Annex 1

MURC – WUURC 2024

Competition Rules

（Official English version）

Directory

MURC – WUURC 2024

一、 Class: AUV

General

This document is the AUV class manual of the MURC – WUURC (Multinational Underwater Robotics Competition – World University Underwater Robot Competition). To participate in this class, participants must register **here.**

Date: July 2024

Place: Vladivostok

Number of team members: 2-10

The competition consists of three steps

- Team Spec Sheet - 10 points
- Engineering poster - 50 points
- Mission - 120 points

Vehicle requirements

- Vehicle: AUV
- Programming language: no limits
- Power: <24V, 20A
- Power source: on board
- Dimensions and weight of the robot: no more than 90x90x90 cm, <50 kg
- The robot should not be equipped with parts (sharp, piercing objects, exposed wires, etc.) that could harm the pool or team members.
- Each team performs on its own robot. Two teams are not allowed to compete on the same robot.

Weighing bonus

Vehicles weighing 50 kg will be allowed to carry out the mission. Before starting a mission, the vehicle must undergo a weighing procedure. Weighing takes place at the workstation before the start of the mission. The vehicle is weighed with all input components without taking into account the tether and the surface part (control

panel, monitor, etc.). The developed vertical profiling float is not included in the device and is not weighed. The measurement will be carried out using a digital scale.

The weight bonus is calculated as follows.
50>x>40 (kg) (no points awarded)
(40-kg)*0.5 (maximum 20 points).

Team Spec Sheet

The purpose of the company spec sheet is to provide the judges with a “snapshot” of your team. It includes basic information about your team and vehicle.

Teams will receive up to 10 points for submitting a spec sheet that is one page in length, follows the file size and naming specifications, and contains all required information.

The spec sheet contents and criteria are contained in the Spec sheet scoring list on the official competition page.

Engineering poster

The purpose of the engineering poster is to present technical information about your AUV in an attractive and easy-to-use format for a wide audience. It is the promotional piece – you must not only present information about your AUV, mission program and your team, but you must also use graphics and design to publicize and “sell” (convince viewers of their value and excellence) your products and people. During the competition, the poster will be evaluated by judges representing various professions (science, robotics, marketing, etc.). While some judges will have a technical background, others will have a communications, marketing, or public relations background. In addition, there will be visitors to the competition who may not completely understand what an AUV is or how it is used.

The maximum poster size is 80x180 cm.

Use the marketing display scoring rubric posted on the official competition page as the guideline for the required components for the Engineering poster.

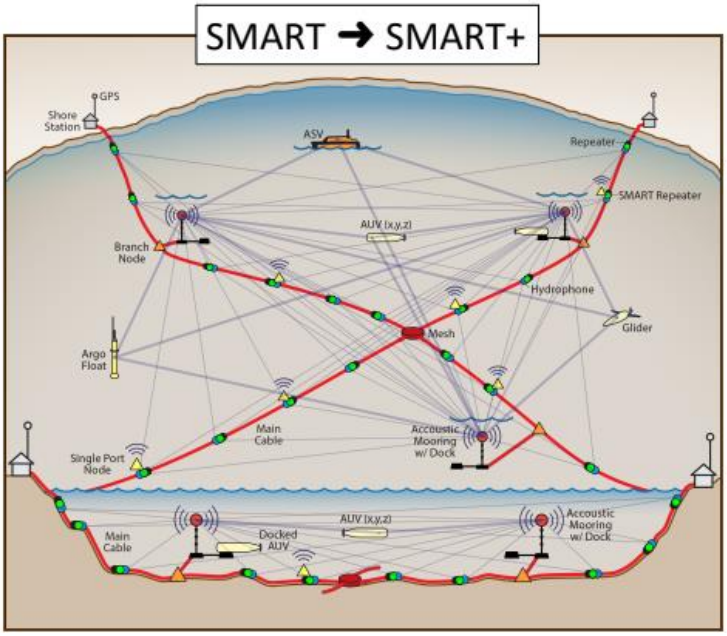
Mission

Context

Miles of submarine cable run underwater, supporting the world's communications infrastructure. However, these cables could be a way to collect data on the state of the ocean and seafloor. To implement the project to develop such “smart” cables, a Joint Task Force was created, including several UN offices. The project is called “SMART cables” (Scientific Monitoring and Reliable Telecommunications) and aims to use existing cables to collect and transmit information about the environment.[1]

One of the problems in developing a global system of “smart” cables is diagnosing the state of underwater sensors. One of the options for solving this problem is the use of AUVs (autonomous underwater vehicles), which can inspect the underwater cable and be recharged at docking stations.

As part of the mission, it is necessary to inspect the underwater cable, install a marker near the damaged sensor and enter the docking station.



Work station

The station consists of a table and 2 chairs located approximately 1 meter from the pool. Pool depth 1 - 2 m (pool depth may vary depending on the competition site). The team must bring a laptop, monitors and other necessary equipment.

Time

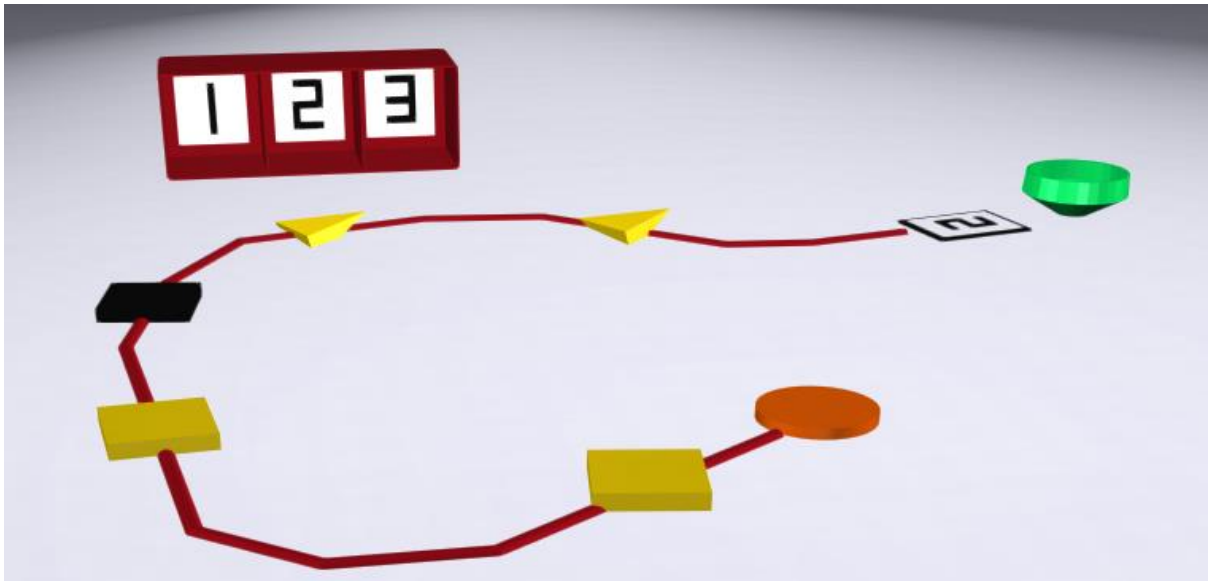
Each team will be given 2 attempts to complete the mission, each lasting 20 minutes. During an attempt, a team can do 3 launches of 5 minutes each.

Each attempt consists of three parts:

- set up at the work station - 3 minutes
- launches - 15 minutes
  The duration of one launch is no more than 5 minutes.
- break down and exit the work station - 2 minutes

Task Descriptions

At the bottom of the pool there is a red cable 50 mm thick and 10-20 m long. The docking station is a structure made of PVC pipes, consisting of 3 cubes 90 cm*90 cm. Sheets are installed on the bottom edge of each cube. On the side faces there are sheets with the cube number.



Mission scheme (Notice: color of rope can be red or black, doc-station will be red)

There are two types of figures on the cable:

- triangles - accelerometers
- squares - temperature sensors.

If the sensors are working, they are yellow; if they are broken, then they are black.

Mission

- The vehicle starts above the red circle in front of the cable. The vehicle needs to inspect the cable (walk along it).
- If the vehicle detects a working temperature sensor, it must touch this sensor and turn on green LEDs. If the vehicle detects a working accelerometer, it should turn 360 degrees and turn on green LEDs.
- If the vehicle detects a broken sensor (black square), then it throws the marker on it and red LEDs turn on.
- At the end of the cable there is a table with a number and a platform with a beacon.
- In the pool, in a random place, there is a docking station with an acoustic pinger.
- The vehicle must identify the number on the table.
- Then the vehicle must take the beacon from the platform and take it to the docking station
- The beacon must be placed on any free floor of the docking station.
- Mooring is carried out on the floor indicated on the table.
- The device can be moored together with the beacon. In this case, the team receives fewer points.
- Beacon simulated by PPR Tee 20 mm
- The team makes the marker themselves and brings it with them to the workstation. (max.size - 7*7*7 cm)

Starting conditions

- The team should prepare a mission program file and name it **mission_team_name** (for example, mission_mur.py). It is prohibited to use programs with a different name.
- The number of sensors on the field is fixed and equal to 5. The position of the sensors is determined randomly before the start by the judge. There is also one broken (black) sensor on the field. This mission set up is used for all teams during one attempt. After all teams have completed the first attempt, the judge determines the placement of sensors for the second attempt.
- The location of the docking station is determined by the judge before the start of the attempt and remains the same throughout one attempt.
- Before starting, the robot must be on the surface of the water in the starting area. It is possible to start the program using mechanical switches, via wireless networks, as well as by launching the program directly on a laptop.
- The robot is launched from a square frame 90x90 cm.
- Before launch, the team can orient their device in the frame in any way they want.
- Under the frame at the bottom of the pool there is a red circle with a diameter of 25 cm. The depth of the field is set on the day of the competition and does not change throughout the entire competition day.

