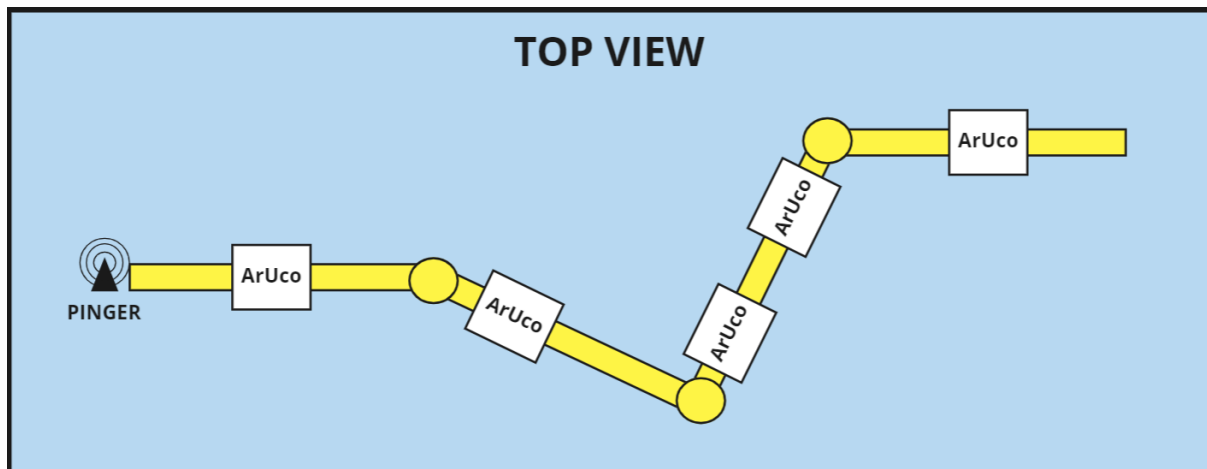# 3   Pipeline Inspection

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.
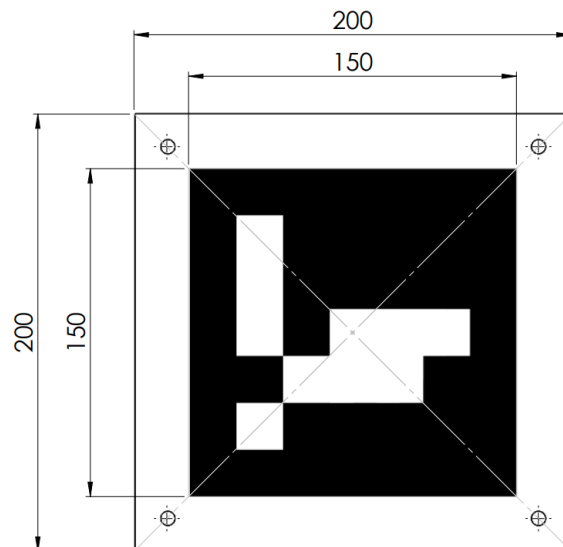
Deliverable:

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.

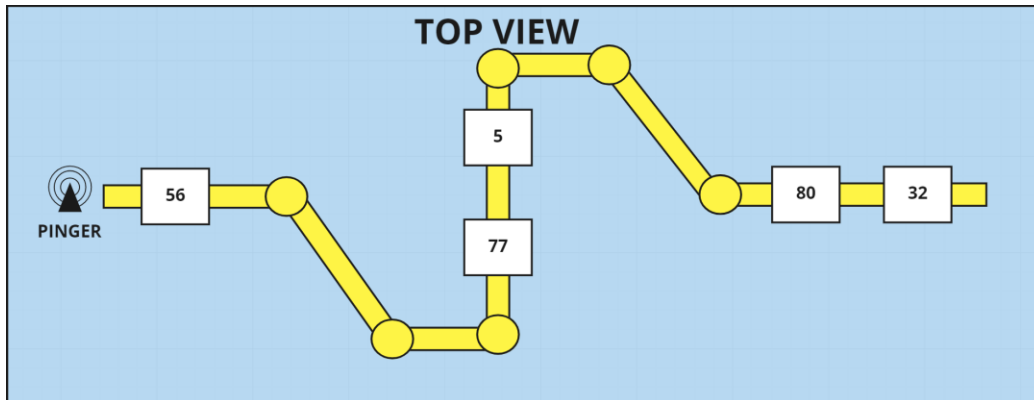| Standard Points		
Result	**Description**	**Points**
Identification of Marker IDs.	Each marker that is correctly identified will be awarded, regardless of the order they are presented. Any markers that do not belong will result in a point deduction. **This score cannot be less than 0.**	+10p per correct marker -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 • The list is in the correct order = +25p • The order is given in the correct direction = +25p	100p
56,5,20,32	• The list contains three correct IDs = +30p • The list contains one incorrect ID = -5p • The list is in the correct order = +25p • The order is given in the correct direction = +25p	75p
77,5,80,32,56	• 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	• The list contains four correct IDs = +40p • The list is in the correct order = +25p • The order is given in the correct direction = +25p	90p
32,5,77	• The list contains three correct IDs = +30p • The list is in the correct order = +25p • The order is not given in the correct direction = 0p	55p

77,32,5	• The list contains three correct IDs = +30p • The list is not in the correct order = 0p • The order is given in the correct direction = +25p	55p
1,2,3,4,5	• The list contains one correct ID = +10p • The list contains four incorrect IDs = -20p	0p (Score cannot be negative)
77,5	• 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 = +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**.