

Mission Booklet

Subsea

TAC Challenge 2023

'Where concept meets reality'



Revision 2.3

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1 Introduction

This document contains information about the area of operation, launch and recovery system (LARS), mission scoring, and technical specifications for each mission. The following sections details the framework for each mission. The details are still under development, but the overall theme and description will likely remain the same. Therefore, some adjustments to the mission details can occur and more details will be coming soon.

The challenge contains four separate missions. They include:

- Subsea docking
- Pipeline inspection
- Valve intervention
- Visual inspection

The teams may freely choose which missions to attempt, however it is encouraged to attempt all to some extent. The execution method for each mission is also for the team to decide. Although autonomous behavior award extra points, piloted solutions will also be rewarded.

Shared Info Folder

Additional information regarding the missions (e.g., images, 3D-models, video footage, etc.) will be submitted on the TAC Challenge Shared Info Folder:

https://tauautonomycenter-my.sharepoint.com/:f:/g/personal/rune_tauautonomycenter_no/EjsFhjDXjT1Aq_TMY_75ITkBSHb7SKBMsYmp_BHMYtX5CQ?e=vG62aG

TAC Community Forum

Any questions concerning the competition details can be directed to TAC Challenge via the TAC Challenge Community Forum:

<https://tacchallenge.vbulletin.net/>

The links to the TAC Community Forum and TAC Challenge Info Folder, as well as other information, can also be found on the TAC Challenge website: <https://tacchallenge.com/>.

2 Subsea Docking

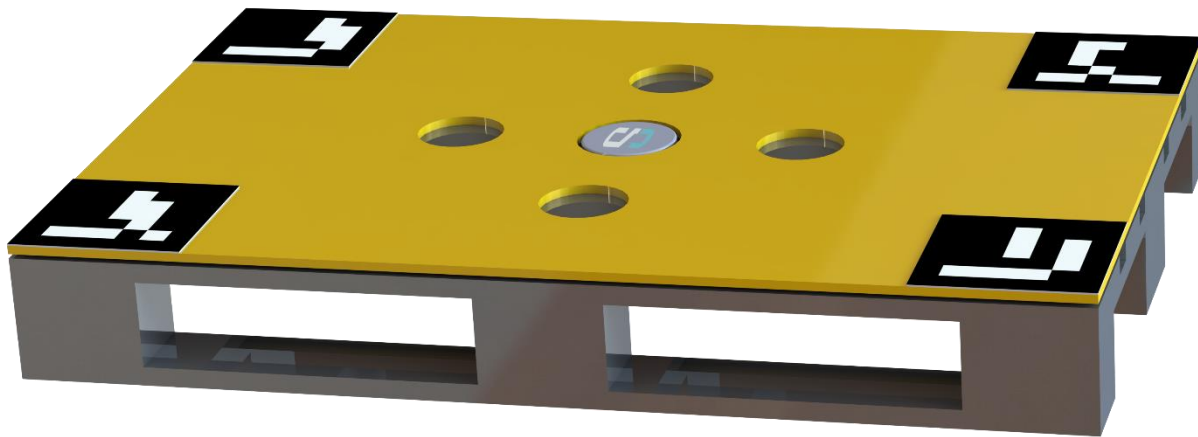
Subsea residency is an important goal in the development of tether-less autonomous underwater vehicles. Subsea charging and data transfer will likely be an important feature required to accomplish this goal.

2.1 Mission Description

A docking station is positioned at an unknown position on the sea floor in the operational area. The vehicle will locate the docking station and then attempt to dock to this station. The docking station is equipped with an inductive 250W Subsea Power Puck, developed by Subsea USB, which can transfer data and power to the vehicle. The team will demonstrate power transfer by illuminating a light equipped on the vehicle connected to the secondary power puck; retrieve the data from the inductive puck and return to the launch and recovery area with this data. The docking station will also be equipped with visual indicators (ArUco Tags). Specific autonomous behavior will also award points.

Deliverables:

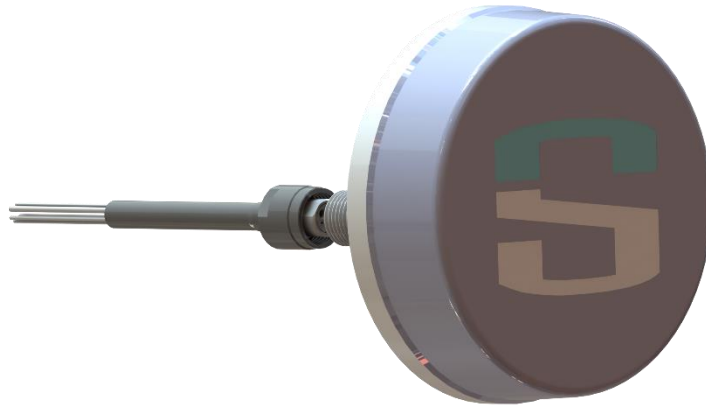
1. Successful demonstration of docking to docking station.
2. Successful demonstration of power transfer.
3. Contents from the file retrieved from the inductive docking station.



2.2 Mission Details

2.2.1 Subsea USB Power Puck

- This system consists of a primary side and secondary side. The *primary Power Puck* is on the docking station and the *secondary Power Puck* is on the drone.
- The Power Pucks can transfer up to 100 Mbps (ethernet) when connected.
- They are also capable of charging batteries up to 250W load.
- The primary Power Puck used is BB8290 and will be equipped on the docking station (by TAC Challenge).
- The secondary Power Puck must be customized depending on the vehicle's power supply.
- The induction puck is placed at the center of the docking station.
- Data sheets, CAD models, and drawings can be found in the Info Folder.