Competition rules and scoring

Mission Scoring

1. Working sensors detected - **up to 40 points**.
   1.1. **5 points for each** - when detecting a sensor, the AUV turned on the correct color indication, but did not perform the correct maneuver (turned on the green LEDs if the sensor was working) or performed the correct maneuver without turning on the light indication.
   1.2. **10 points for each** - when the sensor was detected, the AUV turned on the correct color indication and performed the correct maneuver (turned on the green LEDs, touched the sensor - if it was a square, turned 360 if it was a triangle).
2. Broken sensor detected - **up to 20 points.**
   2.1. **5 points** - the sensor is detected and the red color indication is turned on.

2.2. **20 points** - the sensor is detected, the red color indication is turned on, the marker is thrown.

3. The vehicle follows the cable - **15 points.**
   The step is completed if the AUV detected all five sensors (performed actions on them, including incorrect ones).
4. Installation of a beacon - **up to 15 points.**
   4.1 The beacon has been removed from the platform - **5 points.**
   4.2. The beacon is installed on a free floor of the docking station - **15 points.**
   Free floor - the floor of the docking station on which the AUV is not located.
   4.3. The beacon is installed on the apparatus mooring floor - **5 points.**
5. Docking station detected - **15 points**
   The step is completed if the device has reached the docking station.
6. Mooring at a docking station - **up to 15 points.**
   6.1. The AUV entered the docking station on the wrong floor - **5 points.**
   or
   6.2. The AUV entered the docking station on its floor - **15 points.**
   The criterion is met if the AUV is completely moored into the docking station and no part of it goes beyond.

Total: 120 points

Ending the launch

The launch is stopped fails in the following situations:

Standard situations:

- The vehicle entered the docking station;
- The vehicle floated to the surface, that is, any part of the robot appeared above the water inside the frame.

Emergency situations:

- The maximum launch time has expired;
- The captain asks the judge to complete the launch;

Critical situations:

- The vehicle has violated other requirements described in the rules;

- The participant has violated other requirements described in the rules.

Conducting the competition

1. Competition organizers are preparing a schedule for training in the pool. Each team must undergo a technical inspection of robots to ensure compliance with the requirements.
2. Each team carries out debugging of the robot and training launches according to the schedule.
3. In the final, each team will be given 2 attempts. A team can perform 3 launches in one attempt. The duration of one launch is 5 minutes.
4. The judge calls the teams according to the established schedule.
5. At the beginning, a team member must show the judge a file with a program for completing the mission. The file should be named mission_team (for example, mission_mur.py).
6. If a team uses a file with a different name to complete a mission, then the judge has the right not to count the attempt.
7. Between attempts, teams will be given time to debug the device, within which they can make changes to the program.

Rules

1. The vehicle can enter the docking station only if the “vehicle follows the cable” criterion is met.
2. If the vehicle did not identify one sensor, but correctly oriented itself along the cable and continued moving, then the launch continues.
3. As soon as the vehicle enters the docking station, the judge stops the timer and the launch is completed, the points and time for completing the mission are recorded.
4. If the vehicle floats up, the judge stops the timer and the launch is considered completed, the points are recorded and the maximum time of the launch is set. The captain can complete the launch earlier and the maximum time of the launch is recorded.
5. If time runs out during a launch, the points earned up to that point and the maximum time are recorded.
6. The vehicle in the pool can only be launched by one team member, who is located at the edge of the pool. Before starting, the vehicle must be in the

water in the starting area. A team member located at the edge of the pool must hold the robot. After the judge has given the start and timed it, the team member can start the program.

7. During the attempts, the assistant makes a video recording. If, after the judge has completed the score sheet, the team does not agree with the points awarded, they must inform the judge before signing the score sheet. After this, the video recording of the team's last attempt is reviewed and re-evaluated.
8. At the end of the attempt, the team captain must review the score sheet and sign. Once the evaluation sheet has been signed, appeals will not be accepted.
9. The result of the attempt is the best of three launches.

Determination of final rating

- In the final, the winners are determined by the number of points. The best attempt and the time taken to complete this attempt are counted. If the teams have the same number of points, then the second attempt are taken into account.
- If 3 or fewer teams participate in the final, if a team scores 0 points in two attempts, then the team will not be awarded a prize.

Props description

The start area should be located at the edge of the pool and is a frame of 90x90 cm.

Composition and characteristics of the props (you can download printable layouts from the link: https://drive.google.com/drive/folders/1IzG3nOndhu9swWwJacRyu5uvWtdKUOor?usp=sharing)

№	Type	Color and material	Linear dimensions	Location

1	Frame	Made from polypropylene pipes d20mm. White color.	L x W: 90x90 cm	Located on the surface of the pool above the red circle.
2	Rope	red or black	D50 mm Length 10-20 m	At the bottom of the pool
3	Plaque with a circle (1 piece)	Red circle on a white background. It can be cut from both floating materials (in this case it is necessary to attach a weight to the reverse side) and non-buoyant ones. Materials: alucobond, acrylic, PVC, banner fabric, iron.	Diameter: 25cm. Square size 40*40 cm	Located at the bottom of the pool under the starting frame
4	Sensors	2 squares, 2 yellow triangles. On stands made of PPR pipes d20mm.	L x W: 20x20 cm	They are installed on the rope in any way (4 figures are located on the rope at the same time).
5	Broken sensor (black)	Black square. Mounted on stands made of PPR pipes d20mm.		One sensor is located in any part of the rope.

6	Tables with numbers (at the bottom)	Plates with numbers 1,2,3. They are printed on a banner, glued to sheet material (not buoyant) and weighted.		
	Number plates (for docking station)	plates with numbers 1,2,3. They are printed on a banner and glued onto sheet material to the back walls of the docking station.	L x W: 30x30 cm	
7	Dock station	Made from polypropylene pipes d20mm. Fomax sheets are attached to the lower faces of the cubes. On the back wall of the cubes there are signs with numbers 1,2,3	L x W: 90x90x90 cm	

Examples of rope.

https://sport-setka.ru/kanaty/kanat-dlya-lazanya/

https://forma-sporta.com/goods-642/

https://clck.ru/37ZCud

MURC – WUURC 2024

二、 Class: ROV

General

This document is the main rules of the ROV class of the MURC – WUURC (Multinational Underwater Robotics Competition – World University Underwater Robot Competition). International competition challenges are inspired by MATE ROV competition 2024. To participate in this category, participants must register using the link (will appear later).

Date: July 2024
Place: Vladivostok, Verkhneportovaya 66v
Number of team members: 2-5

The competition consists of three steps

- Engineering poster - **50 points**
- Technical documentation **- 50 баллов**
- Company Spec Sheet **- 20 points**
- Product demonstration - **350 баллов**

Engineering poster

The purpose of the engineering poster is to present technical information about your AUV in an attractive and easy-to-use format for a wide audience. It is the promotional piece – you must not only present information about your ROV, mission program and your team, but you must also use graphics and design to publicize and “sell” (convince viewers of their value and excellence) your products and people. During the competition, the poster will be evaluated by judges representing various professions (science, robotics, marketing, etc.). While some judges will have a technical background, others will have a communications, marketing, or public relations background. In addition, there will be visitors to the competition who may not completely understand what a ROV is or how it is used.

The maximum poster size is 80x180 cm.

Use the marketing display scoring rubric posted on the official competition page as the guideline for the required components for the Engineering poster.

Technical report

A technical report is written by teams to demonstrate:

- understanding of the principles of project activities and teamwork;
- knowledge and skills in the field of assembly and piloting of remotely controlled underwater vehicles (ROV);
- understanding of the principles of safe development and operation of ROV;
- skills in the development of technical documentation;
- reflection.

The criteria by which technical reports will be evaluated will be published before April 1 on the competition page. To prepare the technical report, you can use last year's evaluation criteria (link to the criteria page). The technical report will be evaluated by 2-3 judges and their scores will be averaged. A team can earn a maximum of 50 points for a technical report.

The technical report must be uploaded to the form by May 10, 2023. inclusive.

Company spec sheet

The purpose of the company spec sheet is to provide the judges with a “snapshot” of your company. It includes basic information about your company and vehicle. Companies will receive up to 20 points for submitting a spec sheet that is one page in length, follows the file size and naming specifications, and contains all of the following information:

COMPANY SPECS

- Company and school, club, or community organization name
- Home state and/or country
- Distance required to travel to the World Championship

- History of MATE ROV competition participation. Be sure to specify if your company and/or the members of your company are “new” or “returning.”
- Company photo and caption indicating members’ names and roles (e.g. CEO, CFO, Design Engineer, Pilot, etc.). This photo should include all of the members of your company.
- Range of grade/college levels represented by the members of your company

ROV SPECS

- ROV name if applicable
- Total cost. You must include the approximate cost of any donated items.
- Size and weight measurements
- Total student-hours to design and build. This should include the number of hours that each and every member of the company worked on the vehicle. ▪ Safety features
- Special features
- Photo of the vehicle

REMINDER!!! If all of the above information is included, the specifications for length, size, and naming conventions are followed carefully, and the document is submitted on time, this is an “easy” 20 points! You can find the company spec sheet scoring rubric posted here.

