2022 MATE ROV COMPETITION: PRODUCT DEMONSTRATION AND SPECS BRIEFING

MATE Competition Philosophy

The MATE ROV competition is about **student learning**.

It is designed to be an event that challenges **students** to apply the physics, math, electronics, and engineering skills they are learning in the classroom to solving problems from the workplace.

Mentors (teachers, parents, working professionals) are expected to limit their input to educational and inspirational roles and encouraged to focus on the benefits of the **learning process** and not simply on "winning" the competition.

UN Decade of the Ocean: MATE Inspires ESG

CONTEXT & NEED

The global ocean community is invited to plan for the next ten years in ocean science and technology to deliver, together, the ocean we need for the future we want!
– United Nations Decade of Ocean Science for Sustainable Development

The MATE ROV Competition has accepted this invitation and is challenging its global community of learners to come together to innovate, create, and develop solutions to the problems that impact us all.

The United Nations proclaimed a *Decade of Ocean Science for Sustainable Development* (2021-2030) to support efforts to reverse the cycle of decline in ocean health and to gather the global community behind a common goal: creating improved conditions for sustainable use and development of our world ocean.

The ocean is the largest component of our planet's ecosystem; it stabilizes climate and supports life on Earth and human well-being. However, the First World Ocean Assessment report released in 2016 found that much of the ocean is now seriously degraded, with changes and losses in the structure, function, and benefits from ocean systems.

Understanding how the ocean responds to pressures and taking action to improve management practices is critical for sustainable use and development of this precious resource. Ocean observations and research are critical to predicting the consequences of change, designing ways to mitigate these consequences, and guiding communities to embrace and adapt these practices for the good of us all.

It's no secret that one of the biggest threats the world ocean faces is the impact of climate change. Marine habitats and wildlife are already suffering the consequences of rising sea temperatures and acidification, as are the coastal communities that depend on them. The impact of multiple pressures on the ocean is projected to increase as the human population grows towards the expected 9 billion by 2050. Without aggressive action to reduce carbon emissions over the next decade, the damage to our oceans and our planet has the potential to be horrific.

Marine renewable energies (MREs), such as offshore wind farms, tidal turbines, wave energy converters, and floating solar panels, play a key role in mitigating the effects of climate change and paving the pathway to a sustainable future. MREs provide a significant contribution to the production of low-carbon renewable energy around the world and are an important ally in the fight against climate change. Another ally is Blue Carbon, which is the carbon stored in coastal and marine ecosystems, such as mangroves and seagrasses, the latter of which can absorb and store carbon 35 times more efficiently than rainforests. Aquaculture, the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments, is also an ally in the quest for a sustainable future on our ocean planet. It is the fastest growing food supply sector in the world and is and will continue to be needed to feed an ever-growing human population.

This MATE ROV Competition season the "client" is once again us – our global community – and each task area included within the request for proposals (RFP) aligns with one or more the 17 UN Sustainable Development Goals that, while not specific to the Decade of the Ocean, offer a blueprint to achieve a better and more sustainable future for all. Each task also embraces ESG – the environmental, social, and governance factors that more and more companies and organizations are taking into consideration when making business and management decisions.

Joined by partners Ocean Infinity, Reach The World, and the National Science Foundation-funded GO-BGC Project, among others, the MATE ROV Competition is challenging its community to design and build a remotely operated vehicle and the necessary sensors and tooling to support work to combat climate change, provide clean energy, feed our growing global population, monitor ocean health, preserve our maritime history, and "deliver, together, the ocean we need for the future we want!"

And this is where your mission begins.

