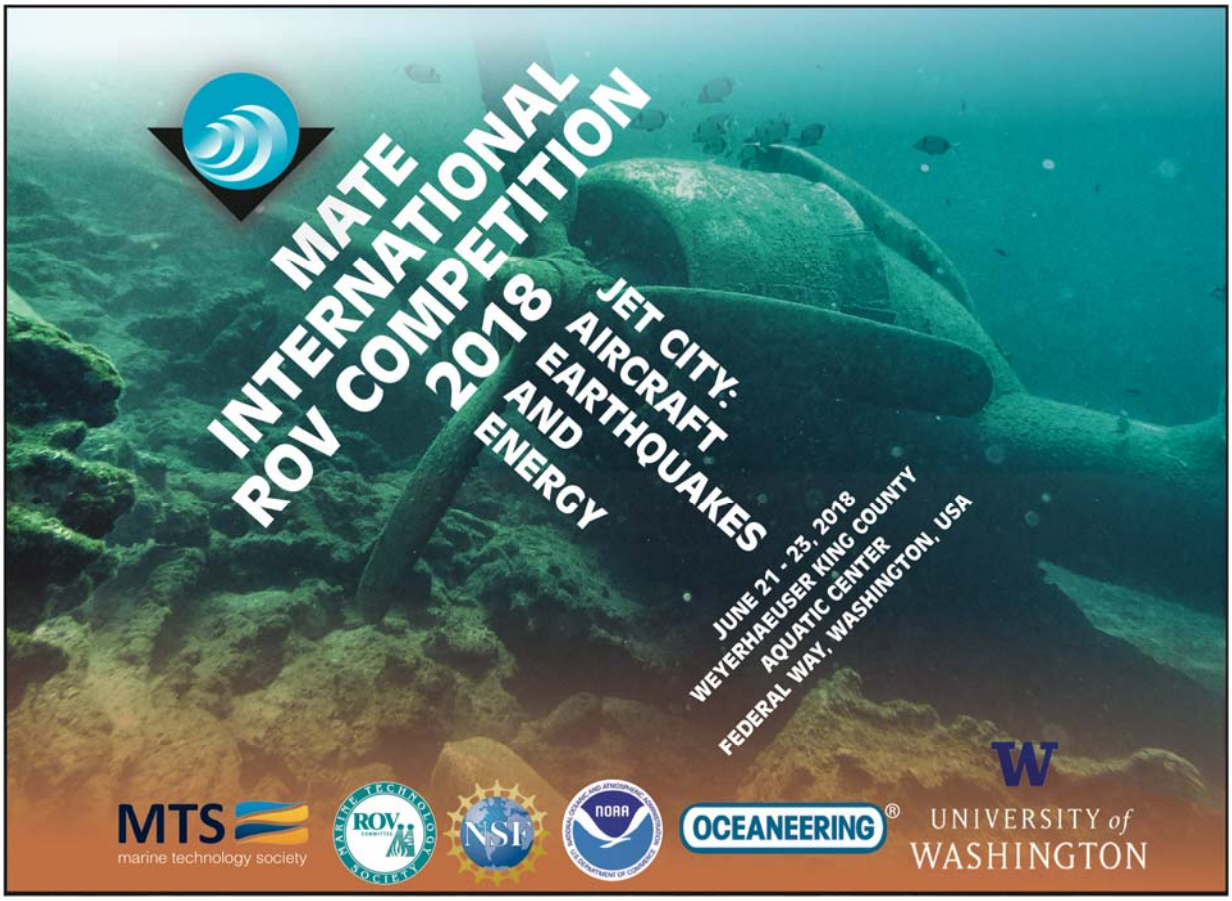
2018

MATE ROV COMPETITION
MANUAL

EXPLORER



2018 MATE ROV COMPETITION:

Jet City: Aircraft, Earthquakes, and Energy

EXPLORER CLASS COMPETITION MANUAL

For general competition information, including a description of the different competition classes, eligibility, and demonstration requirements, visit Team Info.

CONTENTS

OVERVIEW

THINK OF YOURSELVES AS ENTREPRENEURS

From the exploration of shipwrecks to the remediation of disturbed underwater habitat and installation of instruments on the seafloor, individuals who possess entrepreneurial skills are in high demand and stand out in the crowd of potential job candidates. What are entrepreneurial skills? They include the ability to understand the breadth of business operations (e.g., finances, research and development, media outreach), work as an integral part of a team, think critically, and apply technical knowledge and skills in new and innovative ways. Individuals who develop a mindset for innovation and collaboration will be well prepared for the global workplace and ready to tackle today – and tomorrow's – societal challenges.

To help you to better understand and develop these skills, the MATE ROV competition challenges you to think of yourself as an entrepreneur. Your first task is to create a company or organization that specializes in solutions to real-world marine technology problems. Use the following questions as a guide.

- What is your company name?
- Who are its leaders – the CEO (chief executive officer – the leader) and CFO (chief financial officer who oversees the budget and spending)?
- Who manages Government and Regulatory Affairs (i.e. who's in charge of reviewing the competition rules and making sure that they are understood and followed by everyone)?
- Who is responsible for research and development (R&D)?
- Who is responsible for system(s) engineering? Design integration? Testing? Operations?
- Who is responsible for fund-raising, marketing, and media outreach?
- What other positions might you need? (Depending on your personnel resources, more than one person may fill more than one role.)
- What products and services do you provide?
- Who are your potential clients?

In this case, the MATE Center and the Applied Physics Laboratory at the University of Washington are your "clients" who recently released a request for proposals. A request for proposals (RFP) is a document that an organization posts to solicit bids from potential companies for a product or service.

The specifics of your product design and rules of operation as well as the specifics of your product demonstration are included below.

EXPLORER CLASS DEMONSTRATION

All EXPLORER class companies are required to submit a video that:

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

Video specifications:

The video MUST show the following ROV features for the specified amount of time. Companies can narrate the video to better explain how their vehicle meets these required specifications.

