Scoring Guidance

2018 Maritime RobotX Challenge *www.RobotX.org*

The 2018 Maritime RobotX Challenge Task Description document provides descriptions of the requirements for each of the Documentation and System Performance tasks. The *Scoring Guidance* document provides a description of the elements that will be evaluated, judging criteria, and scoring for all Documentation and System Performance Tasks. All submissions are due in accordance with the *RobotX 2018 Task Description* document.

1. Documentation Tasks

There are five (5) Documentation Tasks required and described in the rules:

1. Website
2. Technical Design Paper
3. Team Introduction Video
4. Design Documentation Presentation
5. System Inspection

Documentation Task submissions are part of the Technical Submission Package as described in the *RobotX 2018 Task Description* document. Each Team's on-site Design Documentation Presentation and System Inspection will be conducted and scored during the practice/qualifying days. The Judges will have access to Team websites, the Teams' submitted Technical Design Papers, and Team Introduction Video prior to the start of the on-site judging.

Judges will assign points based on their determination of how well each Team meets the requirements described below. All Documentation Tasks must be completed in English. Teams should use their official Team designation on all Documentation submissions. Team presentation time slots will be randomly assigned based on a lottery system conducted by the Technical Director during the RobotX Orientation.

The scoring breakdown for these tasks is summarized in Table 1.

Table 1. Documentation Task Scoring Summary

Judging Element	Max Potential Points
Website	20
Technical Design Paper	20
Team Introduction Video	20
Design Documentation Presentation	20
System Inspection	20
Total Possible Points	**100**

Per the *RobotX 2018 Task Description* document the Website, Technical Design Paper, and Team Introduction Video must be submitted no later than 26 November 2018. For any item submitted after the due date the maximum potential points for that item will be reduced by one point for each day late. For example, if the Technical Design Paper is submitted (late) on 29 November 2018, the maximum points that may be awarded in this category would be 17 (calculated as: 20 – 3 = 17 (for three days late)). The reduction in potential points will apply only to the Website, Technical Design Paper, and Team Introduction Video. The maximum reduction will be ten points per late item. Any item submitted after 6 December 2018 will be eligible for a potential score of ten points.

Documentation Tasks are important to all Teams. For the Final round of the competition, the total score from all Design Documentation tasks will be added to the final score of System Performance Tasks. The total maximum potential score for the Documentation Tasks is 100 points, making this aspect of the competition roughly equivalent to scores achievable on any one System Performance Task. For the 2018 Maritime RobotX Challenge this means that the scores from the Documentation Tasks have the potential to impact the final rankings.

In addition, Judges may opt to recognize exemplary performance for any of the Documentation Tasks they deem particularly noteworthy. In the event of a tie in the Final Round of the System Performance Tasks, the Overall Score from the Documentation Tasks will be used as a tie-breaker.

Specific Judging criteria for each element of the Documentation Tasks are described in the sections below.

1.1. Website (20 points max)

Each Team's website submission will be judged primarily on the overall visual design, text/graphics balance, organizational flow, utility of the site, and technical merit. Teams should address their selection of sensors and integration of these into the vessel. Video content should be included that illustrates vehicle performance and any developmental testing. At a minimum, Teams should include basic team contact information and recognition of all contributing members. Refer to the RobotX 2018 Task Descriptions document for the minimum content requirements for the website.

Teams will be evaluated on quality of content, ease of website navigation, and basic functional utility. It is not necessary to add animation effects unless it aids in the overall presentation of the team message. Care should be taken to ensure that any special effects are not distracting. The Team Website must be ready for judging by **1200 UTC on 26 November 2018**.

1.2. Technical Design Paper (20 points max)

Technical Design Papers will be judged on overall appearance and adherence to the formatting guidelines, text/graphics balance, discussion of engineering design decisions as they relate to the System Performance Tasks, discussion of System Performance Task objectives and strategy, description of sensors (their intended performance and platform integration), description of propulsion components, description of software employed and/or developed by the Team, and discussion of any innovative hardware or software approaches required to achieve the Team's approach to completing the System Performance Tasks. Teams should use their official Team designation in the title section of the Journal Paper. The Journal Paper is due at **1200 UTC on 26 November 2018**.