TASK 1: Marine Renewable Energy
UN Sustainable Development Goals:

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

TASK 2: Offshore Aquaculture and Blue Carbon
UN Sustainable Development Goals:

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

TASK 3: Antarctica Then and Now – Endurance22 and MATE Floats!
UN Sustainable Development Goal:

- **#13 Climate Action**

REFERENCES

United Nations Decade of Ocean Science for Sustainable Development
17 UN Sustainable Development Goals

A Hotter Future Is Certain, Climate Panel Warns. But How Hot Is Up to Us.
ESG (environmental, social and governance)
Ocean energy: An important ally in the fight against climate change
Marine Renewable Energy
The Blue Carbon Initiative
What is aquaculture?
Value and importance of aquaculture

TASK 1: Marine Renewable Energy
Sea Technology August 2021
The Technology of Offshore Wind Power and the Morro Bay Wind Farm
A metaheuristic optimization model for the inter-array layout planning of floating offshore wind farms - ScienceDirect
The world's first offshore diver less remote hyperbaric tie in operation

TASK 2: Offshore Aquaculture and Blue Carbon
Aquaculture ROVs in The Fish Farming Industry
Aquaculture Cage Net Inspection with Autonomous ROV Navigation
Net Patch Tool Demonstration | Aquaculture
AI Applied to Aquaculture Aims for Improved Efficiency, Healthier Fish
Nonintrusive methods for biomass estimation in aquaculture with emphasis on fish

TASK 3: Antarctica Then and Now – Endurance22 and MATE Floats!
Super colossal holes in Antarctic ice demystified by scientists
GO-BGC | Global Ocean Biogeochemistry Array
2021 MATE Floats! | MATE ROV Competition Website
Endurance22
Shackleton Expedition Color Photos
Benthos in Antarctic Weddell Sea in Decline

DESIGN BRIEF

Below is a summary of the product demonstrations organized by competition class – EXPLORER, PIONEER, * RANGER, NAVIGATOR, and SCOUT. All three product demonstration tasks will be attempted in one product demonstration run.

**Introducing the PIONEER class! PIONEER class is open to first year community colleges and university teams. More information on the PIONEER class will be posted on the MATE ROV Competition website.*

TASK 1: Marine Renewable Energy

Ocean Infinity supports the installation and maintenance of marine renewable energy systems, including floating and fixed offshore wind turbines. The company is equipping its Armada fleet of uncrewed robotic surface vessels with the capability to operate other underwater technologies, such as ROVs, from these platforms. While the vessels are controlled remotely, there is room for a "lean" crew to travel with the ROV to conduct inspections and routine maintenance of offshore wind farms and their

impact on the surrounding environment. The goal is to eventually provide a resident ROV that "lives" on the farm and is preprogrammed to do inspections, maintenance, and monitoring at given time intervals. Until that capability is developed, operators will continue pilot ROVs to complete these tasks as well as to test out the ability of the ROV to "park" itself in a docking station.

EXPLORER, PIONEER, and RANGER tasks:

- Replace a damaged section of an inter-array power cable
    - Conduct a visual inspection of the cable
    - Cut the cable on both sides of the damaged section
    - Remove the damaged section of cable
    - Install a new section of cable
    - Secure the new section of cable in place with wet-mateable connectors
- Replace a damaged buoyancy module on an inter-array cable of a floating offshore wind turbine
    - Remove the failed buoyancy module from the cable
        - Release the clamp
        - Recover the failed buoyancy module
    - Attach a new buoyancy module to the cable
- Monitor the environment
    - Deploy a hydrophone to detect and record the presence of marine mammals
        - Deploy a hydrophone in a designated area
        - Recover the hydrophone to evaluate data
    - Remove a ghost net caught on the wind turbine's substructure
- Pilot into "resident ROV" docking station
    - Autonomously
    - Manually

NAVIGATOR tasks:

- Replace a damaged section of an inter-array power cable
    - Conduct a visual inspection of the cable
    - Cut the cable on both sides of the damage section
    - Remove the damaged section of cable
    - Install new section of cable
- Replace a damaged buoyancy module on an inter-array cable of a floating offshore wind turbine
    - Remove the failed buoyancy module
        - Release the clamp
        - Recover the failed buoyancy module
    - Attach a new buoyancy module
- Monitor the environment
    - Deploy a hydrophone to detect and record the presence of marine mammals
        - Deploy a hydrophone in a designated area
        - Recover the hydrophone to evaluate data
    - Remove a ghost net caught on the wind turbine's substructure

