

2022 MATE ROV COMPETITION:

UN Decade of the Ocean: MATE Inspires ESG

**EXPLORER CLASS: CONDENSED TELEPRESENCE COMPETITION
MANUAL**

For general competition information, including a description of the different competition classes and eligibility requirements, visit [Start Competing](#).

The *TELEPRESENCE: Remotely Connecting to Your Competition Experience* category is available to those teams that have qualified for the MATE World Championship but are not able to attend in person due to travel restrictions, concerns for COVID, funding, etc.

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www.mateii.org

PART 1: PRODUCT DEMONSTRATION

OVERVIEW

EXPLORER class companies will take part in ONE product demonstration that consists of three distinct tasks:

TASK #1: MARINE RENEWABLE ENERGY

TASK #2: OFFSHORE AQUACULTURE AND BLUE CARBON

TASK #3: ANTARCTICA THEN AND NOW: ENDURANCE22 AND MATE FLOATS!

The product demonstration score will be added to your [ENGINEERING & COMMUNICATION](#) and [SAFETY](#) scores to determine your total, overall score for the competition.

SCORING OVERVIEW

The competition consists of product demonstrations, engineering and communication, and safety with the following scoring breakdown:

- **Product demonstrations**
 - 300 points (max), plus a time bonus
 - Product demonstration organizational effectiveness
 - 10 points (max)
- **Engineering & Communication**
 - Technical documentation
 - 100 points (max)
 - Engineering presentations
 - 100 points (max)
 - Marketing displays
 - 50 points (max)
 - Company Spec Sheet
 - 20 points (max)
 - Corporate Responsibility
 - 20 points (max)
 - Virtual Reality assets
 - 25 points (max)
- **Safety**
 - Initial Safety and Documentation Review
 - 20 points (max)
 - Job Safety Analysis (JSAs)
 - 10 points (max)

TOTAL POINTS = 655

TIME

Your company will have 15 minutes to complete the tasks. At any time during the demonstration, you may pilot your ROV to the surface and remove the vehicle from the water for such things as buoyancy adjustments, payload changes, and troubleshooting, but the 15-minute product demonstration clock will not stop. The clock will only stop after all of the tasks are successfully completed and the ROV has been piloted into the “resident ROV” docking station under its own power. Your ROV is not required to return to the surface between tasks.

TIME BONUS

Companies will receive a time bonus for each product demonstration if you:

- 1) successfully complete all the tasks,
- 2) successfully pilot your ROV into the “resident ROV” docking station

Companies will receive 1 point for every minute and 0.01 point for every second under 15 minutes remaining.

IMPORTANT NOTE: Questions about production demonstrations and design and building specifications must be posted to the competition FAQs board located at <http://forums.marinetech2.org/index.php>. This allows all companies to see the questions and answers and helps to avoid duplicate questions. That said, please make sure that your question(s) has not already been asked – and answered – before posting. It is up to the companies to read, comprehend, and comply with ALL rulings posted on the FAQ board.

PRODUCT DEMONSTRATION

Companies competing in the telepresence category of the MATE ROV competition world championship are required to submit videos of the ROV completing the product demonstration tasks.

Since companies will be competing with their own product demonstration props, and a number of tasks require randomization, companies will receive randomized files for using AI to differentiate mortars from live fish, determining the biomass of the fish cohort, determining the location where the float will next surface, and creating a photomosaic of the wreck. Companies will use these images and files instead of using the mission props they created. Additional notes are included in the product demonstration notes of each task. A link to receive the randomized files can be found [here](#). Likewise, companies will need to demonstrate how they have determined the average size of the fish cohort and the length measurement taken of the wreck of the *Endurance*. Companies will need to show their length measurement of the wreck and of each fish, and if they are calculating a true length from those measurements, teams will need to explain how they are arriving at their final length. A number of other minor changes have been made to the product demonstration tasks to reflect the fact that companies will be using their own mission props to complete the mission run.

Companies will NOT submit a safety compliance video. Company safety will be evaluated with an initial safety review conducted from documents submitted on May 26th.

Companies will NOT submit a weight measurement. Companies will not receive points for the weight of their vehicle in the telepresence category. The vehicle must be hand launched into the water.

Product Demonstration Video

Companies will submit videos from two different camera angles from a single product demonstration run. These two camera angles should be synchronized and start at the same time.

The videos should NOT show the 5-minute set-up period, but rather start with submitting the form to download the files for the randomized tasks.

The form to receive a randomized video of fish and morts in a fish pen, fish biomass information, float calculations information, and the eight photos for the shipwreck mosaic can be found [here](#).
[2022 Product Demonstration File Request \(google.com\)](#)

Following the download of randomized information, the video should show the ROV on the pool deck ready to launch. The video must then show company members placing the ROV in the water. When the ROV is in the water at the surface, side of the pool, and company member's hands are clear of the vehicle, the 15-minute product demonstration run starts.

MATE ROV competition judges will use the videos to score the product demonstration run.

After the 15-minute run is completed, the video should NOT show demobilization. The handheld judge's view camera should include a review of the product demonstration score sheet and a description of what tasks the vehicle accomplished, what the vehicle did not accomplish, and the anticipated total score (not including safety or organizational effectiveness). This score is not official but will assist MATE ROV competition judges with scoring the product demonstration run.

Companies may only submit ONE product demonstration run. Additional submissions will not be evaluated.

Cameras: Companies must submit two video angles of the same product demonstration run. These two video angles must be submitted as separate, individual video links:

- A fixed (non-moving) camera showing a birds-eye view of the control station and the side of the pool where the tether management team is working.
- A hand-held camera simulating the eyes (and ears) of the judge. This mobile camera should follow the piloting team when the ROV is in the water, focus in on video monitor camera feeds at the piloting station, and when needed, move to the side of the pool to observe mission items being returned to the surface, side of the pool. The company may communicate to this hand-held camera as if it were a station judge.

For companies attempting autonomous functions, one or both of these required camera angles must clearly show all pilots "hands-free" during the autonomous function of the task.

Both videos submitted should start simultaneously so that judges can check a certain time stamp and observe the feed from a desired camera. All videos must be uncut for the entire product demonstration run.

Submissions

Both videos from the company's product demonstration run must be uploaded to YouTube or Vimeo and the links to those videos provided in the body of an email submitted to the document submissions email: documentsubmissions@marinetech.org.

The subject line of the email MUST be Telepresence Video and the team name.

The body of the email MUST include:

- Competition class
- School / Organization name
- Team name
- City/State/Province/Country (all that apply)
- Name of person submitting
- The video links showing your safety, weight measurements and product demonstration run.

All video links should use the following naming convention: School or organization name_company name_VIDEO TYPE_2022.pdf, where VIDEO TYPE is product demonstration birds-eye, or product demonstration hand-held. For the telepresence category of the world championship, the due date for all video submissions is 11:59 PM, Hawaii Time Zone, on **June 9, 2022**.

Videos must be submitted as links to a YouTube or Vimeo post. Note that all product demonstration videos must be complete and uncut.

PRODUCT DEMONSTRATION

Parts of this document that have changed significantly from the Full Competition Manual are highlighted in yellow!

