

Competition Manual  
Release: 27 May 2021



2021  
EXPLORER CLASS

TELEPRESENCE



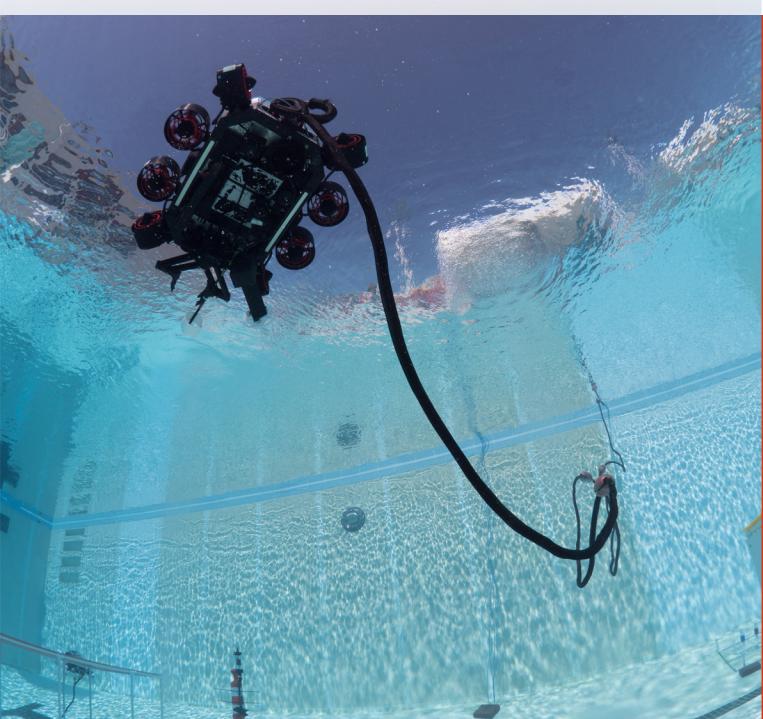
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## **2021 MATE ROV COMPETITION:**

*Excite, Educate, Empower: Students engineering solutions to global problems*

## **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.

### **CONTENTS**

<b>2021 MATE ROV COMPETITION:</b> .....	1
<i>Excite, Educate, Empower: Students engineering solutions to global problems</i> .....	1
<b>EXPLORER CLASS: CONDENSED TELEPRESENCE COMPETITION MANUAL</b> .....	1
<b>EXPLORER CLASS DEMONSTRATION</b> .....	2
<b>PART 1: PRODUCT DEMONSTRATION</b> .....	5
OVERVIEW .....	5
SCORING OVERVIEW.....	5
TIME .....	6
PRODUCT DEMONSTRATION .....	6
Safety Compliance Video .....	7
Product Demonstration Video .....	7
Submissions.....	8
TASK 1: THE UBIQUITOUS PROBLEM OF PLASTIC POLLUTION .....	9
TASK 2: THE CATASTROPHIC IMPACT OF CLIMATE CHANGE ON CORAL REEFS .....	13
TASK 3: MAINTAINING HEALTHY WATERWAYS II: DELAWARE RIVER AND BAY .....	21
PRODUCT DEMONSTRATION RESOURCES .....	27
PRODUCT DEMONSTRATION RESPONSIBILITIES .....	27
<b>PART 3: VEHICLE DESIGN &amp; BUILDING SPECIFICATIONS</b> .....	28

<b>1.0 GENERAL.....</b>	<b>28</b>
<b>2.3 Product Demonstration Safety Inspection.....</b>	<b>28</b>
<b>2.5 Safety Inspection Points .....</b>	<b>29</b>
<b>3.0 SPECIFICATIONS.....</b>	<b>30</b>
<b>3.9 MATE Provided Equipment .....</b>	<b>30</b>
<b>PART 5: ENGINEERING &amp; COMMUNICATION.....</b>	<b>30</b>
<b>5.3 ENGINEERING PRESENTATION .....</b>	<b>30</b>
<b>5.4 MARKETING DISPLAY .....</b>	<b>31</b>
<b>PART 6: SUBMISSION GUIDELINES AND KEY DEADLINES .....</b>	<b>31</b>
<b>6.1 Documentation .....</b>	<b>31</b>
<b>6.2 KEY DEADLINES .....</b>	<b>34</b>



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May 27 Edit: Added additional information on Marketing Display

## EXPLORER CLASS DEMONSTRATION

All EXPLORER class companies, regardless of which overarching competition category they intend to compete in (i.e., In-Person or Telepresence), are required to submit a video that:

- Demonstrates the ability of their vehicle to perform specific tasks;
- Shows compliance with MATE's design, build, and safety specifications.

### Video specifications:

Video specifications: The video MUST show the following ROV features for the specified amount of time. Companies can choose to narrate the video to help explain how their vehicle meets these required specifications. Alternatively, a MATE official may schedule a Skype, Google Hangout, GoToMeeting, Zoom, Webex or other type of video conferencing session with the company. During the session, companies must visually show, and answer questions about, the following ROV features.

The video MUST show in this order:

1. 15 seconds (or more) of the 48-volt power supply (**ELEC-002E**).
2. 15 seconds (or more) showing a properly sized Littlefuse. The company MUST use a ruler to show that this fuse is within 30 cm of Anderson Powerpole connectors. (**ELEC-008E, ELEC-010E**).
3. 30 seconds (or more) of the inside of the control box showing the wiring and components.

MATE will be looking for:

- No exposed wiring (**ELEC-017E**).
  - That the control box is neatly laid out with attention to workmanship. (**ELEC-022E**).
  - Separation and identification of 120VAC wiring from DC and control voltages. (**ELEC-023E**). If 120VAC is not used in the control box, you should video a slide stating that AC power is not used in the control box.
4. 15 seconds (or more) in the control system showing that there is no conversion of the 48V until it reaches the ROV. Power supplies, ESCs, H-Bridges or other voltage conversion devices are not allowed on the surface. (**ELEC-003E & ELEC 004E**)
  5. 30 seconds (or more) showing any hydraulic / pneumatic systems including a pressure release valve and regulator in the system (**FLUID-007, FLUID-011**), and that any pressurized cylinder, pressure storage device meets the MATE specifications of (**FLUID-012, FLUID-013**). In addition, the type of fluid should be clearly stated in the video (**FLUID-002, FLUID-003, FLUID-004**) If the vehicle does not use fluid power, **you should video a slide stating that Fluid Power is not used on this ROV for 10 seconds**.
  6. 15 seconds (or more) showing the tether entering the ROV and strain relief for the tether (**ELEC-024E**)
  7. 60 seconds (or more) total, 10 seconds (or more) per side of the ROV (4 sides plus top and bottom) showing that all motors are waterproofed and propellers are shrouded and protected with guards. There are no sharp edges or elements of the ROV that could cause damage (**MECH-006, ELEC-017E**).

Video demonstrating specific tasks: Following those requirements, the video must demonstrate that the ROV can complete the following product demonstration tasks. The ROV must complete all the tasks within 15 minutes.

The UNCUT video must show the vehicle:

1. Launching safely from the side of the pool and maneuvering to tasks.
  - a. See specifications (**MECH-004 & MECH-005**).
2. Completing the required tasks. This includes:
  - a. **Task 1: The Ubiquitous Problem of Plastic Pollution**
    - i. Removing a ghost net from midwater
      1. Pulling a pin to simulate cutting the ghost net free
      2. Removing the ghost net from the water

- b. **Task 2:** The Catastrophic Impact of Climate Change on Coral Reefs
  - i. Propagating corals onto the reef
    1. Removing one coral fragment from the nursery structure
    2. Outplanting one coral fragment to the designated location on the reef
- c. **Task 3:** Maintaining Healthy Waterways II: Delaware River and Bay.
  - i. Creating a photomosaic of a subway car submerged to create an artificial reef
    1. Position your ROV at five locations around the subway car

**Task 1:** The pin on the ghost net must be positioned in the midwater, at least 50 cm above the bottom of the pool.

**Task 2:** Companies only need to remove and outplant one coral fragment. Companies may choose to use either design (branched or unbranched) of coral fragment.

**Task 3:** Companies do not need to create a photomosaic for the video demonstration. To complete this demonstration, the ROV must position itself with the front of the ROV facing each side of the subway car and also position itself directly above the subway car.

The camera angle must demonstrate that the ROV is under its own power and not assisted by humans when in the water. The MATE ROV Competition requires that the camera show the complete ROV in the field of view at all times. A video that cuts between camera angles will not pass the demonstration requirement of “uncut” footage. The video is permitted to show a split screen or may incorporate a separate window showing the ROV camera or other footage. However, the video MUST show an uncut view of the vehicle from launch to completion of the tasks. The tasks must be completed within 15 minutes.

Companies may complete the tasks in any order they wish.

\* Companies that advance from an EXPLORER class regional with 5 teams or more are not required to submit a video showing completion of the required tasks. **However, these companies must still submit the required specifications video.**

See [6.1.1 Video Demonstration Documentation](#) for submission information.

Companies are allowed to make minor changes to their ROV after their video demonstration, but the overall systems should be the same. Minor changes include adding/removing buoyancy, adding tools/sensors that were not used for the demonstration, etc.

