectangle (50 squares) and a 100m x 100m adjacent square (25 squares), as shown in figure 4. The course for the micro-sailboat (MS) class will be smaller, with 160m x 80m plus 80m x 80m (total of 48 squares, representing 64% of the larger course). The courses will be positioned with the large side facing windward, as shown in figure 4.

Scoring

Figures 5, 6 and 7 show a few examples of possible courses, with the correspondent scores. In figure 5 both boats succeed visiting all the 75 squares, but the 1st place will be assigned to the track on the left because the length of the track outside the course area (measured as the number of track points) is smaller than the track on the right. Figure 6 show 3 examples of a partial accomplishment of the area-scan challenge and the DNS and DNF situations are exemplified in figure 7.

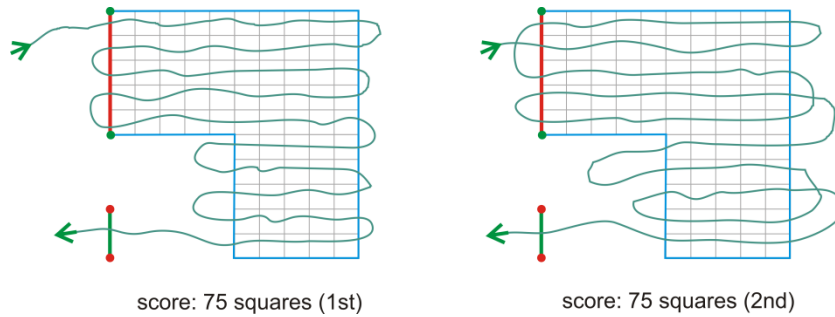


Figure 5 - Successful area-scan

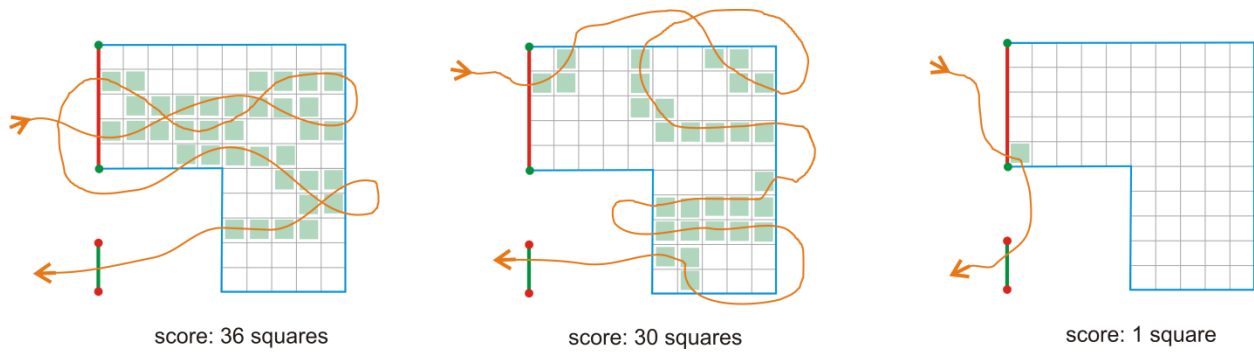


Figure 6 - Partial accomplishment of the area-scanning contest.

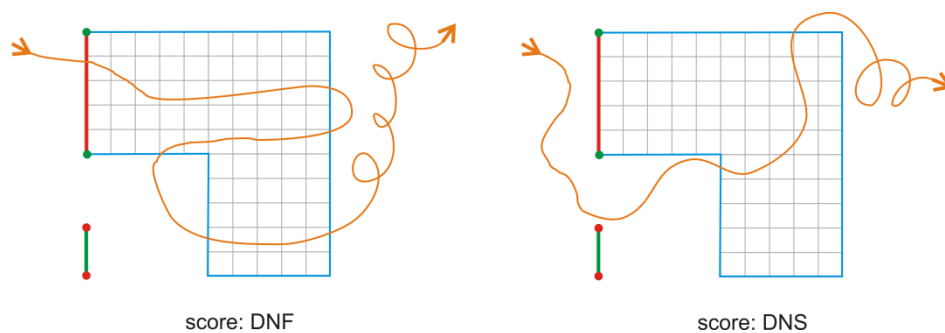


Figure 7 - The DNS and DNF cases.