NOTE for 2022!!!

At the start of the 15-minute product demonstration period, companies must launch their vehicle through a simulated 1-meter square hole in the ice at the surface, side of the pool. The hole in ice will be constructed from ½-inch PVC pipe. Companies are not required to return to the surface through the hole in the ice. Only those product demonstration items being returned for Task 3: Antarctica Then and Now, must be returned through the hole in the ice.

TASK 1: Marine Renewable Energy

UN Sustainable Development Goals:

- **#7 Affordable and Clean Energy**
- **#12 Responsible Consumption and Production**

This task involves the following steps:

- 1.1 Replacing a damaged section of an inter-array power cable**

- **Conducting a visual inspection of the cable – 5 points**
- **Cutting the cable on both sides of the damaged section – 10 points**
- **Removing the damaged section of cable – 5 points**
- **Installing a new section of cable – 10 points**
- **Securing the new section of cable in place with wet-mateable connectors – 5 points each, 10 points total**

1.2 Replacing a damaged buoyancy module on an inter-array cable of a floating offshore wind turbine

- **Removing the failed buoyancy module**
 - **Releasing the clamp – 5 points**
 - **Recovering the failed buoyancy module – 5 points**
- **Attaching a new buoyancy module**
 - **Attaching the new buoyancy module – 5 points**
 - **Securing the clamp – 5 points**

1.3 Monitor the environment

- **Deploying a hydrophone to detect and record the presence of marine mammals**
 - **Deploying the hydrophone in a designated area – 5 points**
 - **Recovering the hydrophone to evaluate data – 5 points**
- **Removing a ghost net caught on the wind turbine’s substructure**
 - **Pulling a pin – 10 points**
 - **Removing the ghost net from the water – 5 points**

1.4 Piloting into “resident ROV” docking station

- **Autonomous docking – 15 points**
- **Manually docking – 5 points**

Total points = 100 points

Product Demonstration Notes:

Companies must complete the steps of Task 1.1: Replacing a damaged section of an inter-array power cable in order. Companies may not skip any steps of this task. Companies must do Task 1.4 Pilot into “resident ROV” docking station as the final task. Once companies have completed Task 1.4, the production demonstration time ends, and no other points may be scored.

Task 1.1 Replacing a damaged section of an inter-array power cable

The steps of this task must be done in order. Companies cannot proceed to the next step until they have successfully completed the previous step. Companies must first complete a visual inspection of the cable to identify damage. The cable will be simulated by three 75 cm lengths of ½-inch pipe held at least 30 cm above the bottom of the pool in cradles created from 1 ½-inch PVC tees cut in half lengthwise. The ends of each section of cable will have a 1-inch end cap covered with Velcro hooks, which will help to secure the simulated wet-mateable connectors of the new section of cable in place. Damage will be simulated by a spot of [brown](#) paint, at least 1.5 cm in diameter. There will only be one damaged spot on the cable, but it may be located on the underside of the cable. The damaged spot will not be hidden by

a cradle. Companies will receive 5 points when they successfully identify the damaged section of cable. Successfully identifying the damaged section of cable is defined as showing the station judge the brown painted spot on a video monitor.

Once the damaged section has been identified, companies must simulate cutting both sides of the cable by pulling [pins](#). Companies will receive 5 points for successfully pulling each pin, 10 points total. Successfully pulling the pins is defined as a pin no longer in contact with the ½-inch pipe of the cable. The pins are not considered debris and may be left in the pool at the end of product demonstration time.

Once the damaged section of cable has been successfully cut, companies must return the damaged length of cable to the surface. Companies may return the section of cable to the surface by any method, including attaching a line to the section of cable and pulling the cable (but not the ROV) to the surface by hand. Companies will receive 5 points when the damaged section of pipe is successfully returned to the surface. Successfully returning the damaged section of pipe to the surface is defined as the damage section removed from the water and placed on the pool deck.

The section of cable will weigh less than 10 Newtons in water.

Once the damaged section of the cable has been removed from the pool, a new section of cable must be installed. The new section of cable will be available on the surface, side of the pool. The new section of cable will be simulated by a 73 cm length of ½-inch PVC pipe with two wet-mateable connectors slid over each end of the pipe, one on each side. The wet-mateable connectors will be simulated by 1-inch x 1 inch x ½-inch tees that have Velcro loops on the inside edge. Additional Velcro loops, 7 cm wide, will be located 8 cm from both ends of the 73 cm length of pipe. The Velcro loops around the pipe will provide friction with the Velcro loops inside the wet-mateable connectors to keep the connectors from sliding off during transport. Two additional wet-mateable connectors will be available on the surface, side of the pool in case a wet-mateable connector does slide off during transport.

Companies will receive 10 points when they successfully install this new section of cable. Successfully installing this new section of cable is defined as the ½-inch length of PVC pipe positioned in both cradles that once held the damaged section of cable. The ends of the pipe must be within the 75 cm gap between the sections of cable that remain on the bottom, and the wet-mateable connectors must be over each end of the pipe.

Once the new section of cable has been successfully installed, companies must secure the new section of cable in place by connecting the wet-mateable connectors to the ends of the old cable. The 1-inch tees simulating the wet-mateable connectors will slide over the ½-inch PVC pipe of the new cable and the Velcro loops on each end of the tee will attach to the Velcro hooks on the 1-inch end caps of the old sections of cable to secure it in place. Companies will receive 5 points each, 10 points total when the new section of cable is secured in place with wet-mateable connectors. Successfully securing the new cable in place is defined as the Velcro loops of the wet-mateable connector tees secured to the Velcro hooks on the end caps on the old section.

Task 1.2 Replacing a damaged buoyancy module on an inter-array cable of a floating offshore wind turbine

Companies must replace a failed buoyancy module attached to an inter-array cable and replace it with a new buoyancy module. The inter-array cable will be simulated by a length of ½-inch PVC pipe painted blue and held at least 30 cm above the bottom of the pool by a length of ½-inch PVC pipe. This section of the inter-array cable will be an extension of the inter-array cable from Task 1.1. Both the failed buoyancy module and the new buoyancy module will be simulated by 2-inch tees with an opening cut lengthwise, which is connected by Velcro to a length of foam flotation.

Companies must remove the failed buoyancy module from around the cable by releasing a clamp. Releasing the clamp will be simulated by rotating the module 180°. A short handle will be attached to the middle opening of the 2-inch tee. At the start of the product demonstration, it will be pointed down. Companies must rotate the handle until it is pointed upwards, which will release the damaged buoyancy module from the cable. Companies will receive 5 points for successfully releasing the clamp and removing the failed buoyancy module from the cable. Successfully releasing the clamp and removing the failed buoyancy module is defined as the no part of the buoyancy module in contact with the ½-inch PVC pipe of the cable.

The buoyancy module will be positively buoyant in water.

The buoyancy module will have less than 5 Newtons of buoyant force in water.

Once the failed buoyancy module has been removed from the cable, it must be recovered. Companies will receive 5 points for successfully recovering the failed buoyancy module. Successfully recovering the failed buoyancy module is defined as the ROV returning the buoyancy module to the surface, side of the pool and the failed buoyancy module being placed on the pool deck.