1.3. Team Introduction Video (20 points max)

Each Team must submit a 2-3 minute video introducing their Team. The video is not intended to present Teams' vehicle design. Points for the Team Introduction Video will be based on video and audio production quality, effective communication of each team member's name and contribution. Creativity and humor are generally appreciated and will be viewed favorably. Teams should use their official Team designation in their video submission. The Team video is due by **1200 UTC on 26 November 2018**.

1.4. Design Documentation Presentation and Questions (20 points max)

Each Team's On-Site Design Presentation/Interview will be conducted during the practice/qualifying days. Each Team is required to present their system design to the judges. This presentation consists of two parts, an oral presentation and a team interview.

Table 2. Design Presentation Time Breakdown

Time Allowed	Element
5 minutes	Team video will be played
20 minutes	Oral Presentation to Judges
10 minutes	Judges' Interaction with Team
10 minutes	Questions from Judges

During their Design Presentation each Team will be evaluated on how well they describe their design decisions, specifically sensor and propulsion selection and platform integration, which support their strategies for each of the System Performance Tasks. The Design Presentation should include the following:

- Introduce all Team members present with a description of their technical or other contributions to the Team.
- Address any aspects of their system design as delivered to the competition site that may be different from that documented in the Journal Paper or Website.
- Describe the Team's competition strategy.
- Explain how the Team's competition strategy influenced selection and use of sensors and algorithms employed to complete the competition challenges.
- Do NOT simply provide a parts list; discuss how the components support the Team's competition strategy.

At the end of the presentation Judges may ask questions which relate to the material presented. After these impromptu questions the judges will conduct a team interview by asking a set of standard questions. This set of standard interview questions will be the same for all teams.

Points for the oral presentation and Team interview will be based on technical merit, quality of the visual aids and the Team's professional and interpersonal behavior. Teams should use their official Team designation on the title slide of their visual aids.

Teams must turn in visual aids they plan to use for their on-site presentation on Saturday, 8 December 2018 during the RobotX Orientation. Visual aids can be provided by e-mail to info@RobotX.org, USB portable drive, or CD/DVD. The On-site Presentation and Interview will be scheduled 10-12 December 2018. Presentation time slots will be assigned by a lottery system conducted by the Technical Director during the RobotX Team Orientation.

1.5. System Inspection (20 points max)

A panel of Subject Matter Expert (SME) Judges will inspect the Team's unmanned system, assessing technical design, craftsmanship, technical innovation, and visual impact of the design. Team members should be present to answer technical questions posed by the judges during this inspection. The System Inspection schedule will be provided at the competition site.

2. System Performance Tasks

The System Performance Tasks occur in three phases: Qualifying Round, Semi-Finals, and Finals. The scoring for System Performance Tasks is structured to provide an overall balance of potential points based on the expected degree of difficulty for each task. Additionally, the individual elements of each task are intended to be evaluated in a binary manner to provide clear criteria for consistently applying a partial score on any task.

Each Team will be assigned an Embedded Team Judge. All scoring decisions made by the Judges are final. Teams may request clarification of any scoring decision through their Designated Team Representative and their Embedded Team Judge.

For the Qualifying Round minimum performance criteria are specified and no points are awarded. For the Semi-Final and Final Rounds points will be awarded as explained in this document.

All teams must complete the mandatory requirement of successful completion of the Navigation Channel to be permitted access to their assigned course daily. This compulsory task is detailed in section 4 of the 2018 Maritime RobotX Challenge Task Description document.