Vehicle requirements

- The dimensions of the ROV should allow it to fit into a cube of 90x90x90 cm.
- The ROV weight is no more than 25 kg.
- There should be no batteries or accumulators on the vehicle. The vehicle's power supply voltage should not exceed 48V. The maximum current should not exceed 15A.
- The vehicle should not have any parts installed (sharp, piercing objects, exposed wires, etc.) that could harm the pool or team members.

Weighing bonus

Vehicles weighing 25 kg will not be allowed to carry out the mission. Before starting a mission, the vehicle must undergo a weighing procedure. Weighing takes place at the workstation before the start of the mission. The vehicle is weighed with all input components without taking into account the tether and the surface part (control

panel, monitor, etc.). The developed vertical profiling float is not included in the device and is not weighed. The measurement will be carried out using a digital scale.

The weight bonus is calculated as follows:
Weight (in air):
< 15 kg +10 points
From 15.01 kg to 20 kg +5 points
From 20.01 kg to 25 kg +0 points
Devices weighing more than 25 kg will not be accepted for other products.

Product demonstration

Context

As last year, three tasks of the competitive mission in 2024 are devoted to solving problems that are relevant within the framework of the Decade of Ocean Sciences for Sustainable Development (2021 -2030). You will undertake work to scale up the Global Ocean Observing System to protect and restore ecosystems and biodiversity and collect ocean data to address climate change.

This year's mission will include diagnosing an ocean data collection system, installing an undersea cable, rehabilitating a coral reef by replanting new corals, and treating sick corals with probiotics. You will also have to determine the habitat of lake sturgeons and develop a buoy for monitoring ocean conditions

All competition tasks are based on existing research projects and tasks that use underwater robots or developments in the field of underwater robotics.

Work station

The station consists of a table and 2 chairs located approximately 1 meter from the pool. Pool depth 3-6 m (pool depth may vary depending on the competition site). The team must bring a laptop, monitors and other necessary equipment.

Time

Each team will be given 2 attempts to complete the mission, each lasting 20 minutes.

Each attempt consists of three parts:

- set up at the work station - 3 minutes
- product demonstration- 15 minutes
- break down and exit the work station - 2 minutes

At any time during the product demonstration you may pilot your ROV to the surface and remove it from the water for things such as buoyancy adjustments, payload changes, and troubleshooting. However, the product demonstration clock will NOT stop. The only time the clock will stop is if a judge determines that there is an issue that is beyond your control. Otherwise, the clock will only stop after all of the tasks are successfully completed, the ROV has returned to the surface under its own power so that it touches the side of the pool, and a member of your company at the product demonstration station has physically touched the vehicle.

Task Descriptions

Teams can complete tasks in any order. However, some task steps require sequential execution **(this will be indicated in the task description).**

The mission consists of three tasks:

- Task 1. OOI: Coastal Pioneer Array - **50 points**
- Task 2. SMART Cables for Ocean Observing - **70 points**
- Task 3. Studying ecosystems and preserving species- **160 points**
  - 3.1. Smart Reefs
  - 3.2. Inland Lakes and Waterways
- Task 4. Robotic buoys GO-BGC - **70 points**

TOTAL: 350 points.

TASK 1: OOI: Coastal Pioneer Array – Relocating ocean observing assets to “answer pressing science questions and gather data”

The Ocean Observatories Initiative (OOI) is an ocean observing network that operates and maintains instruments and sensors that collect and deliver data to better understand the ocean and how it is changing as a result of natural and human-caused processes. Funded by the U.S. National Science Foundation (NSF), OOI connects researchers, educators, and the general public to a wide range of ocean instrumentation through its cyberinfrastructure, all without the need to go to sea. OOI includes more than 900 instruments, and the data collected by these instruments are freely available around the clock in near real-time.

One OOI observatory, the Coastal Pioneer Array, was designed to be re-locatable and suitable for moderate to high winds, waves, and currents on the continental shelf and upper slope. The Coastal Pioneer Array was installed in 2016 off the coast of New England, about 75 nautical miles south of Martha’s Vineyard. The array consisted of moored platforms, such as surface buoys, profiler moorings, and benthic multi-function nodes, and autonomous vehicles. It was maintained by the Woods Hole Oceanographic Institution (WHOI).

1.1 Release the multi-function node (**The steps of this task are performed strictly in order**)

- “Trigger” the release of the multi-function node’s recovery float. - **10 баллов.**

The step is considered completed if the connector is completely removed from the frame and is not in contact with the multi-function node. The connector is not considered waste and can be left at the bottom.

- Visually determine that the recovery float has failed – - **5 баллов.**

The step is considered completed if the team demonstrates to the judge on the screen that the recovery float is not in contact with the multi-function node and floated, but did not reach the surface due to an accident.

- Pull a pin to release the failed recovery float to the surface- **10 баллов.**

The step is considered completed if the team removes the pin holding the recovery float loop and the recovery float is on the surface.

- Return the failed recovery float to the surface, side of the pool - **5 баллов.**

The step is completed when the recovery float is removed from the water.

- Connect a recovery line to the bale on the multi-function node for manual recovery - **20 баллов.**

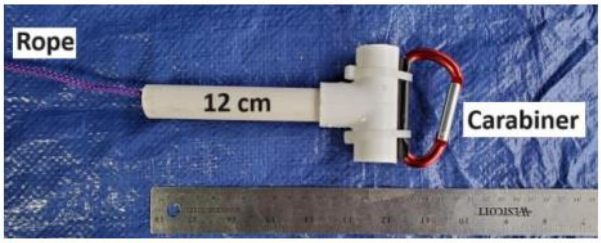
The step is completed if the carabiner is secured to the U-bolt on the assembly multi-function node and does not fall off after installation is complete. The recovery line will be on the surface near the workstation.

Total points = 50 points

Props Description

Type	Photo	Description
multi-function node	 	The unit frame is made of pipe ppr 20, 4 tees ppr 20, two angles ppr 20, and two transition tees ppr 20 to 25. A U-shaped eye bolt is provided for installing the carabiner. The frame is drilled to a plastic box. The box is weighted and is located at the bottom. To install the buoy, a pipe PPR 90 is provided (can be replaced with a larger diameter) 12 cm long. Under the tube there is a hole for installing a pin. To keep the pin in the hole of the basket

		from the inside, it is inserted into the PPR 20 tube.
recovery float		Made from a 20 cm long PPR 63 tube with a plug (can be replaced with a 50 mm tube and a corresponding plug). A rope with a loop at the end is tied to the buoy. The length of the rope is no more than half the depth of the pool (<1 m). At the end of the rope there is a loop for attaching a pin.There are also slots on both sides of the displacer for installing a pin. Floating material is placed at the top of the buoy to help the buoy float to the surface.

Connector		Made from a PPR 20 tube, 36 cm long, and a D20 tee.
	 Left: The pin holding the recovery float. The recovery float rope is stored inside the float, ab pin. The pin passes through a loop in the rope, holding the rope in place until the pin is remov Two notches drilled into the bottom of the recovery float hold the pin in place.  The recovery float pin.	The recovery float rope is located inside it, above the pin. The pin passes through a loop of rope, holding the rope in place until the pin is removed.The length of the rope is no more than half the depth of the pool (<100 cm). Two notches drilled into the bottom of the buoy hold the pin in place.
recovery line	 The MATE ROV Competition provided recovery line.	Made from a PPR 20 tube 12 cm long and a tee. A rope loop (20 см) is attached to the tube, simulating a cord for lifting. A carabiner is attached to the tee. The part of the carabiner that is attached to the tee is wrapped with electrical tape so that the carabiner is fixed and does not rotate.

	 The MATE ROV Competition provided recovery line attached to the #310 U-bolt bale on the multi-function node.	**Пример карабина:** https://www.amazon.com/dp/B08GFX9PFN/ref=pe_386300_440135490_TE_item
		

ЗАДАЧА 2: SMART Cables for Ocean Observing

Science Monitoring And Reliable Telecommunications (SMART) Cables is a project that will equip transoceanic telecommunications cables with sensors to collect data on ocean health and monitor seismic activity. SMART Cables are just that – “smart” – in that they use transoceanic cable power and communications infrastructure to collect and transmit temperature, pressure, and seismic acceleration 2024 NAVIGATOR Class 10 data – all of which are important environmental parameters of the deep ocean that are currently undersampled. This data will not only provide valuable information about the state of the ocean, it will also benefit society by improving earthquake and tsunami early warning systems.

At the core of the “smart” innovation is the SMART Repeater, which houses the sensors that measure temperature, pressure, and seismic acceleration and includes a

pass-through for the telecommunications cable. The telecommunications cable consists of copper wire, which the sensors tap into for power, and fiber optics for data transmission, which allow the sensor data to be shared in real-time.

2.1. Deploy the SMART cable (the steps of this subtask are performed in the specified order)

- Deploy SMART cable through two waypoints located on the bottom of the seafloor – **5 points each, 10 points total**

The step is considered completed if the cable passes through two points (pipe tubes) of the guide. The SMART cable will be placed on the surface near the workstation.

