World Robotic Sailing Championship 2018
Notice of race and competition rules
v1.1

June 18, 2019

1 Introduction

The World Robotic Sailing Championship 2018 will be organized in Southampton, UK, from 26th to 30th of August. The World Robotic Sailing Championship will be followed by the International Robotic Sailing Conference that will be held on August 31st and September 1st at the University of Southampton. 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; the team members can be shared among different teams. The championship will be organized in 4 challenges, each one tentatively allocated to a single day.

2 Classes

The World Robotic Sailing Championship is open to all vessels using only wind and wave energy for propulsion. Besides the more traditional soft or rigid sailing rigs, 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 propulsion unit may be done by mechanical or electrical means, providing that the use of other energy sources is clearly inhibited. The teams must be able to clearly demonstrate this to the race committee. Vessels 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 (length overall, maximum length of the hull measured parallel to the waterline) and the maximum draft of any boat should be limited to 2 m. Hydrofoils are allowed. Sails and appendages may be changed between challenges.

The two classes considered in WRSC 2018 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 4.2 meters LOA and weighting no more than 500 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 in the competitions is of the exclusive responsibility of the team members. Before being allowed to compete, each team has to register a person of contact who will be held responsible for any damage, injury or environmental contamination resulting from any activity of the team, including the operation of their vessel.

All sailing boats will be under the supervision of support vessels provided by the organization. All people on board of a support vessel 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 or near the water. We aim to allow at least one member per team on a support vessel, however the organisers reserve the right to manage the fleet of support vessels, and can refuse access to the support vessels for any reason. All team members must follow the instructions of the competition organisers, the support vessel crew, and the activity centre personnel. The organizers reserve the right to refuse access to restricted areas. For safety reasons, the race area may be confined to a region delimited by 4 marks.

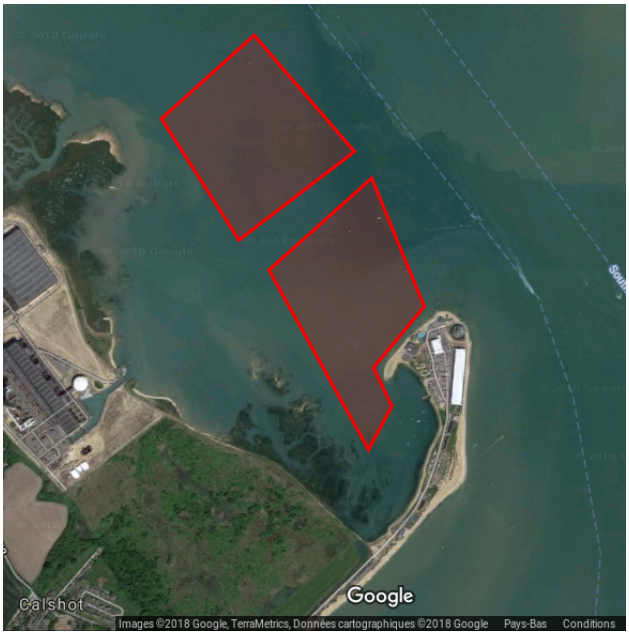

Figure 1: The approximate race area reserved for WRSC

Figure 1 shows approximately the area requested for WRSC that may be subject to last minute adjustments.

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. Remote control is allowed to avoid imminent collisions for the boat with no right of way. Alternatively, a collision may also be prevented by manually holding 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 and the required safety boat has not higher priority tasks.

Any remote controlled or manual measures during a challenge must be communicated to the race committee directly after the challenge.

5 Remote control

All teams are required to be able to take over remote-control of their boats through a wireless connection (WiFi, RC, ...). The country specific regulations on wireless communication must be obeyed, e.g. Wifi boosters beyond the allowed limits may not be used. Should the race committee have doubts about the remote controllability it may ask for a demonstration and restrict participation in challenges.

Remote control is allowed to transport competing vessels to the challenge area, but must be switched off several metres from the start line, with the vessel facing away from the start line.