2.2.2 Subsea USB testing kit

Before the competition, each team can request to receive a test-kit free of cost. This is not necessary to attempt this mission, however it is recommended. This kit includes:

- 1 Primary Power Puck BB8290.
- 1 Secondary Power Puck BB8XXX. The exact model must be chosen depending on the vehicle's power supply.
- Both pucks come with compatible cables with connectors in one end.

The goal is to give the teams a chance to test and get to know the equipment before the competition. This equipment **must be returned** after the competition is complete. Alternatively, the team can decide to purchase the kit at a reduced price (TBA) after the competition.

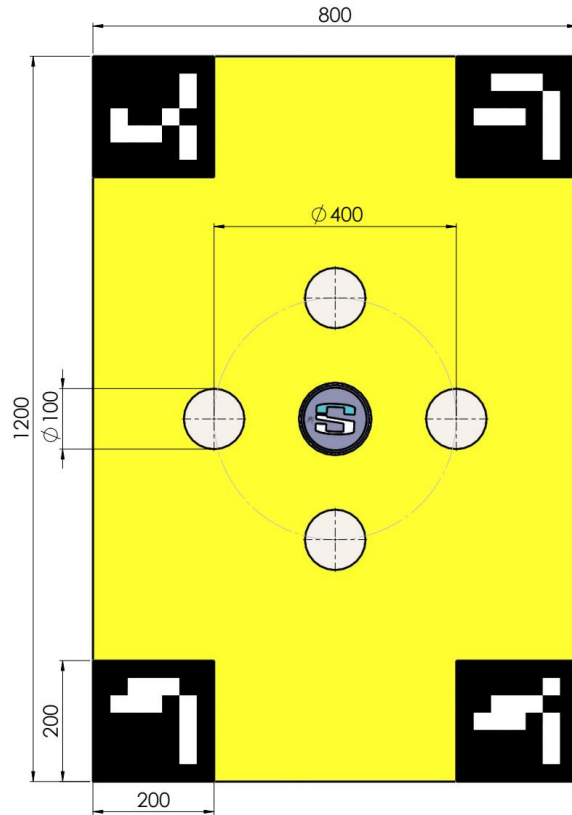
Contact TAC Challenge if your team wishes to receive this test-kit.

2.2.3 Light that indicates power transfer

- To receive extra points, the vehicle can be equipped with a light that illuminates when the secondary power puck receives power from the primary side (i.e., when docked).
- The light is only allowed to be powered by the power puck (i.e., it cannot be controlled and powered by the vehicle). This will be verified by the judges on land before the mission attempt starts.
- This light will be monitored by a secondary ROV at the competition and must therefore be visible from a distance under water.
- This system will be developed by the team.

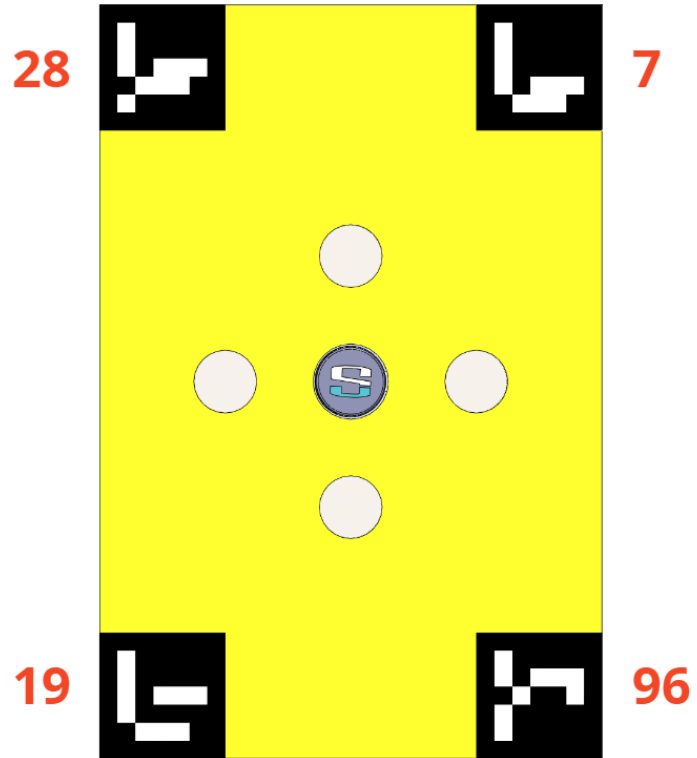
2.2.4 Docking Station

- The station is positioned on the seabed and, due to the elevation, it may not be completely leveled.
- The docking station is equipped with ArUco tags with known positions and IDs.
- The inductive primary Power Puck is located at the center of the docking station.
- Steel plates are located around the center and can be used with magnets to aid the docking.
- The color of the docking plate is not yet decided.
- The overall dimensions of the docking plate are the same as a standard EUR-pallet, which are:
 - Length: 1200 mm
 - Width: 800 mm



2.2.5 ArUco markers

- Four ArUco markers are placed approximately in the corners of the docking station. **The exact position will be announced soon.**
- Original ArUco dictionary is used. See the online generator at: <https://chev.me/arucogen/>
- The marker IDs used are 28, 7, 19, 96; and they are placed in the following order.



2.3 Mission Scoring

2.3.1 Standard points

Standard points will be awarded based on the results of the deliverables.

