# Mission Booklet

TAC Challenge 2024

where concept meets reality

*Developed by Stinger Technology*

*Revision 1*

STINGER

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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 detail the framework for each mission. This is the first revision of the 2024 Mission Booklet and may be subject to small changes if needed.

The challenge contains separate missions. They include:

- Subsea Docking
- Pipeline Inspection
- Visual Inspection*
- Valve Intervention*

**The Visual Inspection mission and Valve Intervention mission will be performed in the same run.*

Each team will be given runs of 45 minutes to complete each mission with 15 additional minutes for mission brief, launch, and recovery. It is important to be on time and be prepared before the mission brief.

The teams may freely choose which missions to attempt, however it is strongly encouraged to attempt all missions to some extent. The execution method for each mission is also for the team to decide. Although autonomous behavior awards 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://1drv.ms/f/s!AvnCq4dhyUHK_FL1SrPuQpFhk38n?e=Ri2OPd

**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

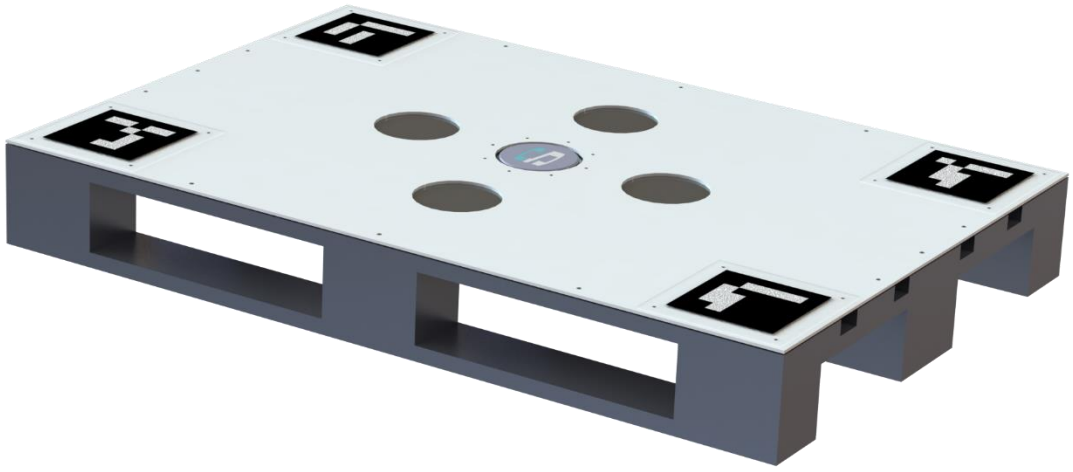
Subsea residency is an important goal in the development of tether-less autonomous underwater vehicles. Subsea charging and data transfer will likely be a key feature required to accomplish this goal.

## 2.1 Mission Description

A docking station is positioned in an indoor training pool in the TAC Building. 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; and establish communication with the docking station. The docking station will also be equipped with predefined visual indicators (ArUco Tags). Specific autonomous behavior will also award points.

**Deliverables:**

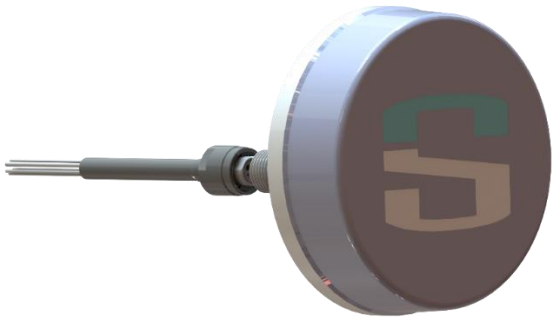
1. Successful demonstration of docking to docking station.
2. Successful demonstration of power transfer.
3. Successful demonstration of inductive communication with docking station.



## 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 primary Power Puck is placed at the center of the docking station.
- The Power Pucks can transfer up to 100 Mbps (ethernet) when connected. Once a connection is obtained, a team member can manually establish communication between the vehicle and a topside computer. No files will be transferred, however the team must demonstrate that there is a connection.
- The pucks are also capable of delivering 250W.
- The primary Power Puck used is **model BB8290** and will be equipped on the docking station (prepared by TAC Challenge).
- The secondary Power Puck used is **model BB8813** (fixed 24VDC output) and will be provided at the competition for the teams to share. It is recommended that the teams prepare for mechanical and electrical integration in advance. TAC Challenge will have a Cobalt Series Cable, Double-ended ( https://www.bluetrailengineering.com/product-page/cobalt-series-cable-double-ended ) that connects the secondary puck to the vehicle.
- Recommended interface connector on the vehicle:
    - Connector: Cobalt Series Bulkhead Connector (male)
    - Pin configuration: 6-pin Hybrid (R1 version)
    - SKU: COB-116H0-R1
    - We cannot guarantee a compatible integration of the pucks if your team does not have this interface connector.
    - **Note:**
        - The R1 FEMALE (new version) **is compatible** with SS MALE (old version).
        - The R1 MALE (new version) **is not compatible** with the SS FEMALE (old version).
    - https://www.bluetrailengineering.com/product-page/cobalt-series-bulkhead-connector
- All teams will use the 24V secondary Power Puck for this mission. If your team has already started to develop a solution that is **not** based on the 24V secondary Power Puck, please contact truls@stinger.no.
- The teams will **not** be able to receive the Power Puck Testing Kit this year. There will be time for the teams to practice this mission during the testing days, prior to the competition days. The Power Pucks and Docking Station will be available at this time.
- Data sheets, CAD models, and drawings can be found in the Info Folder.



### 2.2.2 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.
- There will be no observational ROV in the testing pool, so the light must be visible from the surface.
- This system will be developed by the team.