Companies must also attach a new buoyancy module to the cable. An 8 cm x 1 cm length of Velcro hooks will be located on the underside of the cable section painted blue. A new buoyancy module will be on the surface, side of the pool. The new buoyancy module will have an 8 cm x 1 cm length of Velcro loops on the inside edge of the foam flotation. Companies must attach the new module to the pipe and secure the clamp by connecting the Velcro loops on the module to the Velcro hooks on the bottom of the pipe. Companies will receive 5 points when the buoyancy module is successfully attached to the cable. Successfully attaching the module to the cable is defined as the foam flotation inside the 2-inch tee completely around the ½-inch pipe of the cable. Companies will receive 5 additional points when they successfully secure the clamp. Successfully securing the clamp is defined as the Velcro loops of the new buoyancy module connected to the Velcro hooks on the underside of the ½-inch PVC pipe. The new buoyancy module must also stay in place on the PVC pipe once it has been released by the ROV.

Task 1.3 Monitoring the environment

Companies must deploy a hydrophone into a designated area on the bottom of the pool. The hydrophone will be simulated by a 20 cm length of ½-inch PVC pipe. The hydrophone will be attached to both a buoyancy module constructed from 2-inch PVC pipe and a weighted base constructed from ½-inch PVC pipe by lengths of rope. The designated area will be a 40 cm x 40 cm square painted orange. Companies will receive 5 points when they successfully place the hydrophone within the designated

area. Successfully placing the hydrophone within the designated area is defined as the weight of the hydrophone completely within the designated area. The weight may not be on top of any portion of the ½-inch PVC pipe of the designated area.

The hydrophone must be recovered after being deployed at the designated area for 5 minutes. When companies successfully deploy the hydrophone, the station judge will note the time on the side of the company product demonstration score sheet. Companies may only recover the hydrophone after 5 minutes of water time. Companies will receive 5 points when they successfully recover the hydrophone. Successfully recovering the hydrophone is defined as the hydrophone deployed in the water for 5 minutes, after which time it is returned to the surface side of the pool and placed on the pool deck.

The hydrophone will weigh less than 5 Newtons in water.

Companies must remove a ghost net from the wind turbine's substructure. The net will be constructed from ½-inch PVC pipe and [decorative cloth netting](#) will be attached to the framework with cable ties. The net will be positively buoyant and secured by a rope to a weighted part of the inter-array cable. Companies must pull a pin to simulate cutting the rope and releasing the net from the weight on the bottom. Companies will receive 10 points when they successfully pull the pin. Successfully pulling the pin is defined as the pin no longer in contact with the PVC pipe or netting of the ghost net. After pulling the pin, companies may leave it on the bottom or return it to the surface. The pin is not considered debris.

Once companies have pulled the pin, they must return the ghost net to the surface, side of the pool. Companies will receive 5 points when they successfully remove the ghost net from the water. Successfully removing the ghost net is defined as the PVC pipe and netting completely out of the water and placed on the pool deck. Neither the pin nor the rope holding the net need to be removed from the pool.

The ghost net will have less than 5 Newtons of buoyant force in water.

Task 1.4 Piloting into “resident ROV” docking station

At the end of the product demonstration run, instead of returning to the surface, side of the pool companies must pilot their ROV into a “resident ROV” docking station. The docking station will be 1 meter cubed and constructed from ½-inch PVC pipe. As their final product demonstration task, companies must maneuver their vehicle into this docking station. After entering the docking station, the product demonstration time ends and companies can no longer attempt tasks or receive points. Companies that need to return items to the surface, side of the pool should do so before docking.

Companies may choose to pilot into the “resident ROV” docking station autonomously or manually.

Companies that choose to pilot into the station autonomously are tasked with creating software that will allow their vehicle to autonomously enter the docking station. Companies will receive 15 points when they successfully pilot autonomously into the docking station. Successfully piloting autonomously into the docking station is defined as the ROV positioned completely outside of the docking station, the

company going hands free from the controls, and the ROV moving on its own so that the entire ROV is completely inside the docking station.

Companies may choose to pilot into the docking station manually. Companies will receive 5 points when they successfully dock manually in the station. Successfully docking manually in the station is defined as the ROV under control of the pilot moving until the entire ROV completely inside the docking station.

TASK 2: Offshore Aquaculture and Blue Carbon

UN Sustainable Development Goals:

- **#2 Zero Hunger**
- **#13 Climate Action**
- **#14 Life Below Water**

This task involves the following steps:

2.1 Inspecting an offshore aquaculture fish pen

- Inspecting the netting to identify damaged areas
 - Flying a transect line to identify damaged areas
 - Autonomously inspecting – 25 points
 - Manually inspecting – 10 points
 - Identifying and counting damaged net areas – 5 points
- Repairing a damaged section of netting – 10 points
- Removing marine growth
 - Removing encrusting marine growth - 5 points
 - Removing algal marine growth – 5 points

2.2 Maintaining a healthy environment

- Manage mortality by removing “morts” from the fish pen
 - Using AI to differentiate “morts” from live fish – 10 points
 - Collecting a “mort” – 5 points
 - Inserting “mort” into the collection tube – 5 points

2.3 Measure fish size

- Determine the average size of the fish cohort within 2 cm – 15 points
- Determine the biomass of the fish cohort – 5 points

2.4 Farm seagrass

- Prune an existing seagrass bed – 5 points
- Plant a new seagrass bed – 5 points

Total points = 100 points

Product Demonstration Notes:

Companies must inspect the netting to identify damaged areas before repairing the damaged section. Otherwise, companies may complete the steps of Task 2 in any order.

Task 2.1 Inspecting an offshore aquaculture fish pen

Companies must inspect an offshore aquaculture fish pen. The fish pen will be simulated by a large (up to 2.5 meter by 1.8 meter) sheet of plastic mesh. The plastic mesh will be connected to a ½-inch PVC frame which will be suspended in the water column at a distance of less than 30 centimeters from the pool wall. The plastic mesh netting will be divided by the PVC framework into four sections: top left, top right, lower left and lower right. Red [rope](#) will form a transect line moving horizontally and vertically along the fish pen. Companies must follow the red transect line from one end to the other to inspect the fish pen.

Companies may choose to inspect the fish pen netting autonomously or manually.

Companies that choose to inspect the fish pen netting autonomously are tasked with creating software that will allow their vehicle to autonomously fly along the red transect line to inspect the fish pen netting by flying along the red rope transect line from one end to the other. Companies that successfully inspect the fish pen netting using an autonomous control program will receive 25 points. Successfully inspecting the netting autonomously is defined as the control program flying the vehicle from the starting point to the ending point by following the red line without any input from the company members. Companies may start at either end of the red rope line. No company member should be touching the controls for the entire transect. A tether manager may hold the tether but cannot guide the vehicle in any way. The station judge must be able to see the vehicle moving through the water and following the red rope line from the start to the end on a video screen. The vehicle **MUST** be close enough to the netting that only one length of red rope is visible in the video screen; other sections of the red rope, (at least 30 cm above, below or beside) must not be visible. If the vehicle fails to autonomously follow the red rope, companies may reposition their vehicle at the starting point and try again. There is no limit to how many times the company may try to autonomously follow the red rope line.

