The Singapore AUV Challenge 2024

Rulebook

Current Rulebook version

5.1.2

Last updated on

17 Mar 2024

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Objectives

The goal is for each team to develop an Autonomous Underwater Vehicle (AUV) which can negotiate the tasks put forth under a prescribed time and at the same time, to learn about underwater robotics and have fun in the process.

▲ Figure 1: The SAUVC 2017 Participants.

Structure of the Team

A team may consist of up to **11 participants** including **faculty supervisors**. At least half of the participants must be non-professionals (students, hobbyists, hackerspace members, etc) at the time of registration.

▲ Figure 2: One of the teams with faculty co-supervisors from the 2017 Competition.

Video Submission

All teams have to submit a video of their AUV prior to the competition. The video **HAS TO**

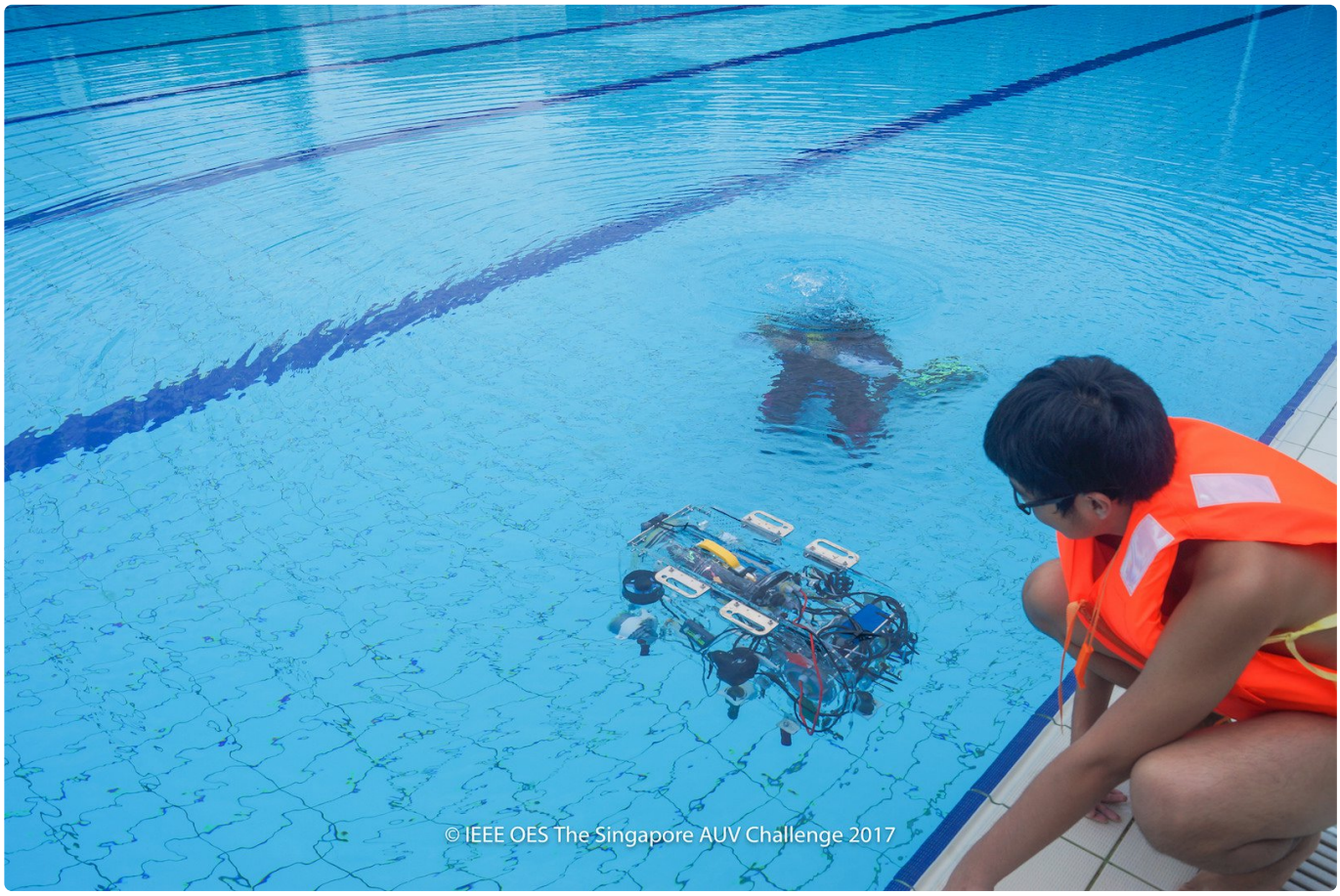
- be maximum **30 seconds** long,
- be submitted before 23:59 January 7th, 2024, Anywhere On Earth,
- showcase the tether-less operation of AUV swimming underwater for at least **10 seconds**.
- show clearly that someone pressing the Kill Switch should stop all thrusters immediately.

Videos will be reviewed by the organizing committee and **30 teams with the best vehicles will be short-listed to attend the competition**.

The organizers reserve the right to publish the video submissions after the competition.

Qualification

- AUVs have to pass a qualifying round before they can participate in the main arena.
- To qualify, an AUV has to swim from **qualification starting line** and pass through the **qualification gate** without surfacing, touching the bottom/wall or the qualification gate.
- The time taken for the **last part** of the AUV to pass through the **qualification gate** will be counted towards the qualification time.
- Teams will be allocated a time slot for the qualification round. Teams may attempt multiple qualifying runs during the qualifying slot.
- If multiple qualifying runs are attempted during the qualifying slot, the fastest successful run will be considered for the final round.
- **Only the top 15** qualified teams, with the fastest time for the qualifying round, will advance to the final round.
- The time taken to pass the qualifier round decides the sequence in which the teams will participate in the final round of the competition. The team that finished the last in the qualifying round would participate first in the final round.