Waypoint A is an unsuccessful cable lay, as the cable is inside one vertical post only. Waypoint B is a successful cable lay, as the cable is inside two vertical posts. Waypoint C is an unsuccessful cable lay, as the cable is only inside one vertical post (the lower right post only).

- Deploy SMART cable through a waypoint located on top of a seamount – 1**0 points**

The waypoint on top of a seamount will be raised 50 cm above the pool bottom on PVC “legs”. Companies will receive 5 points for successfully deploying the cable through each waypoint on the seafloor, and 10 points for successfully deploying the cable through the waypoint on top of the seamount. Successfully deploying the cable through a waypoint is defined as the wire inside two PVC posts of the waypoint.

- Place the SMART repeater in the designated area - **10 points**

The step is considered completed if the repeater is installed in a blue frame, no part of it protrudes beyond the boundaries of the frame and the repeater is not in contact with the ROV.

- Return the end of the cable to surface, side of the pool. - **5 points**

The step is complete when the cable is routed through two Waypoints, the repeater is installed, and both ends of the cable are on the surface.

- Measure the temperature to check the SMART cable sensor readings
  - Within 1C – **15 points**
  - Within 2C – **5 points**

Once the SMART repeater has been successfully placed in the designated area, companies must check the SMART repeater temperature sensor readings. The SMART repeater will include a temperature sensor; the wires for the temperature sensor will run alongside the rope. Companies must measure the temperature at the SMART repeater's temperature sensor to check the temperature sensor is working. Companies will receive 15 points if their temperature sensor is within 1 C of the SMART cable's temperature reading. Companies will receive 5 points if their temperature sensor is between 1.01C and 2C of the SMART cable's temperature reading. Companies must show the judge their temperature sensor readout, but they may include an adjustment or offset, if needed. Companies should inform the judge of any adjustment or offset prior to showing the judge their temperature measurement.

2.2 Connect the AUV docking station to the SMART cable repeater (this subtask is performed only after completing the steps of task 2.1)

- Retrieve the power connector from the AUV docking station - **5 points**

The step is completed if the connector is held by the ROV and is not in contact with the docking station.

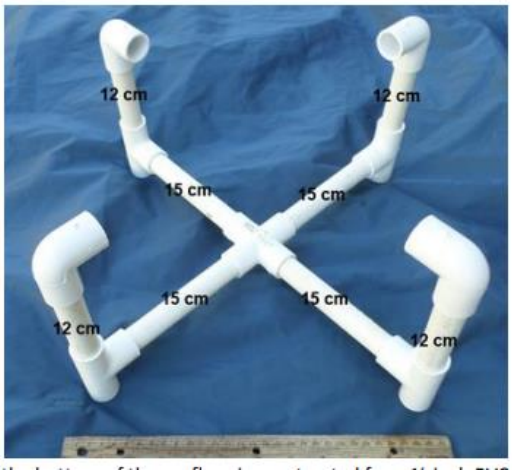
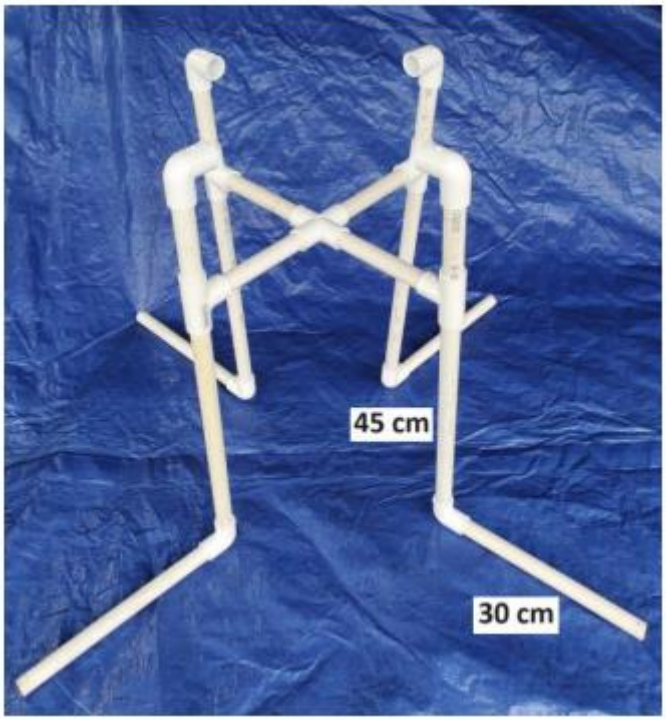
- Install the power connector - **15 points**

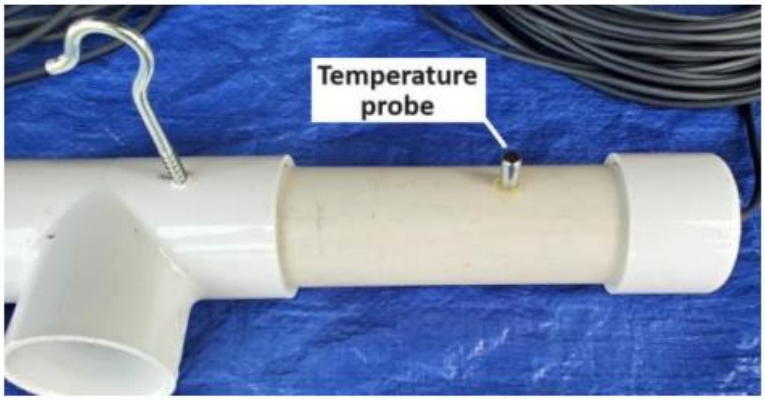
The step is considered completed if the connector is not in contact with the ROV and is inserted into the repeater port.

Total: 70 points .

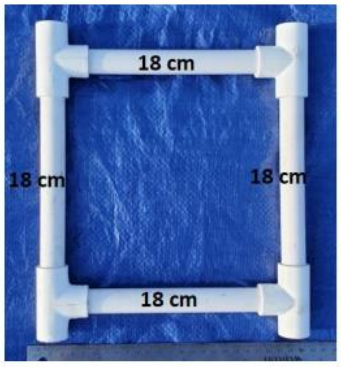
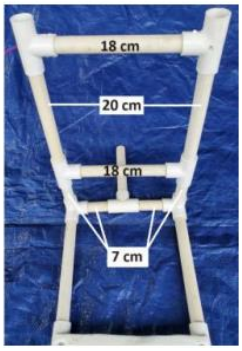
Props Description

Type	Photo	Description

Waypoints (**3**)	 	Made from pipes ppr 20 and fittings of the appropriate size. The lower part of the structure is weighted.
SMART cable with repeater		Made from pipes ppr 50, two plugs and a tee of the appropriate size. A hook is provided for gripping. A cable is attached to both sides of the repeater. The

		length of the cable is selected such that the two ends of the cable can be placed on the surface when installing the repeater in the frame. Inside the open hole of the tee there is Velcro tape (loops) for attaching the connector.
frame		Made from pipes ppr 20, 4 tees and weighted.

		
power connector	 	Made from a PPR 20 tube, a tee and a plug. For ease of gripping, a hook is installed in the tee. A 4 m long rope is attached to the plug (the length can be shortened. The other end of the rope is tied to the docking station. Velcro tape (hooks) is attached to the end of the connector. The connector is weighted and is initially located on the docking station platform.

	 The power connector inserted into the SMART repeater.	
AUV docking station	   	The docking station platform is a square of PPR 20 tubes 18 cm long and four tees. A rectangle made of sheet material (for example, corrugated plastic, fomax, etc.) is fixed on top. The platform is weighted.

Task 3: Understanding ecosystems and saving species

One of the challenges of coral reef conservation is finding ways to non-invasively treat and prolong the life of corals.

As one option, scientists from the KAUST RSRC research center have proposed the use of probiotics to treat sick corals and strengthen healthy coral ecosystems. Research in this area focuses on the idea that healthy organisms and ecosystems

depend on healthy microbiomes. This “microbiome management” is based on the hypothesis that microbes are key members of the “holobiont,” which is a collective term for the host and the many other species that live on, near or within it, and that they connect all ecosystem entities and respond quickly to manipulations with immediate effect and are easier to manipulate than macroorganisms.

To implement this idea, a permanent coral reef research station was developed that includes coral reef sites, research sites where probiotics are introduced invasively into the corals and through a spray system. The station also includes a set of sensors and Doppler receivers for recording environmental parameters.

Similar research methods are used to monitor and conserve fish species diversity. For example, the use of an acoustic sensor system makes it possible to identify potential fish spawning sites.

3A. Smart Reefs

3.1 Probiotics (steps are performed in the specified sequence)

● Place a probiotic irrigation system in the designated location – **10 баллов.**

The step is complete if the irrigation system is not in contact with the ROV and is completely within the yellow frame.

● Deploy the probiotic sprinkler on coral head – **10 баллов.**

The step is considered completed if the irrigation system ring is not in contact with the ROV and is placed on the coral.

● Activate the irrigation system – **5 баллов.**

The step is completed if the team rotates the pipe handle 360 degrees and demonstrates this to the judge on the control panel screen.

3.2 Coral Restoration (can be done at any time)

- Transplant branching coral – **10 points**

Companies will receive 10 points for successfully transplanting the branching coral fragment. Successfully transplanting the coral is defined as the 3/8-inch bolt of the coral fragment positioned inside the vertical 1-inch pipe and the PVC pipe of the coral fragment in contact with the vertical 1-inch pipe of the designated area. The coral fragment(s) must remain successfully transplanted into the coral restoration area for the entire product demonstration run. If the coral fragment is displaced from the designated area at any time during the product demonstration run, the company will not receive points for successfully transplanting the coral fragment. If a coral fragment is displaced from the designated area, companies may attempt to transplant the coral fragment again.