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 fuse. 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**).
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 the platform.
   See specifications **(MECH-004 & MECH-005).**
2. Completing the required tasks*. This includes:
   a. Step 3 of the AIRCRAFT task: Removing debris from the engine.
      For this demonstration, the debris must be on the bottom of the pool, and a designated area located at least 1.5 meters away. Companies must:
      i. Attach their lift bag to the debris
      ii. Inflate the lift bag
      iii. Move the debris to the designated area
      iv. Release the lift bag from the debris
   b. Step 4.1 of the EARTHQUAKES task: Level the OBS.
      For this demonstration companies must rotate the leveling mechanism on two corners of the OBS 1080^{o} (3 times around). Companies do not actually need to level the OBS, just rotate two of the four leveling mechanisms.
   c. Step 5.2 of the ENERGY task: Attach the ADV to the mooring line.
      For this demonstration, companies must attach their velocimeter to a #310 U-bolt located partway up the chain of the mooring. Companies are not required to place the mooring; it may be set up in the demonstration pool already.

The camera angle must demonstrate that the ROV is under its own power and not being guided by human assistance when in the water. The MATE Center 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 do not need to submit a video showing completion of the required tasks. **However, these companies a must still submit the required specifications video.**

See 6.1.1 Video Demonstration Documentation for submission information.

In addition to submitting a video, EXPLORER class companies may be asked to attend the regional competition that is geographically closest to them to demonstrate their vehicle and/or assist with the event.

Regional competitions benefit from the participation of EXPLORER class companies by:

- Showcasing EXPLORER ROVs to RANGER, NAVIGATOR and SCOUT class companies to help them to learn about advanced systems and get ideas for "next year"
- Inspiring RANGER, NAVIGATOR, and SCOUT students to see what's possible if they continue to progress through the competition classes
- Providing examples of educational pathways and potential post-secondary institutions and programs to continue to pursue STEM learning
- Having access to additional volunteers and judges

Companies benefit from attending the regional by:

- Having access to the product demonstration props and the opportunity to conduct a "wet" run
- Receiving feedback from safety inspectors, including identification of potential safety violations and what can be done to enhance their vehicle from a safety standpoint
- Receiving technical help from engineers and technicians as well as from other companies
- Gaining insight and sharing ideas with other companies
- Earning points for the corporate responsibility portion of the competition

Regional coordinators will be reaching out to EXPLORER companies in their region. If your company has not been contacted by March 16th, please contact the coordinator of the regional contest nearest you or the MATE Center for more information regarding your participation.

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: AIRCRAFT
TASK #2: EARTHQUAKES
TASK #3: ENERGY

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**)
    - 260 points (max), plus a time bonus
    - Size and weight restrictions
        - 20 points (max)
    - Product demonstration safety and organizational effectiveness
        - 20 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
        - 10 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 = 640

TIME

Each product demonstration includes:

- 5 minutes to set up at the product demonstration station
- 15 minutes to attempt the tasks
- 5 minutes to break down and exit the product demonstration station

Your company will have 5 minutes to set up your system, 15 minutes to complete the tasks, and 5 minutes to demobilize your equipment and exit the product demonstration station. During the 5-minute set-up, you may reassemble your vehicle after the size determination and weigh-in and place it in the water for testing and/or trimming purposes. The 15-minute demonstration period will begin after the full 5 minutes of set up time expires, regardless of whether the company is ready to start the

product demonstration. It may begin sooner if your CEO notifies the product demonstration station judges that your company is ready to begin.

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 only be stopped by a judge who determines it is necessary for reasons beyond your control. Otherwise, the clock will only stop after all of the tasks are successfully completed, the ROV has returned to the surface under its own power so that it touches the side of the pool, and a company member at the product demonstration station has physically touched the vehicle. Your ROV is not required to return to the surface between tasks.

Your 5-minute demobilization will begin as soon as the 15-minute demonstration time ends, regardless of where your ROV is located (i.e., still at depth, on the surface, etc.).

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.

CONTEXT

The Pacific Northwest area of Washington State is known for its beautiful and lively geography, sitting between the Olympic and Cascade Mountain ranges, their snowcapped peaks hiding temporarily dormant volcanoes and tectonic plates prone to earthquake activity. The combinations of volcanic eruptions and earthquakes have shaped this piece of North America, raising the mountains and creating rivers via the snow melt that flow into deepwater lakes. Earthquakes also cause mudslides, landslides, and lahars that have wiped out large forested areas and resculpted the terrain. A fjord ties the Seattle area to the rest of the world through the Pacific Ocean. Known as Puget Sound, this fjord was formed by these same earth-moving forces. Puget Sound is also susceptible to another earthquake effect: the tsunami.

Seattle's history reflects a wide variety of businesses based on the local geography and natural resources, beginning with logging, farming, and fishing and evolving to high-tech and bio-tech. In addition to this, Seattle is the birthplace of Starbucks, Microsoft, and Boeing, which is why Seattle is known as "Jet City." This only adds to the popularity of the Seattle and Tacoma ports that started booming during the Alaska gold rush. These ports continue to be some of the busiest ports on the west coast today.

The Pacific Northwest has been developed and is constantly changing, but a general reverence for the area's rugged beauty has been a constant. In light of growing concern for the humankind's impact on our world, people in the Pacific Northwest are leading efforts to research and quantify these effects. Brilliant young minds that grew into being on the cutting-edge of the manufacturing and high-tech

industries are now coming together to develop renewable energy options and reduce the dependence on petroleum. Areas of previous industrial activity or environmental disasters are being restored. Invasive species are being removed, while both plant and animal native species are being reintroduced. Organized volunteers educate the public on how to responsibly enjoy all the natural beauty of the Pacific Northwest – and to fight to keep it for all to enjoy for generations to come.

NEED

The Applied Physics Laboratory (APL) at the University of Washington (UW) has issued a request for proposals (RFP) for a remotely operated vehicle (ROV) and crew that can operate in salt and fresh water in the Pacific Northwest. The specific tasks for the ROV and operators include:

1) Locating the wreckage of a vintage aircraft and returning its engine to the surface.
2) Installing or recovering a seismometer.
3) Installing a tidal turbine and instrumentation to monitor the environment.