6 Scoring

The WRSC is organized in 4 challenges scheduled for each day of the event: fleet race, station keeping, area scanning and obstacle avoidance. The scoring for each challenge 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 team that decides against participating in one of the challenges, or does not fulfil the minimum objectives defined for each challenge, will be given a ranking equal to the number of teams 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 place in each class; in each classe, the team with the lowest sum of its obtained rankings will be declared the winner of the World Robotic Sailing Championship.

7 Data recording

7.1 Measurement units

All measurements for scoring are to be made in SI units, with the exception of angles and latitude/longitude measurements, which should use degrees in

decimals, e.g. 60.3456 (chart datum: WGS-84).

The position must be tracked for all data as detailed in the next section. Some challenges offer bonus points for recording specific data, which will be detailed in the challenge description.

7.2 Tracking

Each boat has to fit an official standalone tracking device of ca. 5cmx3cmx10cm size, positioned suitably for GPS reception. Additionally the competing boats should be able to provide the race committee with the tracking data recorded from their own global navigation satellite system (e.g. GPS), since this will be used in case of failure of the official device. 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 may be provided either in CSV (comma-separated values) or binary format. All CSV format files must use three decimal integer number per line, representing: timestamp, $Lat * 10^7$, $Lon * 10^7$. The binary file format uses 12-byte records representing the three 32-bit signed integers of the CSV format in twos complement. The storage order may be little-endian or big-endian, the chosen order must be specified by the team. The allowed data formats are detailed in table 1

name	date format	example	9h recording filesize
CSV-2s	hhmmssdd (representing the hour hh, minute mm, second ss and day dd of the month)	line representing 14:23:34 on the 7th of September (month is not logged!) at lat=41.6887091 (north) and lon = -8.8259850 (west): "14233407, 416887091, -88259850"	1 MByte
CSV-3s	hhmmsssdd, using 3 digits for the field representing the seconds, where the third digit (rightmost) represents the decimal part of seconds	line representing 14:23:34.8 on the 7th of September at lat=41.6887091 (north) and lon=-8.8259850 (west): "142334807, 416887091, -88259850"	1 MByte
CSV-ms	GPS_miliseconds-of-the-week, the number of miliseconds since 00:00 last Sunday	line representing 16:03:29.123 of Wednesday at lat=41.6887091 (north) and lon=-8.8259850 (west): 317009123, 416887091, - 88259850	1 MByte
Binary-2s	binary file using the CSV-2s format		388 KByte
Binary-3s	binary file using the CSV-3s format		388 KByte
Binary-ms	binary file using the CSV-ms format		388 KByte

Table 1: Overview of position data formats

8 Challenges

WRSC will be organized in 4 challenges: fleet race, station keeping, area scanning and obstacle avoidance. 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 challenges will only be run with a minimum sustained wind speed of 6 knots (approximately 3m/s) and a maximum gust wind speed of 20 knots. Each challenge has a time limit. Scores are only counted up to the time limit and teams are asked to finish their attempt and clear the area for the next team at the end of the time limit. If weather and time allows, challenges can be attempted a second time, counting the best attempt. Teams that have not had a first attempt yet get privileged access to GPS trackers and safety boats.

The precise locations and time limits will be announced in the morning of each challenge, according to the regional short-term weather forecast. The race committee may decide to change the challenge days, run challenges over multiple days, or run multiple challenges in one day if deemed necessary due to weather conditions.

The next sections give details on the rules for each of the challenges.

8.1 Fleet race

This challenge is based on the classical triangular sailing race course All boats will start together and race around a triangular course. Separate courses and start times may be used for the different classes.

8.1.1 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.

Teams are scored based on the time between crossing the start line and crossing the finish line. Teams that do not complete the race will be scored according to number of markers they reached in the correct order. Teams reaching the same number of markers will be distinguished based on their time between crossing the start line and arriving at their last marker. Teams starting more than 15 minutes after the official start time will receive a 10%

time penalty. The time limit starts counting from the crossing of the start line.

8.1.2 Minimum objective

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

8.2 Station keeping

Sailing robots have a high potential for use as 'virtual moorings', maintaining a fixed position at sea, consuming little energy and without the requirement for anchoring at the seafloor. This challenge tests the ability of the competing vessels to perform such tasks, whilst also asking for a typical measurement task of such a virtual mooring: Estimating wave conditions. The measurement goals are wave height, wave frequency, and wave direction.