***NOTE for 2021!!!***

Due to the continued impact of the pandemic, EXPLORER class teams are NOT encouraged to attend RANGER/NAVIGATOR/SCOUT regional events this competition season to showcase their vehicle. While both EXPLORER class teams and regional events benefit from this experience, in the interest of the health and safety of all participants, we are discouraging participation this year. We are hopeful to

resume the opportunity (and encouragement!) for EXPLORER teams to attend, showcase their ROVs, and support regional events in 2022.

## PART 1: PRODUCT DEMONSTRATION

### OVERVIEW

EXPLORER class companies will take part in ONE product demonstration that consists of three distinct tasks. Companies will get two attempts at the one product demonstration:

#### **TASK #1: THE UBIQUITOUS PROBLEM OF PLASTIC POLLUTION**

#### **TASK #2: THE CATASTROPHIC IMPACT OF CLIMATE CHANGE ON CORAL REEFS**

#### **TASK #3: MAINTAINING HEALTHY WATERWAYS PART II: DELAWARE RIVER AND BAY**

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**
  - 270 points (max), plus a time bonus
  - Size and weight restrictions
    - 20 points (max)
  - 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)

- Safety Inspection
  - 30 points (max)
- Job Safety Analysis (JSAs)
  - 10 points (max)

**TOTAL POINTS = 675**

## TIME

The telepresence product demonstration includes:

- Size and weight checks
- 15 minutes to attempt the tasks

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, the ROV has returned to the surface under its own power so that it touches the side of the pool, and a company member at the product demonstration station has physically touched the vehicle. 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) return your ROV to the surface under its own power so that it touches the side of the pool, and
- 3) physically touch your vehicle before the demonstration time ends.

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. Companies must submit videos demonstrating:

- Compliance with competition safety requirements
- 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 mapping the coral reef, determining changes in the coral colony, determining the contaminant, estimating the number of mussels, and creating the photomosaic. 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](#). 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.

## Safety Compliance Video

Companies must submit a video showing that they meet safety requirements of the MATE ROV Competition. The requirements for the safety compliance video can be found in the [2.3 Product Demonstration Safety Inspection](#) section.

## Product Demonstration Video

Companies will submit videos from two different camera angles from a single product demonstration run.

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

**Size and Weight:** Companies must demonstrate the size and weight of their vehicle and tether. The vehicle, all tools used on the ROV, and the tether must be sized and weighed. The control system and the top meter of the tether are not included in the size and weight measurements.

The video must show:

- A metric tape measure showing the diameter of the ring.
- The ring fitting over the ROV and tether.
- The ROV and tether on a scale, with the weight measurement displayed in metric units (kg).

An example of a size and weight video is posted [here](#).

The form to receive a randomized photo of the coral reef, a randomized photo of the coral colony, a randomized Raman spectrum, a randomized mussel information document, and five randomized photos of the subway car can be found [here](#).

Following size, weight, and downloads, 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, but rather 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 (including size and weight, but 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. Pilots 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 as well as the safety compliance video must be uploaded to the [Telepresence Category: 2021 MATE ROV Competition Video Product Demonstration Submission Form](#) found [here](#).

All documents should use the following naming convention: School or organization name\_company name\_VIDEO TYPE\_2021.pdf, where VIDEO TYPE is Safety Compliance, 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 July 15<sup>th</sup>, 2021.

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

## **TASK 1: THE UBIQUITOUS PROBLEM OF PLASTIC POLLUTION**

**This task involves the following steps:**

**1.1 Seabin – “Cleaning up our ocean one marina at a time”**

- Disconnecting the old power connector to the recently installed Seabin – 5 points
- Removing a previously installed Seabin’s mesh catch bag – 10 points
- Installing a new mesh catch bag into the Seabin – 10 points
- Reconnecting a new power connector to the recently installed Seabin – 20 points

**1.2 Remediation: Removing plastic pollution from top to bottom**

- Removing floating plastic debris from the surface
  - Removing all 6 pieces of debris – 15 points
  - Removing 3 to 5 pieces of debris – 10 points
  - Removing 1 to 2 pieces of debris – 5 points
  - Removing 0 pieces of debris – 0 points
- Removing a ghost net from midwater
  - Pulling a pin to simulate cutting the ghost net free – 10 points
  - Removing the ghost net from the water – 10 points
- Removing plastic debris from the bottom of the Mariana Trench – 5 points each, 10 points total

**Total points = 90 points**

**Product Demonstration Notes:**

Companies must do the steps of the Seabin – “Cleaning up our ocean one marina at a time” task in order. Companies may not skip any steps of the Seabin task. Companies may complete the steps of Remediation: Removing plastic pollution from top to bottom in any order.

**Task 1.1 Seabin – “Cleaning up our ocean one marina at a time”**

Companies must conduct maintenance on a Seabin recently deployed in open water. The body of the Seabin will be constructed from a 5-gallon bucket. A  $\frac{1}{2}$ -inch PVC framework will be secured inside the bucket approximately 5 cm from the top. The mesh catch bag will be simulated by [mesh netting](#) attached to a framework of  $\frac{1}{2}$ -inch PVC pipe. The framework of the catch bag will sit on the  $\frac{1}{2}$ -inch PVC framework secured inside the open top of the bucket. The power port for powering the Seabin will be attached to a  $\frac{1}{2}$ -inch PVC framework on the outside of the 5-gallon bucket. The Seabin will be attached to a weight on the bottom by a length of rope.

Companies must first disconnect the old power connector from the port on the Seabin. The connector will be constructed from 2-inch PVC pipe. A  $\frac{1}{2}$ -inch PVC pipe handle will act as a grab point on the 2-inch connector. The transmitter side of a 12-volt [inductive coupling power connector](#) will be located at the other end of the 2-inch pipe, in a 2-inch knockout cap and covered with less than 2 mm of epoxy for

waterproofing. Wires will connect the inductive coupling transmitter side to a 12 volt supply on the surface.

The power port will be constructed from 3-inch pipe and will be attached to the  $\frac{1}{2}$ -inch framework on the outside of the Seabin. The receiver side of the inductive coupling power connector will be placed in the bottom, center of the power port and covered with less than 2 mm of epoxy for waterproofing. Wires will connect the receiver to waterproofed LEDs attached to the outside of the power port.

Companies must first disconnect the old power connector from the port on the Seabin. At the start of the product demonstration, the old power connector will be in the power port and the LEDs will be illuminated. Companies must remove the power connector from the port. Companies that successfully disconnect the old power connector will receive 5 points. Successfully disconnecting the old power connector is defined as the power connector under control of the ROV, the LEDs on the port no longer illuminated, and the connector no longer in contact with the power port or the Seabin. Once successfully disconnected, the old connector will be considered debris. To avoid penalty points for leaving debris in the water, companies must keep the connector secured in a gripper on their ROV or return it to the surface.

Once successfully disconnected, companies may pull the connector out of the water by hand. Note: The ROV must first remove the power connector from the power port. Companies cannot pull the power connector from the power port by hand. The connector must be released from the ROV before it is pulled up by hand; companies cannot bring the ROV to the surface by pulling on the connector. Companies that are unable to remove the power connector cannot continue with the Seabin task.

The old power connector will weigh less than 5 Newtons in water.

Once the power to the Seabin has been disconnected, companies must remove the old mesh catch bag and install a new one. Both the old and new mesh catch bag will be identical in construction, but the old mesh catch bag will contain plastic debris. The mesh catch bags will be constructed of mesh netting attached to a framework of  $\frac{1}{2}$ -inch PVC pipe. The PVC pipe framework of the mesh catch bag will rest inside the top of and on the PVC framework inside the Seabin. A PVC handle will act as grab points for the mesh. The PVC handle will extend above the top opening of the 5-gallon bucket.

Companies must first remove the old mesh catch bag from the inside the Seabin. The Seabin will be attached to a line that will be anchored to the bottom of the pool by a weight. The Seabin will be buoyant, floating mid-water. The top of the 5-gallon bucket will be 30 cm to 50 cm below the surface of the water. Companies will receive 10 points when the old mesh catch bag is successfully removed. Successful removal of the old mesh catch bag is defined as the old bag removed from the water and placed on the pool deck.

Once the old mesh catch bag has been removed from the Seabin, companies must install the new mesh catch bag. The new mesh catch bag will be located at the surface, side of the pool during the product demonstration set up time. Companies will receive 10 points for successfully installing the new mesh catch bag. Successfully installing the new mesh catch bag is defined as the mesh catch bag no longer in

contact with the ROV, and the ½-inch PVC framework of the mesh catch bag completely inside and resting flat on the PVC framework secured inside the Seabin.

Note that companies must remove the old mesh catch bag from the Seabin before installing the new one, but companies do not have to return the old mesh catch bag to the surface before installing the new one. For example, companies could remove the old mesh catch bag and hold it in a gripper or set it on the bottom. Companies could then install the new mesh catch bag. Then companies could return the old mesh catch bag to the surface, side of the pool.

Mesh catch bags will weigh less than 5 Newtons in water.