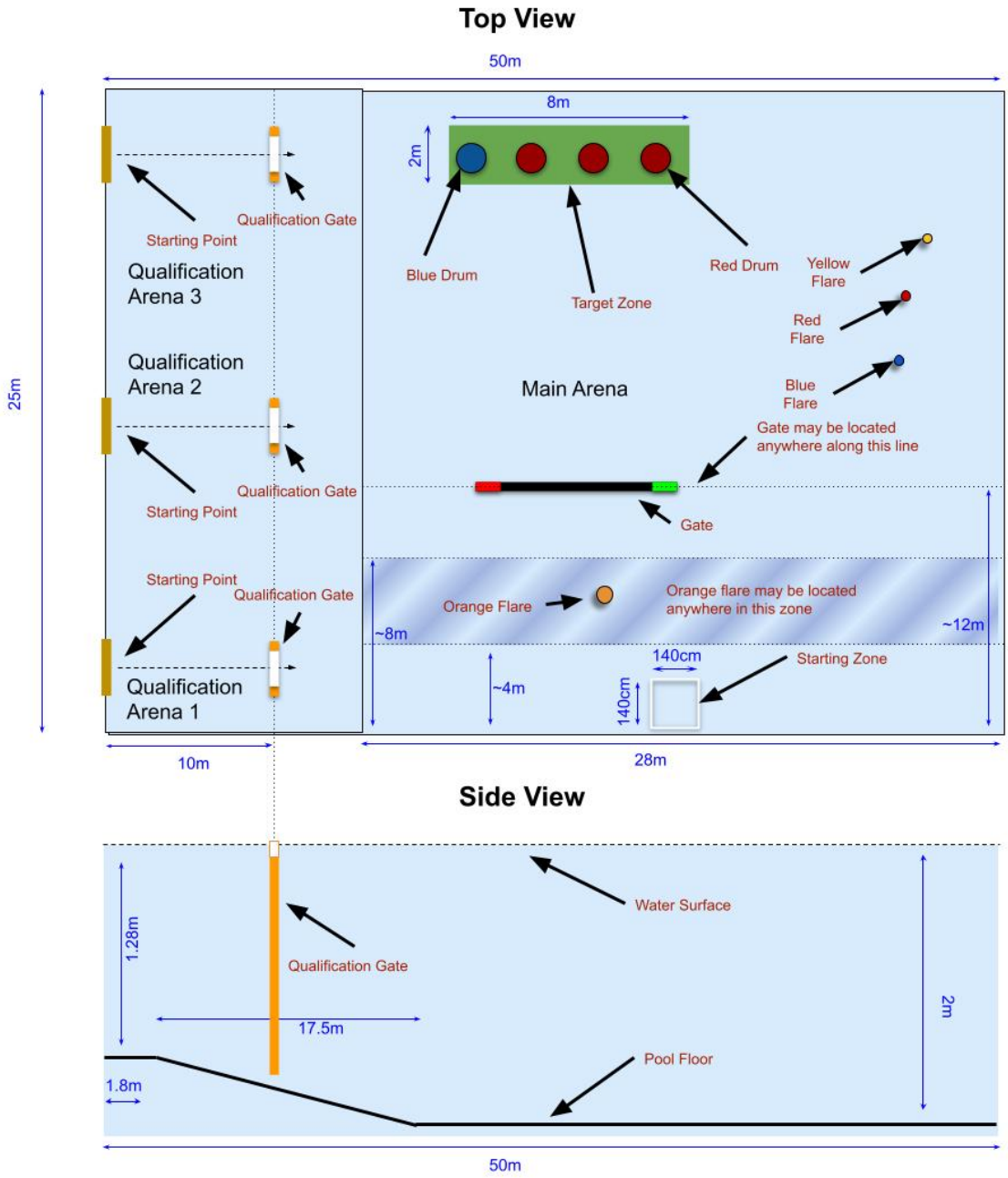


▲ Figure 3: A team attempting qualification in the 2017 Competition.

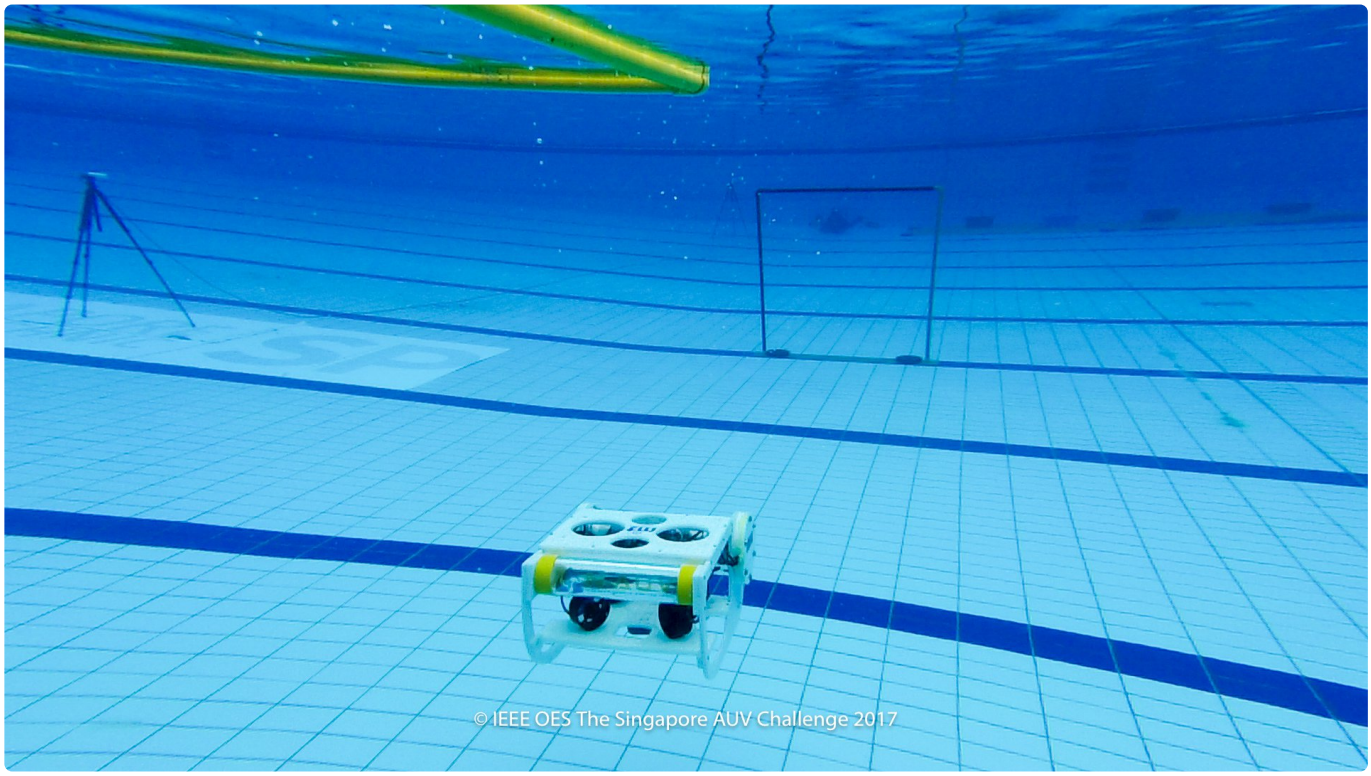
▲ Figure 4: Top view of the qualification areanas from the 2022 Competition.

The Arena

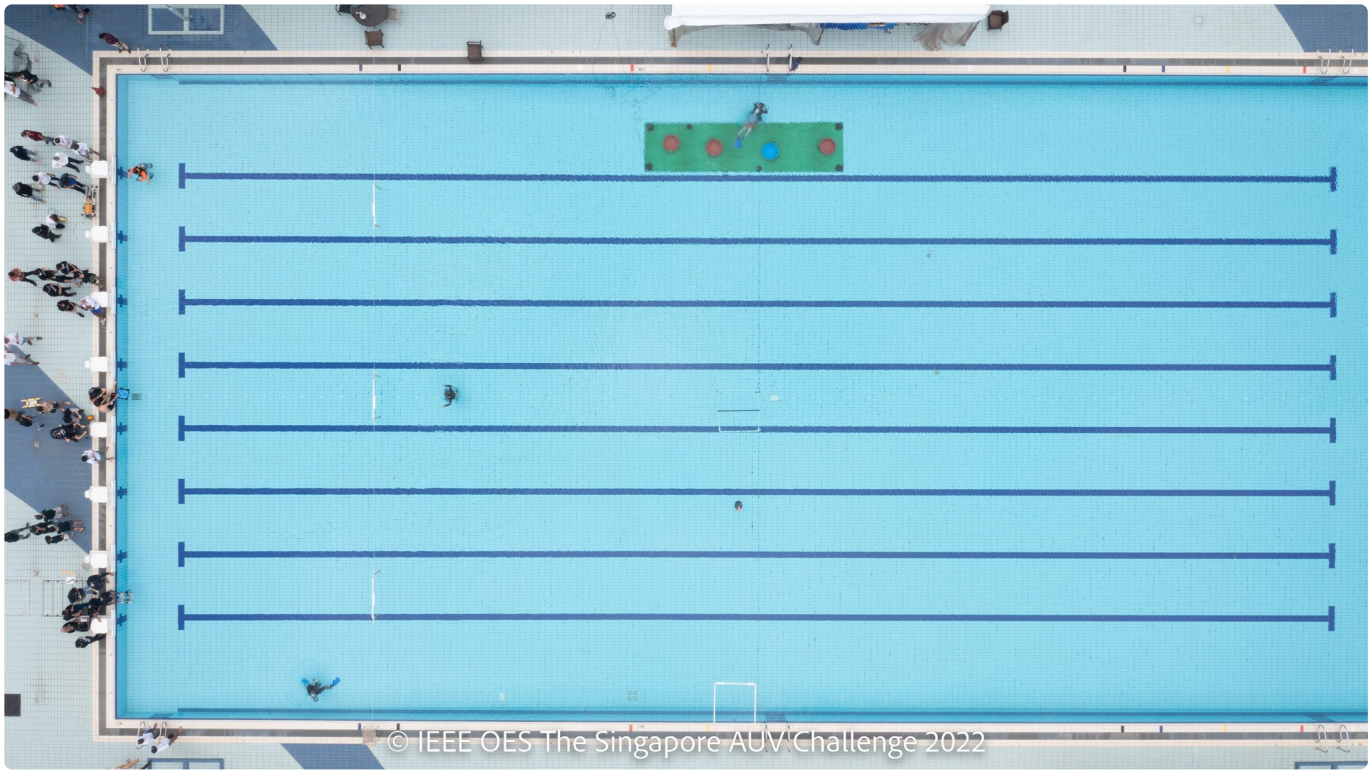
The challenge will be held in an olympic sized swimming pool (50m x 25m).