● Transplant brain coral – **30 баллов.**
  ○ Autonomously **– 30 points**
  ○ Manually **– 10 points**

Companies must also transplant brain coral into the restoration area. The brain coral will have Velcro loops on the underside of the bowl. The restoration area will have a 15 cm square area of red Velcro hooks on a horizontal corrugated plastic sheet surface. Companies must transplant the brain coral from the nursery area to the restoration area. The brain coral may be transplanted autonomously or manually. Companies choosing to transplant the brain coral autonomously are tasked with creating software that will allow their vehicle to autonomously transplant the brain coral from the nursery area to the coral restoration area. Companies that successfully transplant brain coral using an autonomous control program will receive 30 points. Successfully transplanting the brain coral autonomously is defined as the control program moving the vehicle from the coral nursery to the coral restoration area and placing the brain coral on the red Velcro square. Any portion of the bottom of the brain coral may be touching any portion of the red Velcro square. During transplantation, no company member should be touching the controls or other systems. The pilot may manually pick up the brain coral from the coral nursery, but once the brain coral is no longer in contact with the nursery, all movement of the vehicle must be autonomous. A tether manager may hold the tether but cannot guide the vehicle in any way. Companies attempting to transplant the brain coral autonomously should inform the station judge that they are doing so prior to picking up the brain coral. If a company cannot successfully transplant the brain coral onto the Velcro square, they may attempt to do so manually. Companies will get one attempt at performing the task autonomously. If at any time after picking up the brain coral the company must take manual control, they cannot get points for autonomous transplanting. Companies should inform the station judge when they switch to manual transplanting of the brain coral.

3.3 3D Coral Modelling

● Via photogrammetry, autonomously create a scaled 3D model of the coral restoration area – **up to 40 points**

○ Create a 3D model of the coral restoration area – 20 points

○ Measure the length of the coral restoration area (within 5 cm) – 10 points

○ Scale the 3D model using the length of the coral restoration area – 5 points

○ Use the properly scaled 3D model to estimate the height of the coral restoration area (within 5 cm) – 5 points

Or

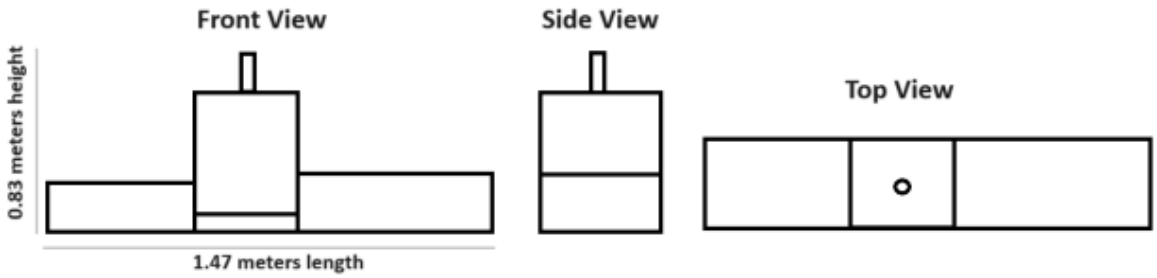
● Manually (CAD) create a scaled 3D model of the coral restoration area – **up to 30 points** ○ Measure the length of the coral restoration area (within 5 cm) – 10 points
○ Measure the height of the coral restoration area (within 5 cm) – 10 points
○ Create a scaled 3D model of the coral restoration area displaying the length and height measurements – 10 points Or
● Manually (paper) create a 3-view technical drawing of the coral restoration area – **up to 20 points**
○ Measure the length of the coral restoration area (within 5 cm) – 5 points
○ Measure the height of the coral restoration area (within 5 cm) – 5 points
○ Create a technical drawing on paper of the coral restoration area, including the measured length and height measurements with at least 3 views (top, front, and side) – 10 points

Companies must measure the length of the coral restoration area and create a 3D model of the restoration area. The coral restoration area will be constructed from ½-inch PVC pipe, will be between 1 meter and 2.5 meters in length, 36 cm wide and an unknown height. A branching coral located at the top of the restoration area will add to its height.
Companies choosing to create a 3D model of the coral restoration area autonomously must use photogrammetry to create a 3D model of the coral restoration area in a CAD program with the proper dimensions displayed. Companies may manually maneuver around the coral restoration area to take photos. Companies may transfer any images from the ROV to a computer or device at the mission station. This transfer does not have to be done autonomously; it can be accomplished "by hand." Companies are allowed to place an object of known dimensions (ruler) on or near the coral restoration area to assist in the measurements. Note that this object of known dimensions would count as debris if it is not under control of the ROV or removed from the pool by the end of product demonstration time.
Companies will receive 20 points for modeling the coral restoration area successfully in a CAD program. Successfully modeling the coral restoration area via photogrammetry is defined as the restoration area displayed as a 3D image on a screen at the product demonstration station. The image should be able to be rotated so that the station judge can view it from any angle. The 3D image must show the branching coral on top of the coral restoration area, but other nearby objects from other coral reef tasks are optional to show in the 3D model. The irrigation system and sprinkler do not need to be shown in the model, but they could be if the photos are taken after the sprinkler system has been deployed. Likewise, the branching coral

and brain coral transplanted onto the coral restoration area do not need to be shown in the model, but those corals could also be shown if the photos are taken after they have been transplanted. Neither the sprinkler nor transplanted corals will add to the overall length of height of the coral restoration area and including them in the 3D model will not affect scoring of this product demonstration task. Companies must also measure the length of the coral restoration area and use that length to scale the 3D image accordingly. Companies will receive 10 points for successfully measuring the length of the coral restoration area. Successfully measuring the length of the coral restoration area is defined as the company measurement being within 5 cm of the true length. Companies must show the station judge their measurement or explain how they are estimating the measurement. Companies may not guess at the length measurement. Once the company provides their length measurement (regardless if it is within 5 cm), the station judge will provide the company with the actual length of the coral restoration area. A company that does not attempt to measure the length will not receive the actual length of the coral restoration area from the station judge and therefore cannot complete the scaling or height estimation steps. Companies should use the actual length provided by the station judge to scale their 3D model of the coral restoration area. Companies will receive 5 points for successfully scaling their 3D model and displaying the length measurement on that model. Successfully scaling the model and displaying the length is defined as the station judge being able to see the length displayed on the 3D model. Using the scaled length of the 3D model, companies must estimate the height of the coral restoration area. The height includes the height of the branching coral on top of the area. Companies will receive 5 points when they successfully estimate the height of the coral restoration area within 5 cm. Successfully estimating the height of the coral restoration area is defined as using the 3D image properly scaled for length to determine the height. The station judge must be able to see the height displayed on the 3D model, and that height must be within 5 cm of the true height. Companies choosing to create a 3D model of the coral restoration area manually using CAD must first measure the length and height of the area. Companies must measure the length and height of the coral restoration area. Companies will receive 10 points for successfully measuring the length of the coral restoration area. Companies will receive 10 points for successfully measuring the height of the coral restoration area. Successfully measuring the length and height of the coral restoration area is defined as the company measurement being within 5 cm of the true length or true height. Note that the approximate width of the coral restoration area will be known from the building specifications. Companies must show the station judge both of their measurements or explain how they are estimating the measurement. Companies may not guess at the length or height

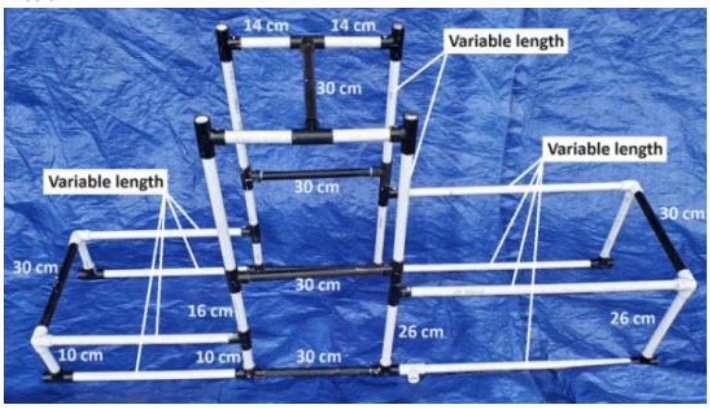
measurement. Companies are allowed to place an object of known dimensions (ruler) on or near the coral restoration area to assist in the measurements. Note that this object of known dimensions would count as debris if it is not under control of the ROV or removed from the pool by the end of product demonstration time. Companies should then create a 3D model of the coral head in a CAD or other program. Companies may input their measurements manually into a CAD or other program to create their 3D model. The length and height measurements should be included in the 3D model, even if those measurements were incorrect. Companies will not receive points for properly measuring the dimensions of the coral restoration area but can still receive points for modeling the area with the measurements taken. Companies will receive 10 points for successfully modeling the 3D coral restoration area. Successfully modeling the restoration area is defined as the model of the restoration area displayed as a CAD model on a screen at the station and the length and height dimensions included on the model. The 3D model should be able to be rotated and viewed from any angle. The length and height dimensions measured by the company must be included on the model. The 3D model must include: • The coral restoration area • The branching coral at the top of the coral restoration area. This coral may be depicted as a single vertical cylinder. The 3D model does not need to include: • The branching coral or brain coral transplanted into the coral restoration area • The 1-inch pipe holder for the branching coral transplant • The red Velcro square • The ½-inch PVC pipe stabilizers that hold the coral restoration area upright • The probiotic irrigation system or sprinkler • The designated area for placing the probiotic irrigation system Companies choosing to create a 3D model of the coral restoration area manually on paper must first measure the length and height of the coral restoration area. Companies must measure the length and height of the coral restoration area. Companies will receive 5 points for successfully measuring the length of the coral restoration area. Companies will receive 5 points for successfully measuring the height of the coral restoration area. Successfully measuring the length and height of the coral restoration area is defined as the company measurement being within 5 cm of the true length or true height. Note that the approximate width of the coral restoration area will be known from the building specifications. Companies must show the station judge both of their measurements or explain how they are estimating the measurement. Companies may not guess at the length or height measurement. Companies are allowed to place an object of known dimensions (ruler) on or near the coral restoration area to assist in the measurements. Note that this object of known dimensions would count as debris if it is not under control of the ROV or removed from the pool by the end of product demonstration time. Once the measurements are taken, companies must create a technical drawing consisting of