Once the new mesh catch bag has been installed, power must be restored to the Seabin. If the new mesh catch bag has not been installed, companies may not attempt to reconnect the power connector. Companies are tasked with designing and creating their own functional power connector to insert into the 3-inch pipe of the power port. The company-built power connector must meet the following specifications:

- Body is 15 cm or more in length
- Body is 5 cm or greater in diameter or width
- Incorporates a waterproofed transmitter side of an inductive coupling power connector

Companies will be tasked with designing and building the transmitter side of the inductive coupling power connector that is capable of providing 12 volts to the receiver side. The powered connector will be considered a **Error! Reference source not found.**; companies must follow the Non-ROV device power specifications to provide power to their connector. Companies powering their non-ROV device from the surface may plug their connector directly into a 12V power supply provided by the MATE ROV Competition or provide their own power source. Connection to the 12V MATE supply will be via red/black [Anderson powerpole connectors](#).

See [3.2.3 Tether length, MECH-003E](#) for the length of cable needed to reach the Seabin.

Companies will receive 20 points for successfully reconnecting the power to the Seabin. Successfully reconnecting the power is defined as illuminating the LEDs on the power port. The station judge must be able to see the illuminated LEDs. The connector must remain inside the port, with the LEDs illuminated for the entire mission run. If the connector falls or is knocked out of the port, or the LEDs are no longer illuminated, the company will lose points for the task, but may try to re-install the connector to re-illuminate the LEDs.

Additional information on the Seabin and the inductive coupling power connector will be provided in the [Prop Building Instructions](#).

***NOTE FOR TELEPRESENCE!!!***

The Seabin task must be completed in a pool of at least 2 meters of depth. The bottom of the Seabin 5-gallon bucket must be suspended at least 0.6 meters above the bottom of the pool. Companies that cannot meet these specifications may not complete any steps of the Seabin task.

### **Task 1.2 Remediation: Removing plastic pollution from top to bottom**

Companies must remove floating plastic debris from the surface of the pool. Six ping-pong balls will be floating on the surface, contained within a 1 meter square  $\frac{1}{2}$ -inch PVC framework. The framework will be attached to the side of the pool by a length of  $\frac{1}{2}$ -inch PVC pipe to keep it from drifting. Companies must remove the ping-pong balls (plastic debris) from the surface and return them to the side of the pool. Companies that successfully remove all six ping-pong balls will receive 15 points. Companies that successfully remove only 3 to 5 ping-pong balls will receive 10 points. Companies that successfully remove only 1 or 2 ping-pong balls will receive 5 points. Successfully removing the plastics debris from the water is defined as the ping-pong balls being removed from the framework under control of the ROV and placed on the pool deck.

Each ping-pong ball will have less than 5 Newtons of buoyant force in water.

Companies must remove a ghost net from midwater. The net will be constructed from  $\frac{1}{2}$ -inch PVC pipe and [decorative cloth netting](#) will be attached to the framework with cable ties. The net will be located midwater in the pool. The net will be positively buoyant, and secured to a weight on the bottom by a rope. 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 must return it to the surface.

Once companies have pulled the pin, they must return the ghost net to the surface, side of the pool. Companies will receive 10 points when they successfully remove the ghost net from the water. Successfully removing the ghost net is defined as the PVC pipe and netting as well as the pin completely out of the water and placed on the pool deck. The weight and rope holding the net do not need to be removed from the pool.

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

Companies must remove plastic debris from the bottom. The plastic debris on the bottom will consist of two 1-gallon plastic Ziploc bags.  $\frac{1}{2}$ -inch PVC pipe inside the bag will provide weight to keep the bag from drifting. The PVC pipe will be secured to the inside of the Ziploc bag with industrial strength Velcro. The Ziploc bag will be open at the top, allowing it to fill with water; it will not contain air bubbles. Companies must remove this plastic debris from the bottom and return it to the side of the pool. Companies will receive 5 points for each bag successfully removed from the water, 10 points total. Successfully removing the debris from the water is defined as placing it on the pool deck.

The Ziploc bag and PVC will weigh less than 5 Newtons in water.

## **TASK 2: THE CATASTROPHIC IMPACT OF CLIMATE CHANGE ON CORAL REEFS**

**This task involves the following steps:**

**2.1 Flying a transect line over a coral reef and mapping points of interest**

- **Flying a transect line over a coral reef**
  - Flying the transect autonomously – 15 points
  - Flying the transect manually – 5 points
- **Mapping points of interest on the reef**
  - Autonomous mapping on a video display – 10 points
  - Manual mapping on a video display – 5 points

**2.2 Using image recognition to determine the health of a coral colony by comparing its current condition to past data**

- **Using image recognition to determine the health of the coral colony**
  - All areas of change successfully identified – 20 points
  - At least one, but not all, areas of change successfully identified – 10 points
  - No areas of change successfully identified – 0 points
- **Using a handbook to determine the health of the coral colony** – 5 points

**2.3 Propagating corals onto the reef**

- **Removing coral fragments from the nursery structure** – 5 points each, 10 points total
- **Outplanting coral fragments to designated locations on the reef** – 5 points each, 10 points total

**2.4 Culling an outbreak of Crown of Thorn sea stars** – 5 points each, 10 points total

**2.5 Collecting samples of sponge species for pharmaceutical research**

- **Collecting a sample of the sponge** – 10 points
- **Returning the sample to the surface** – 5 points

**Total points = 90 points**

**Product Demonstration Notes:**

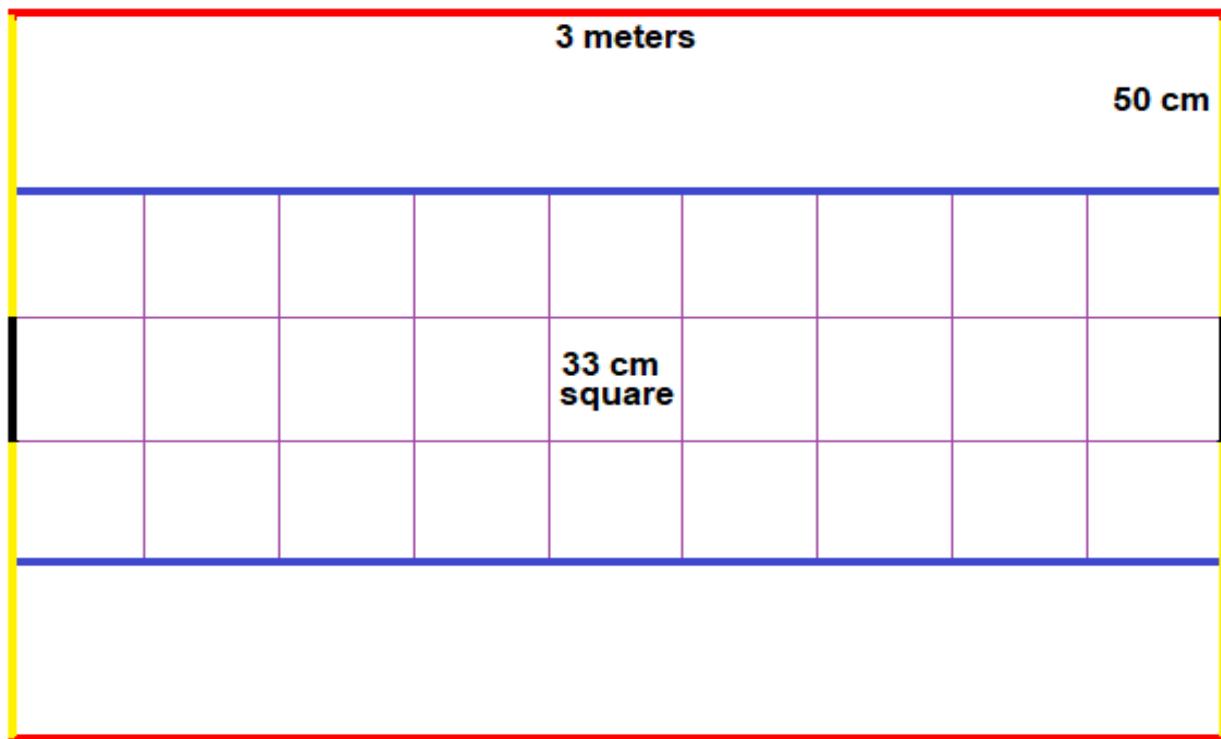
Companies may complete the steps of Task 2: The Catastrophic Impact of Climate Change on Coral Reefs in any order.

**Task 2.1 Flying a transect line over a coral reef and mapping points of interest**

Companies must fly a transect line over a coral reef. The coral reef will be simulated by a  $\frac{1}{2}$ -inch PVC pipe rectangle 3 meters long by 1 meter wide. A grid of 27 squares, 33 cm per side, will be created within this rectangle using [Pink Braided Nylon Mason's Line](#). The 3-meter lengths of PVC pipe that make up the “top” and “bottom” of the reef will be painted blue.

The 1-meter “ends” of the coral reef 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 reef. These additional lengths of pipe will be painted red. The coral reef area will be located on the bottom of the pool.



A diagram of the coral reef. The blue, red, yellow, and black lines are painted  $\frac{1}{2}$ -inch PVC pipes. The purple lines are braided Mason's Line.

Companies must fly a transect line over the coral reef, displaying the video image of the transect on a display screen for the station judge. Successfully flying a transect over the coral reef 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 coral reef.