Before launch and operations, the ROV must complete a series of "product demonstrations" staged at a swimming pool at various regional locations. (Depth requirements vary depending on competition class; see **SPECIFICATIONS** below.) The contract will be awarded to companies that successfully complete the product demonstrations and deliver exceptional engineering and communication components (e.g. technical documentation, engineering presentations, and marketing displays).

(Visit www.youtube.com/watch?v=Tn-jUbpFV4A for sound advice from MATE judge Marty Klein. He references 2015, but his words still hold true for this competition season!)

REQUEST FOR PROPOSALS (RFP)

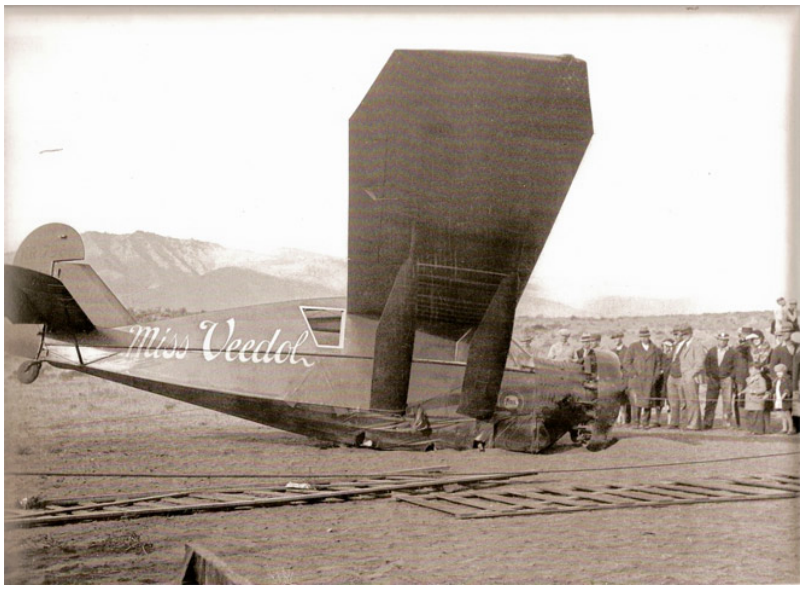
1. General

a. Aircraft

From the dawn of human flight to today, the Pacific Northwest has witnessed flying history from dirigibles and fabric biplanes to jumbo jets, from epic pioneering flights to innovative companies making world travel routine. The region's "history of flight" began in 1910, when American aviator Charles K. Hamilton, known as the "Crazy Man of the Air," became the first to fly an airplane in Washington State at the Meadows Race Track. The Meadows was the premier venue in the Northwest for horse racing in the early 20th century; motorcycles and cars shared the track, and airplanes soon followed.

Another remarkable event in the region's history of flight was in 1931 when the first non-stop trans-Pacific flight ended in a cloud of dust near Wenatchee, Washington. More than 41 hours and 8,000 kilometers after departing Misawa, Japan, Clyde Pangborn and Hugh Herndon, Jr. performed a controlled crash landing. They emerged from their Bellanca Skyrocket, which they named *Miss Veedoh* for a brand of motor oil, as the first aviators to fly non-stop across the Pacific. It wasn't until after World War II that another airplane would

repeat the feat. Pangborn had grown up in western Washington, and today, in honor of the journey, the Wenatchee airport bears his name – Pangborn Memorial Airport.



The end of the trans-Pacific journey for the *Miss Veedoh*
https://www.wired.com/2010/10/1005first-nonstop-transpacific-flight/

However, few would argue that the single most significant event in the flight history of the Pacific Northwest was the foundation of The Boeing Company in Seattle in 1916. William E. Boeing became interested in flight as a means of transportation after observing what was happening in Kitty Hawk, North Carolina. What started as a hobby became a business partnership with U.S. Navy Lieutenant and engineer George C. Westervelt. The two teamed up to build the *Bluebell* seaplane, which Boeing took for its maiden flight in June of 1916. One month later, Boeing created the Pacific Aero Products Company; one year later, he renamed the venture Boeing Airplane Company.

From producing a single canvas-and-wood airplane to transforming how humans fly over oceans and into the stars, Boeing has become the world's largest aerospace company. The company's impact on Washington State is staggering: according to its 2016 impact report, Boeing is the largest private employer in the state and, in that year, donated $1 million in grants to support universities. The report estimated the economic impact of the aerospace industry in Washington at nearly $95 billion, with Boeing being the major contributor. It is because of The Boeing Company's significant local influence that Seattle is informally referred to as "Jet City."

While to the general public Boeing is best known for its commercial aircraft (competitors may be transported to the international competition on a Boeing 737, 777, or 787), Boeing is currently the second largest defense contractor in the world and has a history of building aircraft for military operations. For example, the Boeing 314 Clipper was a long-range "flying boat" and one of the largest aircraft of the time. It's massive wing allowed it to

achieve the range necessary for flights across the Atlantic and Pacific Oceans. The Clipper was pressed into military service during World War II, where it was used for ferrying personnel and equipment to the European and Pacific fronts.

Other Boeing planes also served in World War II. Boeing's B-17 "Flying Fortress" was a four-engine "heavy bomber," which referred to planes capable of delivering the largest payload of air-to-ground weaponry and longest range of their era. The B-17 was primarily used by the United States Army Air Forces in the daylight strategic bombing campaign against German industrial and military targets. Because of the success of this campaign, the Flying Fortress is credited with playing a significant role in winning the war.

Boeing's B-29 "Super Fortress," another four-engine, propeller-driven heavy bomber, also played an important role in World War II. The B-29 featured state-of-the-art technology of the time, such as a pressurized cabin and an analog computer-controlled fire-control system that directed four remote machine gun turrets and could be operated by a single gunner. The most famous B-29s were the *Enola Gay* and *Bock's Car*, the two planes that delivered the atomic bombs that ended the war in the Pacific.