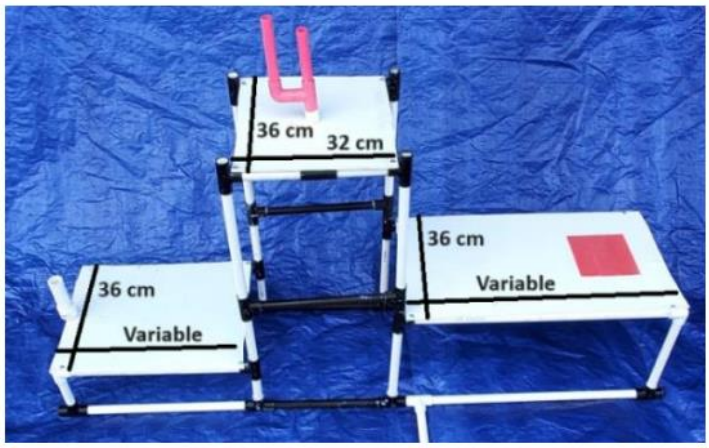
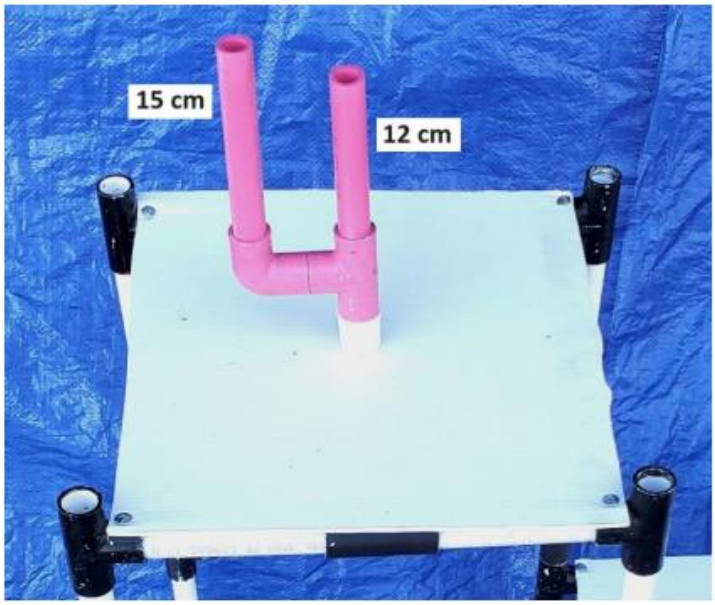
three views – front, top and side – of the coral restoration area. The front view must include the length and height measurements, width does not need to be included on the technical drawing. Companies will receive 10 points for successfully creating the technical drawing of the coral restoration area. Successfully creating a technical drawing is defined as all three views shown to the station judge. The front view must include both the length and height measurements taken by the company, even if those measurements were incorrect. Companies will not receive points for the proper measurements but will receive points for the technical drawing. The technical drawing must include: • The coral restoration area • The branching coral at the top of the coral restoration area. This coral may be depicted as a single vertical cylinder. The technical drawing does not need to include: • The branching coral or brain coral transplanted into the coral restoration area • The 1-inch pipe holder for the branching coral transplant • The red Velcro square • The ½-inch PVC pipe stabilizers that hold the coral restoration area upright • The probiotic irrigation system or sprinkler • The designated area for placing the probiotic irrigation system

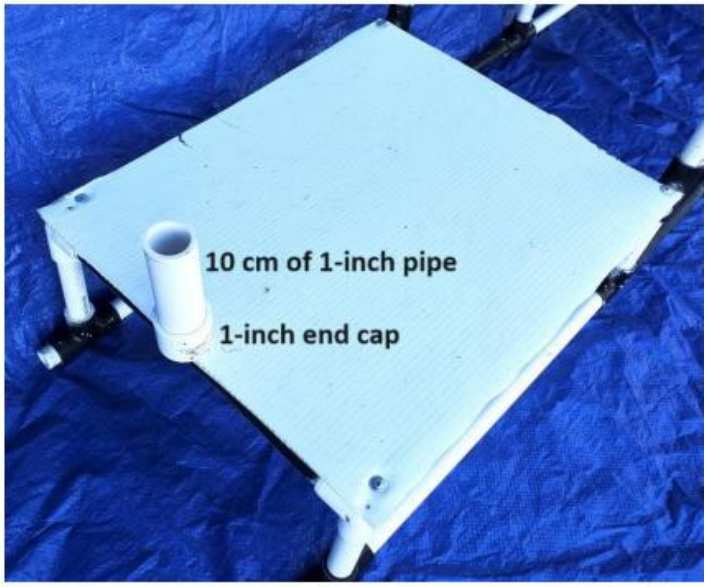
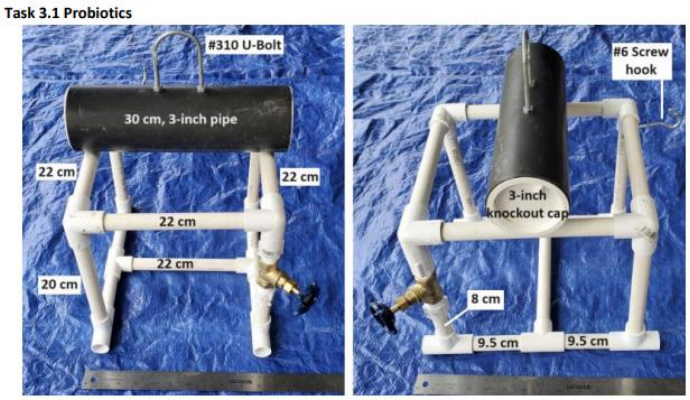
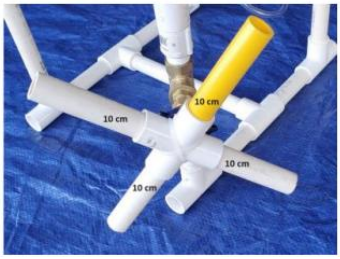


Technical drawing of a coral restoration area showing a front view, side view, and top view.

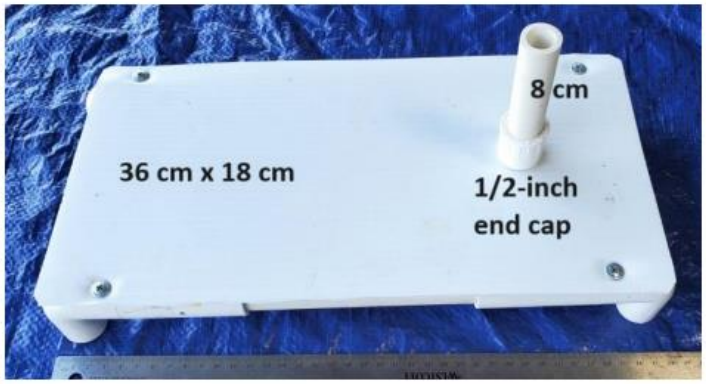
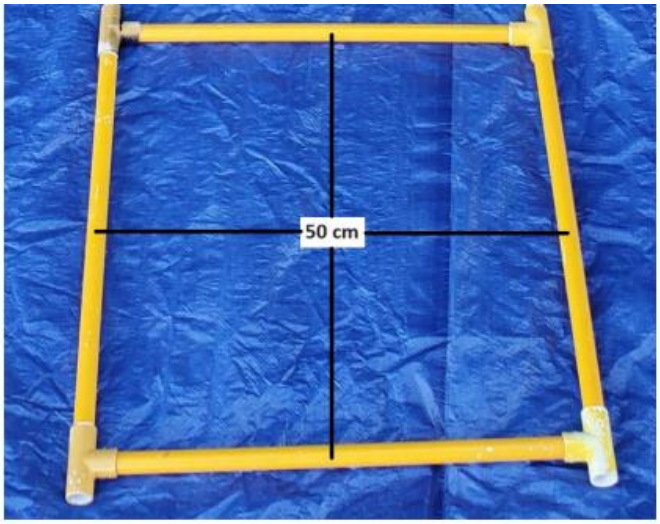
Props description