Standard Points		
Result	Description	Points
Demonstrate successful docking to the docking station	The vehicle must land in the correct position on the indicated landing area on the docking station. Once docked, the vehicle must stay there for at least 10 seconds. This will be evaluated based on the footage from the supervisor ROV.	+20p
Demonstrate power transfer between inductive power pucks	To award these points, the team must integrate the light indicator on the vehicle. When the vehicle is docked and receiving power from the primary power puck, the light must illuminate to indicate this connection. The light is only allowed to be powered by the power puck (i.e., it cannot be controlled or powered by the vehicle). This will be verified by the judges on land before the mission attempt starts. An ROV must be able to observe this light. Failed verification will result in 0 points.	+40p
Demonstrate data transfer between inductive power pucks	Once docked, retrieve the data from the docking station to the vehicle. Present the data retrieved from the docking station to the judges. This data can be presented either during or after the mission attempt.	+40p

2.3.2 Bonus points

Additional bonus points will be awarded if specific autonomous behavior is demonstrated. If the team aims to attempt these specific executions, they must notify the judges during the mission brief.

Bonus Points		
Execution	Description	Bonus Points
Autonomous docking	The drone can be piloted to locate the docking station, however once the docking process has started, piloting is not allowed. Any intervention will disqualify the team from receiving these bonus points.	+40p
Autonomous return to launch and recovery site	Once the docking is complete and drone is ready to return home, the team is not allowed to pilot the drone until it has reached the launch and recovery area. Manually initiating the return process is allowed, other than that the team is not allowed to intervene until the AUV has surfaced in this area.	+40p

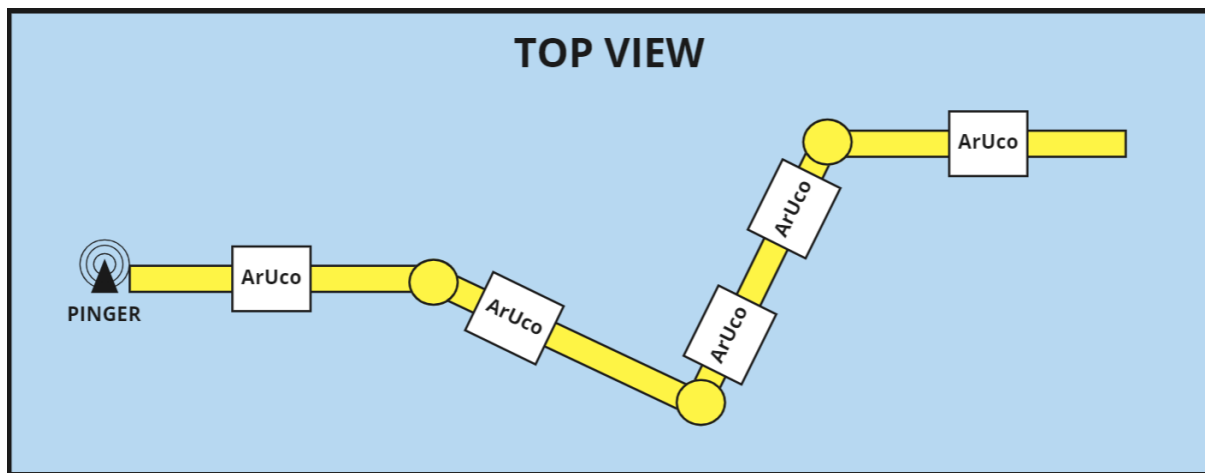
3 Pipeline Inspection

3.1 Mission Description

A pipeline, positioned on the seabed in the operational area, needs to be inspected. The pipeline has an unknown path and position. There is an unknown number of ArUco markers along the pipeline which need to be identified. Delivering this code in the correct order will award maximum points. Specific autonomous behavior will also award points.

Deliverable:

1. A list of marker IDs.



3.2 Mission Details

3.2.1 ArUco markers

- Original ArUco dictionary is used. See the online generator at: <https://chev.me/arucogen/>
- There are between 4 and 10 ArUco markers on the pipeline, however the exact number of markers is unknown.
- The marker IDs can range from 1 to 99. A specific ID will not occur more than once.
- The markers are positioned minimum 0.2 meters apart.
- The marker dimensions will be given soon.
- The rotational orientations of the markers are random.

3.2.2 Pinger

- An acoustic pinger is installed at one end of the pipeline, indicating the start of the pipeline.
- The technical details of the pinger will be given soon.

3.2.3 Pipeline

- The pipeline consists of straight tubes connected with unknown angles ranging from -90 to 90 degrees. There is an unknown number of connections.
- The pipeline is no longer than 10 m in total length.
- The specified pipeline dimensions and color will be given soon.

3.3 Mission Scoring

3.3.1 Standard points

Standard points will be awarded based on the marker ID sequence delivered by the team.