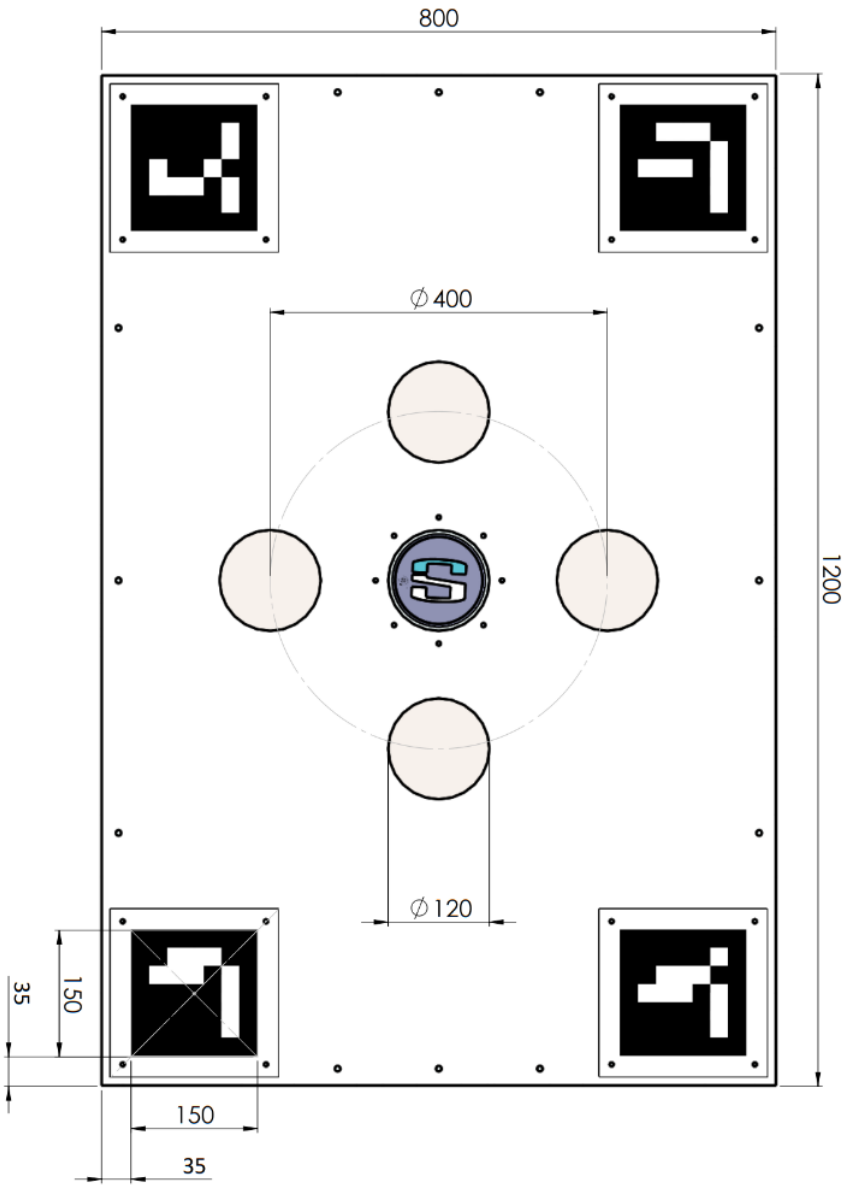
### 2.2.3 Data transfer between vehicle and docking station

- The docking station is connected to a top-side computer running a Web Service script that returns a verification code when a URL is entered by the vehicle.
- Once docked to the docking station, the vehicle should have obtained a connection to the top side computer via the induction plates. The vehicle must then input a URL including the team's name. This can be done autonomously or manually by a team member via the team's vehicle/computer.
- Enter the following in the URL:
    - *http://192.168.123.132:5000/hello/teamTeamName*
    - **The IP-address (marked in blue) above is just an example,** the correct address will be determined during the competition. The team can also choose the IP-address if preferrable. It is important that the network ID, aka the first 3 numbers (in this case 192.168.123), are the same for both team vehicle/computer and docking station computer. The host ID, aka the last number (in this case 132) must be unique.
    - The team's name is free to choose, but it must start with "team" (lower case) and whole name must be one word (no spaces or numbers) as seen in green above.
- If your team's name is *teamTacChallenge* the program will return the following message:
    - *Hello, teamTacChallenge! It is Wednesday, 10 May, 2023 time 19:12:11 and your verification code is: 1234.*

    - The verification code (in yellow) can be used to verify the data connection. **The code above is only an example.**
- The vehicle connection will be logged onto the top-side computer with a time stamp. As long as the connection has been logged by the top-side computer or your team has received the code, the connection is considered successful. The purpose of the code is to prove there has been a connection if the computer logging system fails.
- There will be time to test this during the testing days before the competition.

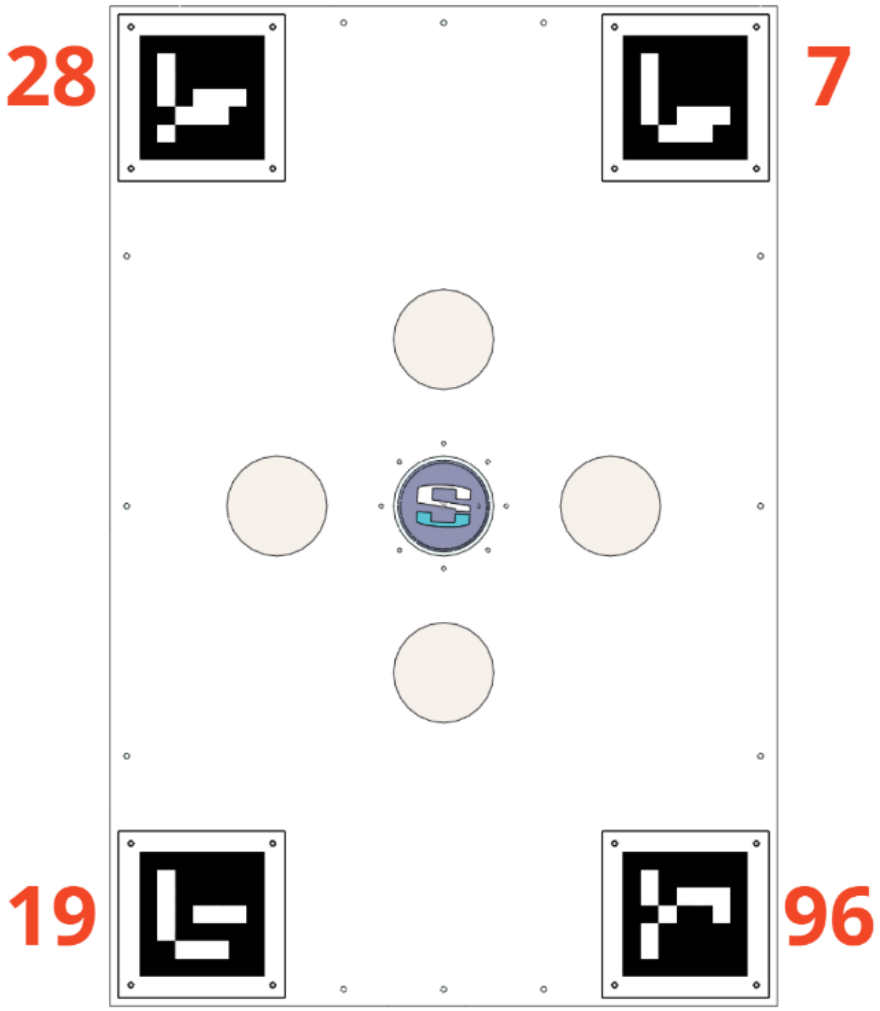
### 2.2.4 Docking Station

- The station is positioned on the bottom of the training pool.
- 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.
- The color of the docking plate (top plate) is WHITE and has a thickness of 4 mm.
- Steel plates are located around the center and can be used with magnets to aid the docking. *Note that if your magnet is too strong, it may attach to the steel plate through the white docking plate.*
- The steel plates are fastened on the underside the white docking plate, making them 4 mm lower than the top of the docking plate. The holes for the steel plates are in other words 4 mm deep and 120 mm in diameter.
- The overall dimensions of the docking plate are the same as a standard EUR-pallet, which are:
    - Length: 1200 mm
    - Width: 800 mm