▲ Figure 5: Top & side views of the Arena (not to scale).



▲ Figure 6: Picture of the Arena from 2017 Competition.



▲ Figure 7: Picture of the Arena from 2022 Competition.

Qualification Arena(s)

The qualification rounds would be held on the side of the main arena.

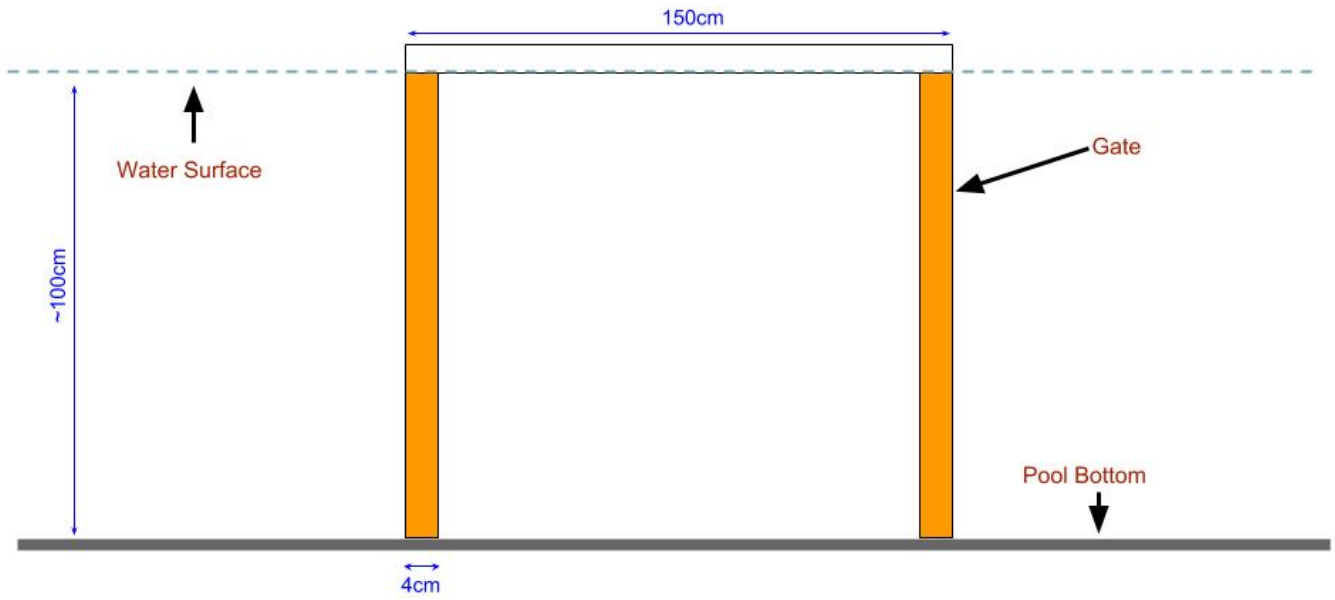
The qualification starting line is a marked 1m wide section of the pool wall from where the AUV should be deployed from. The AUV **has to touch the wall** at the begining of

the run.

At approximately 10m from the starting line the qualification gate is hanging from the surface of the water. The AUV has to go through the gate to qualify. If the AUV touches **ANY** of the 3 sides of the qualification gate, the attempt is considered a failure.

Specification of props

	Prop	Description
1	Qualification Gate	150cm wide and ~100cm deep gate hanging from the water surface with orange markings on both port and starboard sides.



▲ Figure 8: Front-view of the qualification gate.

Starting Zone

The starting zone is a **140×140cm area** marked on the surface of water. The teams **must** start their AUVs from this area. The team may only place the AUV at the water

surface, it must autonomously submerge **before** leaving the starting zone. Teams may also place their communication equipment in the starting zone.

▲ Figure 9: Picture of the Starting Zone from 2022 Competition.

Tasks

There are 4 tasks in the challenge:

1. Navigation
2. Target Acquisition
3. Target Reacquisition
4. Communication & Localization

The first task, Navigation, is mandatory and **must be completed** before attempting any other task. The other tasks can be attempted in any order. Surfacing at any point signifies end of the attempt.

1. Navigation

The aim of this task is to swim through a gate placed at the bottom of the pool. The gate may be located anywhere on a horizontal line, parallel to the side of the swimming pool, approximately 12m away from the starting zone. See Figure 4. The AUV has to swim through the 150 cm tall gate without touching the gate.

A orange flare may be located anywhere in a rectangular zone 4m-8m from side of the arena, before the gate. The AUV **has to avoid** touching the orange flare. Any part of the AUV touching the orange flare causes an immediate abort of the attempt.

▲ Figure 10: Picture of the gate from 2022 Competition.

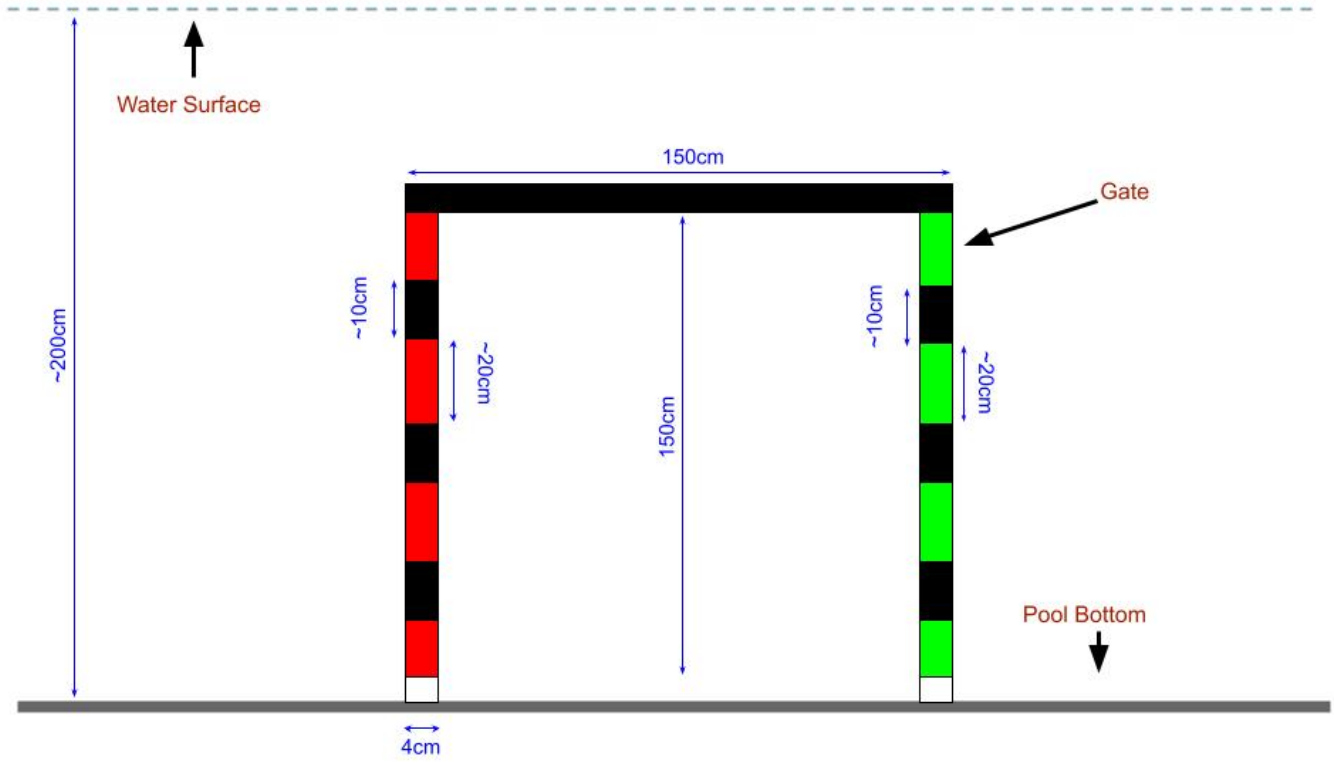
Points

If the AUV successfully passes through the gate,**15 Points** will be awarded.