A Boeing 314 Clipper in flight.
https://en.wikipedia.org/wiki/Boeing_314_Clipper

In addition to Boeing's planes, a number of other aircraft that saw service in World War II and subsequent wars flew in the skies over the Pacific Northwest. The Sand Point Naval Air Station, located at the northwestern end of Lake Washington, saw many of the take-offs and landings; at its peak during World War II, Sand Point hosted more than 5,600 Naval personnel, more than 2,400 civilian workers, and hundreds of aircraft. These included Consolidated Aircraft's PB4Y Privateer patrol bomber and the Chance Vought's Corsair F4U fighter-bomber, among others.

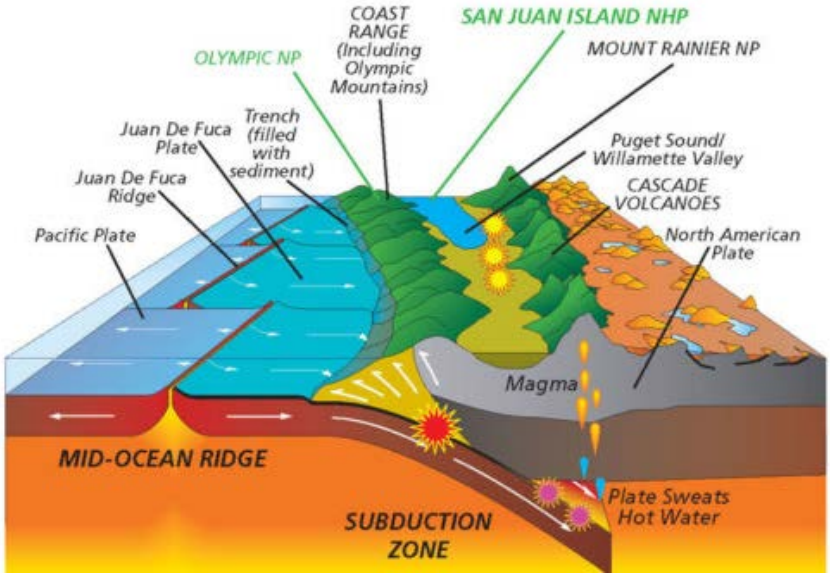
While the majority of take-offs and landings from the air station and nearby Renton Airfield were known quantities, there appear to be several other operations that were not. Historical records released from Navy show a series of test flights in the early days of the

Korean War. According to the de-classified information, not all of these test flights were successful; several aircraft experienced engine trouble, pilot error, or other malfunctions soon after take-off and crash-landed. Suffice it to say, there are huge investments of time, money, and technology resting in the deep and muddy bottom of Lake Washington. The engines of these aircraft, in particular, are of interest, if only to vintage aircraft collectors and museums, including the Seattle-based Museum of Flight.

The APL is looking for an ROV and associated equipment to assist with the search and recovery of these aircraft. Specifically, the APL is in need of contractors for hire who will use flight data available for at least one of these aircraft to determine the area within Lake Washington where it entered the water. Then, once the wreckage is located, the contractor will develop and use image recognition software to identify the type of aircraft using the tail structure. Finally, after clearing debris from the wreckage, the ROV will need to recover the plane's engine and return it to the surface. Given the engine's weight and bulk, the ROV will need to use a lift bag to accomplish this task.

b. Earthquakes

The Cascadia subduction zone is a convergent tectonic plate boundary that stretches from northern Vancouver Island to northern California. This 1,000 km long sloping fault occurs where the Juan de Fuca and North American plates meet. Here, the denser Juan de Fuca oceanic crust plate is moving toward and eventually being thrust at an angle under the less dense North American continental plate. While Juan de Fuca plate is being destroyed at this convergent plate boundary, new oceanic crust is being created along the Juan de Fuca mid-ocean ridge, a divergent plate boundary located farther offshore from the subduction zone. This creation, destruction, and movement of the Earth's crust are all part of the processes known as plate tectonics.



A diagram of the Cascadia subduction zone
http://www.theeventchronicle.com/news/north-america/june-7-fema-will-hold-drill-prepare-9-0-cascadia-subduction-zone-earthquake-tsunami/

Tectonic processes active in the Cascadia subduction zone include the sediment accumulation, subduction, deep earthquakes, and active volcanism of the Cascade mountain range. This volcanism has included such notable eruptions as Mount Mazama (the volcano's collapsed caldera holds Crater Lake) about 7,500 years ago, Mount Meager about 2,350 years ago, and Mount St. Helens in 1980. The Mount St. Helen's eruption was the deadliest and most economically destructive volcanic event in the history of the United States. Fifty-seven people were killed; 250 homes, 47 bridges, 24 km of railways, and 298 km of highway were destroyed.

Earthquakes originating along the subduction zone have the potential to wreak similar havoc. At depths shallower than about 30 km, the zone is locked by friction while strain from subduction of the Juan de Fuca plate slowly builds up. When the fault's frictional strength is exceeded and the rocks slip past each other, or "rupture," the result is often a megathrust earthquake with a magnitude that can exceed 9.0 on the Richter scale. Because of the great length of the fault, the Cascadia subduction zone is capable of producing very large earthquakes.

One such megathrust earthquake occurred along the subduction zone in 1700. The earthquake had an estimated magnitude of 8.7–9.2 and took place from mid-Vancouver Island in British Columbia, Canada, south along the Pacific Northwest coast and as far as northern California. The estimated length of the rupture was about 1,000 km with an average slip of 20 m. It caused a tsunami that struck the coast of Japan.

Geological evidence indicates that megathrust earthquakes (> magnitude 8.0) occurred at least seven times in the last 3,500 years along the subduction zone, suggesting an average repeat time of about 500 years. Seafloor core evidence indicates that there have been 41 subduction zone earthquakes in the subduction zone in the past 10,000 years, suggesting an average earthquake repeat interval of only 243 years. Of these 41 earthquakes, 19 have produced a "full margin rupture," wherein the entire fault opened up.