Companies that choose to inspect the fish pen netting manually must pilot their vehicle to follow the red rope line from start to finish. Companies that successfully inspect the fish pen netting manually will receive 10 points. Successfully inspecting the fish pen netting manually is defined as the vehicle, under control of the pilot, flying along the red line from start to finish. The station judge must be able to see the vehicle moving through the water and following the red rope line on a video screen. The vehicle **MUST** be close enough to the netting that only one length of red rope is visible in the video screen; other sections of the red rope, (at least 30 cm above, below or beside) must not be visible. There is no limit to how many times the company may try to manually fly along the red transect line to inspect the fish pen. A video demonstrating the fish pen netting inspection can be found [here](#).

The red line will be constructed on the mesh as follows:



The red rope line on the fish pen netting. The gray lines will be the PVC framework.

As they fly their vehicles follow the red rope line, companies will inspect the netting for damaged areas. Damaged areas will be simulated by holes, i.e., sections cut out of, the mesh netting. Damaged areas will be rectangular and between 15 cm and 30 cm by 5 cm to 10 cm. **Companies must create four damaged areas in their fish pen netting.** All damaged areas will be within 20 cm of the red rope line and fully within one quadrant (top left, top right, lower left, lower right). The quadrants will be [labeled](#) TL, LL, TR, and LR. The four damaged areas must be spread out in at least two quadrants. Companies must count the number of damaged areas and report the quadrants in which they are located. Companies will receive 5 points for successfully reporting both the number of damaged areas and in which quadrants they are located. **Successfully reporting is defined as the four holes being visible on the video monitor so MATE ROV Competition judges can see them during the inspection fly through.** As the companies indicate a damaged area seen during the inspection, they should also inform the judge what quadrant the damage area is in. For example, as the ROV inspects the netting and the video sees a damaged area in the lower left quadrant, companies should point out that there is a hole and inform the judge view camera that the hole is in the lower left quadrant. **For the MATE ROV Competition judges seeing the four damaged areas, these should be visible during the fly through.**

Companies must also repair one of the damaged areas of netting. A patch for repairing the net will be available on the surface, side of the pool. The patch will be constructed of a 40 cm x 20 cm rectangle of ½-inch PVC pipe with mesh netting attached. A #310 U-bolt will be attached to the PVC pipe to act as a grab point. Two #6 screw hooks will be used to attach the patch to the fish pen netting. Companies must position the patch to completely cover the damaged area of the fish pen netting. Companies will receive 10 points when they successfully repair the damaged area of the netting. Successfully repairing

the damaged area is defined as the patch completely covering the entire damaged area and remaining attached to the fish net netting after the vehicle has released it. The station judge must not be able to see any damaged area outside of the patch once the patch has been released by the ROV.

Companies must remove marine growth from the mesh netting of the fish pen. Encrusting marine growth will be simulated by a ½-inch PVC cross. A 2 cm x 2 cm square of Velcro loops will be attached to the ½-inch cross. The mesh netting of the pen will have a 1.0 cm x 0.8 cm square of Velcro hooks attached to it. The cross will be attached to the mesh netting of the pen by this Velcro connection. Companies will receive 5 points for successfully removing the encrusting marine growth from mesh netting. Successfully removing the encrusting growth is defined as the ½-inch PVC cross no longer in contact with the plastic mesh. The encrusting growth is not considered debris and may be left in the pool at the end of product demonstration time.

Companies must also remove algal marine growth. The algal marine growth will be simulated with pipe cleaners. The pipe cleaners will have a loop at one end to act as a grab point. The other end of the pipe cleaners will be inserted into holes drilled into the ½-inch PVC pipe of the framework of the netting. There will be three algal marine growths on one section of pipe. All three algal growths will be within 50 cm of each other. Companies will receive 5 points for successfully removing all three algal marine growths from the netting. Successfully removing the algal growth is defined as the pipe cleaners no longer in contact with the 1 ½-inch PVC pipe of the netting framework. All three algal growths must be successfully removed to receive points. The algal marine growth is not considered debris and may be left in the pool at the end of product demonstration time.

Both the encrusting and algal growths will be located at least 20 cm from any damaged area of the fish pen netting.

Task 2.2 Maintaining a healthy environment

Companies must maintain a healthy environment by removing dead fish “morts” from the pen.

Companies are tasked with creating software that can determine the difference between morts and live fish. **Companies will be sent a link to a video showing live fish and morts in offshore aquaculture fish pen.** During the product demonstration run, companies can use their software to evaluate this video and highlight morts with a red box. Companies will receive 10 points when their program successfully differentiates between live fish and morts. Successfully differentiating between live fish and morts is defined as showing the station judge on a video screen the downloaded video with all morts highlighted in a red box. Multiple red boxes can be used to highlight individual morts, or a group of morts can all be highlighted by the same red box. Companies can choose to skip this step and move directly to collecting morts.

Practice videos will be uploaded to the [MATEROVCompetition EXPLORER Challenge](#) website. Companies can use these videos to train their algorithms.

Morts will be simulated by [rubber fish](#). Weight will be added to the fish to make it negatively buoyant. One mort will be located in the product demonstration area. Companies must collect this mort from the

bottom and insert it into a collection tube for removal to the surface. The collection tube will be simulated by a 5-gallon bucket which will be weighted and sitting upright on the bottom of the pool adjacent to the “resident ROV” docking station. Companies will receive 5 points when they successfully collect the mort. Successfully collecting the mort is defined as the rubber fish under control of the ROV and no longer in contact with the bottom of the pool. Companies will receive an additional 5 points when they successfully insert the mort into the 5-gallon bucket collection tube. Successfully inserting the mort into the collection tube is defined as the rubber fish no longer in contact with the ROV and inside the open top of the 5-gallon bucket.

The rubber fish mort will weigh less than 5 Newtons in water.

Task 2.3 Measure fish size

Companies must measure the length of three fish and determine the average length. The three fish will be simulated by [rubber fish](#). The rubber fish will be cut into two pieces and elongated with a variable length of ½-inch PVC pipe. The fish will be positively buoyant and suspended approximately 1 meter off the bottom of the pool by rope or line. Each fish will be between 35 cm and 65 cm in length.

Companies will use their own fish and will know the overall length of their fish prior to measuring. Before measuring, companies should inform the hand-held / judge camera the length of each of their fish and the average length of the three fish. Companies must then measure the length of all three fish and determine the average length. Companies will receive 15 points for successfully calculating the average length of the three fish. Companies should explain to the judge how they plan to measure the length of each fish before proceeding with their measurements. Companies are required to show a measurement being taken on the fish. If that measurement is not the total length of the fish, companies must explain to the hand-held / judge camera how they are determining the overall length of the fish, including showing their work on any calculations. Companies must do this for all three fish. Companies must then average the three fish lengths and successfully measuring the fish is that average being within 2 cm of the average length told to the hand-held / judge camera prior to measuring the fish. Companies only get one attempt to determine the average length of the fish. If they are not within 2 cm, companies may not try again.