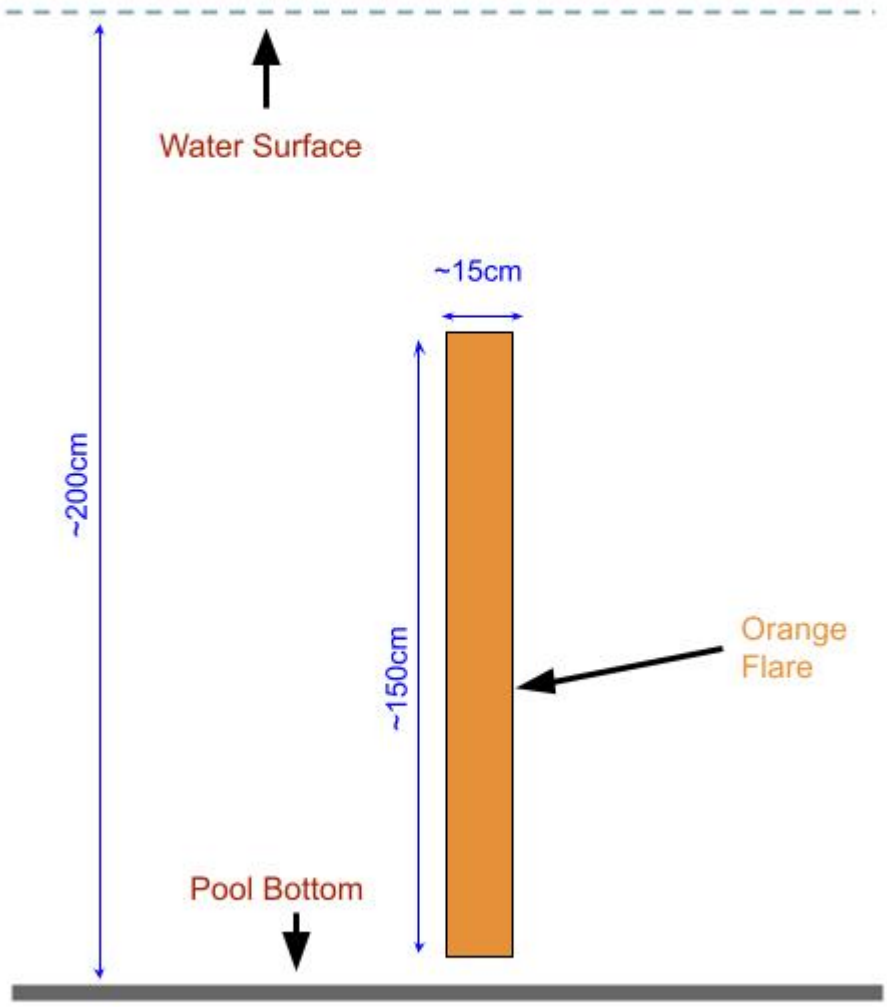
Specification of props

	Prop	Description
1	Gate	150cm wide and 150cm tall gate with striped red and green markings on port and starboard sides respectively.

	Prop	Description
2	Orange Flare	150cm tall and ~15cm diameter flare, and orange in color.



▲ Figure 11: Front-view of the gate.



▲ Figure 12: Front-view of the orange flare.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▲ Figure 13: Orange flare from 2022 Competition.

▲ Figure 14: Gate and orange flare from 2022 Competition.

2. Target Acquisition

The aim of the task is to detect and acquire a target among a series of drums at the bottom of the pool, in the target zone.

A target zone is defined by a green colored mat laid out on the floor of the pool. The mat is 8m x 2m in size. Figure 4. shows the location of the mat with respect to the arena.

There are 4 colored drums in the arena. All of them are on the mat. One of the drums, chosen at random, will be blue in color, while the rest are red in color. One of the red drums, chosen at random, will contain an acoustic pinger. The AUV needs to drop a ball in one of the drums to successfully complete this task. Points will be awarded based on which drum the ball is dropped into. In the event of multiple balls being dropped, only the **first ball** is taken to consideration.

The location of the red drum which contains the acoustic pinger may be randomized between attempts, as may be the order of the drums. The order of the drums and location of the pinger will be decided by the organizing committee.

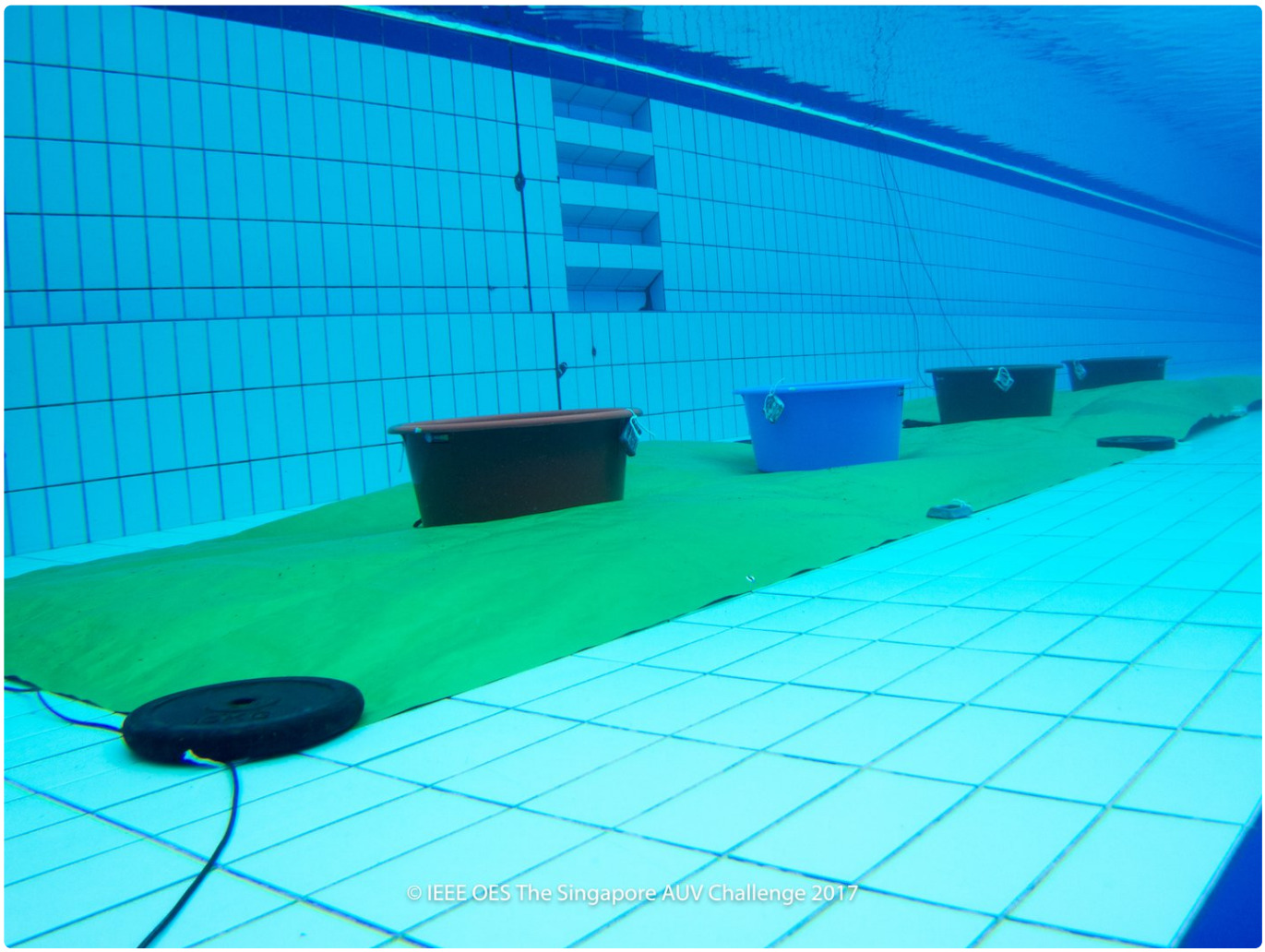
Points

Points will be awarded as follows.