800
1200
∅400
∅120
35
150
150
35

### 2.2.5 ArUco markers

- Four ArUco markers are placed approximately in the corners of the docking station. The exact position and dimensions are indicated in the figure.
- Original ArUco dictionary is used. See the online generator at: https://chev.me/arucogen/
- The frames around the markers are made of clear plastic.
- 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

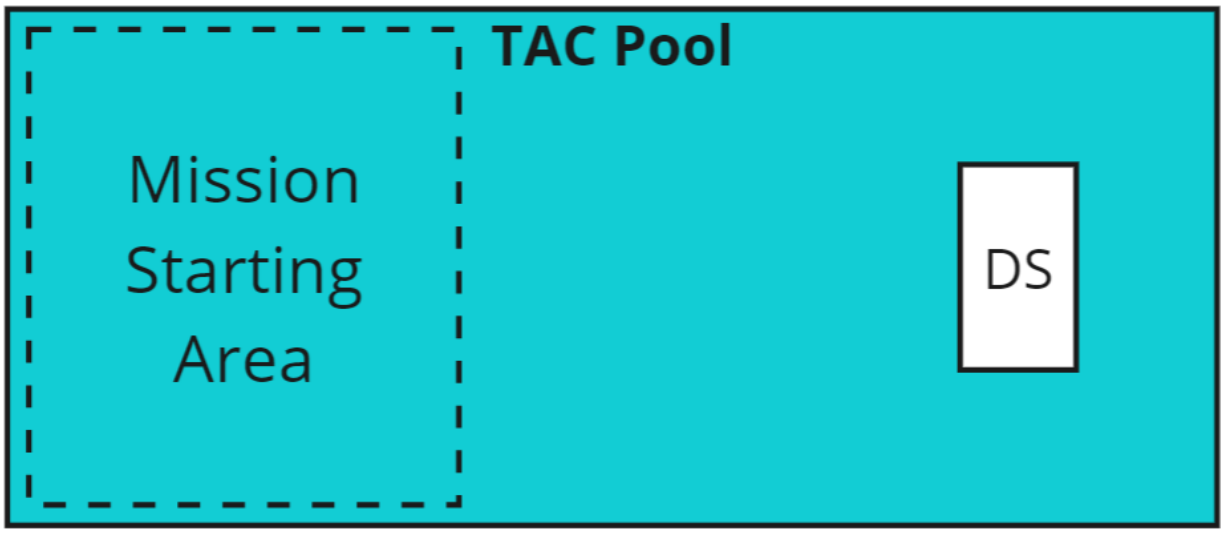
Standard points will be awarded based on the results of the deliverables.

| 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 by viewing from the poolside.** | +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 top-side before the mission attempt starts. An ROV must be able to observe this light. **Failed top-side verification will result in 0 points.** | +50p |
| Demonstrate data transfer between inductive power pucks | Once docked, establish a connection with the docking station computer and register using a URL. The connection will be verified by the verification code or logging system. **Points will be awarded as long as at least one verification method works (code or log).** | +50p |

### 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 must start in the starting area of the pool. Once the mission attempt has started, piloting is not allowed. The drone cannot be piloted to locate 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. Any intervention will disqualify the team from receiving these bonus points for that attempt. The team can attempt autonomous docking as many times as they wish within the run-time. **This will be evaluated by viewing from the poolside** | +100p |



# 3 Pipeline Inspection

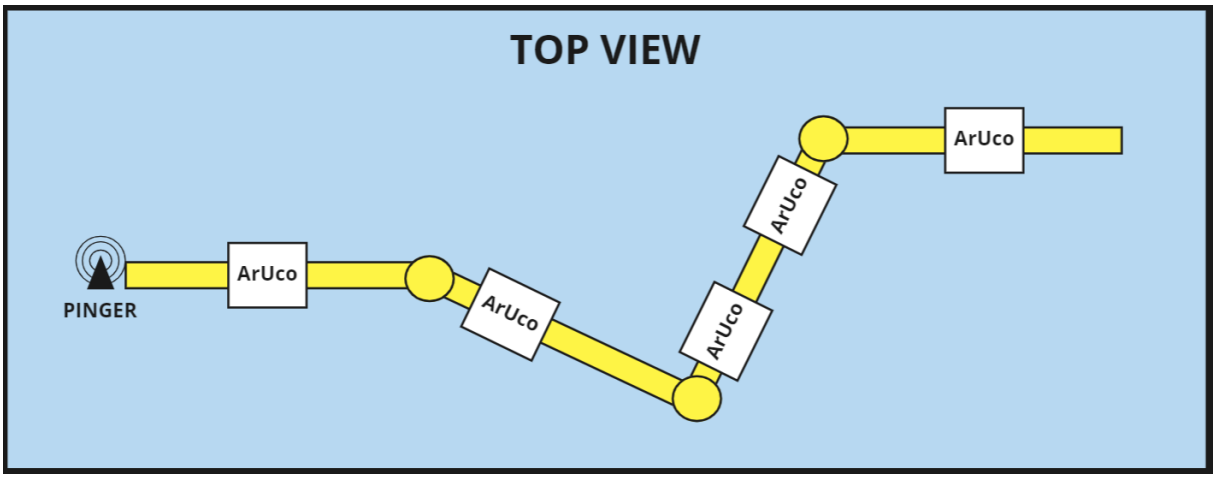
Pipeline inspections will likely become one of the main user cases for autonomous underwater vehicles. Path planning, navigation, acoustic positioning, and situational awareness are important capabilities to accomplish these sorts of missions.

## 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 reward maximum points. Specific autonomous behavior will also reward points.