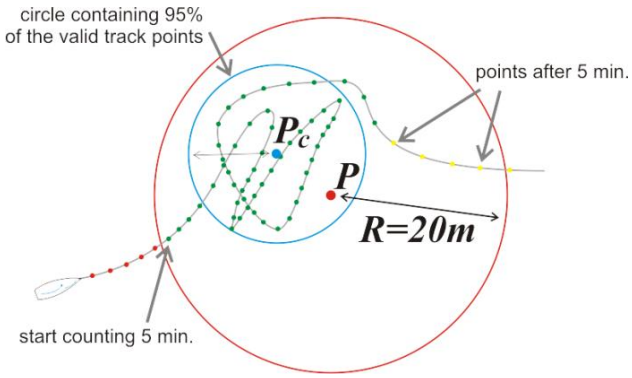

Figure 2: Scoring procedure for the station keeping challenge

The station keeping challenge uses a single waypoint P (see Figure 2). After entering a circle with radius $R = 20m$ around the waypoint, the sailing vessel aims to stay as close as possible to the waypoint for 5 minutes. The challenge is started by releasing the sailing boat at least 40m away from the waypoint P.

8.2.1 Scoring

The score is calculated from the positions recorded by a tracker during the 5 minutes after first recording a position within the 20 m radius around P as follows: A second point P_c is calculated as the average of the coordinates of all positions. To be qualified for scoring, the point P_c must be inside the 20 m circle, regardless of the individual positions. A circle is fitted around P_c, containing 95% of the positions. The radius of this circle around P_c is R_{min}, and this radius is used for scoring. The score is normalised to the vessel length overall (LOA) as $\frac{R_{min}}{LOA}$. A 5% reduction of the score can be received for each of the individual measurement goals, if the result is within a 20% margin around the estimates by the race committee. In total three reductions of 5% each can be achieved. Boats are then ranked by minimum score.

8.2.2 Minimum objective

To be scored in this contest, the vessel must enter the $R = 20m$ circle around P and continue to sail autonomously for five minutes after entering. The resulting point P_c must be inside the 20m circle around P.

8.3 Area scanning

In recent years, an increasing number of attempts is made at using maritime vessels in collaboration. A typical collaborative task is efficiently scanning a large area. The collaborative area scanning challenge asks teams to take the abilities and scanning goals of other teams into consideration to optimise their own points.

The scanning task is performed over a large area around the competition, that is structured in a grid. The boxes of the grid are assigned coordinates. Not all of the scan area may be suitable for all boats, and it is courtesy of the teams to choose scan goals suitable for their vessel. The challenge runs over an extended time period over which teams can launch and recover their vessels repeatedly either by requesting a safety boat (based on availability; first come first serve) or by remote controlling the boat from the pontoon to a start buoy. If a team wants to recover the boat, they must first register the current time with the race committee, so any positions after this time can be discarded. During the area scanning challenge, the tracker position

is made available to all teams live via the tracking website. Teams may update highlevel goals (e.g. waypoints) on their vessel remotely or change the software on the vessel before launching again after a recovery. Directly controlling the actuators (e.g. remote control) is not allowed. The race committee may ask to inspect the code determining updates to the vessel and can apply penalties if the goal updates are used too excessively. The boundaries of the scan area, the grid size, and the challenge start- and end time are announced on the morning of the challenge day. A bonus can be obtained by providing depth measurements.

The depth measurements must be provided as one value per box, in CSV format giving a latitude and longitude value inside the box, the depth estimate and a timestamp for the estimate (the timestamp is needed for tide compensation). The timestamp may be in one of the three formats that is given in table 1. If multiple values are given, the first value in the CSV table is used.

The tracking data of all vessels is available live via the tracking website.

The area scanning challenge starts at the start time, and ends at the end time given by the race committee on the day. The race committee may split the challenge into two groups by randomly selecting boats for each group.