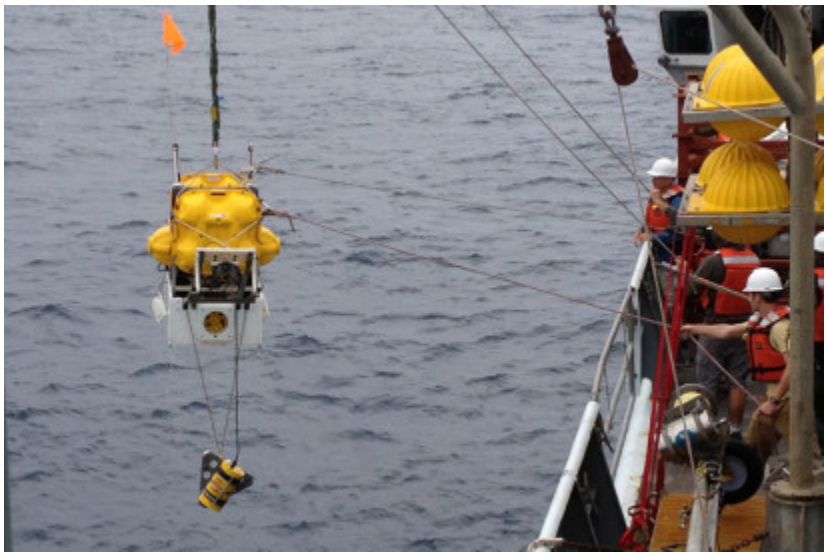
There is also evidence of accompanying tsunamis with most earthquakes in the subduction zone. One strong line of evidence is fossil damage from tsunamis in the Pacific Northwest and historical Japanese records of tsunamis.

The next rupture of the Cascadia Subduction Zone will likely cause widespread destruction throughout the Pacific Northwest. Scientists estimate that within the next 50 years there is an 84% chance of a magnitude 6.5 or higher earthquake in the Puget Sound region, where both Seattle and Federal Way, the site of the 2018 international competition, are located. The odds are less for Oregon and northern California, but still significant.

Government agencies, research institutions, and industries all along the Cascadia subduction zone are interested in studying and monitoring seismic activity. The studies include

experiments using geologic and geophysical data to model the crust and mantle, as well as the installation of sensor networks such as ocean bottom seismometers (OBS), hydrophones, and high definition cameras on the seafloor to measure physical, chemical, geological, and biological changes in real time.

For one such project, the APL is currently looking for an array of OBSs that can be deployed along the subduction zone and integrated into an existing cabled observatory – the Ocean Observatories Initiative Cabled Array (http://oceanobservatories.org/array/cabled-array/), which was featured in the 2013 MATE ROV competition. The plan is to connect each OBS to the central power and communications hub so scientists on shore can access the data in real time. The APL is calling for bids from contractors who can develop and test new technology to power the OBS without the typical wet-mate power connection: the lab is looking to power an OBS via inductive coupling. In addition, the contractors will need to receive data from the OBS via a wireless connection.



An ocean bottom seismometer being retrieved after spending 10 months on the seafloor. http://news.berkeley.edu/2015/11/02/scientists-map-source-of-northwests-next-big-quake/

c. Energy

The Pacific Northwest has and continues to invest considerable resources in researching, developing, and implementing renewable energy systems. Part of what is driving this is Initiative 937, which was on the ballot passed by the voters of Washington in November 2006. The law requires that utilities provide 15% of their power from renewable sources by 2020. The law specifically excludes hydropower from existing or new dams.

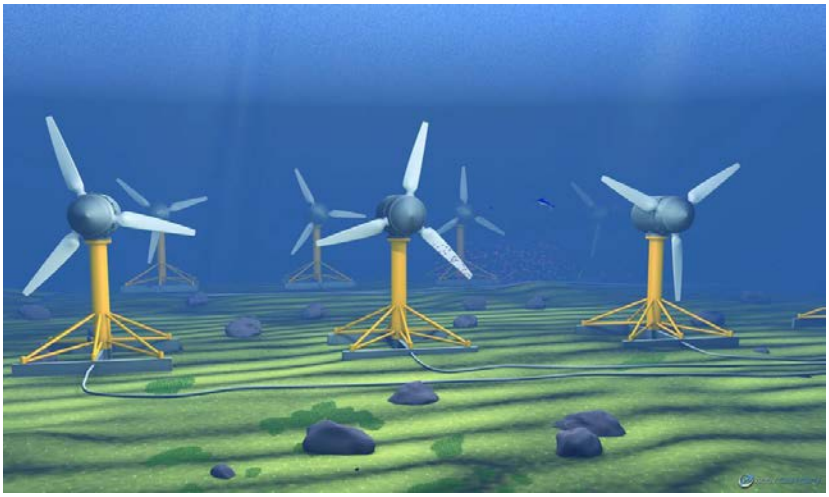
Progress is being made toward this goal. According to a 2013 report by the Renewable Northwest Project, Washington State had invested over $8.1 billion in new renewables (wind, solar, and bioenergy); the power generation capacity of the systems installed was

2,980 megawatts (MW). The estimated number of jobs created from these projects was nearly 4,000. In April 2017, Washington was ranked number two on a list of top ten U.S. states that use the most renewable energy; Oregon was ranked number one.

Most recently, a new incentive program for citizens and businesses passed the Washington State Legislature and was signed into law by the Governor. The Senate bill modifies tax incentives for renewable energy systems and provides guidance for recycling related components. Projects eligible for incentives under the new program include renewable energy systems such as solar photovoltaic energy systems, anaerobic digesters, and wind generators used for producing electricity. The start date was July 2017.

While neither the report nor the bill specifically mentioned tidal energy, Washington State research institutions, government agencies, and industries are exploring the potential and practicality of harnessing the energy derived from the moon's, and to a less extent the sun's, gravitational pull. There have been and are currently a number of projects aimed at identifying suitable locations for tidal power generators, also known as turbines, in Puget Sound. These studies look at tidal current velocity, bathymetry, and other environmental factors, such as the impact of the turbine on marine mammals and the benthic community. Given the level of recreational activity and commercial traffic, including cargo containers bound for the port of Seattle, fishing and aquaculture boats, and the largest fleet of passenger and car ferries in the U.S., shipping lanes and boat traffic must be taken into consideration as well.