**Deliverable:**

1. A list of marker IDs.

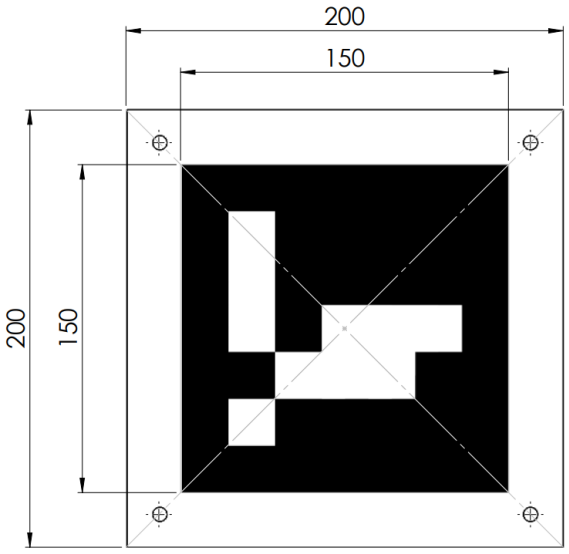



## 3.2 Mission Details

### 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. 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 horizontally, minimum 0.2 meters apart from each other. The rotational orientations of the markers are random.
- The frame around the marker is made of clear plastic with a white background.
- The marker dimensions [mm] and pipeline are given in the figures below.

### 3.2.2 Pinger

- An acoustic pinger is positioned at one end of the pipeline, indicating the start of the pipeline.
- The pinger is MFP-1 from JW Fishers.
- The data sheet can be found in the Shared Info Folder.
- Technical details:
  - Frequency: 30kHz.
  - Repetition rate: 2 sec
  - Pulse length: 4ms


### 3.2.3 Pipeline

- The pipeline consists of straight tubes connected with unknown angles (limited between -90 to 90 degrees per angle). There is an unknown number of connections.
- The pipeline is no longer than 10 m in total length.
- The pipeline will be positioned at a constant depth (as much as possible).
- Pipeline diameter is 200 mm.
- Pipeline color is YELLOW.
- The pipeline is made from various ventilation pipes and joints similar to the following image.

## 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<br><br>-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.** | +25p |
| 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.** | +25p |

### 3.3.2 Bonus points

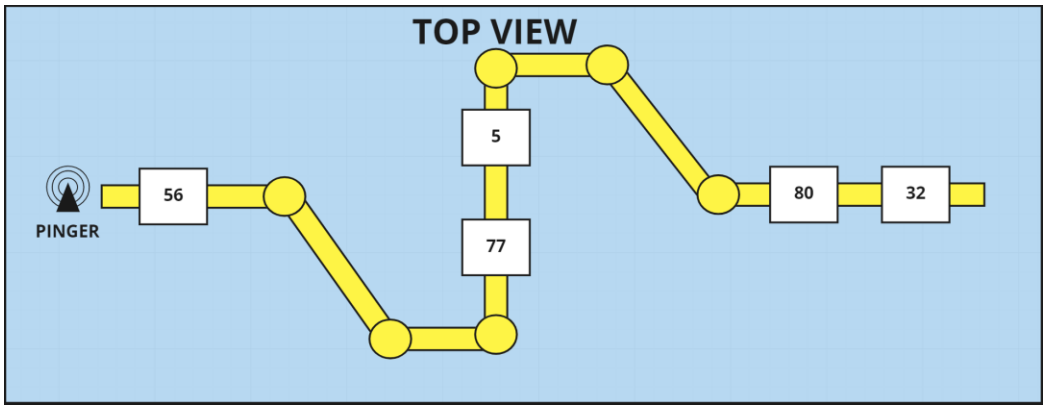
Additional bonus points will be awarded if specific autonomous behavior is demonstrated. If the team aims to attempt these specific executions, they must notify the judges during the mission brief.

| Bonus Points | | |
|---|---|---|
| **Execution** | **Description** | **Bonus Points** |
| Autonomous detection of Marker IDs. | Results must be generated by the ROV/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 reasonable time will disqualify the team from receiving these bonus points. | +10p per marker |
| Autonomous localization of pipeline from mission launch. | Once the mission has started, the team is not allowed to pilot the AUV until it has reached and located the pipeline/pinger. The team is not allowed to intervene until the AUV has indicated that the pipeline/pinger is found. | +100p |
| Autonomous tracking of pipeline. | The AUV 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. | +100p |
| Autonomous return to launch and recovery site | Once the mission is complete and the drone is ready to return home, the team is not allowed to pilot the drone until it has reached the lunch and recovery area. Manually initiating the return process is allowed, other than that the team is not allowed to intervene until the AUV has reached this area. | +50p |

## 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 | • The list contains all correct marker IDs = +50p<br>• The list is in the correct order = +25p<br>• The order is given in the correct direction = +25p | 100p |
| 56,5,20,32 | • The list contains three correct IDs = +30p<br>• The list contains one incorrect ID = -5p<br>• The list is in the correct order = +25p<br>• The order is given in the correct direction = +25p | 75p |
| 77,5,80,32,56 | • The list contains all correct marker IDs = +50p<br>• The list is not in the correct order = 0p<br>• The order is not given in the correct direction = 0p | 50p |
| 77,5,80,32 | • The list contains four correct IDs = +40p<br>• The list is in the correct order = +25p<br>• The order is given in the correct direction = +25p | 90p |
| 32,5,77 | • The list contains three correct IDs = +30p<br>• The list is in the correct order = +25p<br>• The order is not given in the correct direction = 0p | 55p |

| | | |
|---|---|---|
| 77,32,5 | • The list contains three correct IDs = +30p<br>• The list is not in the correct order = 0p<br>• The order is given in the correct direction = +25p | 55p |
| 1,2,3,4,5 | • The list contains one correct ID = +10p<br>• The list contains four incorrect IDs = -20p | 0p<br>(Score cannot be negative) |
| 77,5 | • The list contains two correct marker ID = +20p<br>• The list is in the correct order, but contains less than three IDs = 0p<br>• The order is given in the correct direction = +25 | 45p |

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 **400 points**.

# 4 Visual Inspection

There are strict inspection requirements for subsea assets. To be able to inspect these subsea structures, the vehicles must provide good underwater imaging and situational awareness.