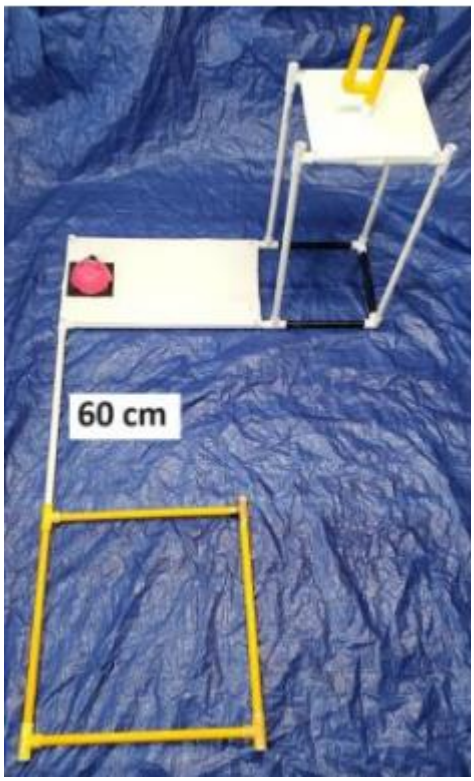
Type	Photo	Description
The coral restoration area		Made from pipes ppr 20, weighted. Height no more than 40 cm. Rectangles of sheet material (corrugated plastic, fomax,

		etc.) are attached to the frames.
Elkhorn coral		
The transplant location for the brain coral		

		
irrigation system	  	

		
The sprinkler system	  	

		
		
irrigation system designated area		Frame made of pipes ppr 20 and 4 tees. Weighted
brain coral		Plastic bowl with a diameter of 12-15 mm. For carrying, there is a 30 cm loop with attached buoyancy. Velcro tape (loops) is glued along the edges.

		The bowl is weighted (a stone attached to Velcro is used as a weighting agent, but other materials can be used as a weight.
		

3B. Inland Lakes and Waterways

3.3 Determine the location of sturgeon spawning grounds

● Recover an acoustic receiver – **10 points.**

The step is completed when one of the three acoustic receivers is removed from the water.

● Determine the location of a potential spawning site - **до 15 points.**

- ○ Create a graph of sturgeon locations from the acoustic receiver data – **10 points**
- ○ Determine the potential spawning site - 5 points

Once the acoustic receiver has been recovered, companies will receive a table that contains data on sturgeon spawning sounds (also known as “sturgeon thunder”) from the mission station judge. NOTE: If the mission station judge does not immediately provide this table, companies should request it. This table will include data from all three acoustic receivers collected over 15 days. The data will be printed on a laminated sheet. The data may also be provided as a .csv file on a USB 2.0 thumb drive. Contact your regional coordinator or check your regional information document for more information on how the data will be available at the mission station. Companies must use this data to create a graph of the number of sturgeon in each location over the course of 15 days. Companies will receive 15 points for successfully creating a graph of the data. Successfully creating a graph is defined as showing the station judge a graph with all 45 data points plotted as 3 receivers, each containing 15 data points. How companies graph the data is up to them, but the graph should logically show sturgeon numbers from all three acoustic receivers. The graph must be titled and must have both axes labeled (# of sturgeon, day #).

3.4. Characterize the habitat at potential spawning site (steps are performed in any order and can be performed independently of 3.3).

- Place an ADCP – **10 points.**

The step is considered completed if the receiver is completely located within the orange frame at the intended spawning site and is not in contact with the ROV.

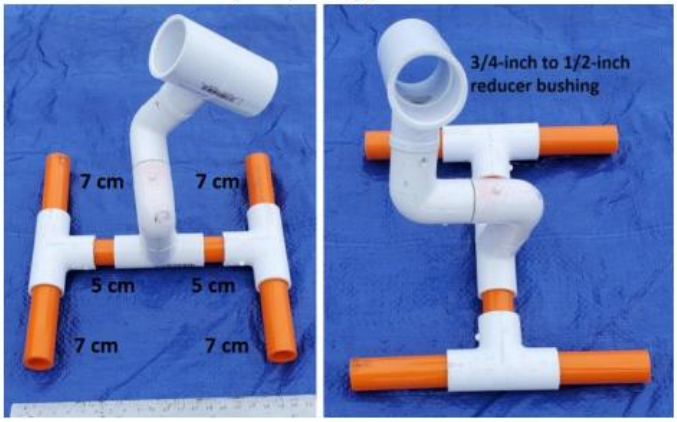
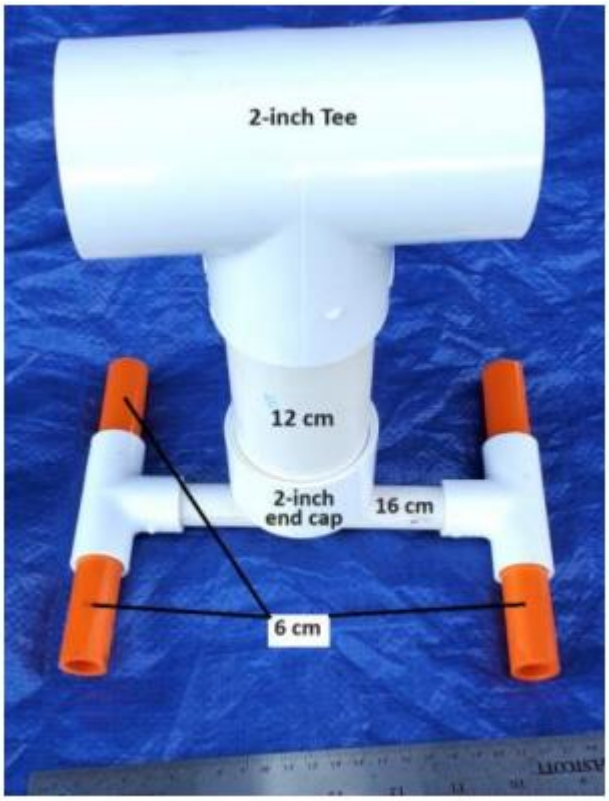
- Recover a sediment sample – **10 points.**

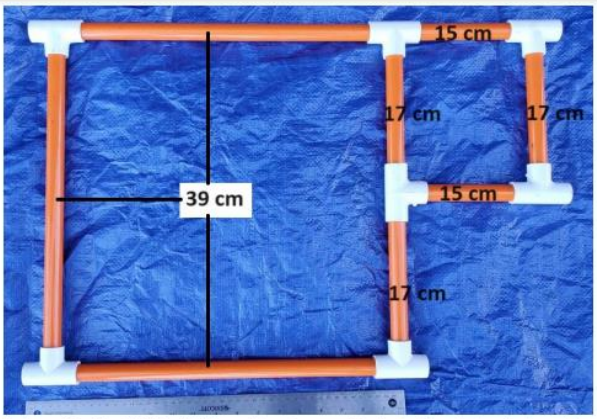
The step is completed when one of the five sample stones is removed from the water.

Total points: 160 points.

Props description

Type	Photo	Description

Acoustic receiver (3)	 	
The Acoustic Doppler Current Profiler (ADCP)		

designated area for the ADCP with the sediment area	 The designated area for the ADCP with the sediment area attached. The designated area is constructed from ½-inch PVC pipe. 	

sediment sample		The sediment sample consists of Beach Pebbles with Velcro hooks attached.

ЗАДАНИЕ 4: Robotic buoys GO-BGC.

The goal of the GO-BGC project is to create a global network of chemical and biological sensors that will monitor the health of the ocean. The network of robotic buoys already includes more than 100 ocean observation devices around the world, and the planned number of buoys is 500! We suggest that you develop such a buoy and collect data using it.

4.1.Design and construct an operational vertical profiling float

Company design and construct a vertical profiling float:

- Prior to the competition, design and construct a vertical profiling float with a temperature sensor – **5 points.**
- Deploy the float into a designated area – **5 points.**

The step is considered successfully completed if the vertical profiling float is delivered to the area marked with a green marker and does not come into contact with the ROV.

- Float completes a vertical profile – **15 points.**

Vertical profile 1

■ Float completes first vertical profile

- Using a buoyancy engine – 10 points
- Using a different mechanism – 5 points

■ Float communicates data to the mission station – 5 points

■ Data is graphed as depth over time – 10 points

Vertical profile 2

■ Float completes a second vertical profile

- Using a buoyancy engine – 10 points
- Using a different mechanism – 5 points

■ Float communicates data to mission station – 5 points

■ Data is graphed as depth over time – 10 points

OR

Company does not design and construct a vertical profiling float or float does not communicate data to the mission station.