- Drop the ball in the blue drum: **30 Points**
- Drop the ball in the red drum with the pinger: **50 Points**
- Dropping the ball in any other red drum: **10 Points**

Specification of props

	Prop	Description
1	Drum	60cm in diameter and 30cm in depth.
2	Ball	3.5-4.5cm in diameter and weigh no more than 200g in air. Provided by teams.
3	Drum Pinger	RJE International Pinger Model No. ULB-362B/45 kHz.



▲ Figure 15: Picture target zone and drums from the 2017 Competition.

▲ Figure 16: Picture of a 45kHz pinger.

3. Target Reacquisition

The aim of this task is to reacquire a previously detected target.

This task is only attempt-able if the Target Acquisition has been successfully completed. Furthermore, the AUV has to leave the target zone, before it can attempt the Target Reacquisition task. Every part of the AUV needs to clear the target zone, before it can be considered outside the target zone.

After the AUV is outside the target zone, it needs to reacquire the target and pick up the ball that it dropped in the Target Acquisition task. The AUV has to hold on to the ball till the end of attempt to successfully complete this task.

This task does not have to be attempted immediately after Target Acquisition task, other tasks may be attempted in between.

Points

If the AUV successfully picks up the ball and holds on to it till the end of the attempt, **60 Points** will be awarded.

Specification of props

	Prop	Description
1	Target zone	Green mat 8m x 2m in size.

	Prop	Description
2	Ball	Same ball used in target acquisition task. Provided by the teams.

4. Communication & Localization

The aim of this task is to localize on coloured flares and bump them causing a golf ball to drop out. There are **3 coloured flares** in the arena, one **red coloured flare**, one **yellow coloured flare** and one **blue coloured flare**. These flares could be located **anywhere** within the main arena. The AUV may locate and bump a flares in **a specified order**, which may be communicated to the AUV, to receive bonus points.

On every attempt, after the AUV successfully completes the *Navigation task*, the team will be informed of the **order** in which the flares have to be bumped. The **specified order** may be different between different attempts. The order will specified using the following notation, joined by a hyphen (-).

- Red : **R**
- Yellow : **Y**
- Blue : **B**

So, for example, specifying the order as **R-B-Y** would mean that the AUV has to bump the **red flare** first, followed by the **blue flare** and finally the **yellow flare**.

The team is then allowed to communicate the **order** with their AUVs using their communication equipment.

Points

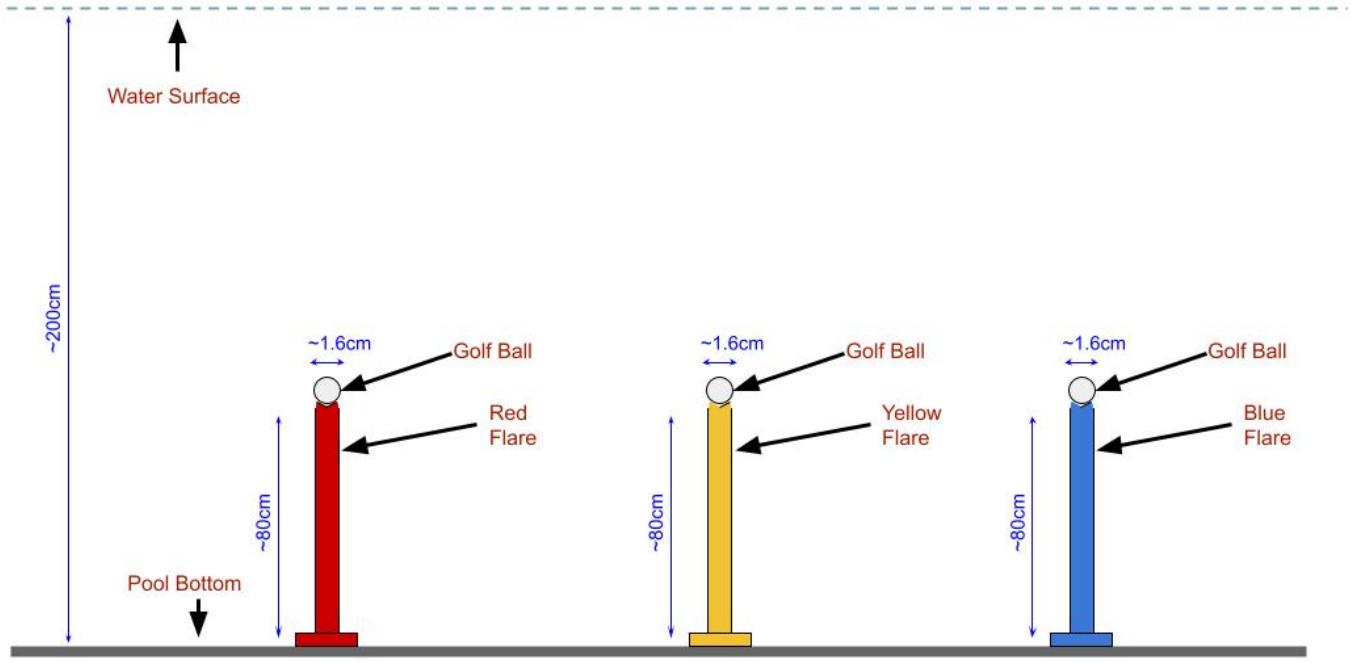
Points would be awarded as follows.

- Successfully causes the ball to drop from any flare via contact or proximity : **20 Points per flare**
- Successfully causes the ball to drop all 3 flares in the **specified order** : **60 Points** (in addition to above)

Specification of props

	Prop	Description

	Prop	Description
1	Red Flare	80cm tall, ~1.6cm in diameter, and red in color.
1	Yellow Flare	80cm tall, ~1.6cm in diameter, and yellow in color.
1	Blue Flare	80cm tall, ~1.6cm in diameter, and blue in color.



▲ Figure 17: Side-view of the flares.

Surfacing

Breaching the surface any point during the mission causes end of the current attempt, the total points for that attempt will be computed based on the tasks accomplished in that attempt and the timing bonus (if applicable) and a **5 Points** bonus for ending. The team may wish to retry if they still have time left.

Aborting

At any time during the mission, current attempt can be aborted, by indicating to the Game Master. The divers would then retrieve the AUV back to the starting zone. The timing for the current attempt is stopped at the time of indication. The team may wish to retry if they still have time left.

In the case of an aborted attempt, the team would be awarded the points for all previously successfully completed tasks during the current attempt.

Automatic Abort

If the AUV touches the bottom or the side walls of the pool for **a cumulative time of more than 10 seconds or 5 discrete touches**, the current attempt would be automatically aborted. The divers would then retrieve the AUV back to the starting zone. The team may wish to retry if they still have time left.

In the case of an automatic aborted attempt, the team would be awarded the points for all previously successfully completed tasks during the attempt.