These projects also investigate the practicality and costs associated with tidal power systems. Tidal currents are very predictable, and therefore very favorable with respect to the planning of energy production and maintenance. However, how feasible is it to tap into an existing or build a new shore-based power station to receive and make use of the power generated? Is the expense of installation and maintenance worth the reward of power generation?



Conceptual drawing of a tidal turbine array
http://tidalenergytoday.com/2015/05/22/bureau-veritas-issues-updated-guide-on-current-and-tidal-turbines/

Photo showing the scale and magnitude of the real thing
http://www.siemens.co.uk/pool/news_press/news_archive/2012/seagen.jpg

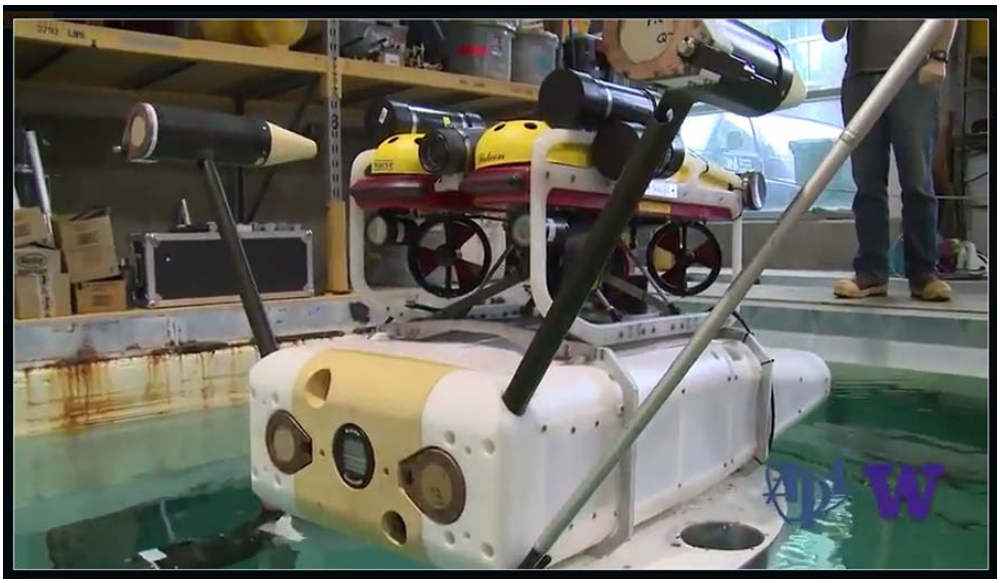
The best way to capture tidal energy is to place the turbine in a narrow channel between two landmasses. When the tide comes in, the water rises on one side of the channel and pours down the channel to the other side. When the tide goes out, the water on the higher side pours back through the channel where the water level has dropped. The movement of the water turns the rotor of the tidal turbine. The turbine is connected to a generator; together these convert the kinetic energy of the tidal currents into electricity. Water is 830 times denser than air, and therefore can generate electricity at lower speeds than wind turbines.

The APL is supporting a study lead by the Northwest National Marine Renewable Energy Center (NNMREC) investigating the feasibility of tidal power near Point Wilson, which is located on the mouth of Admiralty Inlet near Port Townsend, Washington. Based on the data collected to date and an expedited permitting process, the project received the green light to install a single array of tidal turbines on the condition that 1) the area continue to be monitored for environmental impact and 2) researchers transplant eelgrass into an adjacent area previously disturbed by dredging activities. If the installation goes well, the data continues to show negligible impact, and a cost analysis of the installation and power generation proves favorable, Washington State will put out a contract for bid to install additional tidal arrays.

A team from the APL and the university's Mechanical Engineering Department developed the Intelligent Adaptable Monitoring Package, or I-AMP, to monitor tidal velocities and environmental impacts. The I-AMP is an elongated fiberglass structure outfitted with a suite of sensors including optical and acoustic cameras, strobe lights, hydrophones, fish tag

receivers, and an acoustic Doppler current profiler (ADCP). The I-AMP is designed to be connected to an ROV that can fly the I-AMP down and install it on a docking station that sits on the seafloor near a tidal turbine. The docking station includes a wet-mate data and power cable that runs back to shore, making the data available to researchers in real time.

While the Saab Falcon ROV, affectionately named the Millennium Falcon by APL researchers, was suitable for testing the I-AMP in the university's test tank, the APL is now looking for a smaller, light-weight vehicle to install the I-AMP in the study area. In addition, the vehicle will need to be capable of deploying a mooring and attaching to it in midwater an Acoustic Doppler Velocimeter (ADV), which will continuously measure water velocity at the midwater depth to compare to the I-AMP's current measurements.



The Saab Falcon ROV deploying the I-AMP in the UW test tank.
http://www.apl.washington.edu/project/project.php?id=amp

d. Document Scope and Purpose

This and the following sections contain the technical specifications and requirements for ROV services needed to support the Applied Physics Laboratory at the University of Washington. In 2018, ROV services include:

1) AIRCRAFT

- Using flight data to determine the search zone for the wreckage
- Identifying the aircraft using the tail section
- Removing debris from the engine using a lift bag
- Returning the engine to the surface using a lift bag
- Returning all lift bags to the surface, side of the pool

2) EARTHQUAKES

- Powering a simulated ocean bottom seismometer (OBS) by inductive coupling

- Receiving WiFi data from the OBS
- Using the data to level the OBS
- Displaying seismograph data points supplied by the OBS

3) ENERGY

- Using tidal data and nautical charts to determine the optimum region for a tidal turbine
- Using tidal data to calculate the maximum possible energy generation at the location
- Installing a tidal turbine in the optimum location
- Installing an Intelligent Adaptable Monitoring Package to monitor the area
- Placing a mooring a given distance from the base of the tidal turbine
- Suspending an Acoustic Doppler Velocimeter at a given height on the mooring

2. Specifications

See the specific tasks described below as well as the VEHICLE DESIGN & BUILDING SPECIFICATIONS and COMPETITION RULES sections.