Standard Points		
Result	Description	Points
Identification of Marker IDs.	Each marker that is correctly identified will be awarded, regardless of the order they are presented. Any markers that do not belong will result in a point deduction. This score cannot be less than 0.	+10p per correct marker -5p per incorrect marker
Correct order of Marker ID sequence (mirrored sequence is accepted).	Points will be awarded if all markers presented on the list are in the correct order. Any markers missing from the list will not affect this score. The mirrored sequence order is also accepted. To receive these points the list must contain more than two IDs.	+15p
Correct starting point of sequence.	Points are awarded if the sequence starts from the correct direction. The starting point is defined by the location of the pinger. Points are awarded even if marker IDs are misplaced, missing, or do not belong, as long as the first ID in the sequence is closer to the pinger than the other markers on the presented list. To receive these points the list must contain more than one ID.	+15p

3.3.2 Bonus points

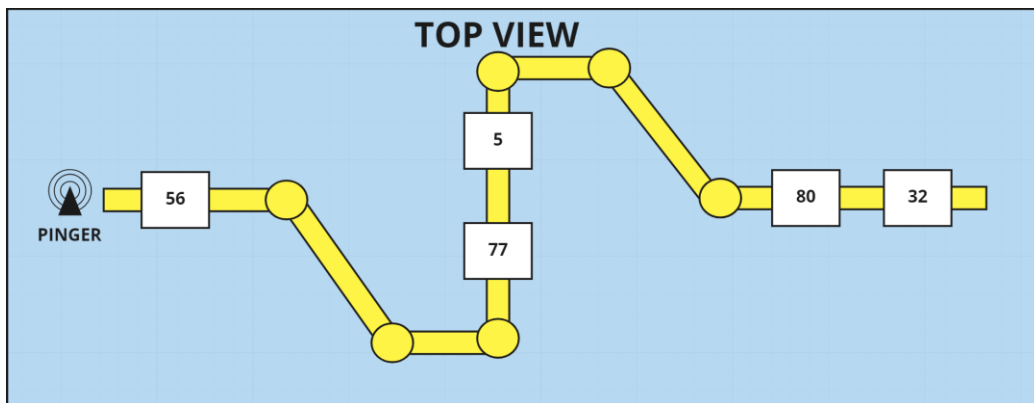
Additional bonus points will be awarded if specific autonomous behavior is demonstrated. If the team aims to attempt these specific executions, they must notify the judges during the mission brief.

Bonus Points		
Execution	Description	Bonus Points
Autonomous detection of Marker IDs.	Results must be generated by the AUV and printed on the display screen/results file once the pipeline inspection is complete. Manual adjustments to this list or failing to produce the list within unreasonable time* will disqualify the team from receiving these bonus points.	+10p per marker
Autonomous localization of pinger from mission launch.	Once the mission has started, the team is not allowed to pilot the drone until it has reached and located the pinger. The team is not allowed to intervene until the AUV has indicated that the pinger is found.	+40p
Autonomous tracking of pipeline.	The drone can be piloted to locate the pipeline, however once the pipeline inspection has started, piloting is not allowed. Any intervention will disqualify the team from receiving these bonus points.	+40p

3.4 Example

This section will attempt to clarify the rules by giving an example. The following image illustrates a top view of a hypothetical pipeline where the ArUco marker IDs are given. Only the standard points are included in this example. The total amount of points will depend on the demonstration of the autonomous behavior.

Correct deliverable (solution): 56,77,5,80,32



The following table will compare various deliverables (results) for this example mission and attempt to explain how the point system works.

Example deliverable	Explanation	Standard points awarded
56,77,5,80,32	<ul style="list-style-type: none"> • The list contains all correct marker IDs = +50p • The list is in the correct order = +15p • The order is given in the correct direction = +15p 	80p
56,5,20,32	<ul style="list-style-type: none"> • The list contains three correct IDs = +30p • The list contains one incorrect ID = -5p • The list is in the correct order = +15p • The order is given in the correct direction = +15p 	55p
77,5,80,32,56	<ul style="list-style-type: none"> • The list contains all correct marker IDs = +50p • The list is not in the correct order = 0p • The order is not given in the correct direction = 0p 	50p
77,5,80,32	<ul style="list-style-type: none"> • The list contains four correct IDs = +40p • The list is in the correct order = +15p • The order is given in the correct direction = +15p 	70p
32,5,77	<ul style="list-style-type: none"> • The list contains three correct IDs = +30p • The list is in the correct order = +15p • The order is not given in the correct direction = 0p 	45p
77,32,5	<ul style="list-style-type: none"> • The list contains three correct IDs = +30p • The list is not in the correct order = 0p • The order is given in the correct direction = +15p 	45p
1,2,3,4,5	<ul style="list-style-type: none"> • The list contains one correct ID = +10p • The list contains four incorrect IDs = -20p 	0p (Score cannot be negative)
77,5	<ul style="list-style-type: none"> • The list contains two correct marker ID = +20p • The list is in the correct order, but contains less than three IDs = 0p • The order is given in the correct direction = +15 	35p

If the whole mission is executed autonomously, as described in the Bonus Points table, the total amount of points achievable for this example will be **210 points**.

4 Visual Inspection

4.1 Mission Description

An underwater structure, located on the seabed in the operational area, must be inspected. Known images or objects are positioned on the structure and must be recognized to achieve points. Specific autonomous behavior may also award points.