Minimum objective

To be qualified in this contest, a sailboat must cross the start line and the finish line within the time limit (illustrated by the rightmost example in figure 6).

Time limit

The time limit for this challenge is 30 minutes.

9.4 Collision avoidance

The collision avoidance contest will evaluate the ability of a sailing boat to detect and deviate from an unexpected obstacle appearing in its path. The course area will be set with four waypoints forming a 150m x 20m rectangle, with one longest side facing windward (see figure 8). Sailboats must enter the rectangle by one of the shortest sides, keep sailing within the rectangle to the opposite short side, turning back after crossing each short side. After completing at least two legs, a physical obstacle will be placed in the course area before the sailboat turns back into its direction.

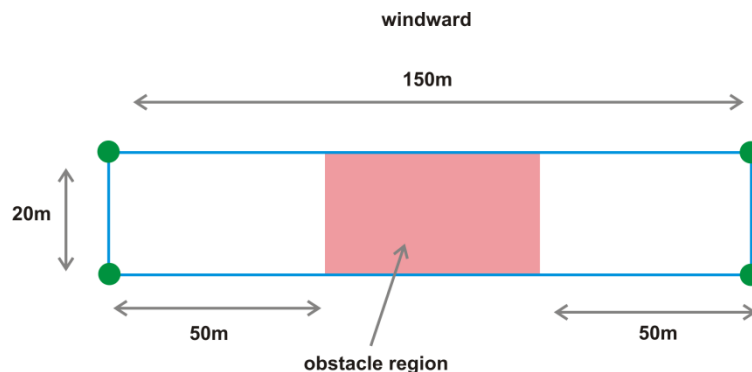


Figure 8 - Course for the obstacle avoidance contest.

The obstacle will occupy the whole 20m of the course width and will be placed somewhere between 50m from each short side (the pink region in figure 8). The sailboat should deviate from the obstacle, not touching it, and return to the course as soon as possible to complete at least one more full leg. The “obstacle” will be made with one or two red or orange RIBs, towing a line with red or orange balloons with gaps between them not larger than 1m. After placed in position, the RIBs will do their best to maintain the obstacle in place.

Scoring

The sailboats will be scored according to the following table (refer to figure 9)

1. the sailboat did not clearly initiate a maneuver to deviate from the obstacle: 0 points (red path);
2. the sailboat did start a maneuver to move away from the obstacle, but she hits the obstacle: 2 points (violet);

3. the sailboat did deviate from the obstacle not touching it, but failed to return to the course area within 5 minutes: 5 points (orange);
4. the sailboat did deviate from the obstacle not touching it and did return to the course area, but failed to complete the last full leg: 10 points (blue);
5. the sailboat succeeded completing the obstacle avoidance challenge: 15 points

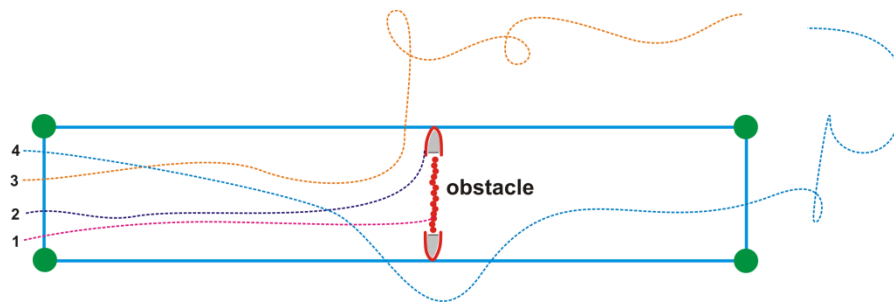


Figure 9 - The four unsuccessful cases in the obstacle avoidance contest.

To break a tie in cases 4 and 5, the number of track points outside the course area will be considered, as the percentage of the number of track points registered in the last full leg. For example, if in the last leg (from one short side to the other short side) a sailboat has recorded 100 track points and for avoiding the obstacle she registered 25 track points outside the course rectangle, she will be scored with 25 (the smaller the better).

Minimum objective

To be scored in this contest a sailboat must keep sailing valid legs, without crossing the long sides of the rectangle, until the obstacle is positioned.

Time limit

The time limit for this competition will be set to 30 minutes.