3. Maintenance and Technical Support

The company shall warrant the ROV and associated systems and equipment for at least the duration of the product demonstrations. Repair or replacement shall be at the company's expense, including the cost of shipping the ROV to and from the competition facility.

4. Shipping and Storage

Refer to Shipping Information for specifics on shipping to the international competition site.

Delivery of the ROV and associated systems and equipment shall be no later than the date of the geographically closest regional contest or by June 21, 2018, which is the start date of the international competition.

5. Evaluation Criteria

a. Technical documentation
b. Engineering presentation
c. Marketing display
d. Company spec sheet
e. Product demonstration
f. Safety

6. References

a. AIRCRAFT

- http://www.boydski.com/diving/wreck_dives.htm
- http://www.memorieshop.com/Seattle/LakeWashington/
- https://vimeo.com/94997616
- http://www.cnn.com/2017/08/19/us/uss-indianapolis-wreckage-found/index.html

- Nelson, Timothy A. *Jet City Rewind*. June 2016. ISBN-13: 978-0764351068
- http://www.museumofflight.org/Exhibits/first-airplane-flight-washington-state
- https://www.wired.com/2010/10/1005first-nonstop-transpacific-flight/
- http://www.u-s-history.com/pages/h1832.html
- http://www.boeing.com/resources/boeingdotcom/company/about_bca/washington/2016
- impact-report-01-03-17/impact_report_010317.pdf
- http://www.historylink.org/File/2249
- https://en.wikipedia.org/wiki/Boeing_B-17_Flying_Fortress
- https://en.wikipedia.org/wiki/Boeing_B-29_Superfortress

b. EARTHQUAKES

- https://en.wikipedia.org/wiki/Cascadia_subduction_zone
- https://www.britannica.com/science/plate-tectonics
- http://www.crew.org/earthquake-information/history-of-earthquakes-in-cascadia
- https://pnsn.org/outreach/earthquakesources/csz
- https://en.wikipedia.org/wiki/Mount_St._Helens
- https://earthquake.usgs.gov/data/crust/cascadia.php
- http://www.interactiveoceans.washington.edu/story/Broadband_Ocean_Bottom_Seismometer
- https://uwerisobservatory.wordpress.com/what/
- http://www.apl.uw.edu/project/project.php?id=rsn

c. ENERGY

- https://climatekids.nasa.gov/tidal-energy/
- http://www.energy.wsu.edu/Documents/Renewable%20Energy%20Incentives%20FAQ_9-5-17.pdf
- https://www.usnews.com/news/best-states/slideshows/these-states-use-the-most-renewable-energy
- http://en.calameo.com/read/000674314facc79901597
- http://www.alternative-energy-tutorials.com/tidal-energy/tidal-energy.html
- http://depts.washington.edu/nnmrec/
- http://www.apl.washington.edu/project/project.php?id=seafloor_tidal_power
- http://www.apl.washington.edu/project/project.php?id=amp
- http://blogs.dickinson.edu/ecoreps/2014/04/01/tidal-power-in-puget-sound/
- https://energy.gov/eere/articles/calming-waters-impact-turbulence-tidal-energy-systems
- http://deepzoom.com/

IMPORTANT NOTE: Questions about production demonstrations and design and building specifications must be posted to the competition FAQs board located at www.marinetech.org/forums/. 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.

SIZE AND WEIGHT RESTRICTIONS

The Applied Physics Laboratory at the University of Washington has included an ROV size and weight requirement in the request for proposals (RFP). Smaller, lighter vehicles will be given special consideration, and vehicles above a certain size and weight will not be considered.

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

- The topside control system and 1 meter of tether going into the control system
- Non-ROV devices or independent sensors such as:
    - Lift bags
    - Inductive coupling power device if removable from ROV

Vehicles will be measured and weighed in the EXPLORER on-deck circle 15 to 20 minutes prior to the company's product demonstration run. Note that the vehicle will be measured and weighed before each product demonstration run. The size and weight bonus, if any, will be added to each product demonstration score.

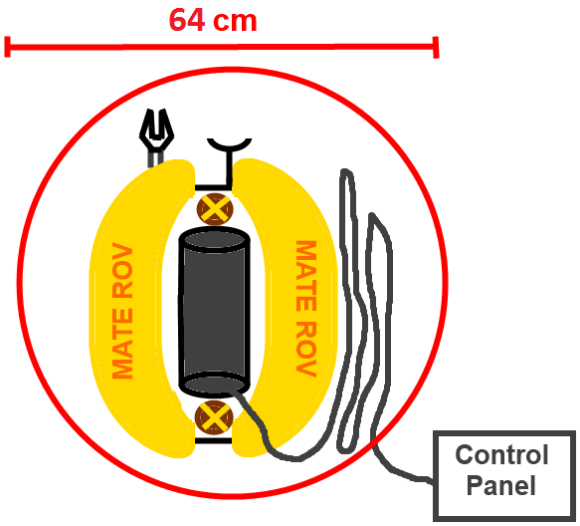
2018 size and weight parameters

Size measurements will be made using the two largest dimensions of the ROV. Three rings with diameters of 60 cm, 75 cm, and 85 cm will be located on a table in the on deck circle. Companies will place their vehicles on the table and, when ready, ask a MATE Center competition official to make the size measurement. The vehicle measurement must include the vehicle and all manipulators/tools that will be used in the product demonstration as well as the vehicle's tether. The simulated OBS and any lift bags constructed by the company will not be included in size and weight. The control system and 1 meter of tether may be outside of the measurement circle.

Hand powered lifts and levers and tether management systems may be used with the vehicle. Hand powered lifts and levers will not count towards the size or weight of the ROV. Tether management systems that can be separated from the vehicle will not count towards the size or weight of the ROV.