Deliverable: *TBA*



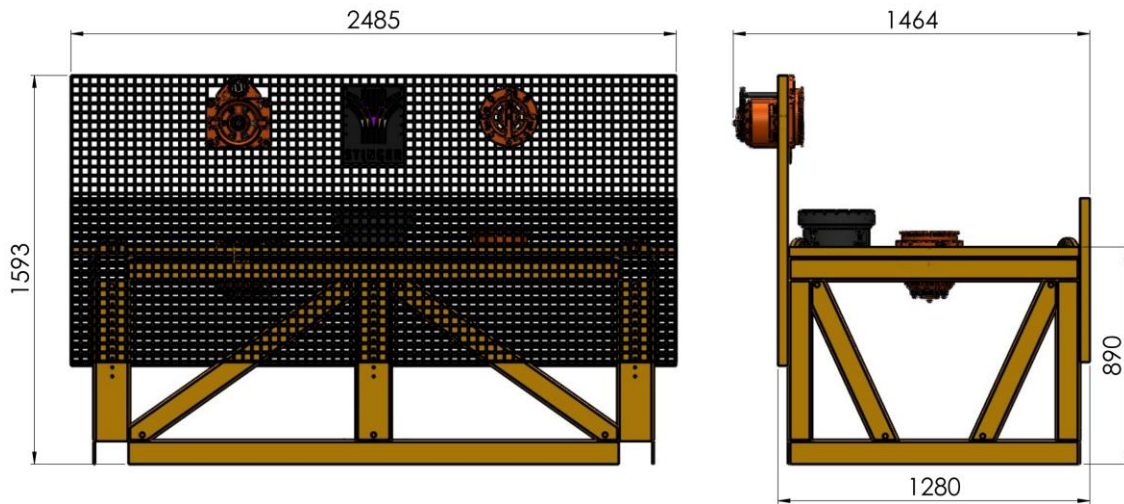
4.2 Mission Details

4.2.1 Subsea structure

- The following images depicts the subsea structure that will be used for this mission.



- The subsea structure has the overall dimensions in mm:



- The color of the subsea structure is:
 - RAL 1004 (golden yellow)
 - RGB = 228, 158, 0

4.2.2 Objects to be recognized

TBA

4.3 Mission Scoring

TBA

4.4 Example

TBA

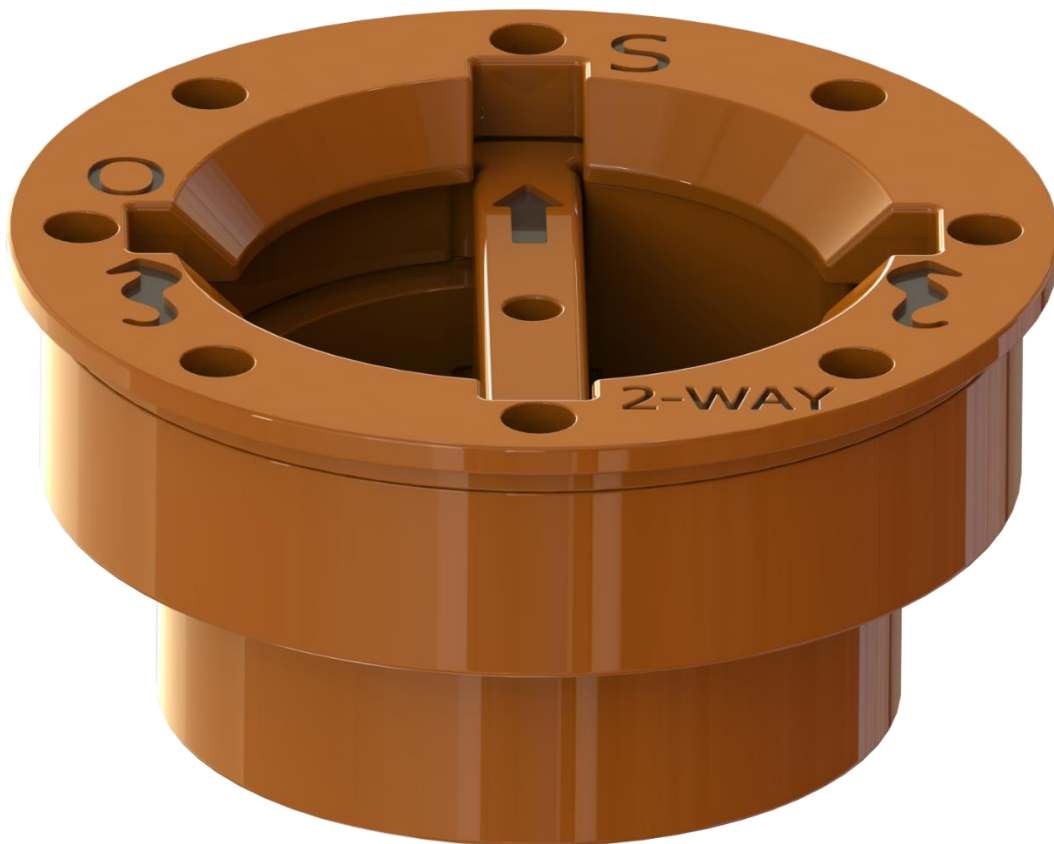
5 Valve Intervention

5.1 Mission Description

Two valves are positioned on the same underwater structure from the previous mission. The valves have a standardized subsea interface and can be turned either clockwise or anticlockwise in a 90-degree sector. Before the mission starts, a judge will inform the team on which way the valves must be turned and its final position. To achieve points, the team must operate the valves according to the information given by the judge. Specific autonomous behavior will also award points.

Deliverable:

1. Perform the valve operation, which will be observed by the judges.

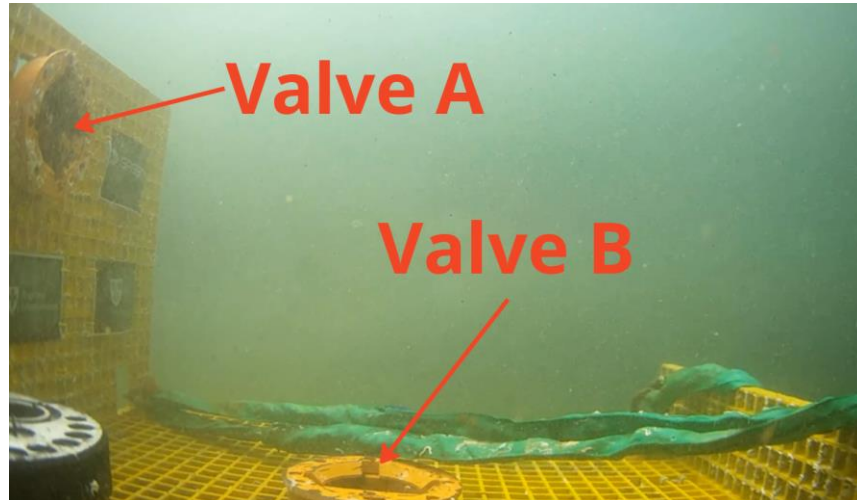


5.2 Mission Details

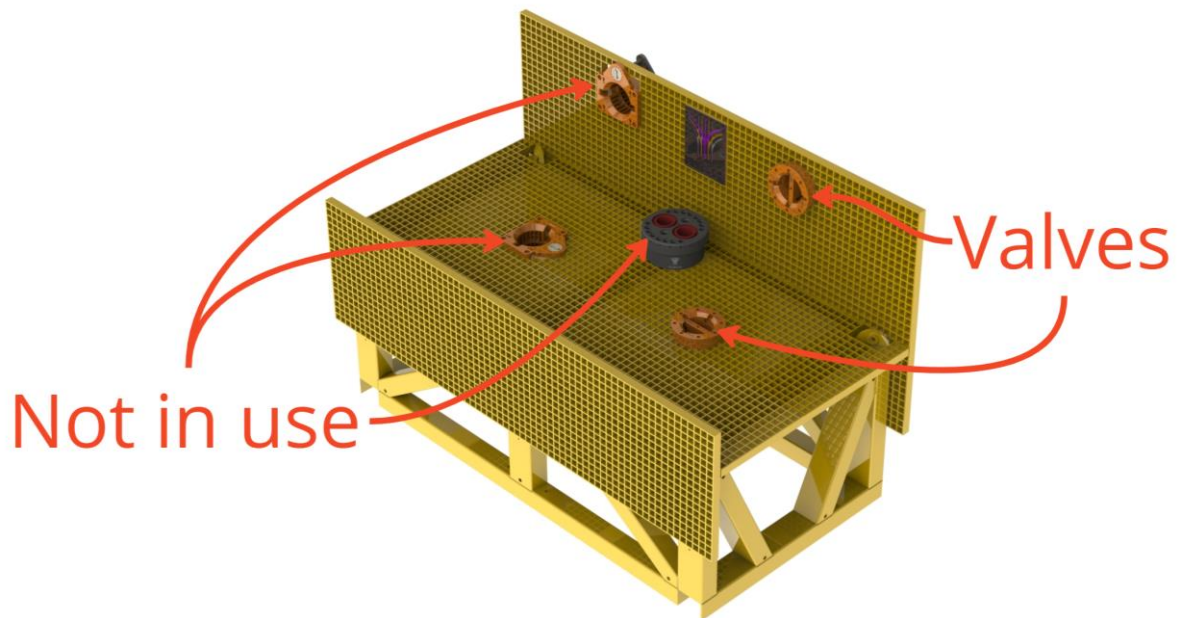
Additional resources are uploaded to the Shared Info Folder.

5.2.1 Valve positions

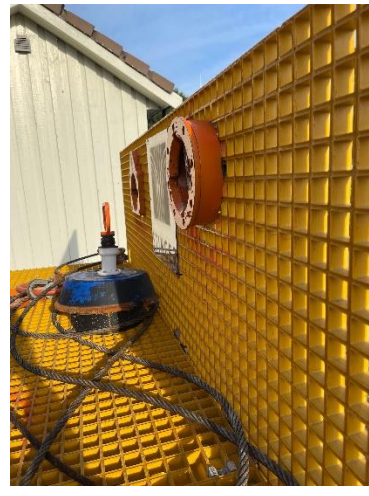
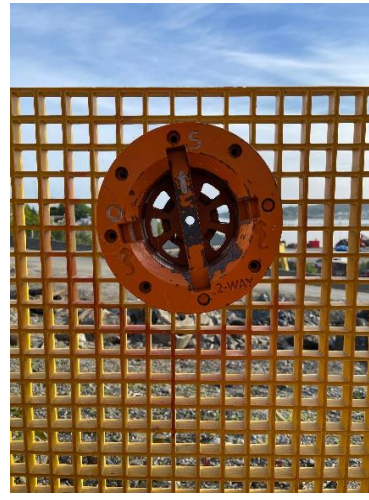
- The following image shows the valves on the subsea structure located in the competition area.



- Valve A is placed on the vertical surface and Valve B is placed on the horizontal surface.



- The following images show the valves that will be used in this competition:

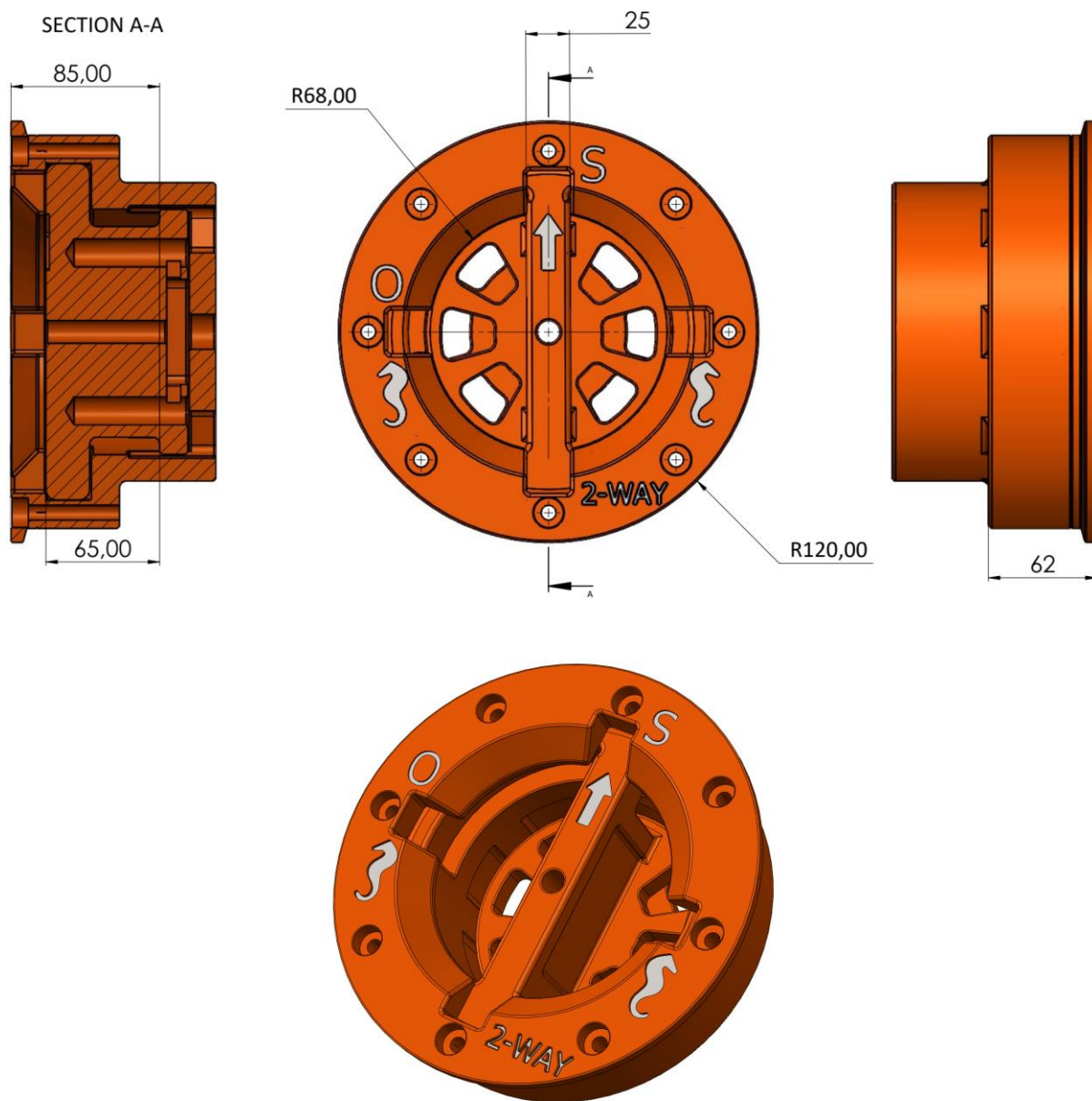


5.2.2 Valve Color

- The color of the valves is:
 - RAL 2004 (pure orange)
 - RGB = 226, 83, 3

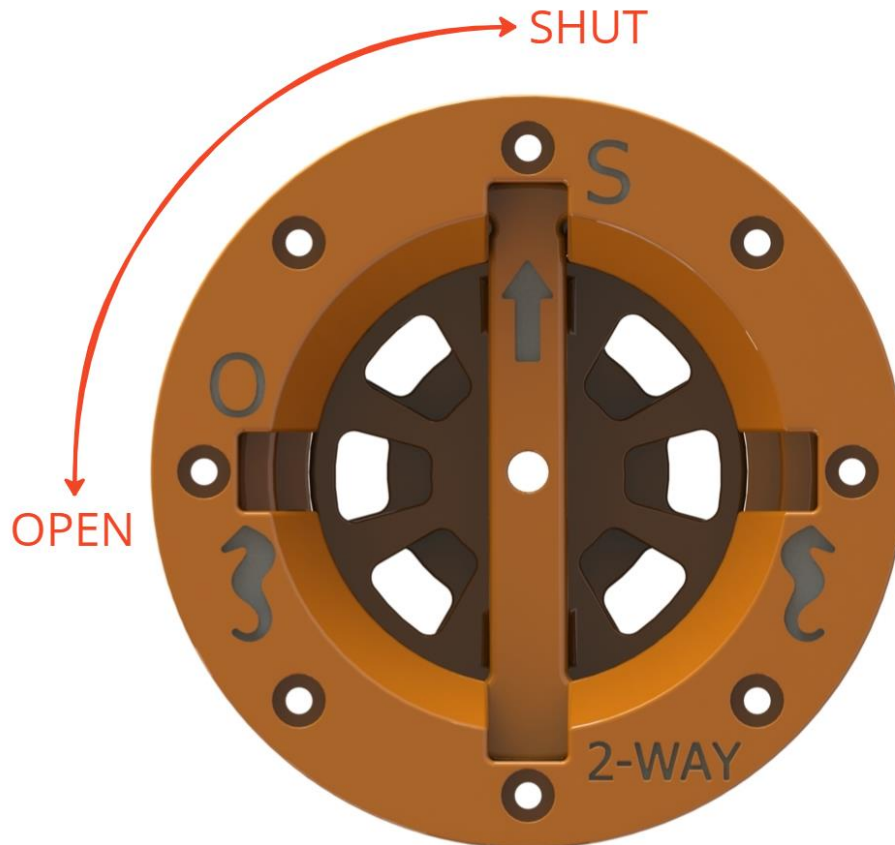
5.2.3 Valve dimensions

- The standard subsea valve has the overall dimensions:
 - Outer radius: 120 mm
 - Inner radius: 68 mm
 - Valve bucket depth: 85mm
 - Handle depth: 65 mm
 - Handle thickness: 25 mm