2.1. Qualifying Round Judging Criteria

During the Qualifying phase of the competition, the tasks are judged in a binary manner. Judges will record when a team's AMS successfully completes a challenge. Once a team has successfully completed at least 5 challenges, they qualify for access to the full Competition Course where individual tasks are interlinked. Minimum success criteria for qualifying on the System Performance Tasks are detailed in the sections below. There are no scores kept for the qualifying round. Teams may attempt tasks multiple times until they successfully complete the task, so the rules are effectively pass/try again (instead of pass/fail)!

System Performance Task success criteria for the Qualifying Round is summarized in Table 3.

Table 3. Summary of Qualifying Round Task Success Criteria

Task	Minimum Success Criteria
Entrance and Exit Gates	The AMS must transit through any entry gate, go around the marker buoy, then transit through any exit gate.
Avoid Obstacles	The AMS must transit across an obstacle field, starting near one of the boundary markers and ending at/near the marker buoy diagonally across from the starting buoy.
Find Totems	The AMS must locate and circle the two correct totem buoys in the correct order and in the correct direction.
Scan the Code	The AMS must inspect and correctly report a three color display shown on the light tower. Teams are also required to display the recorded color pattern on their own console as detailed in the 2018 RobotX Task Description document.
Identify Symbols and Dock	The AMS must dock in the docking bay that contains the CORRECT symbol of the day.
Detect and Deliver	The AMS must place at least one of the allotted four racquetballs into at least one of the holes in the correct face of the Detect and Deliver Task.
Underwater Ring Recovery	The AMS must recover at least one ring to the surface platform. The ring must be secured by the AMS to be considered successfully recovered.

2.1.1. Entrance and Exit Gates

To qualify on this task, the AMS must autonomously enter the task through any ENTRY GATE, transit around the marker buoy, and return through any EXIT GATE. For the Qualifying Round this allows teams that do not have a hydrophone system to demonstrate autonomous navigation and perception.

2.1.2. Avoid Obstacles

To qualify on this challenge, the AMS must transit across an obstacle field. For the Qualifying Round, the AMS must start near one of the boundary markers and transit to the marker buoy diagonally across from the starting buoy. The AMS should attempt to avoid all obstacles encountered along its transit route.

2.1.3. Find Totems

To qualify on this task, the AMS must locate and circle the two correct totem buoys in the correct order and in the correct direction. For the Qualifying Round the color and order in which to circle the buoys will be posted at the TD tent daily. The correct direction for circling each color totem is described in the 2018 Maritime RobotX Challenge Task Description document.

To successfully circle the totem, the AMS must transit around the totem until it has crossed its approach path, transiting at least 360 degrees.

2.1.4. Scan the Code

To qualify on this task, the AMS must report the correct color sequence displayed on the light buoy.

Teams are required to display the recorded color pattern on their own console as detailed in the 2018 RobotX Task Description document. The color sequence reported must be the correct color sequence displayed on the light buoy.

Should the AMS send multiple reports of the color sequence the judges will consider only the last data reported.

2.1.5. Identify Symbols and Dock

To qualify on this task, the AMS must successfully dock in the docking bay that contains the correct symbol of the day. Note the symbol is defined as a color and shape combination. For the Qualifying Round the correct Docking Symbol for each course will be published to Teams daily.

A docking attempt is considered successful if the AMS fully enters a docking bay between two of the adjacent pontoons. A docking attempt in which the AMS straddles a pontoon will be considered unsuccessful.

2.1.6. Detect and Deliver

To qualify on this task, the AMS must place at least one of the allotted four racquetballs into at least one of the holes in the correct face of the Detect and Deliver Task. The correct face is defined as the face displaying the correct symbol. Each team will be permitted to attempt up to four (4) balls per qualifying run.

For the Qualifying Round the correct Detect and Deliver Symbol for each course will be published to Teams daily.

2.1.7. Underwater Ring Recovery

To qualify on this task, the AMS must recover at least one ring to the surface platform. The ring must be secured by the AMS to be considered successfully recovered. For the Qualifying Round, Launch and Recovery of a tethered AUV system is not mandatory. This allows teams that do not have a separate deployable underwater system to qualify on this task by demonstrating autonomous perception and mechanical actuation.