The ROV must also remain at a certain height over the reef during the transect. While flying the transect over the coral reef, both blue painted PVC pipes must be in the video display at all times and neither red line 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 are tasked with creating software that will allow their vehicle to autonomously fly a transect line over the coral reef. Companies that successfully fly a transect over the coral reef using an autonomous control program will receive 15 points. Successfully flying the transect line autonomously is defined as the control program moving the vehicle from one end of the transect to the other without any input from the company members. No company member should be touching the controls or other

systems for the entire flight of the 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 must be able to see both blue PVC pipes but neither of the red pipes in the video display at all times. If the vehicle fails to autonomously fly the transect, companies may reposition their vehicle at one end of the coral reef, above a black painted length of PVC, and try again. Either end of the coral reef may be used as the starting point for the transect. There is no limit to how many times the company may try to autonomously fly the transect. Companies that cannot successfully autonomously fly the transect line may attempt to fly the transect manually. Companies should inform the station judge if they decide to do so.

Alternatively, companies may attempt to fly the transect manually. Companies may pilot their vehicle to move over the coral reef from one end to the other. Companies that successfully fly the transect line manually will receive 5 points. Successfully flying the transect line manually is defined as the vehicle, under control of the pilot, moving from one end of the transect to the other. 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 during the flight of the transect. If the vehicle fails to fly the transect, companies may reposition their vehicle at one end of the coral reef, above a black painted length of PVC, and try again. Either end of the coral reef may be the starting point for the transect. There is no limit to how many times the company may try to manually fly the transect.

Companies must also map points of interest on the coral reef. For the Telepresence category, companies will download a randomized image of the coral reef just prior to the 15-minute product demonstration run. There will be six points of interest located within the coral reef image. These points of interest are related to the other steps of Task 2. Descriptions of the items will be detailed with those tasks. The six points of interest are:

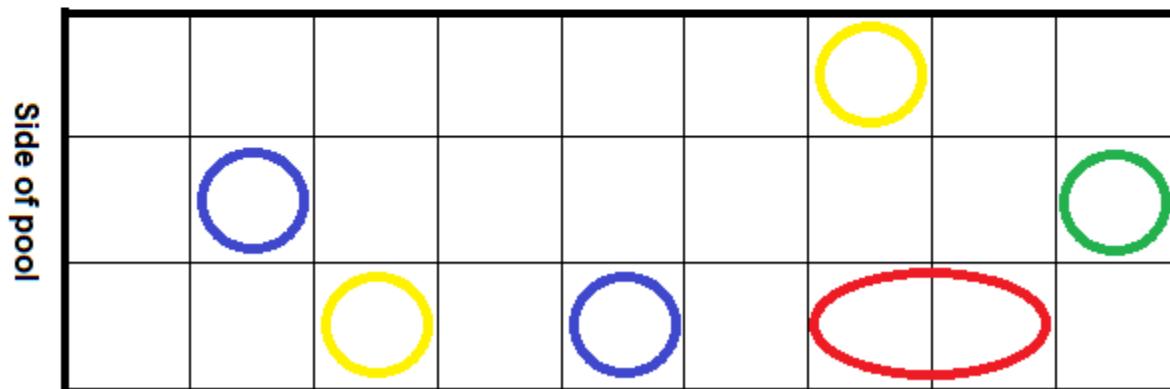
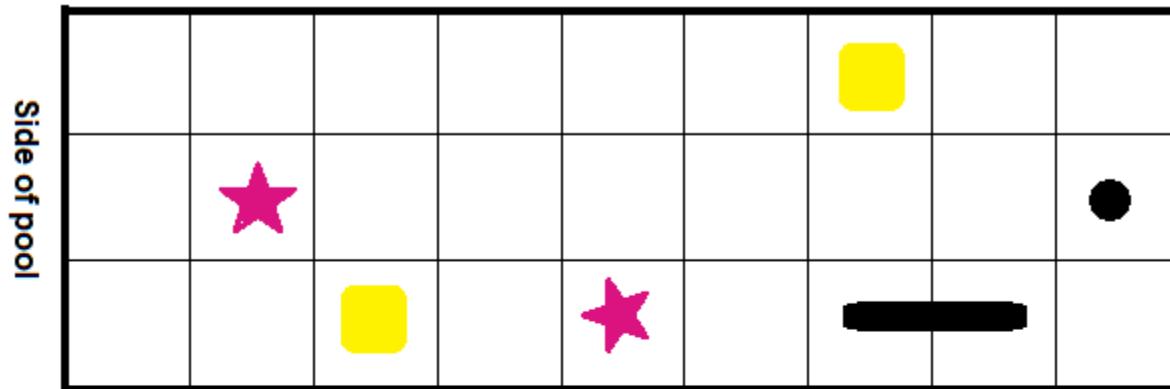
- One larger coral colony (occupying two adjacent squares)
- Two designated areas for outplanting coral fragments
- Two crown of thorn sea stars
- One sponge

Companies are tasked with creating software to autonomously map the locations of the points of interest on the grid system. Companies should design a display with 27 squares. The squares should be arranged in a nine x three grid copying the orientation of the coral reef grid in the pool. The software must autonomously overlay a colored circle in the proper square for each point of interest (the larger coral will encompass two squares and each square should be marked). The two adjacent squares containing the larger coral colony should each be overlaid with a red circle. The two squares containing designated areas for outplanting coral fragments should each be overlaid with a yellow circle. The two squares containing the Crown of Thorn sea stars should each be overlaid with a blue circle. The square containing the sponge should be overlaid with a green circle. Companies will receive 10 points for successfully mapping the location of the points of interest autonomously on their video display map. Successfully mapping the locations is defined as all circles appearing in the proper grid squares with no input from the company. Companies may use two circles or one oval (elongated circle) to overlay the coral colony that occupies two squares. The station judge must see the circle overlays. Companies may inform the judge that the overlays have appeared, but should not touch the control station while doing

so. Companies not able to autonomously map the points of interest may not retry this task, but may still map the points of interest manually. Companies should inform the station judge if they decide to map manually.

The intent for autonomous mapping is to develop a software program that uses the downloaded image then creates a map of grid squares and places those points of interest in the appropriate grid squares autonomously. The map of grid squares presented to the judges for scoring cannot be the downloaded image itself or a screenshot of the image. The map of grid squares must be an independent image, not a copy of the downloaded image. Companies may not manipulate the image before transferring it to another device to autonomously create the map. Companies may manually transfer that image to another device, but companies may not make any changes to the image manually. Any manual manipulation of the image before transferring it to another device would be considered manual mapping the points of interest.

Alternatively, companies may choose to manually map the locations of the points of interest on the grid system. Manually marking the locations on the map must still be done on a video display screen, but company members may use a program to physically draw colored circles on the grid. Companies should design a display with 27 squares. The squares should be arranged in a nine x three grid copying the orientation of the coral reef grid in the pool. Circles can be manually overlaid into the proper squares for each point of interest (the larger coral will encompass two squares and each square should be marked). The two adjacent squares containing the larger coral colony should each be overlaid with a red circle. The two squares containing designated areas for outplanting coral fragments should each be overlaid with a yellow circle. The two squares containing the Crown of Thorn sea stars should each be overlaid with a blue circle. The square containing the sponge should be overlaid with a green circle. Companies will receive 5 points for successfully mapping the location of the points of interest on their video display map. Successfully mapping the locations is defined as all circles appearing in the proper grid squares. Companies may use two circles or one oval (elongated circle) to overlay the coral colony that occupies two squares. Companies only get one opportunity to manually map the six points of interest. Companies that cannot successfully create the map manually will not receive points for mapping.



Top: Reef with coral colony, two locations for outplanting coral fragments, two sea stars, and a sponge.

Bottom: Colored circle overlays in the proper squares to match the organisms on the reef.

For both autonomous and manual mapping of the points of interest, the grid map should identify the orientation of the map, i.e., which edge is closest to the side of the pool.

Mapping the points of interest is separate from flying the transect line. Companies may choose to do the two tasks simultaneously or may choose to do the two tasks individually.

### **Task 2.2 Using image recognition to determine the health of a coral colony by comparing its current condition to past data**

A large coral colony will be located in the reef. The coral colony will be constructed from  $\frac{1}{2}$ -inch PVC pipe. The base of the coral will be located in two squares in the coral reef grid. Companies must determine the health of the coral colony by comparing the current image to an image taken one year ago. For the telepresence category, companies will download a randomized current image of the coral colony just prior to the 15-minute product demonstration run. Companies must compare images to assess whether the coral has grown, is damaged/has died, is bleached/blotched, or has recovered from bleaching/blotching. Growth is defined as the coral colony having new pink branches not seen in the previous image. Damage or death is defined as the coral colony missing branches that were seen in the previous image. Coral bleaching or blotching is defined as pink colored branches from the previous

photo having turned white. Recovery from bleaching or blotching is defined as white branches from the previous photo now being colored pink.

Companies must compare the downloaded current coral colony to the previous image and show any changes on a video display. The base of the coral will be painted black, will not change shape or color, and should not be used in the image comparisons.