Timing Bonus

At the end of an attempt, as long as the AUV has successfully completed at least **2 tasks**, the Navigation task and any other task, bonus points proportional to the remaining time will be awarded in accordance with the following formula.

```
Bonus points = (900 - RUN_TIME) • 0.03
```

For eg. For a run time of 420s, Bonus = (900-420)•0.03 = 14.4 Points

Penalties

There are penalty points for touching the floor or wall of the pool at any time, and also for touching the gate during a specific attempt. This penalty points are:

	Description	Penalty Points
1	Touching the gate	2
2	Touching the bottom of the pool or wall	5

Examples

Here are some examples scenarios and how they would be scored.

Example 1

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task, but touches the side of the gate while passing through.
- AUV can't find the location next task and ends the mission by rising to the surface.

	Task	Points
1	Navigation Task	15
2	Touching the gate	-2
3	Surfacing	5
	Attempt Total	18

Example 2

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task.
- AUV can't find the location of the next task and has to aborted and retrieved by divers.

	Task	Points
1	Navigation Task	15
	Attempt Total	15

Example 3

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task.
- AUV find the drums and successfully drops the ball in the blue drum, but

touches the side of the wall momentarily while looking for the drum.
- AUV tries to find the flares, but can't find it and has to be aborted and retrieved by divers.

	Task	Points
1	Navigation Task	15
2	Target Acquisation Task (Visual)	30
3	Touching the wall	-5
	Attempt Total	40

Example 4

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task.
- AUV find the drums and successfully drops the ball in the blue drum.
- AUV locates the red flare and knocks off the golf ball.
- AUV surfaces with run time of 400 seconds.

	Task	Points
1	Navigation Task	15
2	Target Acquisition Task (Visual)	30
3	Communication & Localization Task	20
4	Surface Bonus	5
5	Run time Bonus	15
	Attempt Total	105

Example 5

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task.
- Team is given the squence of R-B-Y for the flares.
- AUV find the drums and successfully drops the ball in the blue drum.
- AUV locates the red flare and knocks off the golf ball.
- AUV locates the yellow flare and knocks off the golf ball.
- AUV touches the bottom of the pool for more than 10 seconds while trying to find 3rd flare and gets automatically aborted by divers.

	Task	Points
1	Navigation Task	15
2	Target Acquisation Task (Visual)	30
3	Communication & Localization Task	40
	Attempt Total	85

Example 6

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task.
- Team is given the squence of R-B-Y for the flares.
- AUV find the drums and successfully drops the ball in the blue drum.
- AUV locates the red flare and knocks off the golf ball.
- AUV locates the yellow flare and knocks off the golf ball.
- AUV locates the blue flare and knocks off the golf ball.
- AUV touches the bottom of the pool for more than 10 seconds while trying to find 3rd flare and gets automatically aborted by divers.

	Task	Points
1	Navigation Task	15
2	Target Acquisation Task (Visual)	30

	Task	Points
3	Communication & Localization Task	60
	Attempt Total	105

Example 7

- Team launches AUV from starting zone.
- AUV crosses the gate and completes the Navigation task.
- Team is given the squence of R-B-Y for the flares.
- AUV find the drums and successfully drops the ball in the blue drum.
- AUV locates the red flare and knocks off the golf ball.
- AUV locates the blue flare and knocks off the golf ball.
- AUV locates the yellow flare and knocks off the golf ball.
- AUV surfaces with run time of 400 seconds.

	Task	Points
1	Navigation Task	15
2	Target Acquisation Task (Visual)	30
3	Communication & Localization Task	120
4	Surface Bonus	5
5	Run time Bonus	15
	Attempt Total	185

Specification of AUV

Size

- The AUV must fit within a 140 × 100 × 100 cm box.
- An AUV with dimension of less than 70 cm × 50 cm × 50 cm will be given bonus **10 points**.
- The AUV must not weigh more than 52 kg in air.
- An AUV weighing less than 42 kg in air will be given bonus **10 points**.

Power

- Power must be self contained.
- **Tethers of any sort are not allowed**, except when calibrating AUV sensors during practice rounds.
- The voltage of the power source used by each AUV must not exceed 24VDC.

Safety

- AUVs must not leak and pollute the pool.
- AUVs must be designed and manufactured as to pose no danger of any kind to anyone or anything at the venue.
- AUVs **must have a kill switch** that turns off the vehicle including thrusters, or any other population mechanism.
- The kill switch must be **easily accessible** to a diver. This must be marked in bright color.
- Pressure of any compressed gas used must not exceed **6 bars**.
- AUV must be completely autonomous.
- The use of explosives, fire or hazardous chemicals is prohibited. Certified lithium batteries are allowed.
- If lasers are used, they must be of class 2 or lower. Care must be taken to protect all persons at the venue from harm. Beams must be oriented in such a fashion that they cannot shine into the eyes of the spectators.

▲ Figure 18: Example a kill switch on an AUV from 2015 Competition.

Communications

- Untethered communications with the AUV **are allowed** in the main arena.
- AUVs can carry their own "underwater" communication equipment.
- Teams are allowed to deploy "top-side" communication equipment in the starting zone during the game.
- All "underwater" communication equipment on the AUV *MUST fit* within the size limits for the AUV.
- Any "underwater" communication equipment on the AUV is considered a part of the AUV.
- The "top-side" communication equipment *MUST fit* within the dimensions of the starting zone and weigh no more than 42 kg in air.
- Any "top-side" communication equipment must stay within the starting zone. It may be submerged in the water, and can have **a single tether** to the surface.
- Any "top-side" communication equipment submered in the water, must not leak and pollute the pool.
- Any "top-side" communication equipment must be removed at the end of the game.

Game Procedure

Sequence of events during the competition

- AUVs will undergo weight and size check. Bonus points, if applicable, will be awarded.
- AUVs will be tested for battery, oil or lubricant leak check, and a waterproofness check. Failing either would bar the team from attempting to qualify until the AUV passes the checks.f
- Team will proceed to qualifying round. The bonus points for size and weight is applicable only if the team passes the qualifying round.
- Top 15 qualified teams (according to fastest qualifying round times) will proceed to the final rounds of competition.
- The final round will be held in the main arena.
- The top five teams from the final round will be allowed to attempt the bonus round.

Practice Rounds

- Teams will be allowed to practice in the main arena after they successfully complete the qualifying round, subject to availability of time slots and the schedule during the competition.
- No tethers are allowed at ANY time inside the main arena.
- Teams will be allowed calibrate their AUV sensors with tethers, at the edge of the pool, with the vehicle held **stationary**.

Length of a game

- Each team is given **15 minutes** to complete the tasks.
- In any of the following cases, the game ends immediately.
    - Disqualification is announced in the game.
    - When the Judges determine that the game cannot continue.
- Setting up of AUV
    - Five minutes is given for setting up the AUV before the game starts.
    - No more than two members of respective teams can engage in setting up of their AUV at the poolside.
    - The two designated members setting up must wear life jackets. Failure to do so may result in disqualification.

    - Any team that fails to complete setting their AUV within five minutes can resume the setting up again once the game starts.
    - Setting up during the game uses the allocated time for the tasks and game.
    - The AUV can only start from the start zone. This is the only place where the AUV is allowed to be on the water surface.
    - The AUV must start its maneuver only after it has **completely submerged** in the water.

Retries

- A retry attempt can be made only after the Judges' permission.
- The AUV will be passed to the two designated team members standing beside the pool by the divers.
- A retry would mean that the AUV starts from the start zone with 0 points
- A maximum of 15 minutes is allowed including all the retries.
- The attempt with the highest score (including retries) will be considered for final scoring.

Certificate of Participation

- Teams whose AUVs successfully complete the qualifier round will receive Certificate of Participation.
- Teams whose video submissions have been accepted & attend the competition will receive a Certificate of Participation.
- Failing the above two criteria, no Certificate of Participation will be awarded.