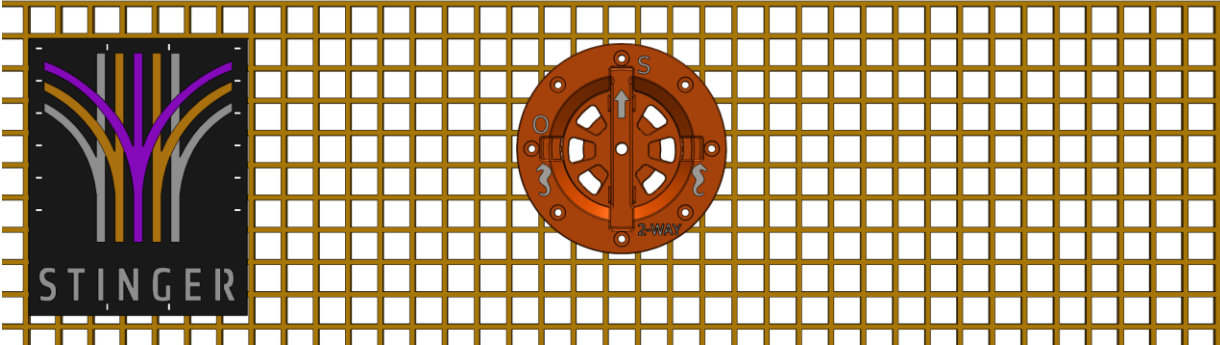
5.2.4 Valve function

- The valve can only be rotated 90 degrees. The arrow on the handle can only be moved between position S (shut) and position O (open). During the competition, the vehicle must rotate the valve to the position given by the judges before the mission attempt. The team is not guaranteed to know the current position of the handle.

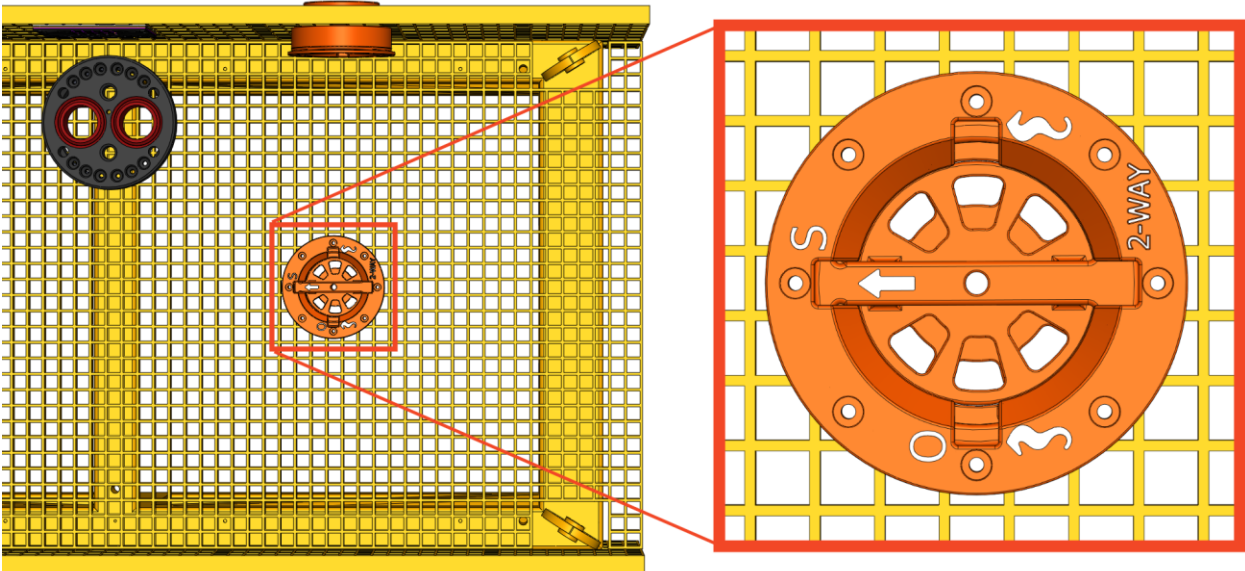


5.2.5 Valve Orientations

- Valve A:



- Valve B:



5.3 Mission Scoring

5.3.1 Standard Points

Standard points will be awarded based on the results of the deliverables.

Standard Points		
Result	Description	Points
Operate the subsea valves to the required position.	The vehicle must operate the subsea valves to the required positions given by the judges beforehand. This will be evaluated based on the footage from the observing ROV.	+40p per valve

5.3.2 Bonus Points

Additional bonus points will be awarded if specific autonomous behavior is demonstrated. If the team aims to attempt these specific executions, they must notify the judges during the mission brief.

Bonus Points		
Execution	Description	Bonus Points
Autonomous valve operation	The drone can be piloted to locate the subsea valves, however once the valve operation has started, piloting is not allowed. The drone must be at least one 0.5 meters away from the valve before starting the autonomous operation. Any intervention will disqualify the team from receiving these bonus points.	+40p per valve

5.4 Example

The following images are of the Valve Intervention Mission from TAC Challenge 2021 and 2022.