2.2. Semi-final and Final Round Judging Criteria

In the Semi-final and Final Rounds Teams will be required to attempt several of the individual tasks assembled as an integrated course. The unmanned systems will demonstrate autonomy and perception by completing tasks using information obtained from one or more prior tasks. Teams must cross through an ENTRY GATE before attempting any other tasks.

For the Semi-Final and Final rounds a time period will be specified. Teams are encouraged to utilize their full time period to compile as many points as possible for each run. This year, there are no scoring incentives for finishing early, and any time remaining will NOT be used as a tie-breaker. Instead the Documentation Task scores will be used as a tie-breaker. As described in Section 1 of this document, the potential score for Documentation Tasks is tied to timely submission of the Technical Package. By including scores from the Documentation Tasks, we are elevating the importance of the Documentation Task and of meeting deadlines.

Table 4. Max Point for Semi-finals and Finals

Task Name	Max Points
Entrance and Exit Gates and Scan the Code	75
Avoid Obstacles	110
Find Totems	60
Scan the Code	Included Above
Identify Symbols and Dock	45
Detect and Deliver	80
Underwater Ring Recovery	138
Design Documentation	100
MAX Possible Points	**608**

2.2.1 Entrance and Exit Gates and Scan the Code

In the Semi-final and Final Rounds teams must start their run by entering the competition course through one of the entry gates. The correct entry gate will be identified by a random beacon signal. The light buoy from the Scan the Code task will be located beyond the set of entry gates. Once the AMS detects the light buoy it must do the following:

1) Report the color sequence.
2) Record and display the color sequence on the team console for inspection by the judges.
3) Maneuver beyond the light buoy based on the first color displayed per the following instruction:
   - If the first color is RED, the AMS should pass the light buoy to its STARBOARD side.
   - If the first color is GREEN, the AMS should pass the light buoy to its PORT side.
   - If the first color is BLUE, the AMS should circle the light buoy 360 degrees. This may be done in either a clockwise or counter-clockwise direction.

After completing all other System Performance Tasks, the AMS must exit the course through the exit gates. The correct exit gate will be identified by a random beacon signal.

Points will be awarded as follows:

- The AMS will score 5 points for transiting through any ENTRY GATE or EXIT GATE.
- The AMS will score 25 points for transiting through the CORRECT ENTRY GATE. This score is either/or, and is not additive to a score for any gate.
- The AMS will score 15 points for exhibiting the correct behavior based on the first color displayed on the light buoy of the Scan the Code task.
- The AMS will score 10 points for reporting and recording the correct color sequence displayed by the light buoy.
- The AMS will score 25 points for successfully navigating through the CORRECT EXIT GATE. This score is either/or, and is not additive to a score for any gate.
- 5 points will be deducted for any obstacle or course element hit or straddled on this task.

MAX TOTAL = 25 (correct entry gate) + 15 (correct transit behavior) + 10 (correct report/record) + 25 (correct exit gate) = 75 points

2.2.2 Avoid Obstacles

For the Semi-final and Final rounds, the AMS must transit across an obstacle field, and may do so in the following manners:

1) As for the Qualifying Round, the AMS may start near one of the boundary markers and transit to the marker buoy diagonally across from the starting buoy.
2) Alternatively, the AMS may transit the obstacle field in a 'lawnmower pattern' per the following description. The AMS enters the obstacle field from one edge of the obstacle field and transits across the field to the opposite side of the obstacle field. After reaching the far side of the obstacle field, the AMS may exit the boundary of the obstacle field and execute a 'U-turn', then re-enter the field and transit back across the obstacle field on a unique travel path. In other words, the AMS may not retrace its path through the obstacle field. In the lawnmower pattern the AMS may go back and forth across the obstacle field multiple times, but each crossing must be through a unique path. To score points executing the lawnmower pattern, the AMS must make at least two full crossings of the obstacle field.