Companies may develop image recognition software to identify and display the areas of change on the coral colony to the station judge. On a video screen, the company's program should outline areas where the coral has changed. The following parameters must be used:

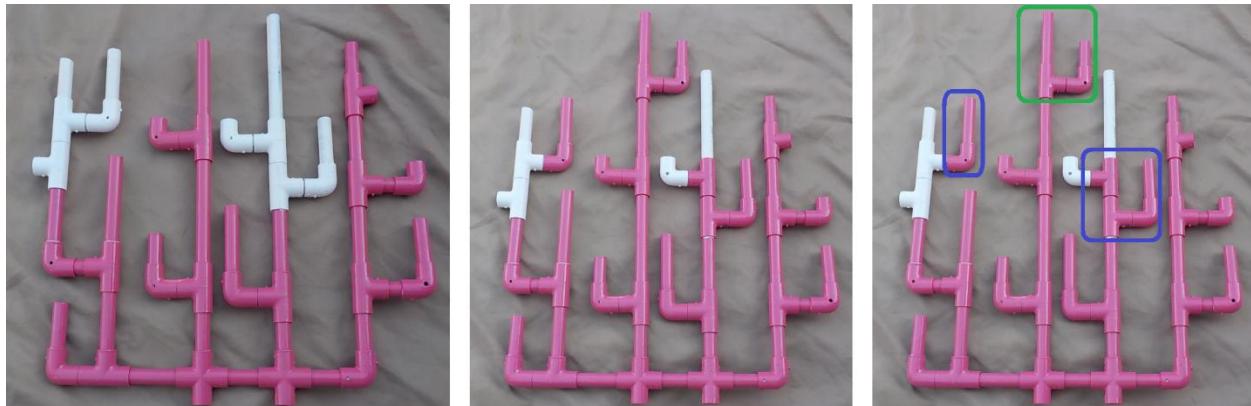
- Areas of growth should be outlined with a green overlay or marked with a green rectangle/circle around the affected area.
- Areas of damage or death should be outlined with a yellow overlay or marked with a yellow rectangle/circle around the affected area.
- Areas of bleaching/blotching should be outlined with a red overlay or marked with a red rectangle/circle around the affected area.
- Areas that have recovered from bleaching/blotching should be outlined with a blue overlay or marked with a blue rectangle/circle around the affected area.

Every coral colony will have two to four areas of change, but only one or two categories of change. For example, a coral colony may have two areas of growth, and one area of recovery from bleaching and blotching (three areas of change, but only two categories of change). Or a coral colony may have four instances of bleaching/blotching (4 areas of change, but only one category of change).

Once the image recognition program has identified the areas of change, companies must show their display, outlining the areas of change, to the station judge. Companies that successfully outline all areas of change using image recognition will receive 20 points. Companies that successfully outline at least one area of change, but do not outline all the areas of change, will receive 10 points. Successfully outlining an area is defined as the area of change overlaid with the proper color for the type of change.

Companies using image recognition may not define the image area on their screen for their program to examine. For the telepresence category, companies may transfer the image to another device, but the image downloaded may not be manipulated in any way.

A “before” [photo of the coral colony](#) is available to all companies. This photo will represent the image of the coral colony from one year ago. Companies using image recognition may use this photo to construct their own “before” coral colony to compare the current coral colony.



Left: The coral colony photo from 1 year prior.

Center: The coral colony as it is today.

Right: The coral colony with all areas of change identified. There is one area of growth, and two areas of recovery from bleaching/blotching.

Alternatively, companies may determine the health of the coral colony by manually comparing the current image to an image taken of the coral colony one year ago using the photo of the coral colony from one year prior. An image of the coral colony taken one year ago can be found [here](#). Companies will receive 5 points when they successfully determine the health of the coral colony by manually comparing the current image to the image from one year ago. Successfully determining the health of the coral colony manually is defined as outlining all areas of change on the coral colony photo from one year prior to the station judge and informing the judge what type of change has taken place. The company member informing the judge of the type of change should use the terms growth, death or damage, bleaching/blotching, or recovery from bleaching/blotching.

### **Task 2.3 Propagating corals onto the reef**

Companies must propagate corals onto the reef. Coral fragments will be constructed from  $\frac{1}{2}$ -inch PVC pipe. A  $\frac{3}{8}$ -inch-16, 3-inch bolt will be attached inside the  $\frac{1}{2}$ -inch pipe of the coral fragment. Four coral fragments will be located on a nursery structure. The nursery structure will be constructed from  $\frac{1}{2}$ -inch PVC pipe. The coral fragments will sit upright on the nursery structure, with the  $\frac{3}{8}$ -inch bolt sitting loosely in an upright section of  $\frac{1}{2}$ -inch pipe on the nursery structure. Companies must remove two coral fragments from the  $\frac{1}{2}$ -inch pipe of the nursery structure. Companies will receive 5 points for each coral fragment successfully removed from the structure, 10 points maximum. Successfully removing a coral fragment from the nursery structure is defined as the  $\frac{1}{2}$ -inch pipe and  $\frac{3}{8}$ -inch bolt under control of the ROV and no longer in contact with the  $\frac{1}{2}$ -inch pipe of the nursery structure. Companies will not get additional points for removing more than two coral fragments from the nursery structure.

Coral fragments will weigh less than 5 Newtons in water.

Once the coral fragments have been removed from the nursery structure, they must be outplanted onto the coral reef. Two designated areas will be located within the coral reef area. Designated areas will be constructed from a  $\frac{1}{2}$ -inch PVC pipe framework covered with a yellow-colored corrugated plastic sheet. A section of 1-inch PVC pipe will rise vertically from the designated area. Companies must insert the

coral fragment into the 1-inch PVC pipe. Companies will receive 5 points for successfully outplanting each coral fragment, 10 points total. Successfully outplanting a 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 outplanted into the designated 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 outplanting the coral fragment. If a coral fragment is displaced from the designated area, companies may attempt to outplant the coral fragment again. Companies may try outplanting the same coral fragment, or may retrieve a different coral fragment from the nursery structure and outplant that fragment.

#### **Task 2.4 Culling an outbreak of Crown of Thorn sea stars**

Companies must also cull an outbreak of Crown of Thorn sea stars. Two Crown of Thorn sea stars will be located in the coral reef area. Sea stars will be constructed from ½-inch PVC pipe. Sea stars are culled by injecting them with ox bile. For the purposes of the product demonstration, the ox bile injection will be simulated by a Velcro to Velcro stick. A 5 cm x 5 cm square of Velcro loops will be attached to the center of each sea star. Companies must attach an injection device of Velcro hooks to the Velcro loops on the Crown of Thorn sea stars.

Companies must construct and use their own sea star injection devices of Velcro hooks. Company created Velcro hooks must not exceed 6 cm x 6 cm square, should be large enough for the judge to determine that it has been attached to the sea star, and should be black in color. The station judge must be able to see the Velcro hooks attached to the Velcro loops on the sea star. Any additional objects attached to the Velcro hooks should not obscure the judge's view of the Velcro connection.

Companies will receive 5 points when they successfully inject each Crown of Thorn sea star, 10 points total. Successfully injecting the Crown of Thorns sea star is defined as the Velcro hooks on the injection device attached to the Velcro loops on the sea star. The Velcro hooks must remain attached to the sea star for 10 seconds after being released by the ROV. If the hooks fall off the sea star, companies may try again.

Each MATE Competition injection device will weigh less than 5 Newtons in water.

#### **Task 2.5 Collecting samples of sponge species for pharmaceutical research**

Companies must also collect samples of sponge species for pharmaceutical research. The sponge will be constructed from three 2-inch couplings, with weight inside, stacked on top of each other. A length of green tape around the middle of each coupling will help it to stand out from the pool bottom.

Companies are required to collect only the top most coupling. The remainder of the sponge, i.e., the bottom two couplings, must remain on the pool bottom and cannot be knocked over.

Companies will receive 10 points when the top coupling of the sponge is successfully removed from the stack. Successfully removing the top coupling is defined as the uppermost 2-inch coupling under control of the ROV and no longer in contact with the two couplings on the pool bottom. The two couplings on the pool bottom must remain stacked on top of each other for the entire product demonstration run. If

at any time the remaining stack is knocked over, companies will not receive the points for collecting the sample of the sponge.

Once the sponge sample is collected, companies may return the sponge sample to the surface. Companies will receive 5 points when they successfully return the sponge sample to the surface, side of the pool. Companies that do not receive points for collecting the sponge due to knocking over the stack, may still receive points for returning the sample to the surface, side of the pool.

With weight, the sponge sample will weigh less than 5 Newtons in water.

Companies may not destroy or knock over any portion of the coral reef area. Companies that knock over the remaining portion of the sponge sample will not get points for collecting the sponge.

Companies that displace coral fragments from the designated locations will not receive points unless those coral fragments are replaced before the product demonstration time expires. Companies that knock over the large coral colony, or drag it from its location on the reef, will be penalized 5 points. At the end of the product demonstration period, the station judge will examine the coral reef area to determine if any items have been disturbed or displaced. The station judge will confirm with the company whether points are removed or penalized due to disturbing or displacing objects in the coral reef area.