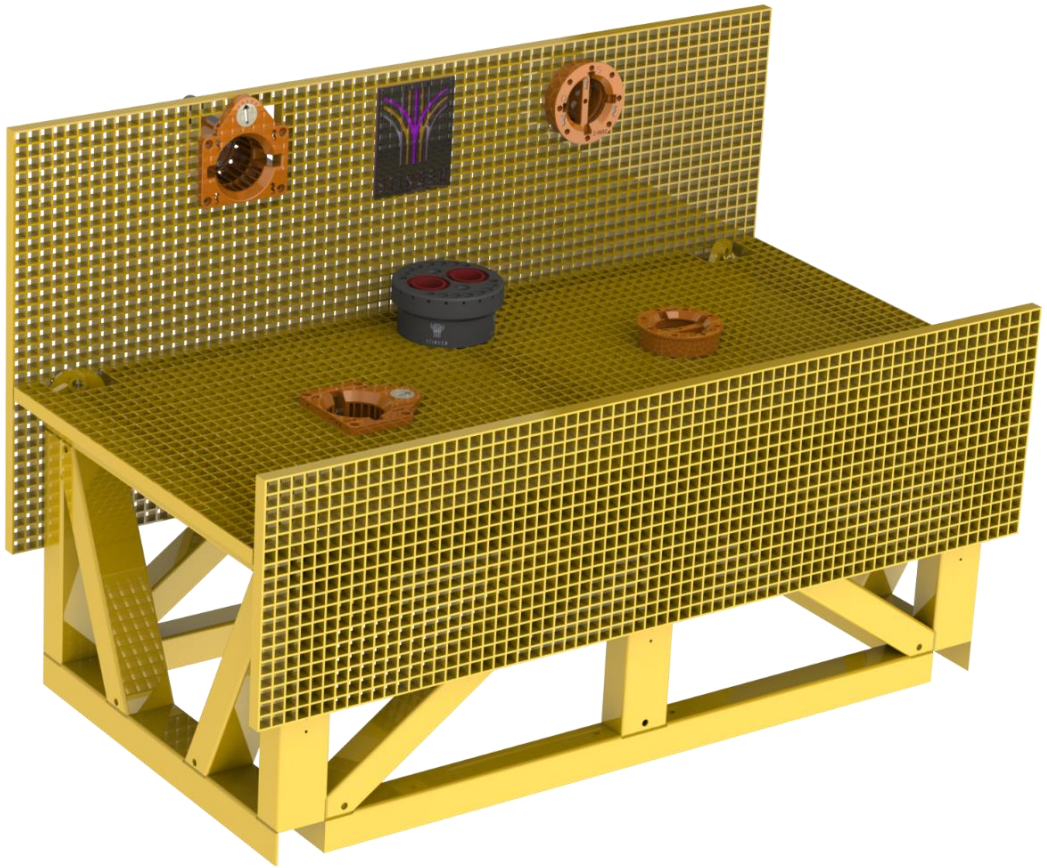
## 4.1 Mission Description

An underwater structure, located on the seabed in the operational area, must be inspected. Various ArUco markers are positioned on the structure and must be identified to achieve points. The markers are positioned in various places, some harder to inspect than others. Specific autonomous behavior may also award points.

*The Visual Inspection mission and Valve Intervention mission will be performed in the same run.*

**Deliverable**:

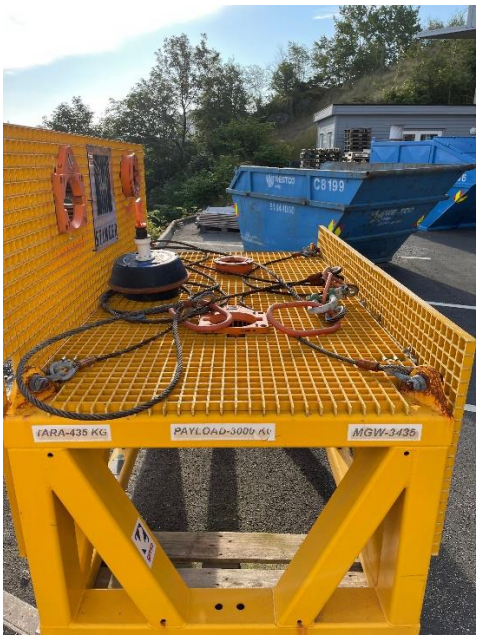
1. A list of marker IDs.



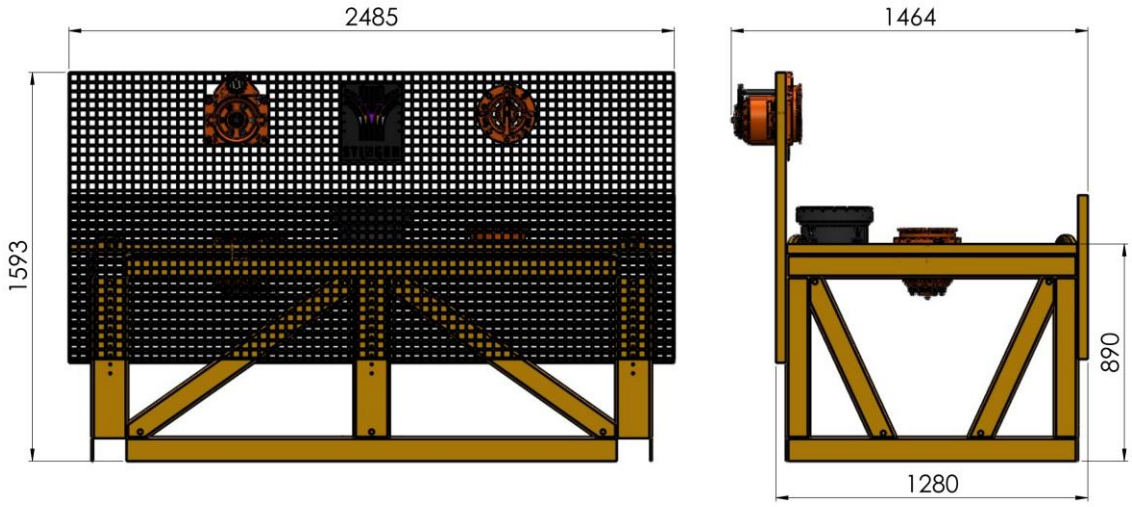
## 4.2 Mission Details

### 4.2.1 Subsea structure

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



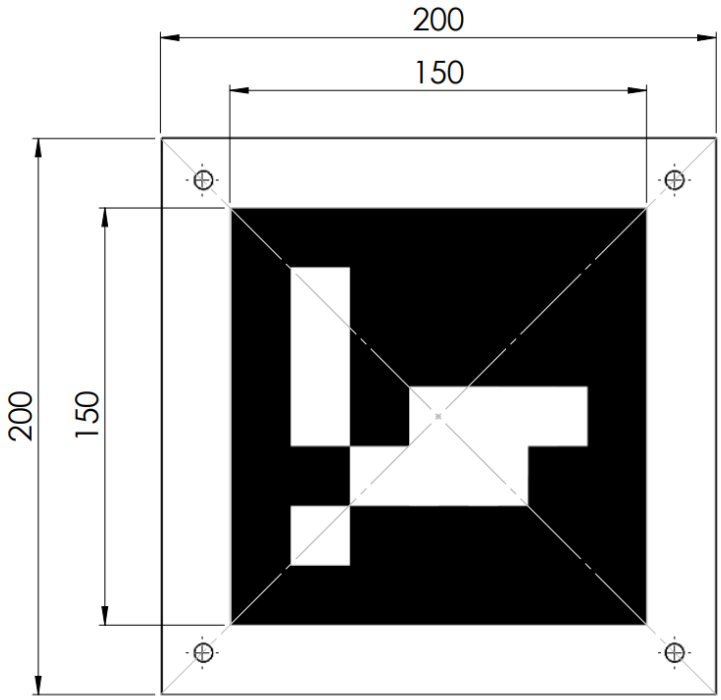

- The subsea structure has the overall dimensions [mm]:




- The color of the subsea structure is:
  - RAL 1004 (golden yellow)
  - RGB = 228, 158, 0
- The following image shows the subsea structure inspected by an ROV:

### 4.2.2 ArUco markers

- Original ArUco dictionary is used. See the online generator at: https://chev.me/arucogen/
- There are between 5 and 10 ArUco markers on the subsea structure, however the exact number is of markers is unknown.
- The marker IDs can range from 1 to 99. A specific ID **may** occur more than once.
- The markers can be positioned anywhere on the subsea structure. The rotational orientations of the markers are random.
- The frame around the marker is made of clear plastic with a white background.
- The marker dimensions are given in the following figure [mm].



## 4.3 Mission Scoring

### 4.3.1 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.** | +20p per correct marker<br><br>-10p per incorrect marker |

### 4.3.2 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 ROV/AUV and printed of the display screen/results file once the pipeline inspection is complete. Manual adjustments to this list or failing to produce the list within reasonable time will disqualify the team from receiving these bonus points. | +20p per marker |

# 5 Valve Intervention

Subsea intervention is crucial for maintaining and servicing underwater assets, installations, and infrastructure in offshore environments. Standard subsea valves are used by ROVs to control and manage such assets.

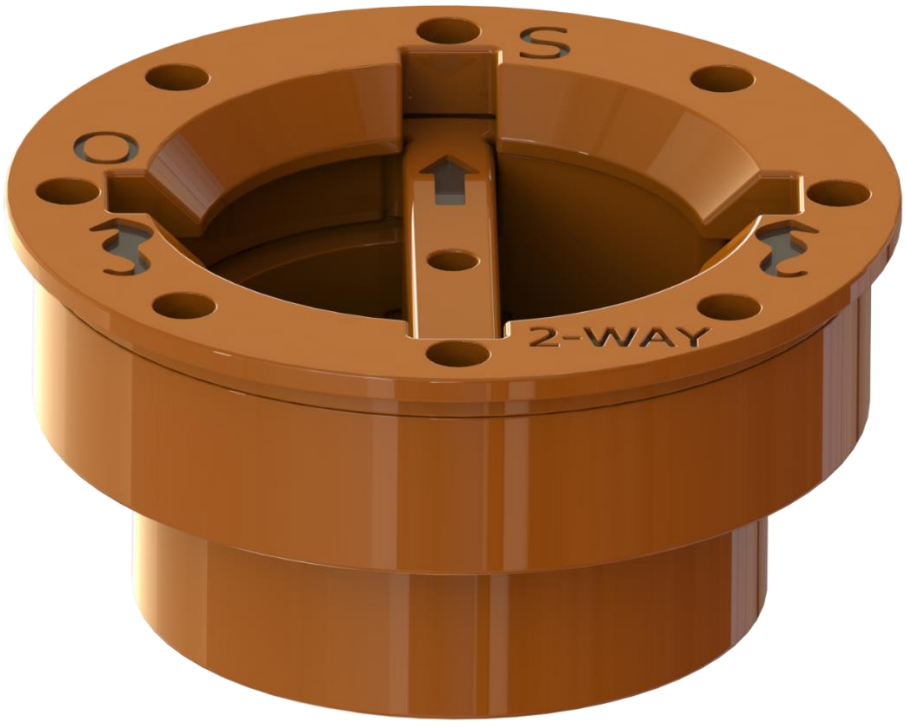
## 5.1 Mission Description

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.

*The Visual Inspection mission and Valve Intervention mission will be performed in the same run.*