• Provided data is used to graph depth over time **– 10 points**

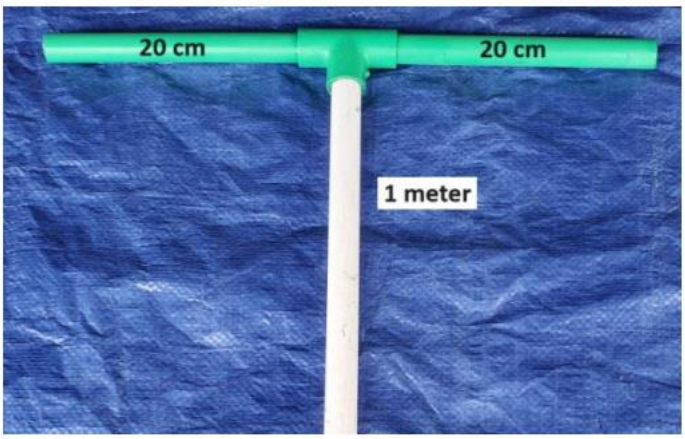
Total = **70 баллов**

Prior to the competition, companies must build a float capable of completing a vertical profile (i.e., traveling from the surface to the bottom and back to the surface) and collecting and communicating data to the mission station. Companies that design their float with a buoyancy engine will receive additional points. A buoyancy engine moves fluid from inside the float to outside the float, displacing seawater and changing the density of the float. Using a motor to change the volume (push or pull a syringe, pump water into or out of, or expand a section) of the float constitutes "using a buoyancy engine". Using thrusters to directly move the float constitutes "using a different mechanism." Companies that do not use a buoyancy engine to complete their vertical profiles will receive fewer points. The float must also be capable of communicating data to a receiving device (i.e., the receiver) located at the surface at the mission station. The company is responsible for designing and constructing both the transmitter on the float and the receiver that displays the data at the mission station. Companies must submit a one-page Non-ROV device document outlining their float design, detailing its operation, including the mechanism the float uses to descend/ascend (e.g., a buoyancy engine, thruster, or other), and demonstrating that it does not violate any safety rules. This document must also detail how the float communicates with the company's receiver at the mission station. This Non-ROV device document must be submitted in advance of the competition. Companies will

receive 5 points for designing and building a float. Successfully designing and building a float is defined as submitting a nonROV device document and transporting the float to the product demonstration station.

Once the float has been deployed, it must communicate to the receiver located on the surface at the mission station. Companies are responsible for constructing both the transmitter on the float and the receiver at the mission station. Companies should design their float so that the transmitter can be maintained high enough above the surface of the water to communicate with the mission station. The float must communicate (i.e., transmit) the following information to the mission station, referred to as the defined data packet: • Company number (provided by MATE a few weeks prior to the competition) • Time data (UTC or local or float time [float time would be time since float starts recording]) • Pressure data • Depth data (optional) • Any additional data as required by the company to complete this task If a pressure to depth conversion is completed by the sensor on the float, companies may transmit depth data as part of their defined data packet. Alternatively, companies may choose to only transmit pressure data as part of their defined data packet and convert pressure to depth at the mission station. Pressure data must be displayed in pascals (pa) or kilopascals (kpa). Depth data must be displayed in meters (m) or centimeters (cm). Pressure data (and depth data if transmitted) must correlate to a set time transmitted from the float. For example, a defined data packet from EXPLORER 01 could be: EX01 1:51:40 UTC 9.8 kpa 1.00 meters

Props description

Type	Photo	Description
green mark		Made from PPR 20 tubes, and attached to the side of the pool near the starting area (located on the surface).

Penalty points

Safety: During the mission, the team must follow the safety rules established on the site. In case of violation, the team receives 5 penalty points

Tether: A team member may not pull on the ROV tether to move or rotate it. If this rule is violated for the first time, the referee issues a warning to the team. For subsequent violations, the team is awarded 5 penalty points.

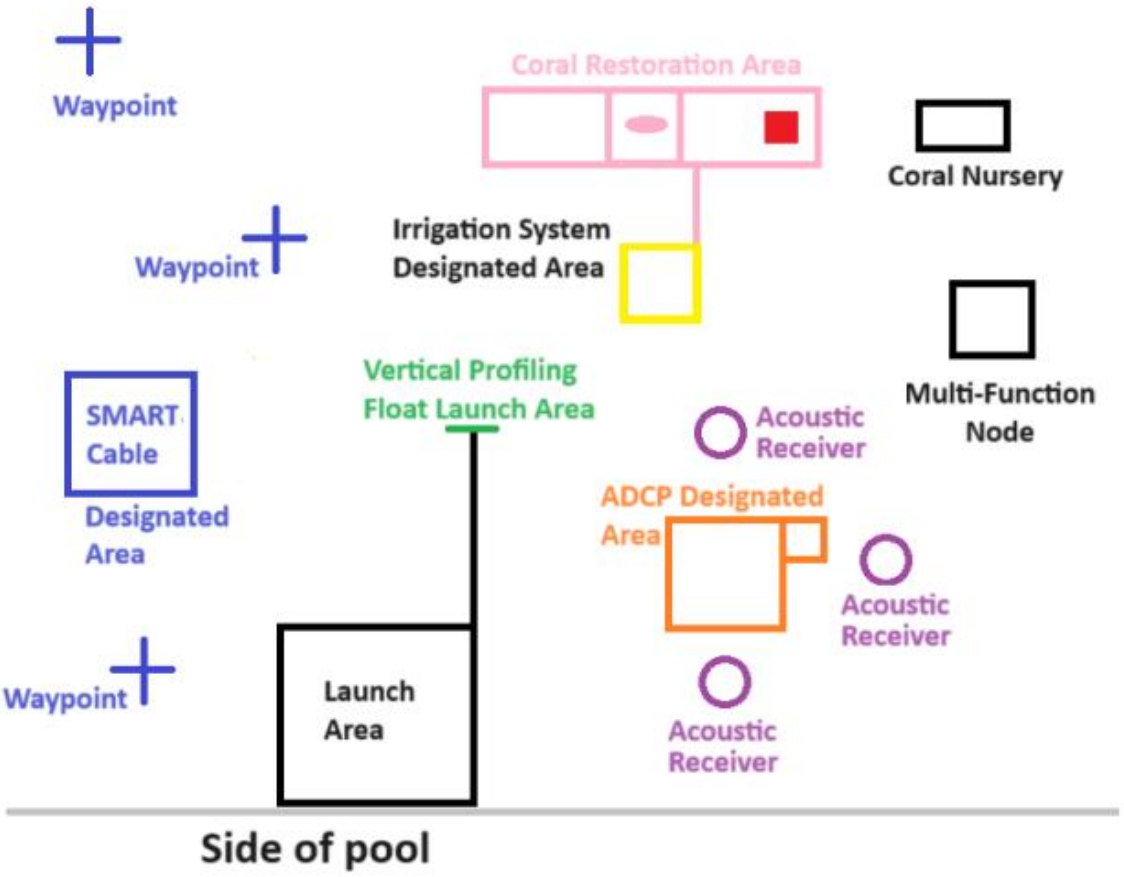
Communication: During the mission, team members are prohibited from communicating with each other regarding the location of the vehicle and the need to turn it. Communication between the pilot and the cable manager regarding cable position and feed is allowed. If this rule is violated for the first time, the team is given a warning. For subsequent violations, the team is awarded 5 penalty points.

Diver Assistance: In the event that the team requires the assistance of a diver to lift and/or release the ROV, the team has the right to request assistance. The time of trying with help does not stop. The team is awarded 5 penalty points.

Communication with judges

Product demonstration judges and other competition officials will only communicate with students. Judges and officials will NOT communicate with mentors, parents, or other non-student members regarding product demonstration information, challenges, or other issues except during pre- and post-competition briefing sessions. Companies that wish to issue a challenge during the product demonstration run should immediately communicate this challenge to the product demonstration judges. The judges will discuss and 2024 NAVIGATOR Class 56 attempt to resolve the issue. If a decision cannot be made, the product demonstration judges will consult with the head judges and competition technical manager to resolve the issue.

ROV class product demonstration set up:



三、Class: Creative Concept

1. Participation Requirements

The Creative Concept Track focuses on the creative design presentation and demonstration of underwater robots. Designs should be based on the operational tasks and technical requirements of the AUV/ROV tracks, incorporating overall assembly, components, and key technological innovations.

Design proposals should feature functional principle innovation or layout innovation. The main innovative points, calculation processes, design drawings, implementation approaches, and application analysis of the participating works should be introduced through the design documentation. The documentation must not exceed 25 pages, and the technical introduction section should not contain any identity information such as the name and logo of the participating units, to facilitate blind review online later.

Submissions are encouraged to include a functional demonstration video, which can be a real object demonstration or a 3D model demonstration. Two versions of the video can be prepared: a demo version not exceeding 2 minutes and 200MB in size, and a complete version not exceeding 5 minutes and 1GB in size.

The entries must not contain any content related to state secrets, with the participating units responsible for their review.

2. Competition Rules

2.1 Competition Process

Participating teams will determine the order of presentation defense through an online lottery. After the announcement of the defense order, the teams can enter the waiting room in advance and present their defenses in turn. Experts will score based on the team's defense and the design documentation to determine the final competition results.

The total time for each team's defense should not exceed 10 minutes, including no more than 5 minutes for product presentation, with the remaining time allocated for questions and answers.

The presenter must be a member of the team and cannot be replaced by anyone outside the team.

2.2 Scoring Details

The scoring criteria are as follows：

evaluation criteria	weight	criteria explanation
Innovation and Uniqueness	40%	The design is novel and innovative with unique principles, demonstrated by solving similar tasks in new ways or addressing previously unsolved challenges.
Feasibility and Practicality	30%	The design is rational, with clear implementation plans, potential task capabilities and features, application prospects, and engineering feasibility.
Content and Structure of Documentation	20%	The logic is strong, with clear layers, and the arguments are clear and distinct, supported by thorough theoretical analysis and experimental data.
Defense Performance	10%	The presentation is fluent and clear, with concise and precise language, tight logic, and good on-site performance.

The final interpretation rights belong to the competition organizing committee