The AMS will score points for each full transit across the obstacle field. For the lawnmower pattern, the AMS may score points for up to ten full unique transits. After ten unique transits, no further points will be awarded.

The AMS must avoid all obstacles. A penalty will be assessed for any obstacles hit or straddled.

Points will be awarded as follows:

- The AMS will score 5 points for entering the obstacle field near a perimeter marker.
- The AMS will score 20 points for navigating in a diagonal across the obstacle field.
- The AMS will score 5 points for exiting the obstacle field near the diagonally opposite perimeter marker.
- The AMS will score 10 points for each pass through the obstacle field when executing the "Lawnmower Pattern" up to a maximum of ten passes through the obstacle field, and a minimum of two passes through the obstacle field.
- 2 points will be deducted for any obstacle or course element hit or straddled on this task.

MAX TOTAL for a Diagonal Run = 5 (start near a perimeter marker) + 20 (transit diagonally) + 5 (exit near a perimeter marker) = 30 points.

MAX TOTAL for a Lawnmower Pattern = 5 (start near a perimeter marker) + 100 (ten unique transits across the obstacle field) + 5 (exit near a perimeter marker) = 110 points.

2.2.3 Find Totems

For the Semi-final and Final rounds the AMS must locate the Totems and circle them in the correct sequence and in the correct direction. The order of execution is determined by Scan the Code. The correct sequence to circle the color totems is given by the sequence of colors from the Scan the Code light tower. The correct direction for a corresponding color totem is described in the 2018 Maritime RobotX Challenge Task Description document.

To successfully circle the totem, the AMS must transit around the totem until it has crossed its approach path, transiting at least 360 degrees.

The AMS must avoid all obstacles. A penalty will be assessed for any obstacles hit or straddled.

Points will be awarded as follows:

- The AMS will score 5 points for circling any color totem up to three unique totems total.
- The AMS will score 5 points each for circling the totem in the correct direction according to its color.
- The AMS will score a 2X multiplier for circling three totems in the correct order as established by the color sequence of the **Scan the Code** and in the correct direction.
- 5 points will be deducted for any obstacle or course element hit or straddled on this task.

MAX TOTAL (for circling three totems in the correct sequence and in the correct direction) = 15 (circle three totems) + 15 (circle three totems in the correct direction) = 30 X 2 (bonus for circling three totems in the correct sequence and correct direction) = 60 points

2.2.4 Scan the Code

For the Semi-final and Final rounds, this task will be combined with the Entrance and Exit Gates task. The Scan the Code light tower will replace the black can buoy from the Qualifying round. Execution and scoring for this task is described above.

2.2.5 Identify Symbols and Dock

For the Semi-final and Final rounds, the AMS must successfully dock in any docking bay. A docking attempt is considered successful if the AMS fully enters a docking bay between two of the adjacent pontoons. A docking attempt in which the AMS straddles a pontoon will be considered unsuccessful.

Based on the shape of the symbol in the docking bay, the AMS must execute a station keeping demonstration per the following:

- Triangle: 5-10 seconds
- Circle: 15-20 seconds
- Cruciform: 25-30 seconds

The AMS should hold station for no less than the minimum amount of time, nor more than the maximum time per the above description. A course judge will determine the time of each station keeping demonstration. The AMS should then depart the docking bay. The station keeping demonstration is considered at an end when the AMS begins its departing maneuver.

After the station keeping demonstration, the AMS must successfully dock in the remaining docking bay. No station keeping demonstration is required on the second docking bay.

Points will be awarded as follows:

- The AMS will score 5 points for entering the first dock.
- The AMS will score 25 points for station keeping in the first dock according to its shape.
- The AMS will score 5 points for departing the first dock.
- The AMS will score 5 points for entering the second dock.
- The AMS will score 5 points for departing the second dock.