## **TASK 3: MAINTAINING HEALTHY WATERWAYS II: DELAWARE RIVER AND BAY**

**This task involves the following steps:**

- 3.1 Retrieving a sediment sample from inside a drain pipe to analyze for contaminants**
  - Deploying a device into the pipe to collect a sediment sample – 25 points
  - Returning the sample to the surface – 10 points
  - Determining the type of contaminant(s) present in the sediment sample – 5 points
- 3.2 Estimating the number of mussels in a mussel bed**
  - Deploying a quadrat and counting the number of mussels in the quadrat – 5 points
  - Estimating the number of mussels and the total amount of water filtered by the mussel bed – 5 points
- 3.3 Eel restoration**
  - Removing a trap full of eels from a designated area – 10 points
  - Placing an empty eel trap in a designated area – 10 points
- 3.4 Creating a photomosaic of a subway car submerged to create an artificial reef**
  - Take an image of the four sides and the top of the subway car – 5 points
  - Create a photomosaic of the submerged subway car
    - Autonomously– 15 points
    - Manually– 5 points

**Total points = 90 points**

**Product Demonstration Notes:**

Companies may complete the steps of Task 3: Maintaining Healthy Waterways II: Delaware River and Bay in any order.

**Task 3.1 Retrieving a sediment sample from inside a drain pipe to analyze for contaminants**

Companies will be required to retrieve a sediment sample from the end of a drain pipe and determine the type of contaminant(s) present in the sample. The drain pipe will be 3.0 to 3.2 meters in length, and constructed from [6-inch Corex drain pipe](#). The Corex drain pipe will rest on the bottom of the pool and will not curve. The far end of the pipe will be covered. The drain pipe will be weighted down.

The sediment sample will be constructed from 1-inch PVC pipe with two 1-inch end caps attached to each end. Holes will be drilled in the pipe and the end caps to allow water into the pipe. A 32-cm length of rope will act as a grab point for the sediment sample. The 1-inch pipe will be covered with [white industrial strength Velcro loops](#). The sediment sample will be located at the far end of the drain pipe.

The sediment sample will weigh less than 5 Newtons in water.

Companies may build and deploy a secondary (micro-ROV) from their primary ROV or develop and build another device to retrieve the sample from the end of the drain pipe. A micro-ROV will be considered a non-ROV device. See **Error! Reference source not found.** for additional information. Companies will receive 25 points when the sediment sample is successfully removed from the 6-inch pipe. Successfully removing the sediment sample from the pipe is defined as the 1-inch pipe of the sediment sample completely outside of the 6-inch Corex drain pipe. The micro-ROV or other device must move into the drain pipe and remove the sample. The Corex drain pipe cannot be lifted, shaken, or otherwise moved or manipulated to cause the sediment sample to fall or roll out of the open end.

Companies should be prepared for low light levels inside the Corex drain pipe.

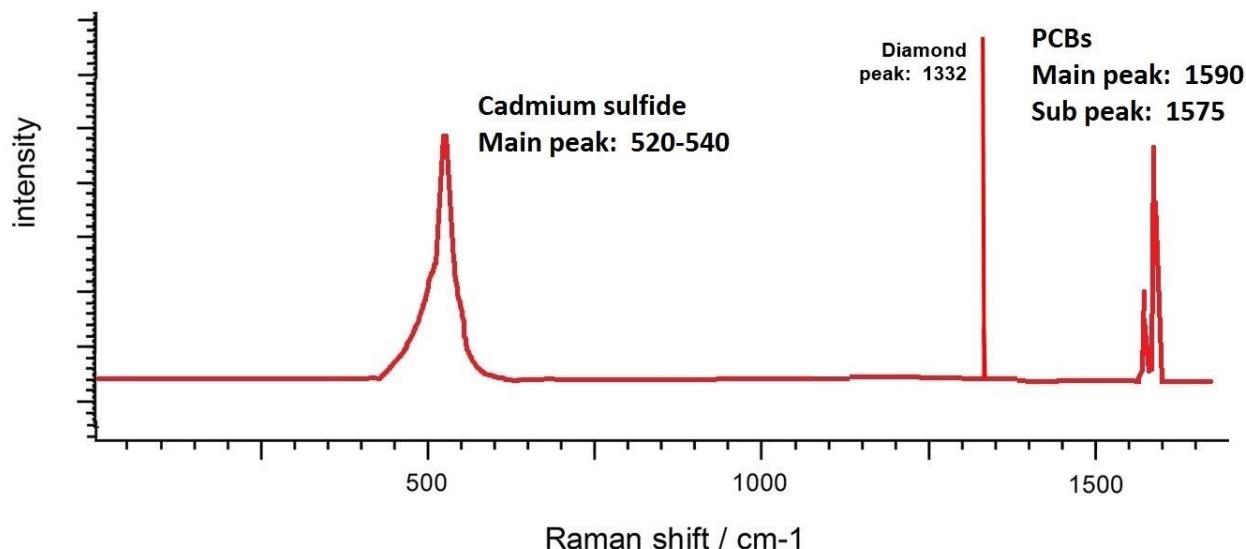
Once the sediment sample has been removed from the drain pipe, it must be returned to the surface. Companies will receive 10 points when they successfully remove the sediment sample from the pool. Successfully removing the sediment sample is defined as returning the sample to the surface, side of the pool and placing it on the pool deck.

Once the sediment sample is at the surface, companies can retrieve the sediment's Raman spectrum.\* For the telepresence category, companies will download a randomized Raman spectrum just prior to the 15-minute product demonstration run. Companies must compare the sample's spectrum to a chart of peaks and sub peaks of known chemical contaminants. Companies must evaluate the spectrum and the chart to determine what type of contaminant(s) are present in the sediment. Companies will receive 5 points when they successfully determine the contaminant(s) present in the sediment. Successfully determining the contaminant(s) is defined as showing the station judge which chemical contaminant(s) from the chart match the peaks and sub peaks of the spectrum retrieved in the sediment sample. The spectrum will contain peaks and sub peaks for one or two chemical contaminants.

\*Note: Raman spectroscopy is commonly used in chemistry to determine the chemical composition of an object or substance. It can identify and quantify molecules and produce a chemical “fingerprint” of that object or substance. The chemical fingerprint, also known as the spectrum, is generated when the scattered Raman photons pass into a detector where they are broken into their respective wavelengths and plotted. For more information about Raman spectroscopy, see the REFERENCE section of the competition manual.

In Raman spectroscopy, diamonds are used as reference peaks in spectra from unknown sources. The spectrum will have a diamond spike for reference purposes.

<u>Chemical contaminant</u>	<u>Main Peak (cm<sup>-1</sup>)</u>	<u>Sub Peak(s) (cm<sup>-1</sup>)</u>
Arsenic Sulfide	385	420
Cadmium Sulfide	520 – 540	
Copper Oxide	297	
Diamond	1332	
Lead	1054	
Mercury	547	435
Polyflouroalkyl	1560 to 1580	1325
PCBs	1590	1575



Raman spectrum of sediment contaminated with CdS (520-540 cm<sup>-1</sup>) and PCBs (1590 and 1575). Note the diamond peak (1332 cm<sup>-1</sup>).

### Task 3.2 Estimating the number of mussels in a mussel bed

Companies must estimate the number of mussels in a mussel bed. The area of the mussel bed will be constructed from a square of corrugated plastic approximately 1.2 m x 1.2 m attached to a PVC framework. The mussel bed will lay flat against the bottom of the pool. Small, painted plastic disks will simulate the mussels. Companies are required to create their own 0.5 meter x 0.5 meter quadrat and place it on mussel bed. The inner dimensions of the quadrat **MUST** be 50 cm x 50 cm square.

Companies that do not have a quadrat within 1 cm of those dimensions will not be able to complete the task. All edges of the quadrat must be completely on the corrugated plastic of the mussel bed. No portion of the quadrat may rest over the side of the corrugated plastic sheet. Companies that do not successfully deploy their quadrat may try again, but once the quadrat is successfully placed, it should not be moved (i.e. repositioned to get a different mussel count). The quadrat, if separate from the ROV, must be carried down by the ROV. The company built quadrat is not considered debris. Companies will not be penalized for leaving their quadrat in the pool at the end of mission time and, if asked, divers can retrieve the quadrat and return it to the company without penalty after the mission time ends.

Once the quadrat has been deployed, companies must count the number of mussels inside the quadrat. Companies must show the product demonstration station judge the quadrat and report the mussels within that quadrat. Companies should count every mussel that has any part of its “shell” inside the dimensions of the quadrat. For example, if only a small section of the plastic disk (mussel shell) shows inside the quadrat, it still should be counted. Companies will receive 5 points when they successfully count the number of mussels inside the quadrat and inform the station judge of that number. Successfully counting the number of mussels in the quadrat is defined as counting the same number of mussels in the quadrat as the station judge.

Companies receive one chance to count the mussels; if the company count is incorrect (i.e., not the same as the judge’s count), companies will receive 0 points for counting the mussels. Companies may still continue on using their inaccurate count, but will not receive points for counting mussels.

For the telepresence category, companies will download a randomized sheet with the mussel bed dimensions and the average filtration rate of the mussels just prior to the 15-minute product demonstration run. When the company has counted the number of mussels within the quadrat, they may consult the downloaded sheet. Companies should assume the mussel bed is rectangular. The dimensions given will be length and width (in meters) of the bed. Filtration rate of the mussels will be given in liters per hour. Companies must first use their mussel count and the area of the mussel bed to estimate the total number of mussels in the bed. Companies will receive 5 points for successfully estimating the number of mussels in the bed and the total amount of water filtered by the mussel bed every hour. A successful estimation of the number of mussels in the bed is defined as the total number of mussels being within 1 mussel of the actual count. A successful calculation of the total amount of water filtered by the mussel bed is defined as the total amount within 1 liter of the actual amount. Companies must report their total number to the station judge.