8.3.1 Scoring

A box in the grid is considered visited by a vessel if at least one track point of the vessel is registered within that box within the scan time. One point is available for each box, the final value of the box is this point divided by the number of vessels that visited the box. Each team receives the final value of all of the boxes that were visited by the team. If a team can provide a depth estimate for a box that is within 20% of the race committee reference, a 5% bonus is added to the final value of the box.

Boats will be ranked by the final score they achieved from boxes visited by their vessel.

8.3.2 Minimum objective

To be qualified in this challenge, a vessel must register at least one track point within the scan area during the scan time.

8.4 Collision avoidance

When operating in a crowded environment, autonomous sailing vessels must be able to operate within a limited area, but also be able to avoid unexpected obstacles. The collision avoidance challenge will evaluate the ability of a sailing boat to remain in a predefined channel, detect an unexpected obstacle, deviate from its path for obstacle avoidance and then return to its path again. The course area will be set with four waypoints forming a rectangle with the longest side facing windward (see figure 3). Sailboats must enter the rectangle by one of the short 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.

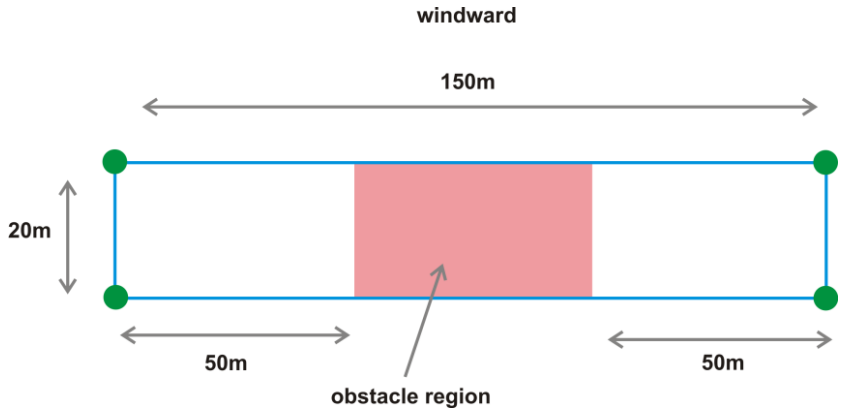

Figure 3: Course for the obstacle avoidance challenge

The obstacle will occupy a large portion of the course width and will be placed somewhere between 50m from each short side (the pink region in figure 8). The sailboat should log the first detection of the obstacle, deviate from its original path without touching the obstacle, and return to the course as soon as possible to complete at least one more full leg. The obstacle will be made from orange balloons, transported by a motorised vessel. The motorised vessel will do its best to stay far from the course, keeping the obstacle on the side of the vessel that is pointing away from the competing sailing vessel. After being placed in position, the motorised vessel will do its best to maintain the obstacle in place.

point	leg	description	requirement
A	-2	complete the entire leg within the rectangle	-
B	-1	complete the entire leg within the rectangle	-
C	0	log the vessel position and time of the first detection of the obstacle	-
D	0	show visible signs of deviating from the original path	C
E	0	no collision with the obstacle	C, D
F	0	return within the square before completion of the leg	C, D, E
G	1	complete the entire leg within the rectangle	-

Table 2: Scored actions during the obstacle avoidance challenge.

8.4.1 Scoring

The runs are counted relative to the leg that has the obstacle added. Table 2 lists all actions that can be achieved during the obstacle avoidance challenge, the leg during which they can be achieved, and what actions are required to be successfully completed before. Each successfully completed action is worth 1 point each. The different legs are differentiated based on the time of crossing the short end at the start of each leg. Where possible, successful actions are determined based on the tracking logs; the log of action C may be provided by the team to the race committee in the preferred format of the team. For actions D and E the race committee considers feedback from the safety boat and the vessel that places the obstacle. The teams are ranked by the number of actions achieved, the higher the number the better. If multiple teams score a full set of actions, the time spent outside of the rectangle during the obstacle avoidance is taken into consideration, the less time spent outside of the rectangle, the better. The time is determined from the timestamp of the last log position inside the rectangle to the first log position back within the rectangle.

8.4.2 Minimum objective

To be scored in this challenge, a vessel must enter the rectangle and complete at least one leg within the rectangle, or it must log the detection of an obstacle in the correct leg.