**Deliverable:**

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

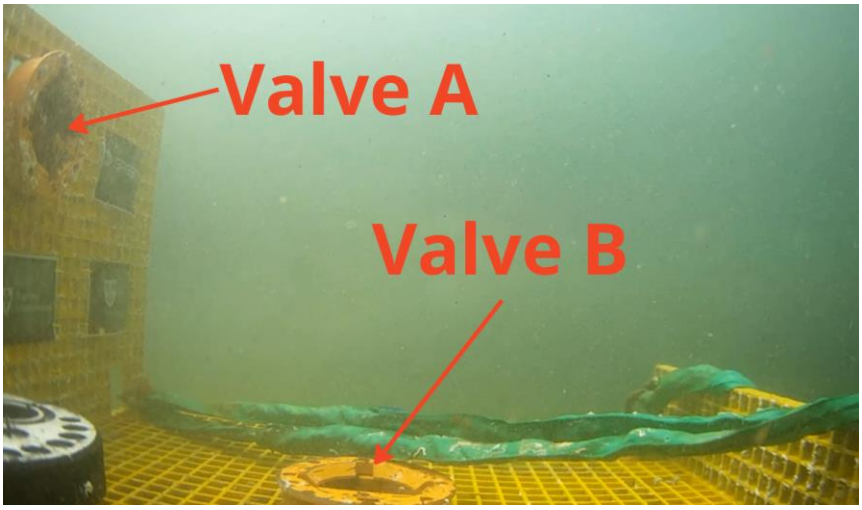


## 5.2 Mission Details

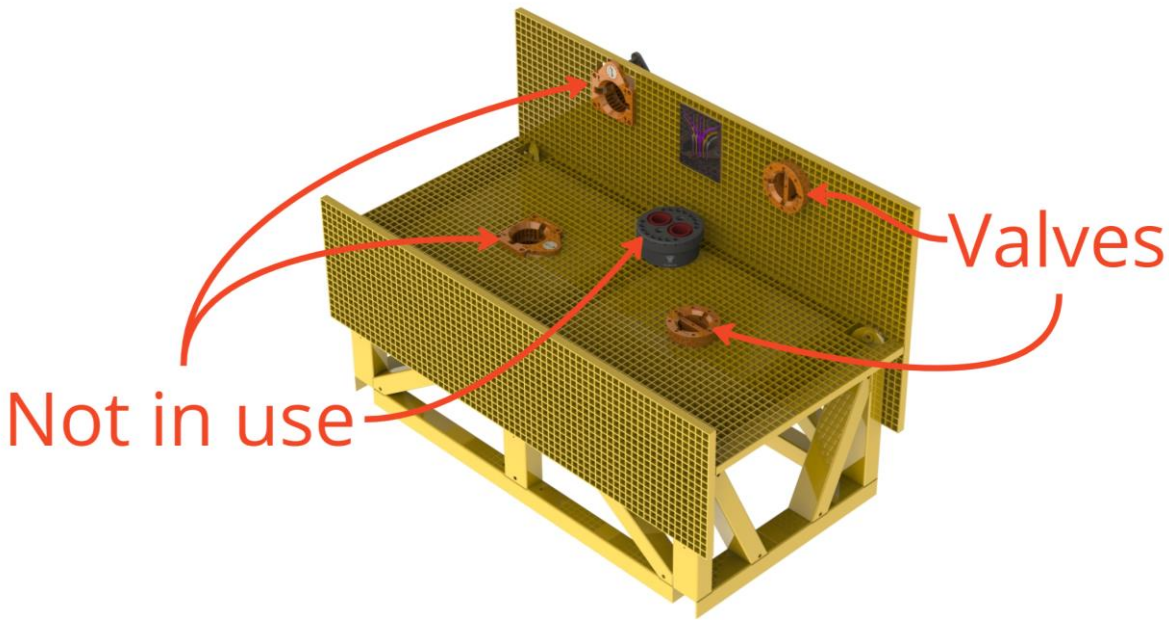
Additional resources are uploaded to the Shared Info Folder.

### 5.2.1 Valve positions

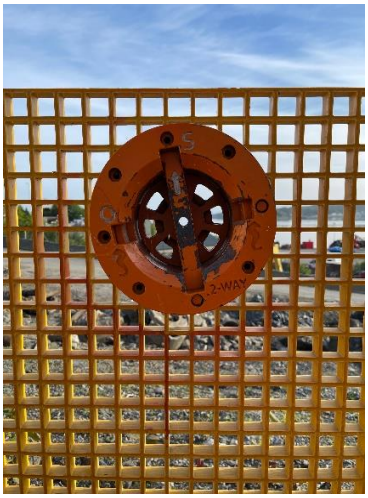
- The following image shows the valves on the subsea structure located in the competition area.




- 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:

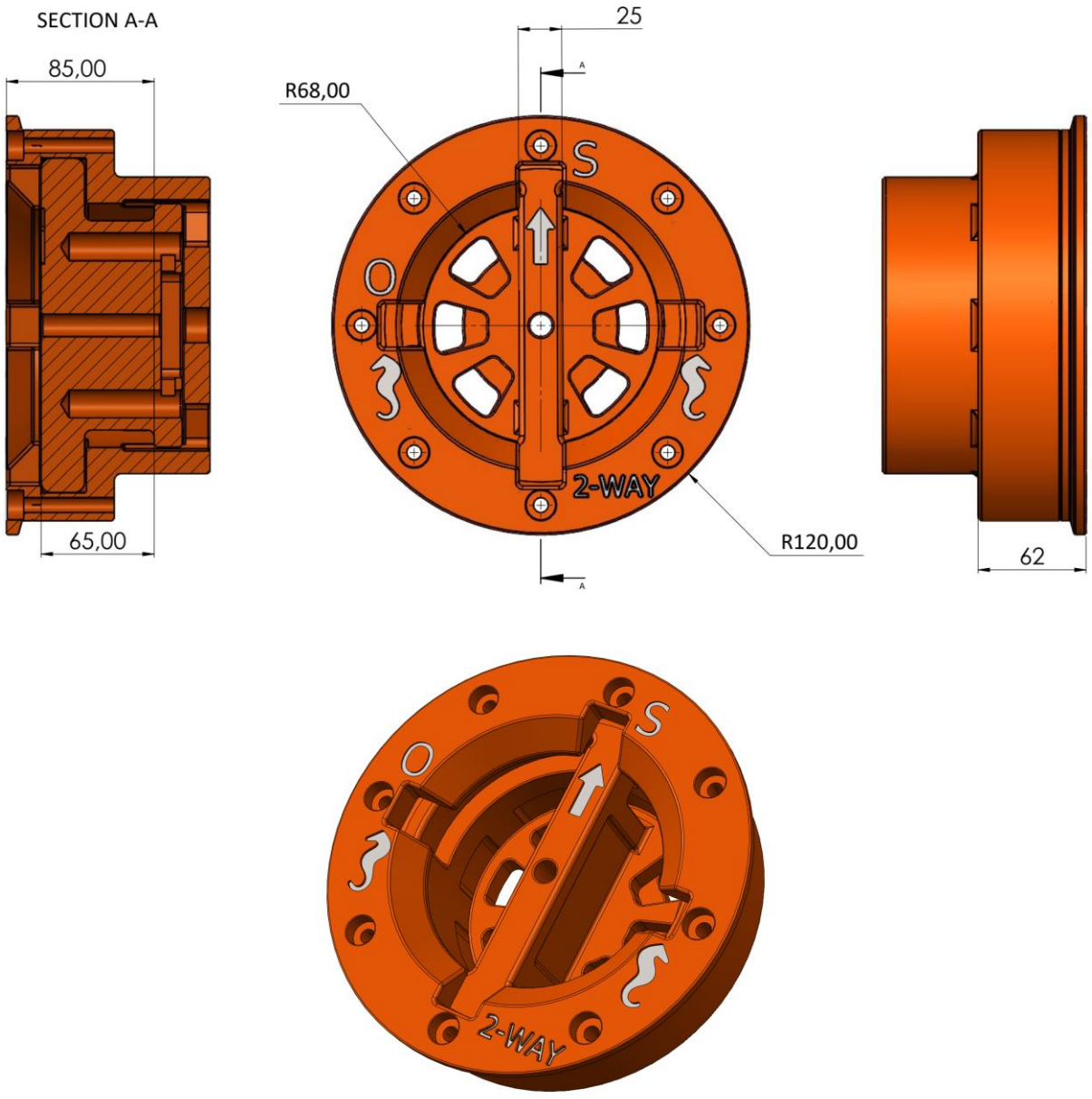


### 5.2.2 Valve Color

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

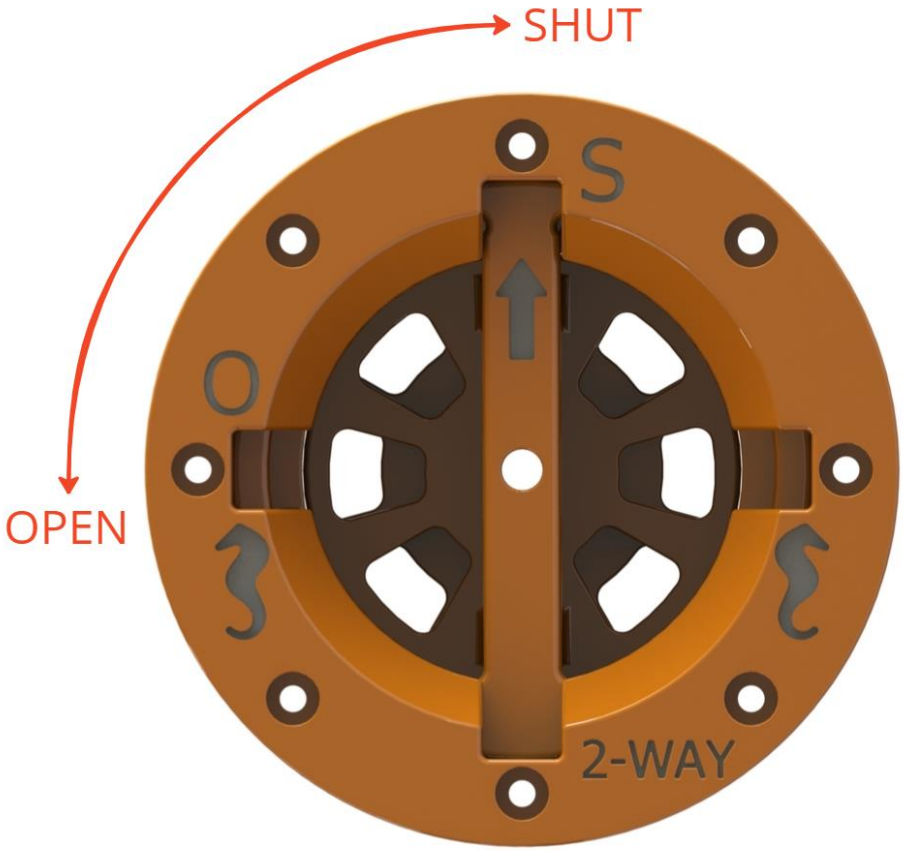
### 5.2.3 Valve dimensions

- 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
- CAD files are available in the Shared Info Folder.



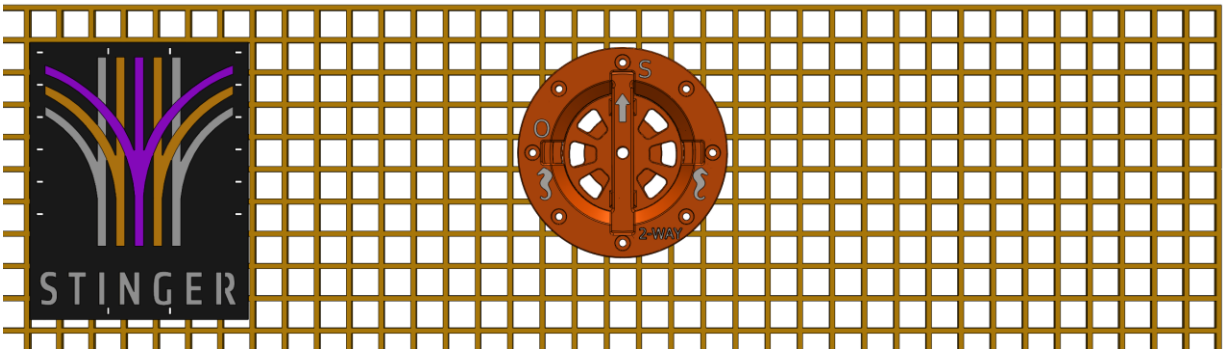
### 5.2.4 Valve function

- 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 (the starting position can be somewhere in between O and S).
- The valves are 3D-printed replicas and does not require high torque to turn the handle. It is similar to the torque needed to push a normal door handle.

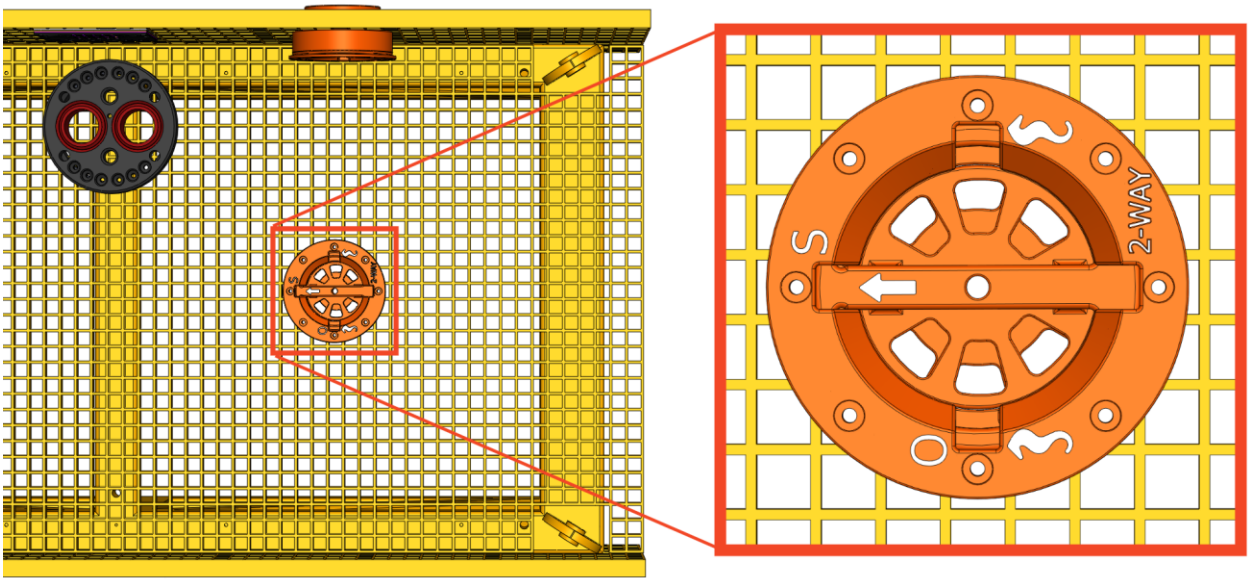


### 5.2.5 Valve Orientations

- 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.** | +50p 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 specific 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. | +100p per valve |

## 5.4 Example

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