MAX TOTAL = 5 (enter first dock) + 25 (station keeping demonstration based on shape) + 5 (exit first dock) + 5 (enter second dock + 5 (exit second dock) = 45 points

2.2.6 Detect and Deliver

For the Semi-final and Final rounds, the AMS may place up to four racquetballs into any of the holes on either face of the Detect and Deliver Task. A point multiplier will be applied for placing balls through the holes in the correct face. The correct face is defined as the face displaying the correct symbol. For the Semi-final and Final rounds the correct face is the face which displays the same shape as the shape displayed in the docking station where the AMS first docks.

Points will be awarded as follows:

- The AMS will score 5 points for each ball placed through the large hole.
- The AMS will score 10 points for each ball placed through the small hole.
- The AMS will score 2X multiplier for each ball through the correct face.

MAX TOTAL = 40 (four balls through small hole) x 2 (multiplier for correct face) = 80 points

2.2.7 Underwater Ring Recovery

For the Semi-final and Final rounds, the AMS may recover underwater rings to the surface platform. The rings must be secured by the AMS to be considered successfully recovered. There are a total of six rings, two rings at each of three levels. Points will be scored for each ring recovered, with progressively more points awarded for rings recovered from the middle and lower levels. A multiplier will be in effect for recovering multiple rings.

The AMS may retrieve the rings by using a tethered underwater vehicle. Points may be scored for successfully launching and recovering the underwater vehicle from the surface platform.

The AMS may also retrieve the rings by using a mechanical arm or other device that is not detached from the surface platform. If this is the case no points are awarded for launch and recovery of the retrieval system. This allows teams that do not have a separate deployable underwater system to score points for demonstrating autonomous perception and mechanical actuation.

The AMS may recover rings from any of the three levels.

Points will be awarded as follows:

- The AMS will score 15 points for successfully launching a tethered underwater vehicle from the surface platform.
- The AMS will score 15 points for successfully recovering and stowing a tethered underwater vehicle back to the surface platform.
- The AMS will score 1 point for each ring recovered from the upper level of the Ring Recovery Task.
- The AMS will score 3 points for each ring recovered from the middle level of the Ring Recovery Task.
- The AMS will score 5 points for each ring recovered from the lower level of the Ring Recovery Task.
- The AMS will score a multiplier by summing the total of the ring score and multiplying by the number of rings successfully recovered.

MAX TOTAL = 15 (launch an underwater vehicle) + 15 (recover the underwater vehicle) + 108 [18 (recover all 6 rings) x 6 (multiplier for recovering 6 rings)] = 138 points

3. Summary of Scoring Approach

3.1. Scoring: Qualifying Round

For the **Qualifying Round ONLY**, each System Performance Task will be completed individually. Each attempt at a Task will be recorded separately. No score will be awarded. The judges will determine if the minimum criteria for demonstrating proficiency on a task has been met.

To qualify to run on the full competition course, teams must demonstrate proficiency on a minimum of five (5) of the seven (7) tasks. Qualifying to run on the full Competition Course will automatically earn the Team a place in the Semi-Final Rounds.

3.2. Scoring: Semi-final Round

Scoring in the **Semi-final round is DIFFERENT** from the Qualifying Round. Once a team has qualified to run on the Competition Course, scores will be calculated based on all tasks completed in a single run. Each time a Team completes an attempt on the Competition Course the total points accumulated will be summed and recorded by the judges.

Each run on the full competition course will be recorded separately. A Team may make multiple attempts on the full competition course, and each attempt will be scored. The best score earned will be used to determine placement in the Finals round.

3.3. Scoring: Final Round

Teams may attempt to complete the Final round course as many times as they wish within their allotted time. Judges will record scores for each attempt, and the best score will be counted. Crossing of the ENTRY GATE threshold is considered the start of a new attempt. A run is considered complete when either time runs out, or the AMS passes through the EXIT GATE.