The three fish suspended in the water column may move, twist, and turn due to currents in pool. Currents may be intentionally created in the pool to create movement of the simulated fish.

Companies must next calculate an estimate of the biomass of the fish cohort (every fish being harvested in the pen). After measuring the fish and determining the average length (correctly or incorrectly), companies will be given a randomized average length of the fish. Companies will use the average fish length and the following equation to calculate the biomass of the cohort:

$$M = N * a * L^b$$

- M is the Biomass (kilograms)
- L is the average length (centimeters)
- N is the number of fish in pen
- a and b are determined by species and environmental conditions.

The values for L, N, a and b will be provided to companies as one of their randomized downloads. Companies that do not attempt to measure the average fish length will not have the opportunity to calculate the biomass of the cohort. However, companies that attempted to measure the average fish length, but did not come within 2 cm of the expected value, may still attempt to calculate biomass of the cohort. Companies will receive 5 points when they successfully calculate the biomass of the cohort in the pen. Successfully calculating the cohort biomass is defined as informing the station judge of the calculated cohort biomass estimate and that estimate being within 5 kilograms of the actual value. Companies have only one attempt to calculate the cohort biomass. If they are not within 5 kilograms, companies may not try again. Companies should report the cohort biomass in kilograms.

For example, if the average length of the fish is 44 cm, N = 20,000, a = 0.0021, and b=3.561, companies would calculate the cohort biomass as 29,894 kg.

Task 2.4 Farm Seagrass

Companies are also required to farm seagrass. This includes pruning existing seagrass beds and planting new ones. Seagrasses will be simulated by green foam sheets attached to ½-inch PVC pipe; the seagrass bed for planting will also include plastic mesh attached to the ½-inch PVC pipe. The simulated seagrass bed that requires pruning will be located on the bottom of the pool. The simulated seagrass bed for planting will be located on the surface, side of the pool. Pruning will be simulated by collecting a simulated seagrass bed from the bottom of the pool. Companies must prune seagrass from the bottom and return it to the surface. Companies will receive 5 points for returning the seagrass sample to the surface. Companies must also plant a new seagrass bed in a designated area. The designated area will be a 41 cm square of ½-inch PVC pipe painted green. Companies will receive 5 points for successfully planting the new seagrass bed. Successfully planting the seagrass is defined as the entire length of ½-inch PVC completely within the designated area. No part of the seagrass may be on top of or outside of the green square.

TASK 3: Antarctica Then and Now – Endurance22 and MATE Floats!

UN Sustainable Development Goal:

- **#13 Climate Action**

This task involves the following steps:

3.1 MATE Floats!

- **Recovering a GO-BGC float to conduct diagnostics**
 - **Determining the location where the float will next surface – 5 points**
 - **Recovering the float – 10 points**
- **Designing and constructing an operational vertical profiling float**
 - **Prior to the competition, building a float – 5 points**
 - **Deploying the float in the designated area – 5 points**
 - **Float completing vertical profiles**
 - **Float completes two profiles– 25 points**
 - **Float completes one profile– 15 points**

3.2 Endurance²²

- **Finding and mapping the location of the *Endurance***
 - **Flying a transect over the area of the wreck – 10 points**
 - **Mapping the wreck – 5 points**
- **Creating a photomosaic of the wreck**
 - **Collecting images of all sections – 5 points**
 - **Autonomously creating the photomosaic – 20 points**
 - **Manually creating the photomosaic – 10 points**
- **Measuring the length of the wreck from bow to stern**
 - **Within 10 cm of the true distance – 10 points**
 - **Within 10.1 to 20 cm of the true distance – 5 points**
 - **Not within 20 cm of the true distance – 0 points**

Total points = 100 points

Product Demonstration Notes:

Once the GO-BGC float has been recovered, companies may no longer receive points for determining the location where the float will next surface. Companies must complete their calculations prior to retrieving the GO-BGC float in order to receive points for determining the location of the float.

NOTE for 2022!!!

The GO-BGC float must be returned to the surface through the hole in the ice. Returned/recovered items from other tasks do not need to be returned through the hole in the ice and can be recovered anywhere along the side of the pool.

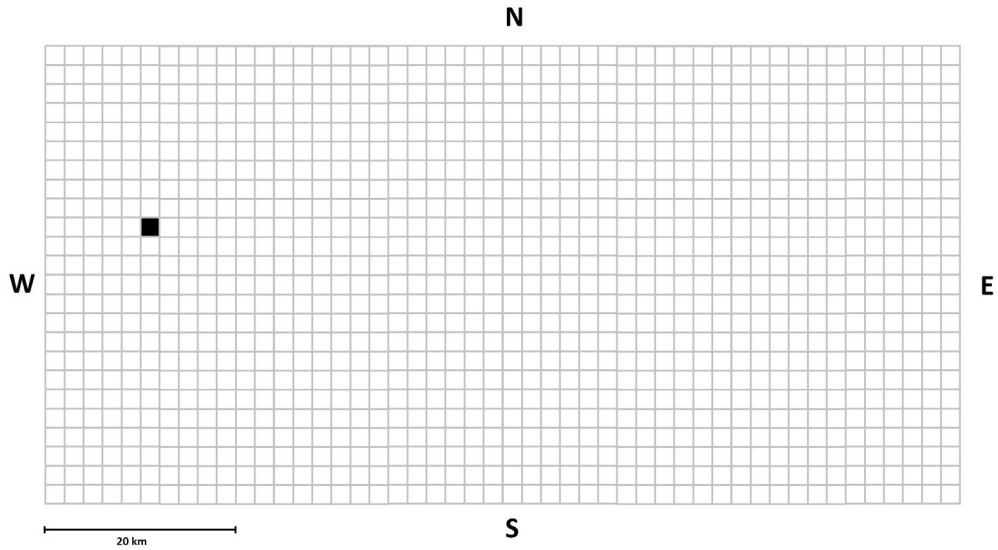
Task 3.1 *MATE Floats!*

Companies must determine the location within the polynya where the GO-BGC float will next resurface. Companies must have on hand a [grid map](#) showing the location where the float previously surfaced. Companies will be provided with the following information as one of their downloaded files:

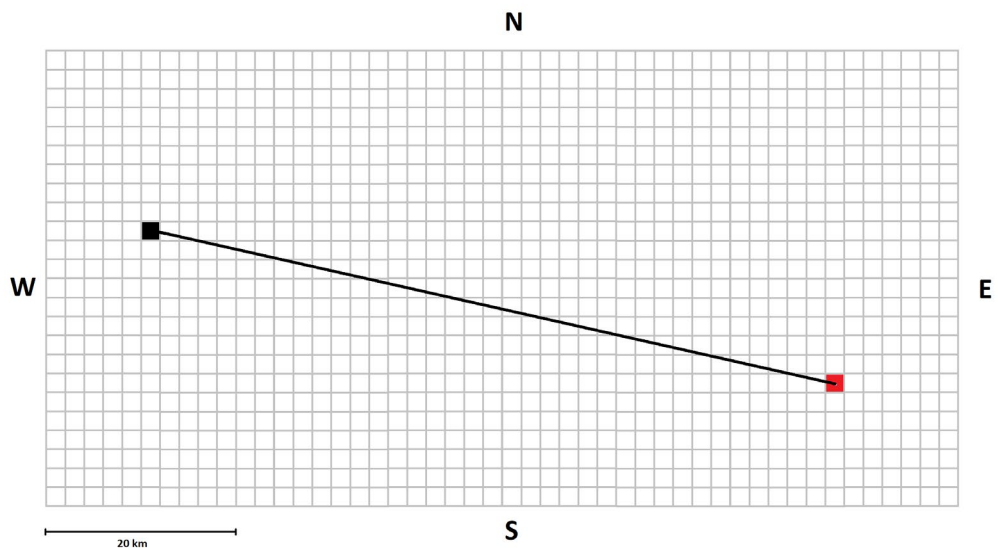
- Current speed
- Current direction
- Time (in hours) until next surface event

Companies must use this data to plot on the grid map the square where the GO-BGC float will next surface. Companies will receive 5 points for successfully plotting the location where the float will next surface. Successfully plotting the location is defined as plotting the location within the exact square of the actual location on the grid map. Companies must show this plot to the station judge prior to end of the product demonstration run. Once time has expired, no more calculations can be made.

Companies should have at least one paper copy of the grid map as they begin set up at the product demonstration station. Companies may also choose to download a copy of the map (a PNG file is available on the competition website) and plot the location on their digital map.



A blank map with the grid square where the GO-BGC previously surfaced marked (black square).



In this example, companies would be provided with the following information: the current is moving at 103° at 0.143 m/s . The float will resurface 144 hours later. Using that data, companies can determine that the float moved 74.13 km at 103° . Calculations show that translates into movement of 72.39 km east, and 16.71 km south. The plotted grid square is colored red. Note that each square represents 2 km square.

Companies must also recover the GO-BGC float. The float will be constructed from 2-inch PVC with an end cap / knock out cap attached to one end. Flotation inside the pipe will make the float positively buoyant. The GO-BGC float will be corralled in a 0.5-meter square PVC frame floating on the surface of the water. Companies will receive 10 points when they successfully recover the float. Successfully

recovering the float is defined as the GO-BGC float removed from the water through the hole in the ice and placed on the pool deck.

The GO-BGC float will have less than 10 Newtons of buoyant force in water.

Prior to the competition, companies must build a float capable of completing a vertical profile (i.e., travel from the surface to the bottom and back to the surface). EXPLORER class companies must design their float with a buoyancy engine. A [buoyancy engine](#) moves fluid from inside an internal reservoir to a flexible bladder located externally. This displaces seawater, changing the density of the float.

Companies will receive 5 points for designing and building a float. Companies must submit a one-page document outlining their float design, detailing its operation, including the design of its buoyancy engine, and demonstrating that it does not violate any safety rules. This document must be submitted in advance of the competition.

The ROV must deploy the float into the designated area. The designated area will be a 0.5-meter square PVC frame floating on the surface of the water. It will be different from, but adjacent to the PVC square holding the GO-BGC float to be recovered. Companies will receive 5 points when they successfully deploy their float in the designated area. Successfully deploying the float is defined as the float no longer in contact with the ROV and the top of the float breaking the surface of the water inside the 0.5-meter designated area.

Once the float has been deployed, it should attempt to complete two vertical profiles. A vertical profile is defined as any part of the float on or above the surface, descending in the water column until any part of the float touches the bottom, then ascending to and breaking the surface once again. After descending, the float does not need to break the surface inside the designated area. Companies must use a buoyancy engine to move their float through the water. A buoyancy engine is defined as moving air or liquid from inside the float to a bladder outside the float, changing the volume and thus the density of the float. Companies will receive 15 points for completing their first vertical profile and 10 additional points for completing their second vertical profile, 25 points total.

The float must be less than 1 meter in overall height. The float may not have a diameter/length/width greater than 18 cm.

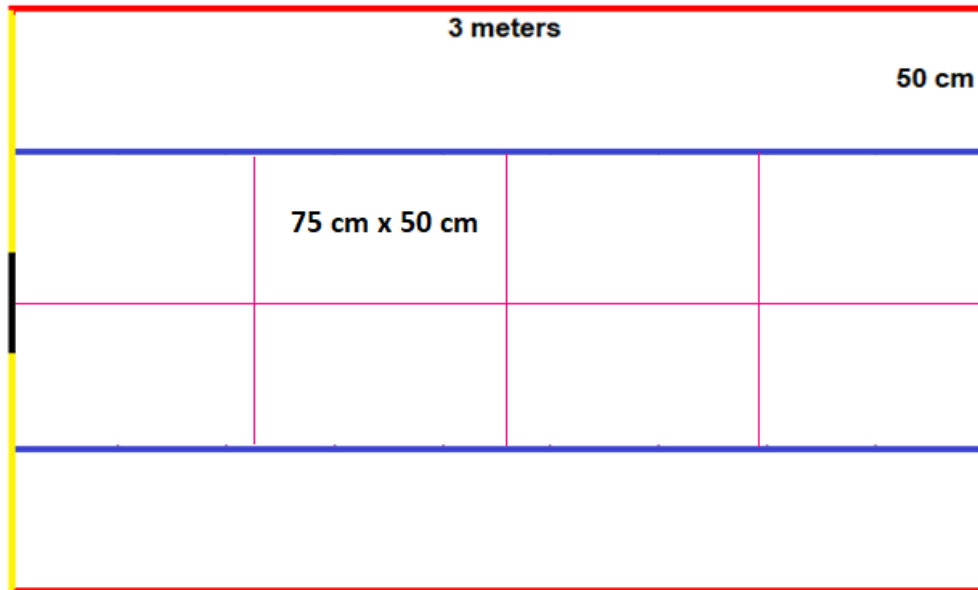
The company-built float must move independently from the ROV. The float must operate independently; it may not be connected to the shore by a tether. The float will operate as a non-ROV device (see [3.3.1 Non-ROV Device Power Specifications](#) in the competition manual) for additional rules on powering a non-ROV devices.

Task 3.2 Endurance²²

Companies must fly a transect line over the search area for the *Endurance*. The search area of the wreck will be simulated by a ½-inch PVC pipe rectangle 3 meters long by 1 meter wide. A grid of 8 rectangles, 75 cm x 50 cm, will be created within the search area using [Pink Braided Nylon Mason's Line](#). The 3-meter lengths of PVC pipe that make up the “top” and “bottom” of the area will be painted blue.

The 1-meter “ends” of the area of the wreck will be divided into three 33 cm sections. The middle 33 cm section will be painted black, while the two outer sections will be painted yellow.

An additional 3-meter length of PVC pipe will be located 50 cm from the top and bottom of the search area. These additional lengths of pipe will be painted red. The search area will be located on the bottom of the pool.



A diagram of the search area. The blue, red, yellow, and black lines are painted ½-inch PVC pipes. The pink lines are braided Mason’s Line.