SCOUT tasks:

- Replace a damaged section of an inter-array power cable
    - Remove the damaged section of cable
    - Install a new section of cable
- Attach buoyancy modules to inter-array cables of a floating offshore wind turbine
    - Remove the failed buoyancy module
    - Attach a new buoyancy module
- Support environmental impact studies
    - Deploy a hydrophone to detect and record the presence of marine mammals
    - Remove a ghost net caught on the wind turbine's substructure

TASK 2: Offshore Aquaculture and Blue Carbon

Aquaculture companies like Forever Oceans use ROVs like the BlueROV2 to inspect offshore aquaculture pens and maintain a healthy environment for both fish stock and the surrounding ocean community. Similar to offshore wind farms, the goal is to eventually "park" an ROV within the pen and preprogram it to carry out inspections and maintenance. However, until that time, operators are needed to perform these tasks, which include inspecting the nets for structural integrity, making repairs, and removing fish mortalities (aka "morts").

In addition to marine renewables, Ocean Infinity supports Blue Carbon initiatives like Project Seagrass. Project Seagrass restores and cultivates seagrass beds, which are extremely effective at absorbing and storing CO_2. Project Seagrass is currently looking for a mechanism that can both "plant" new and prune existing seagrass beds; pruning keeps the grasses healthy and promotes growth.

EXPLORER, PIONEER, and RANGER tasks:

- Inspect an offshore aquaculture fish pen
    - Inspect the netting to identify damaged areas
        - Fly a transect either autonomously or manually to identify damaged areas
        - Identify and count damaged areas
    - Repair the damaged area
    - Remove marine growth
        - Remove encrusting marine growth
        - Remove algal marine growth
- Maintain a healthy environment for fish stock
    - Manage mortality by removing morts from the fish pen
        - Use AI to differentiate morts from live fish
        - Collect a mort
        - Insert the mort into the collection tube
- Measure fish size
    - Determine the average size of the fish stock
    - Determine the biomass of the fish
- Farm seagrass
    - Prune an existing seagrass bed

- Plant a new bed of seagrass

NAVIGATOR tasks:

- Inspect an offshore aquaculture fish pen
  - Inspect the netting to identify damaged areas
  - Repair the damaged area
  - Remove marine growth
    - Remove encrusting marine growth
    - Remove algal marine growth
- Maintain a healthy environment for fish stock
  - Manage mortality by removing morts from the pen
    - Collect a mort
    - Insert the mort into the collection tube
- Farm seagrass
  - Prune an existing seagrass bed
  - Plant a new bed of seagrass

SCOUT tasks:

- Inspect an offshore aquaculture fish pen
  - Repair the damaged area
  - Remove marine growth
    - Remove encrusting marine growth
    - Remove algal marine growth
- Maintain a healthy environment for fish stock
  - Manage mortality by removing morts from the pen
- Farm seagrass
  - Prune an existing seagrass bed
  - Plant a new bed of seagrass

TASK 3: The Antarctic Then and Now – Endurance22 and MATE Floats!

The goal of the National Science Foundation (NSF)-funded GO-BGC Project is to build a global network of chemical and biological sensors that will monitor ocean health. Scientists, engineers, and technicians are using NSF grant funds to build and deploy 500 robotic ocean-monitoring floats around the globe, including in Antarctic waters.

Reach The World is part of an expedition to find the *Endurance*, Sir Ernest Shackleton's ship which was crushed by sea ice and sank in the Weddell Sea in November 1915. Organized and funded by the Falklands Maritime Heritage Trust, *Endurance22* is scheduled to set sail in February 2022. While the coordinates where the ship sank were documented, the challenge lies in accessing the wreck. The expedition will use an icebreaker to get close to the location; if they can't reach the site itself, they will set up a camp on the moving pack ice. The plan is drill holes in the ice through which operators will deploy an ROV, flying transects until they find the ship.