For example, if the overall size of the mussel bed is 43 meters by 8 meters, and the company counted 7 mussels in their 50 cm x 50 cm quadrat, the total number of mussels in the bed is 9,632. If the filtration rate of a single mussel is 0.97 liters per hour, the total amount of water filtered by the mussel bed in one hour is 9,343.04 liters.

### **Task 3.3 Eel restoration**

Companies must remove a trap full of eels and replace it with an empty trap to aid in eel restoration. Both eel traps will be identical. The framework for the eel trap will be constructed from  $\frac{1}{2}$ -inch PVC pipe. Plastic mesh will surround the framework. A #310 U-bolt will act as a grab point for the eel trap.

At the start of the product demonstration run, a trap with eels in it will be located in a designated area on the pool bottom. Another, empty trap will be located on the surface, side of the pool.

Eels will be simulated by 1-inch PVC pipe. The designated area will be constructed from  $\frac{1}{2}$ -inch PVC pipe.

Companies must remove the trap full of eels from the bottom and return it to the surface, side of the pool. Companies will receive 10 points for successfully removing the trap. Successfully removing the trap full of eels is defined as removing the trap from the water and placing it on the pool deck.

Companies must place the empty eel trap in the designated area on the bottom. Companies will receive 10 points for successfully placing the trap in the designated area. Successfully placing the trap is defined as the trap no longer in contact with the ROV, upright, and completely within the designated area. No portion of the trap may be sitting on top of any part of the designated area.

Both the full and the empty eel trap will weigh less than 5 Newtons in water.

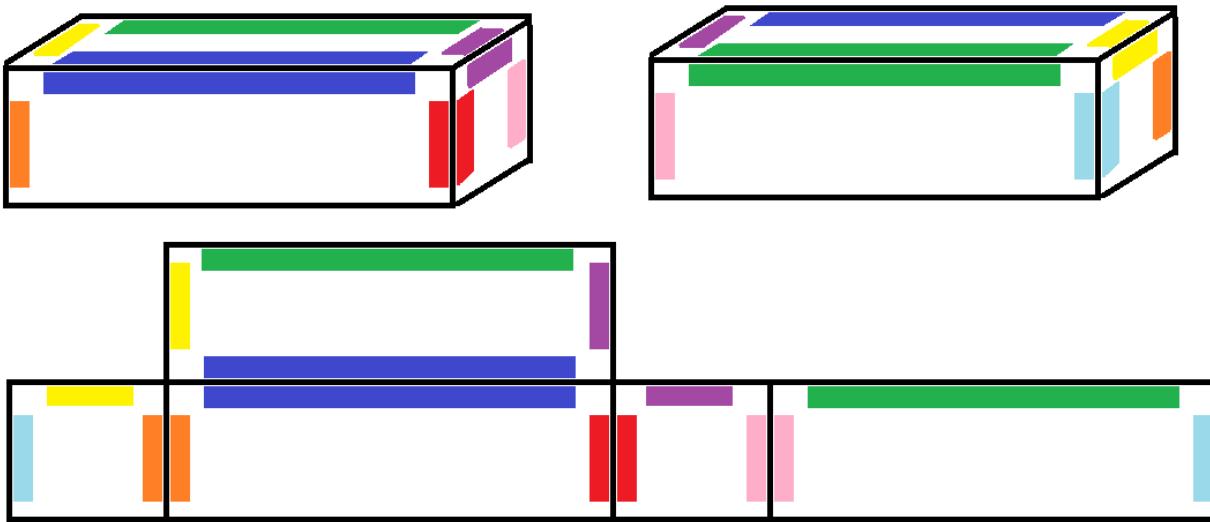
#### **Task 3.4 Creating a photomosaic of a subway car submerged to create an artificial reef**

Companies must create a photomosaic of the four sides and top of the subway car submerged to create the artificial reef. The framework for the subway car will be constructed from  $\frac{1}{2}$ -inch PVC pipe.

Corrugated plastic sheets will be attached to the four sides and to the top of the PVC framework. The simulated subway car will be approximately 120 cm long, 60 cm wide, and 60 cm tall. A length of colored tape will run along each edge, a different color for every edge. Companies may use this colored tape to assist in matching up the sides for the photomosaic.

Companies must take an image of each side of the subway car and an image of its top. Companies will receive 5 points for successfully taking an image of each side of the subway car. Successfully taking an image is defined as the entire side within the video screen and the three colors on the side clearly visible to the station judge. Companies must take all five images to get points, no partial credit is given. Companies must take all five images to proceed to the photomosaic creation task.

For the telepresence category, companies will download a randomized set of five images, one of each side of the subway car just prior to the 15-minute product demonstration run. These images must be “stitched” together showing all four sides in a row with the colored tape matching on each edge. The image of the top of the subway car must be “stitched” to the long edge (120 cm edge) of one side of the subway car.



*Top: Diagram of color matching on subway car.*

*Bottom: Photomosaic of the subway car to be displayed on video screen. Note: Colors may vary, but each subway car will have eight distinct colors on the eight edges.*

Companies are tasked with creating software to autonomously “stitch” the images together into a photomosaic. Companies that successfully “stitch” the images together autonomously will receive 15 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 five images to another device (e.g., a laptop computer or tablet) at the product demonstration 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.

Alternatively, companies may create the photomosaic of the subway car manually. Companies that successfully “stitch” the images together manually will receive 5 points. 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 attempting to create the photomosaic of the submerged subway car autonomously cannot manipulate the images prior to being transferred to the device that is stitching them together autonomously. Any manipulation of a photo would be considered manual creation of the photomosaic.

Once transferred to a device, a software program should then autonomously join the photos into a photomosaic matching the colored edges of each side of the subway car. The program should match the colors on the side of the subway cars; using the order the photos are taken / delivered to the program is not considered autonomous.

An image of the subway car photomosaic will be available in the product demonstration prop building instructions & photos document. The color combinations will be different at each mission station, but the colors on one side (top) will always match the color on the adjoining side. Colored, not white, tape will always be used.

**Time bonus:**

If a company has successfully completed all product demonstration tasks and is returning to the surface with the Seabin mesh catch bag, plastic debris, the ghost net, the sponge, or the full eel trap, the product demonstration time will stop when a member of the company touches the vehicle. The mesh catch bag, plastic debris, the ghost net, the sponge, or the full eel trap onboard may be detached and set on the pool deck after the clock has stopped. If any of these items is subsequently dropped from the vehicle and sink to the bottom, the company will not receive points for returning the item to the surface, time will not restart, and the company will not receive a time bonus.

## PRODUCT DEMONSTRATION RESOURCES

The [EXPLORER Coral Colony photo](#) will show an image of the coral colony taken one year prior.

The [EXPLORER Raman spectrum chart](#) notes the peaks and sub-peaks of various chemical contaminants.

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:

- Coral reef image for mapping
- Image of the coral colony with changes
- Raman spectrum of contaminants
- Mussel information
- Five images of the sides and top of the subway car for creating a photomosaic.

Companies should receive the files via e-mail within minutes of submitting the form. These files and images must be downloaded at the start of each attempted mission run. The uncut video of the product demonstration run must include these files being received from the form. This can be done before the 15 minute product demonstration run starts, but the video showing receipt of the files and the product demonstration run video must be uncut.

***NOTE for 2021!!!***

## PRODUCT DEMONSTRATION RESPONSIBILITIES

Companies will provide all of their own product demonstration resources. This includes in-water mission props as well as handbooks and charts at the station. 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).

Conventions: All values contained in this document are threshold values unless specifically stated otherwise. All water depths are given in meters (m). All dimensions and measurements utilize SI units.

EXPLORER class companies participating in a regional competition should contact [your regional coordinator](#) or visit [your regional contest's website](#) to find out any specific requirements for your regional.

### 2.0 SAFETY

#### 2.3 Product Demonstration Safety Inspection

Companies competing in the telepresence World Championship will submit a safety video along with their product demonstration videos. This video may be separate from the product demonstration video, or may take place prior to the product demonstration video. The safety video must show the following ROV features for the specified time:

1. 15 seconds (or more) of the 48 volt power supply (**ELEC-002E**).
2. 15 seconds (or more) showing a properly sized fuse (EXPLORER class fuses must be a Littelfuse: JCase fuse with the proper holder [HLJC1001G]). The company MUST use a ruler to show that this fuse is within 30 cm of Anderson Powerpole connectors. (**ELEC-008, ELEC-010**).
3. 30 seconds (or more) of the inside of the control box showing the wiring and components.  
MATE will be looking for:
  - o No exposed wiring (**ELEC-017**).
  - o That the control box is neatly laid out with attention to workmanship. (**ELEC-022**).