General Restrictions

- Team members are not allowed inside the swimming pool at any point during the game.
- Team members may not disturb the water surface once the game starts.
- Members of other teams are not allowed in the game area.
- Nobody is allowed to wear any footwear near the pool area.

- The Judges may suspend the challenge if weather turns unfavorable.
- The pool area must be evacuated in case of lightning.

Disqualification

Teams may be disqualified if :

- Oil or lubrication leaks causing the pollution of pool.
- Battery leak causing the pollution of pool.
- The AUV damages or tries to damage the arena, facilities or equipment.
- The team performs any acts that are not in the spirit of fair play.
- The team fails to obey instructions or warnings issued by the Judges or Game Master.
- If the team does not abide by the the general restrictions.

Others

- The legitimacy of any actions not provided in this rulebook will be subject to discretion of the Judges.
- The dimensions, weights, etc. of the field, facilities and equipments stated in this rulebook have a margin of error of ±5% unless otherwise stated. However the dimensions and weights of the AUVs as stated in the rule book are the maximum and cannot be deviated.
- The Judges may demand additional explanations on safety issues when the safety of a vehicle is deemed to be in question.

Feedback

If you spot any errors in the rulebook or have queries about the rules, please email rules@sauvc.org or contact us through our website.

Bonus Round: Oceanic Navigation

For SAUVC 2024, there is a bonus round with a single task called Oceanic Navigation. This was created to allow teams to experience the challenges of operating in an oceanic environment. The bonus round will be held in the TCOMS Ocean Basin, a cutting-edge facility for testing and developing marine technology. The basin is located at the National University of Singapore.

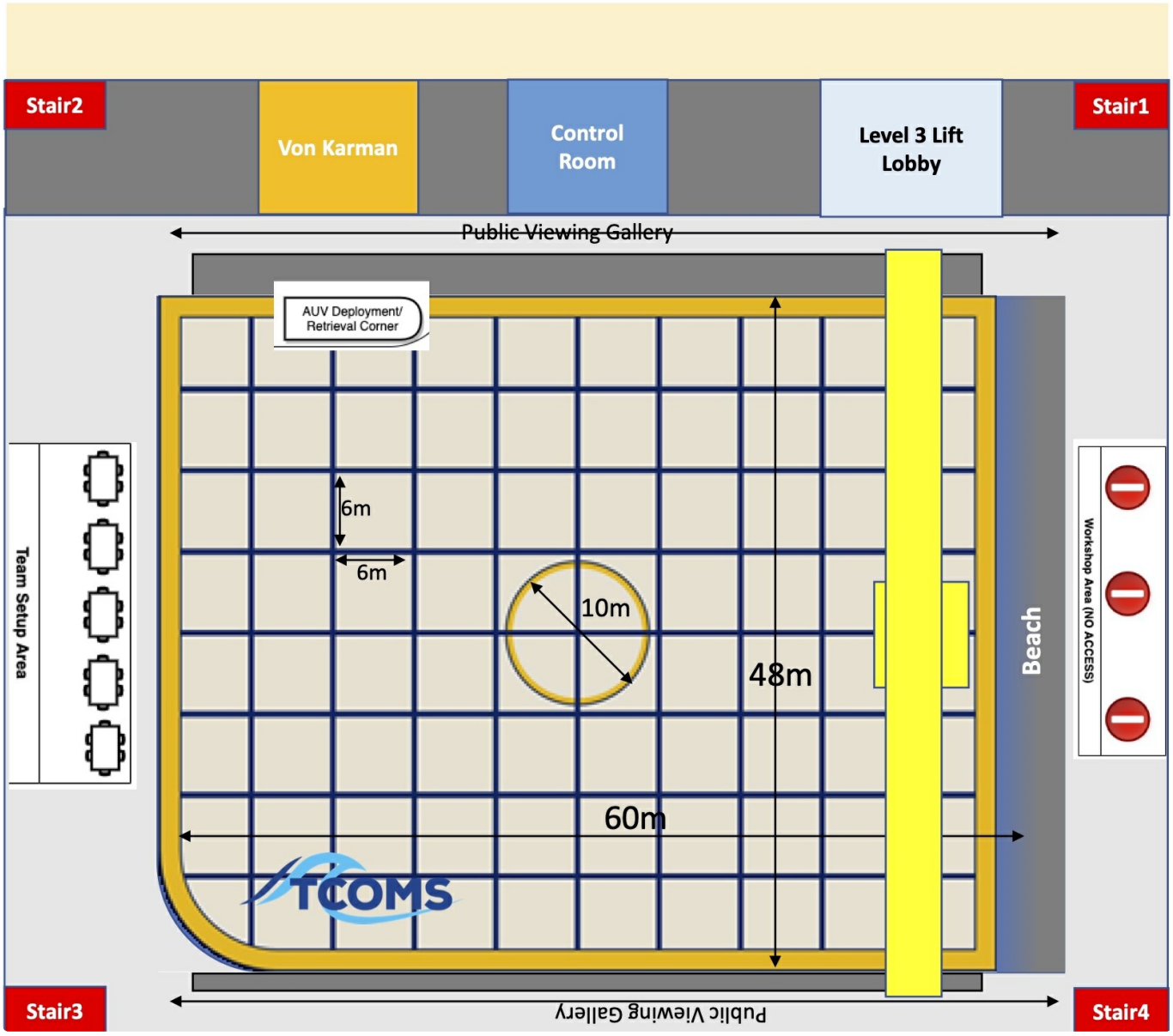
▲ Figure 19: Ocean basin at TCOMS.

The aim of this task is for the AUV to swim through a gate in the middle of the pool. At the ocean basin, the AUVs will have to deal with waves and currents. Only the top teams from the final round will be invited to the bonus round.

An orange flare may be located anywhere in the ocean basin. The AUV **has to avoid** touching the orange flare. Any part of the AUV touching the orange flare causes an immediate abort of the attempt.

Arena (Ocean Basin)

The basin is equipped with a wave generator capable of generating waves up to 0.5m in height and a current generator capable of generating currents up to 1.5m/s. The wave and current generators may be activated during the bonus round.



▲ Figure 20: Top view of the ocean basin arena.

This layout is for illustration purposes only; Deployment and retrieval location may be subject to changes.

Since the basin is a research facility, and the area is not typically open to the public, only a small predetermined number of the participants and viewers will be allowed into the facility to watch the attempt from the viewing gallery.

Members of the team doing the attempt will have to operate at the AUV Deployment/Retrieval corner under the supervision of SAUVC committee members.

Judges and TCOMS staff will be located in the subcarriage in the facility which will be

positioned above the gate, providing a direct view of the gate. After a successful round/abort, the AUV will be retrieved by divers.

Details on the number of participants allowed to enter the viewing gallery will be released at a later date.

Starting Zone

The starting zone is a **140×140cm area** marked on the surface of the water. The teams **must** start their AUVs from this area. The team may only place the AUV at the water surface, it must autonomously submerge **before** leaving the starting zone.

Surfacing

Breaching the surface at any point during the mission causes end of the current attempt. The team may wish to retry if they still have time left.

Deployment

Due to the logistics involved in deploying the AUV, teams are not allowed to manually deploy the AUV. The AUV will be deployed to the starting zone by Ocean Basin staff. The team **must** provision a **delayed start function** for the AUV to start its thrusters **120 seconds** after they have passed it to the Ocean Basin staff. That way the Ocean Basin staff have enough time to move the AUV to the starting zone and leave the area before the AUV starts its mission. The start time for the first attempt will be measured from the time the AUV starts thrusting in the starting zone.