While its primary focus is the search for the shipwreck, the expedition represents an opportunity to gather data on the extraordinarily diverse range of species, including sponges, sea stars, and cold-water corals, that inhabit the benthos of the Weddell Sea. Given the remoteness and infrequency in studying and sampling, it's been difficult to predict how benthic communities will react to climate-based changes in the environment.

EXPLORER, PIONEER, and RANGER class tasks:

- *MATE Floats!*
    - Recover a GO-BGC float to conduct diagnostics
        - Determine the location where the float will next surface
        - Recover the float
    - Design and construct an operational vertical profiling float
        - Prior to the competition, build a profiling float
        - Deploy the float in the designated area
        - Complete vertical profiles
- Endurance22
    - Find and map the location of the *Endurance*
        - Fly a transect over the area of the wreck
        - Map the wreck
    - Create a photomosaic of the wreck
        - Collect images of all sections of the wreck
        - Create a photomosaic
    - Measure the length of the wreck

Or (if the expedition is postponed until 2023!)

- Polar science
    - Fly a benthic transect and map the location of glass sponges, brittle stars, and sea stars
        - Fly a transect over the area
        - Map benthic species
    - Create a photomosaic of transect area
        - Collect images of the area
        - Create a photomosaic
    - Collect samples of benthic species
        - Collect a glass sponge
        - Collect a brittle star

NAVIGATOR tasks:

- *MATE Floats!*
    - Recover a GO-BGC float to conduct diagnostics
        - Determine the location where the float will next surface
        - Recover the float
- Endurance 22
    - Find and map the location of the *Endurance*

        - Fly a transect over the area of the wreck
        - Map the wreck
    - Measure the length of the wreck

Or (if the expedition is postponed until 2023!)

- Polar Science
    - Fly a benthic transect
    - Map the location of glass sponges, brittle stars, and sea stars
    - Collect samples of benthic species

SCOUT tasks:

- *MATE Floats!*
    - Recover a GO-BGC float to conduct diagnostics
        - Determine the location where the float will next surface
        - Recover the float
- Endurance22
    - Deploy an anchored buoy to mark the location of the shipwreck

Or (if the expedition is postponed until 2023!)

- Polar science
    - Collect samples of benthic species

SPECS

What follows is a summary of the electrical and fluid power requirements for each competition class. The complete design and building specifications will be included within the competition manual.

NOTE: Watch for new safety requirements and additional, detailed electrical specifications within the competition manuals.

EXPLORER

- 48 volts, 30 amps DC. Conversion to lower voltages must be done on the ROV, not topside.
- Pneumatics and hydraulics are permitted provided that the company follows the specifications included within the competition manual.
- Lasers are permitted provided that the team follows the specifications included within the competition manual.
- Camera is required.
- Depth requirement at the international competition: 4 meters.
- Maximum size: None. However, tasks will require companies to launch through a 1-

meter x 1-meter square hole in the “ice” and pilot inside a 1 cubic meter docking station.
- Maximum weight: 35 kg. Vehicles above 35 kg will not be allowed to compete in the product demonstration. See below for additional details on weight requirements.

PIONEER

- 48 volts or 12 volts, 30 amps DC. If 48 volts is used, conversion to lower voltages must be done on the ROV, not topside.
- Pneumatics and hydraulics are permitted provided that the company follows the specifications included within the competition manual.
- Lasers are permitted provided that the team follows the specifications included within the competition manual.
- Camera is required.
- Depth requirement at the international competition: 4 meters.
- Maximum size: None. However, tasks will require companies to launch through a 1-meter x 1-meter square hole in the “ice” and pilot inside a 1 cubic meter docking station.
- Maximum weight: 35 kg. Vehicles above 35 kg will not be allowed to compete in the product demonstration. See below for additional details on weight requirements.