- Separation and identification of 120VAC wiring from DC and control voltages. (**ELEC-023**). If 120VAC is not used in the control box, you should video a slide stating that AC power is not used in the control box.
4. 15 seconds (or more) in the control system showing that there is no conversion of the 48V until it reaches the ROV. Power supplies, ESCs, H-Bridges or other voltage conversion devices are not allowed on the surface (**ELEC-003E & ELEC 004E**).
  5. 15 seconds (or more) showing the tether entering the ROV and strain relief for the tether (**ELEC-024**).
  6. 30 seconds (or more) showing any hydraulic / pneumatic systems including a pressure release valve and regulator in the system (**FLUID-007, FLUID-011**), and that any pressurized cylinder, pressure storage device meets the MATE specifications of (**FLUID-012, FLUID-013**). In addition, the type of fluid should be clearly stated in the video (**FLUID-002, FLUID-003, FLUID-004**). If the vehicle does not use fluid power, **you should video a slide stating that Fluid Power is not used on this ROV for 10 seconds**.
  7. 60 seconds (or more) total, 10 seconds (or more) per side of the ROV (4 sides plus top and bottom) showing that all motors are waterproofed and propellers are shrouded and protected with guards. There are no sharp edges or elements of the ROV that could cause damage (**MECH-006, ELEC-017**).
  8. 15 seconds (or more) for each powered tool, manipulator, and grabber on the ROV. Their source of power should be stated.
  9. 30 seconds (or more) showing the micro-ROV (if used). The source of power for the ROV, as well as the size of the fuse, should be stated. Companies using onboard batteries must review the properties of their battery container.
  10. 30 seconds (or more) showing the powered Seabin (if used). The power source for the Seabin should be stated.

**NOTE:** Teams are responsible for going through each of the listed specifications and showing how each item meets that specification. Just showing what you have is not sufficient, it MUST meet the called out specification.

#### ***NOTE for 2021!!!***

All items used on the ROV MUST participate in and pass safety inspection. Companies that use a device that did not participate in and pass the safety inspection will be disqualified.

## **2.5 Safety Inspection Points**

If the safety inspection video does not show compliance with all the safety rules, companies will not be scored on their product demonstration run. If companies submit their safety and product demonstration videos prior to the deadline, safety inspectors will inform the team of any violations and allow them to fix those violations and resubmit their safety and product demonstration videos. Note: It may take judges and volunteers up to 5 work days to evaluate your safety video. Companies will lose 10 points each time they fail and must resubmit a safety inspection video.

## 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. 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.

**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. This rubric will be posted by April 1, 2021. In the meantime, companies may refer to the previous year's rubrics posted [here](#) for a general idea of the categories and points. 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. This rubric will be posted by April 1, 2021. In the meantime, companies may refer to the previous year's rubrics posted [here](#) for a general idea of the categories and points.

## PART 6: SUBMISSION GUIDELINES AND KEY DEADLINES

### 6.1 Documentation

Companies advancing to the Telepresence category of the World Championship are required to submit technical documentation, a company spec sheet, a marketing display, a SID, a fluid power diagram (if

fluid power is used), a non-ROV device design document, a non-ROV device SID, and a company safety review. In addition, companies may submit a JSA, documents supporting their corporate responsibility efforts, and assets for the MATE ROV Competition VR World workstations.

***NOTE for 2021!!!***

The links provided in this section are for companies advancing to and submitting documentation for the telepresence world championship. For companies attending EXPLORER class regionals, regional contests may not require all of the documentation. Contact [your regional coordinator or visit your regional contest's website](#) to determine what documentation must be submitted for your regional and the date it is due. Submit regional documentation directly to your regional coordinator.

DOC-006: All required documentation sent to the MATE ROV Competition MUST be in searchable PDF format (see <https://fd4686477cb19f983f54-68abf00cbc1a2cc111562c013cb867db.ssl.cf1.rackcdn.com/SearchablePDFs.pdf>) for information about creating searchable PDFs. For companies attending a regional competition, coordinators will provide you with submission guidelines for documentation. See the **Assets for the MATE ROV Competition VR World** document (coming soon!) for the proper format to submissions.

DOC-007: The technical documentation may be up to 8 MB in size, the other documents are restricted to a maximum file size of 2MB.

DOC-008: All documents should use the following naming convention: School or organization name\_company name\_DOCUMENT TYPE\_2021.pdf, where DOCUMENT TYPE is technical documentation, spec sheet, marketing display, SID [type – electrical or fluid], non-ROV device design, company safety review, or JSA. For the world championship, due date for all documentation is 11:59 PM, Hawaii Time Zone, on July 1<sup>st</sup>, 2021. Submission information and forms can be found [here](#).

**Submit only your final documents and use only ONE form** (multiple files can be attached to one form). Revised documents submitted at a later date and/or multiple forms will not be accepted. The MATE competition will use the date-stamp on your form to determine your initial submission.

***NOTE for 2021!!!***

Upon submitting your documentation, you will receive a confirmation email noting all of the documents that were successfully uploaded and submitted. **Check this notification carefully to verify that all of your documents were properly uploaded and submitted!** If there was an error while submitting your documents, contact the MATE ROV Competition and upload **ALL** documents again.

### ***6.1.1 Video Demonstration Documentation***

DOC-009: Qualification videos must be submitted no later than 11:59 PM, Hawaii time, June 13<sup>th</sup>, 2021. [Video submission](#) information can be found [here](#). The following naming convention should be used for your video demonstration submissions: School or organization name\_company name\_video demonstration\_2021.

MATE competition organizers will review the videos and respond by June 18<sup>th</sup> for the qualification videos. Video submissions will NOT be accepted after June 13<sup>th</sup> – NO EXCEPTIONS. Video conferences will not be scheduled after June 13<sup>th</sup>. If the video does not clearly demonstrate that the company's vehicle meets the specifications and accomplishes the tasks, the company is not eligible to participate in the World Championship. No extensions past the due date will be given for any reason.

DOC-010: The product demonstration and safety videos must be submitted no later than 11:59 PM, Hawaii time, July 15<sup>th</sup>, 2021. Videos can be submitted [here](#). The following naming convention should be used for your video demonstration submissions: School or organization name\_company name\_video product type 2021 (where video type is Safety Compliance, product demonstration birds-eye, or product demonstration hand-held).

DOC-011: Videos must be submitted as links to a YouTube or Vimeo post. Note that the product demonstration videos must be a complete, uncut videos.

**MATE strongly encourages companies to submit their videos or arrange for a video conference with a MATE official well before June 13<sup>th</sup> for qualification or July 15<sup>th</sup> for the product demonstration.** That way, if an issue is found, companies will have the opportunity to address the issue and submit an updated video, or schedule another video conference, before the deadline. **Note that it may take MATE up to 5 working days to evaluate a video submission or respond to a request to schedule a video conference.**

#### ***6.1.2 Image Recognition Documentation***

##### ***NOTE for 2021!!!***

The MATE ROV Competition is not requiring documentation submission for autonomous control or image recognition in 2021.

#### ***6.1.3 Corporate Responsibility Documentation***

DOC-015: Submission information for corporate responsibility efforts can be found [here](#):

DOC-016: The following naming convention should be used for corporate responsibility documentation: School or organization name\_company name\_Corporate Responsibility ##\_2021, where ## is the number of the document uploaded. You can upload a variety of file types (pdfs, jpegs, etc.) and multiple files, but the size of each file should not exceed 2MB. Number each file to distinguish between them.

**Submit only your final corporate responsibility documents and use only ONE form** (multiple files can be attached to one form). Revised documents submitted at a later date and/or multiple forms will not be accepted. The MATE competition will use the date-stamp on your form to determine your initial submission.

DOC-017: For the world championship, due date for the corporate responsibility documentation is 11:59 PM, Hawaii Time Zone, on July 1<sup>st</sup>, 2021.

NOTE: By submitting your documentation, you are giving the MATE ROV Competition permission to publish these documents on its web site.

## 6.2 KEY DEADLINES

Below is a summary of key dates and deadlines for the 2021 MATE competition season. Note that regional competitions will have their own set of key dates and deadlines. For companies attending EXPLORER class regionals, contact [your regional coordinator or visit your regional contest's website](#) for more information.

- December 1, 2020: Registration opens (note that registration for the World Championship and individual regional competitions will open as locations and dates are secured).
- April 26, 2021: Last day to register for the fluid power quiz.
- May 15, 2021: Last day to submit laser specifications, hydraulic fluid information, and pressure release valve specifications. Companies with regional competitions earlier than May 15 should plan to submit specifications early to allow at least 1 week for approval.
- June 13, 2021: EXPLORER class video demonstration submission deadline.
- **New this year!!!** June 24, 2021: Deadline for companies that qualify to register for the World Championship in either the In-Person or Telepresence category.

Companies competing in the Telepresence category of the World Championship have the additional deadlines of:

- July 1, 2021:
  - 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 for MATE ROV COMPETITION VR WORLD workstations:
    - Company name, organization/school name, home state and/or country, and tagline
    - Company logo
    - 3 number of photos for the photo wall
    - Slideshow of images
    - 3D CAD or photo of ROV

- Marketing display “commercial” submitted as a video, slideshow, or GIF

**NOTE: Details on the VR World workstations assets will be provided in a separate document and are coming soon!**

- July 1, 2021: Deadline to register for a scheduled time slot for the company’s Engineering Presentation, which will take place between July 16-22, 2021
- July 15, 2021: Submission deadline for the company’s Product Demonstration and Safety Inspection videos (**additional details coming soon!**)

**\*\*\*IMPORTANT!!!** Regional competition winners will have 10 days after their regional event to submit their VR WORLD assets; companies progressing through either the [EXPLORER](#) or [RANGER](#) class video demonstration submission pathway will have until July 1 to submit their assets for the VR space, but are highly encouraged to submit their assets early in order to best “promote” their company products and services to the VR World!