Points

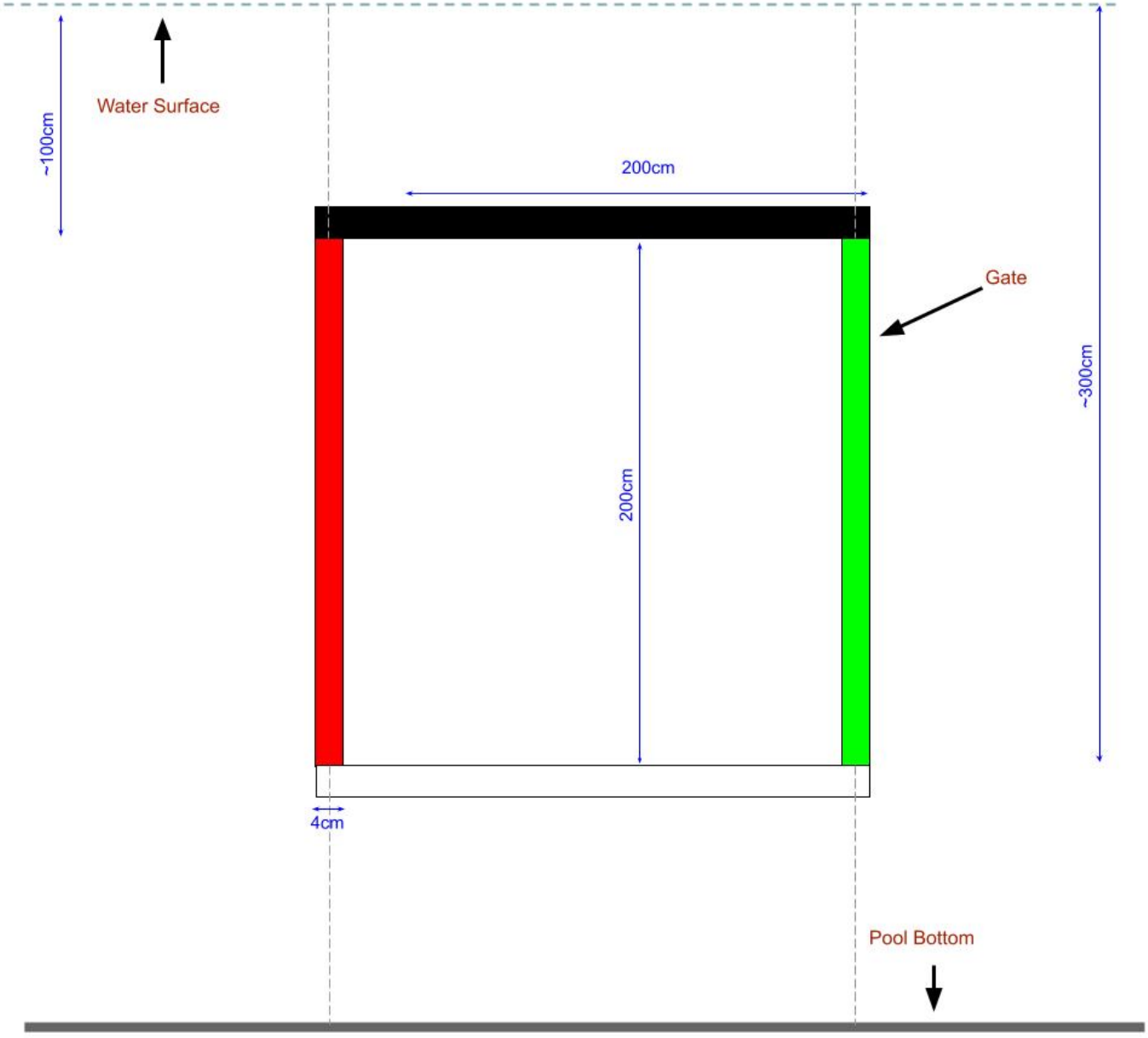
There will be no points awarded for the bonus round. The teams will be ranked based on the time taken to the end of the attempt ONLY IF the team successfully managed to complete the task. The team with the fastest time will be ranked first in the bonus round.

Specification of props

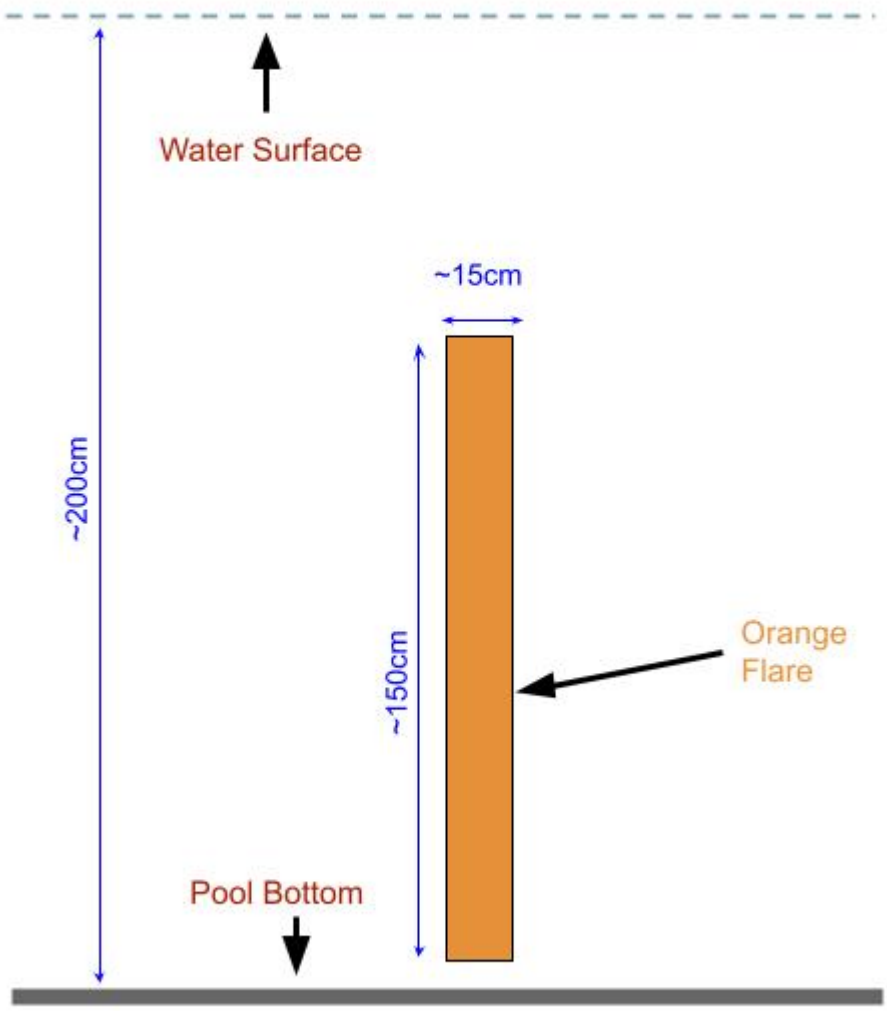
The gate is located in the middle of the basin, ~25m from the starting zone. The gate is 200cm tall and 200cm wide. The gate is marked with red and green stripes on the port and starboard sides respectively.

Prop	Description

	Prop	Description
1	Gate	200cm wide and 200cm tall gate with red and green markings on port and starboard sides respectively.
2	Orange Flare	150cm tall and ~15cm diameter flare, and orange in color.



▲ Figure 21: Front-view of gate



▲ Figure 22: Front-view of the orange flare.

Gameplay (Bonus round)

Only the top teams from the final round will be allowed to attempt the bonus round. Ranking for the bonus round will be tabulated separately from the main competition. The top teams in the bonus round will receive a special bonus prize regardless of their performance in the main competition.

There will be NO practice time for the bonus round. The teams will be given 30 minutes to attempt the bonus round. The teams may attempt the bonus round as many times as they wish within the 30-minute time slot. The team may choose to abort the attempt at any time. However, the retrieval of the AUV might take some time because of the logistics involved.

- All the safety conditions and game procedures including aborting still apply during the bonus round.
- **No communication** with the AUV is allowed during the bonus round.
- The teams are **not allowed to deploy any other equipment** into the basin.
- Due to the sensitive nature of the equipment in the basin, the AUVs **must not touch the walls or the floor of the basin**. Any part of the AUV touching the walls of the basin causes an immediate abort of the attempt.