RANGER

- 12 volts, 25 amps DC. Conversion to lower voltages is permitted topside and on the ROV.
- Pneumatics and hydraulics are permitted provided that the company follows the specifications included within the competition manual.
- Lasers are permitted provided that the team follows the specifications included within the competition manual.
- Camera is required.
- Depth requirement at the international competition: 2.5 meters. Depth requirement may vary at regional competitions. Contact your regional coordinator or check your regional competitioninformation document.
- Maximum size: None. However, tasks will require companies to launch through a 1-meter x 1-meter square hole in the “ice” and pilot inside a 1 cubic meter docking station.
- Maximum weight: 25 kg. Vehicles above 25 kg will not be allowed to compete in the product demonstration. See below for additional details on weight requirements.

NAVIGATOR

- 12 volts, 15 amps DC. Conversion to lower voltages is permitted topside and on the ROV. Anyonboard electrical power source is not permitted.
- Manually powered hydraulics and pneumatics are permitted. Pneumatic systems cannot exceed ambient pool pressure and must follow the fluid power specifications included within the competition manual.

- Lasers are NOT permitted.
- Camera is required.
- Depth requirement: Varies depending on the regional event. Contact your regional coordinatoror check your regional competition information document.
- Anderson Powerpole connectors are required on all vehicles.
- Maximum size: None. However, tasks will require companies to launch through a 1-meter x 1-meter square hole in the "ice."

SCOUT

- 12 volts, 15 amps DC. Conversion to lower voltages is permitted topside and on the ROV. Any onboard electrical power source is not permitted.
- Manually powered hydraulics and pneumatics are permitted. Pneumatic systems cannot exceed ambient pool pressure and must follow the fluid power specifications included within the competition manual.
- Lasers are NOT permitted.
- Depth requirement: Varies depending on the regional event. Contact your regional coordinator or check your regional competition information document.
- Anderson Powerpole connectors are required on all vehicles.
- Maximum size limit: None.

WEIGHT POINT VALUES

Considering some of the environments in which the ROVs will be operating, an ROV weight requirement has been included in the request for proposals (RFP). Lighter vehicles will be given special consideration and vehicles above a certain weight will not be considered. Certain product demonstration tasks will also limit the overall size of the vehicle.

All weight measurements will include the vehicle, all tools and components, and the tether. The following will NOT be included in the length or weight measurement:

- The topside control system and 1 meter of tether going into the control system
- EXPLORER, PIONEER, and RANGER vertical profiling floats

EXPLORER & PIONEER

Weight (in air)	
< 20 kg	**+10 points**
20.01 kg to 28 kg	**+5 points**
28.01 kg to 35 kg	**+0 points**

Vehicles that cannot fit through the hole in the ice, or vehicles greater than 35 kg in weight will not be allowed to compete in the product demonstration.

RANGER

Weight (in air)	
< 15 kg	+10 points
15.01 kg to 20 kg	+5 points
20.01 kg to 25 kg	+0 points

Vehicles that cannot fit through the hole in the ice, or vehicles greater than 25 kg in weight will not be allowed to compete in the product demonstration.

NOTE: In addition to the weight limitations described above, companies must be able to transport the vehicle and associated equipment to the product demonstration station and to the engineering presentation room. The ROV systems must be capable of being safely hand launched.

RESOURCES

Teams are permitted to use the materials of their choice provided that they are safe, will not damage or otherwise mar the competition environment, and are within the defined design and building specifications.

Teams are encouraged to focus on engineering a vehicle to complete the product demonstration tasks, when considering design choices, teams should ask themselves which one most efficiently and effectively allows them to solve the problem. Re-using components built by previous team members is permitted provided that the current team members evaluate, understand, and can explain their engineering and operational principles. Using or re-using commercial components is also permitted, provided that team members evaluate, understand, and can explain their engineering and operational principles. Teams will be questioned extensively on their overall design and component selections during their engineering presentations.

TIME

The complete competition manual will be released by November 30, 2021; teams have from that date until the regional events in the spring of 2022 to construct their vehicles and prepare the engineering and communication components (technical documentation, engineering presentations, and marketing displays). Visit www.materovcompetitionorg or join the MATE competition listserv to ensure a timely delivery.