Companies must fly a transect line over the search area, displaying the video image of the transect on a display screen for the station judge. Successfully flying a transect over the search area is defined as starting at one end of the transect and moving to the other end of the transect. Starting at one end of the transect is defined as the ROV directly above the black length of PVC pipe on either end of the wreck site.

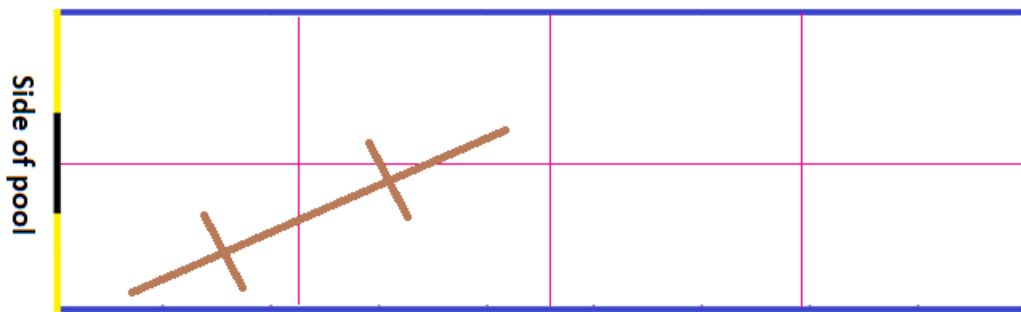
The ROV must also remain at a certain height over the search area during the transect. While flying the transect over the search area, both blue painted PVC pipes must be in the video display at all times and neither red pipe may be visible in the video display. If any section of red pipe is seen in the video display, or both blue pipes are not seen in the video display at all times, the ROV has failed to successfully fly the transect.

A video showing successful and unsuccessful flying of the transect line can be seen [here](#).

Companies must position their vehicle above the black PVC pipe on one end of the search area and fly a transect over the search area. Companies that successfully fly a transect over the search area will receive 10 points. Successfully flying the transect is defined as the ROV positioned above the black PVC pipe on one end of the search area and moving the vehicle to a position above the black PVC pipe on the

other end of the search area. The station judge must be able to see the vehicle moving through the water and must be able to see both blue PVC pipes, but neither of the red pipes, in the video display at all times. Companies that do not successfully fly the transect may reposition their ROV above a black PVC pipe and try again. There is no limit to how many times the company may attempt to fly the transect. Either end of the search area may be used as the starting point for flying the transect.

Companies must also map the wreck. The wreck will be created from ½-inch PVC pipe painted [brown](#). The wreck will be located completely within the search area. The wreck will occupy some, but not all, of the rectangles. Companies must map the locations of the wreck on a video display screen. Companies should design a display with 8 squares, arranged in a four x two grid copying the orientation of the search area grid as it is positioned in the pool. Companies should draw an image of the wreck in the map. Companies will receive 5 points for successfully mapping the wreck. Successfully mapping the wreck is defined as the diagram of the wreck drawn into every rectangle that contains a portion of the wreck. Companies only get one opportunity to map the wreck. Companies that cannot successfully map the wreck on their first try will not receive points for mapping.



Top: Search area with the shipwreck.

The map should identify which edge is the side of the pool.

Benthic species (glass sponge, sea stars and brittle stars) may occupy some rectangles. These species do not need to be drawn on the map.

Flying the transect and mapping the wreck are separate tasks. Companies may choose to do the two tasks simultaneously or may choose to do them individually.

Companies must create a photomosaic of the wreck site. Companies must take eight images of the wreck site, one of each rectangular section. Each image should contain only one entire rectangle. The image may show parts of adjacent rectangles, but not an entire rectangle other than the target imaged. Companies will receive 5 points when they have successfully collected all eight images. Successfully collecting all eight images is defined as showing the station judge a separate image of each of the eight rectangles. Each rectangle should show the complete rectangle, but only parts of the adjacent rectangle.

For the telepresence category, companies will download a randomized set of eight images, one of each rectangle in the wreck site just prior to the 15-minute demonstration run. These images must be “stitched” together showing the complete photomosaic of the wreck site. **Note: Companies MUST take**

the 8 images of the grid in the pool for the first portion of this task but will not use those 8 photos to create the photomosaic. The photomosaic will be created using the 8 downloaded images.

Companies may choose to stitch together the images into a photomosaic autonomously or manually.

Companies that choose to stitch the images into a photomosaic autonomously are tasked with creating software to “stitch” the images together. must create a program to “stitch” the images into a photomosaic. Companies that successfully “stitch” the images together autonomously will receive 20 points. Successfully “stitching” the images together autonomously is defined as no input from company members. The photomosaic must be compiled and shown to the station judge within the 15-minute product demonstration period. Companies may transfer the eight images to another device (e.g., a laptop computer or tablet) at the product demonstration station to have that device “stitch” the images together. Companies may not transfer the images to anyone not at the product demonstration station; doing so will result in disqualification. **All work must be done by company members or devices at the product demonstration station.** Companies transferring images to another device should inform the station judge of their intended actions.

Companies that choose to stitch the images into a photomosaic manually will receive 10 points for successfully stitching the images together. Successfully “stitching” the images together manually is defined as a company member at the product demonstration station using a program to physically cut and paste the images into a photomosaic. Art programs such as Photoshop, MSPaint, or others can be used. This photomosaic must be compiled and shown to the station judge within the 15-minute product demonstration period.

Companies must measure the length of the wreck from bow to stern. The wreck of the *Endurance* will be constructed from ½-inch PVC. The bow of the wreck will stick up from the bottom of the pool at a 45° angle, the stern will stick up from the bottom of the pool at a 90° angle. Both the bow and the stern will rise approximately 30 cm off the bottom of the pool. **Companies will use their own shipwreck and will know the overall length of their shipwreck prior to measuring. Before measuring, companies should inform the hand-held / judge camera the length of wreck.** Companies must measure the length of the wreck from the topmost point of the bow to the topmost point of the stern. Companies will receive 10 points if their measurement is within 10 cm of the true distance. Companies will receive 5 points if their measurement is between 10.1 and 20 cm of the true distance. Companies will receive 0 points if their measurement is greater than 20 cm from the true distance. Companies are required to show a measurement being taken of the shipwreck. If that measurement is not the total length of the shipwreck, companies must explain to the hand-held / judge camera how they are determining the overall length of the wreck, including showing their work on any calculations. Companies only get one attempt to measure the length of the wreck, if their measurement or calculations are not correct, they may not try again.

The wreck of the *Endurance* is a historical site and must be preserved. Therefore, companies will be penalized 5 points each time their ROV comes into contact with the wreck of the *Endurance*, up to a penalty of 25 points total. This includes the ROV tether and other components. If any part of the ROV

comes in contact with the, the station judge will inform the company and the company will be penalized 5 points.

PRODUCT DEMONSTRATION RESOURCES

Prior to the product demonstration run, companies will complete a [Telepresence Randomized Files Form](#). Once submitted, companies will receive (via the e-mail they entered on the form) a randomized:

- Video link of fish and morts in a fish pen
- Biomass information
- Float information
- Eight images of the wreck area for creating a photomosaic.

Companies should receive the files and YouTube link via e-mail within minutes of submitting the form. The product demonstration videos submitted by the company should show the files being successfully received after submitting the form. From the point of submitting the form to receiving the randomized files, the product demonstration videos should remain uncut.

NOTE for 2022!!!

PRODUCT DEMONSTRATION RESPONSIBILITIES

Companies will provide all of their own product demonstration resources including all in-water mission props. Product demonstration props MUST be built to the specifications in the [Product Demonstration Prop Building Instructions & Photos](#). If MATE station officials feel a product demonstration prop is not sufficiently accurate to the given specifications, they will not score that task.

Companies are permitted to create a basket to collect multiple product demonstration items. Any collection basket MUST be included in size and weight measurements. A collection basket is considered debris if still in the pool and not under control of the ROV when product demonstration time ends. Any collection basket must be deployed and returned by the ROV; it may not be pulled to the surface by hand or a surface device.

PART 3: VEHICLE DESIGN & BUILDING SPECIFICATIONS

1.0 GENERAL

Questions about vehicle design and building specifications, as well as competition rules, should be posted to Competition Help within the MATE Forum Hub (<http://forums.marinetech2.org/>). This ensures that all companies can view the questions and answers and helps to avoid duplicate questions. That said, companies should make sure that their questions have not already been asked – and answered – before posting. When posting their question, companies should reference the specific specification (e.g. ELEC-002E).

2.0 SAFETY

2.3 Product Demonstration Safety Inspection

Companies competing in the telepresence World Championship will NOT submit a safety video along with their product demonstration videos. Company safety will be determined by an initial safety inspection conducted from documentation companies submit on May 26th.

2.5 Safety Inspection Points

Companies will receive points for an initial safety inspection but not for on onsite safety inspection.

3.0 SPECIFICATIONS

3.9 MATE Provided Equipment

MATE will NOT provide equipment to teams competing in the Telepresence category of the World Championship.

PART 5: ENGINEERING & COMMUNICATION

5.3 ENGINEERING PRESENTATION

Companies participating in the Telepresence category will deliver their presentations via Zoom. Companies participating in the telepresence category will be contacted with a date and time to register for their Engineering Presentation. Your company will have 15 minutes to deliver your presentation to a panel of working professionals – individuals who represent science, exploration, government, and industry. (Don't assume that these same individuals will evaluate your company's technical documentation!) After the presentation, the judges will take 10-15 minutes to ask the members of your company questions about your ROV. The judges will evaluate both your presentation and responses to their questions. Each judge on the panel will award a score (100 points max). Judges' scores and comments will be returned to you shortly after the event.

Engineering Presentations will take place between June 6th and June 13th. Companies will be contacted by a MATE ROV Competition Telepresence Engineering Presentation Judge to arrange a date and time for their Engineering Presentation.

All student members of your company must be prepared to participate in the presentation and question and answer (Q&A) period. You are required to have your ROV with you during the Zoom presentation; if you are not able to gather in the same space, one of your company members will need

to have the ROV available for viewing by the judges. For larger companies, the main presentation may be done by a subset of the overall company. During the Q&A, all members of the company should be prepared to answer. However, if one student is better suited to answer a specific question, the others may defer the question to that student to answer. For example, if a judge calls on the pilot to answer a question about the tether, the pilot can respond by informing the judge that the tether manager was the lead on that system and allow the tether manager to answer without penalty or loss of points.

NOTE: Even with the video conferencing delivery, the engineering presentation is still intended to be a “face-to-face” interaction where students and representatives from industry become engaged in conversation. You are not permitted to use audio visual aids, such as slide projectors, computer projection screens, white boards, etc.; however, you are welcome to distribute handouts via a link within the chat box to help judges better understand the information that you are presenting. Electronic forms of presentation (e.g. PowerPoint or Keynote slides) **are NOT permitted.**

Instructors, mentors, family members, friends, and members of other companies are permitted to attend. However, we ask that those in attendance be respectful and courteous throughout the presentation and follow-up question and answer period. All spectators (non-company members) including mentors, must have their video turned off and will be muted for the entire presentation. Be mindful that this presentation may be a stressful time for the students. If the room becomes crowded or the spectators become distracting, it is up to the judges’ discretion to request that some or all spectators leave the presentation. **While they are permitted to attend, instructors and mentors are not allowed to participate.**

Use the engineering presentation scoring rubric posted [here](#) as the guideline for the required components for the engineering presentation. Judges may ask questions regarding any of these topics not covered in the presentation as well as other questions about the vehicle, the mission theme, or the company.

5.4 MARKETING DISPLAY

Prior to the competition, your company’s display will be evaluated and scored by a completely different group of working professionals – individuals who will represent science, business, government, industry, and education/outreach.

Each judge will award a score (50 points max). Judges’ scores and comments will be returned to you shortly after the event.

Companies competing in the Telepresence category of the World Championship will submit a digital copy of their marketing display along with their other Engineering & Communication documents. See **[PART 6: SUBMISSION GUIDELINES AND KEY DEADLINES](#)** for more information.

The size limit for the Telepresence category marketing display is 8MB.

For the Telepresence category, judges will not award discretionary points for pamphlets, journals, etc. These discretionary point items should not be submitted for the Telepresence marketing display.

Use the marketing display scoring rubric posted [here](#) as the guideline for the required components for the marketing display.

PART 6: SUBMISSION GUIDELINES AND KEY DEADLINES

6.1 Documentation

Companies participating in the telepresence category of the World Championships will submit all the documentation required for in-person teams but **will also submit their marketing display.**

Documentation is due on May 26th. When documentation is submitted, indicate your team is participating in the telepresence category. See [Documentation Submissions | MATE ROV Competition Website](#) for information on submitting your documentation.

See the Full Competition Manual for additional instructions on submitting your documentation.

6.1.1 Product Demonstration Video Submission

Companies should submit both their handheld, judge view camera angle and their bird's eye view camera angle to documentsubmissions@marinetech.org.

The subject line of the email should be Product Demonstration Video.

The body of the email must include:

- Competition Class
- School/Organization Name
- Team Name
- City/State/Province/Country
- Name of person submitting
- The links to the two videos
 - Birds eye camera view
 - Hand-held judge view

Submissions are due by 11:59 PM (Hawaii Time) on June 9th, 2022.

6.2 KEY DEADLINES

Below is an updated summary of key dates and deadlines for the 2022 MATE ROV telepresence event.

- May 26, 2022: Deadline for companies that qualify to register for the World Championship in either the In-Person or Telepresence category.
- May 26, 2022:
 - Technical documentation
 - Company spec sheet
 - Marketing display
 - SIDs (including electrical, fluid, Non-ROV Device)
 - Non-ROV device design document
 - Company safety review
 - Job site safety analysis (optional)
 - Corporate responsibility documentation (optional)
 - Assets OR access code for MATE ROV COMPETITION VR WORLD workstations (optional)
- June 6 – June 13, 2022: Engineering Presentations.
- June 9, 2022: Submission deadline for the company's Product Demonstration videos.