Companies may detach manipulator arms and other equipment and place that equipment, next to, on top of, or inside the vehicle frame, but all of the equipment that will be used must be present and fit within the measurement circle. For example, a company may remove a manipulator arm that extends 20 cm in front of the vehicle and place it on top of the vehicle. The measurement will be made with the arm on top of the vehicle provided that the length and width are still the largest diameters.

The size rings will be placed over the two largest dimensions of the ROV.



An EXPLORER class vehicle, with tools attached and tether coiled beside the ROV, inside the 60 cm diameter ring. This vehicle would earn the company +10 bonus points on the product demonstration score.

Weight measurements will be conducted using a digital scale. In addition, companies must be able to personally transport the vehicle and associated equipment to the product demonstration station and to the product presentation room. ROV systems must be capable of being safely hand launched.

Competition officials will use the following chart to award points for size and weight:

Size		Weight (in air)	
< 64 cm diameter	**+10 points**	**< 17 kg**	**+10 points**
64.1 cm to 75 cm	**+5 points**	**17.01 kg to 25 kg**	**+5 points**
75.1 cm to 92 cm	**+0 points**	**25.01 kg to 35 kg**	**+0 points**

Vehicles above 92 cm in diameter, or greater than 35 kg in weight, will not be allowed to compete in the product demonstration.

Size and Weight Protocol

Only the six designated product demonstration company members will be allowed into the on-deck circle during and after the measurement and weigh in. Once a company's vehicle has been measured and weighed, it must remain there until the company moves to its product demonstration station. Companies that detach equipment from the vehicle may not re-install that equipment until the 5-minute set up period. At that time, companies may replace any items that were detached for the measurement, but no new equipment (i.e., equipment that was not included in the size and weight measurements) may be added to the vehicle. If it is discovered that a company added equipment that was not included in the measurements, the company will not be permitted to compete in that product demonstration run.

Videos showing simulated size and weight measurements are posted here.

PRODUCT DEMONSTRATION

TASK 1: AIRCRAFT

This task involves the following steps:

- **Using flight data to determine the search zone for the wreckage – 10 points**
- **Identifying the aircraft using the tail section – 20 points**
- **Removing debris from the engine using a lift bag – up to 45 points**
    - **Attaching the lift bag to the debris – 5 points**
    - **Inflating the lift bag to raise debris – 5 points**
    - **Moving the debris from the wreck area – 5 points**
    - **Releasing the lift bag from the debris using …**
        - **A manual release – 5 points**
        - **A magnetic / reed switch release – 10 points**
        - **A WiFi or Bluetooth release – 20 points**
        - **A frequency-selective acoustic release – 30 points**
- **Returning the engine to the surface side of the pool using a lift bag – up to 20 points**
    - **Attaching the lift bag to the engine and inflating – 10 points**
    - **Returning the engine to the surface, side of the pool – 10 points**
- **Returning all lift bags to the surface, side of the pool – 5 points**

Total points = 100

Product Demonstration Notes:

Companies must complete the steps of this task in order. Companies may choose to skip step 1, using flight data to determine the search zone and/or step 2, identifying the aircraft using the tail section. However, if these steps are skipped, companies may not attempt them at a later time. Companies are required to complete all of the steps of removing the debris from the engine before returning the engine to the surface side of the pool. Lift bags must be deployed in the water during the product demonstration run in order to receive points for returning lift bags to the surface, side of the pool.

Companies will receive the aircraft's flight data and a map of Lake Washington at the start of the 15-minute product demonstration run. The flight information will include:

- take-off location
- heading
- ascent airspeed in ms-1
- ascent rate in ms-1
- time after take-off in seconds of engine failure

- descent airspeed in ms-1
- descent rate in ms-1
- wind speed
- wind direction

Companies will assume the airplane heading after engine failure remains the same. Wind speed will change over time; companies will be given the wind speed equation. The take-off location will be either Naval Air Station Sand Point or Renton Airfield.

Companies will use the flight data to determine the search zone for the wreckage. The search zone should be expressed as a distance (in meters) and direction (in degrees) from the take-off point. Companies will receive 10 points for successfully identifying the search zone. Distance should be within 1 meter of the actual distance. Direction should be within 0.5 degrees of actual direction. Companies may not guess the proper search zone; they should be prepared to show their calculations (or display their spreadsheet) to the product demonstration station judge. Companies that misidentify the search zone may choose to recalculate the location for full points. **Companies that cannot identify the proper search zone, or choose not to complete this step of the task, can continue with the remaining product demonstration tasks, but will not receive points for using flight data to determine the search zone for the wreckage and will only receive half of the points for each of the other steps of this task.** For example, if companies successfully release the lift bag from the debris using a WiFi release, they will only receive 10 points, not 20.

Map of Lake Washington.
www.google.com/maps

Flight data example:

- Aircraft takes off from Naval Air Station Sand Point at a heading of 184°
- Airspeed on ascent is 93 ms-1
- Ascent rate is 10 ms-1
- Aircraft experiences engine failure 43 seconds after take-off
- Airspeed on descent is 64 ms-1
- Descent rate is 6 ms-1
- Wind is blowing from 270°
- Wind decreases over time using the following equation: w(t)= -(1/720)*t^2+25. Wind speed is m-1

Additional note: The aircraft flies a course of 184° (no correction for wind) before engine failure. Companies should not take wind into account until the descent.

Companies can use this data to create ascent movement, descent movement, and wind movement. Companies would combine these three vectors to report a final distance and direction from the take-off point.

On an XY grid system:

Ascent movement:	-278.956 meters along X axis (west)
	-3989.259 meters along Y axis (south)
Descent movement:	-319.950 meters along X axis (west)
	-4575.494 meters along Y axis (south)
Wind movement:	1794.044 meters along X axis (east)
	0 meters along Y axis
Total movement:	1195.138 meters along X axis (east)
	-8564.752 meters along Y axis (south)

Reported search zone: **8648 meters** in direction **172 degrees** from Sand Point Naval Air Station.

Companies must identify the type of aircraft using image recognition software. Companies are responsible for developing image recognition software that will identify the aircraft using characteristics of the aircraft's tail structure. The tail structure will be constructed from corrugated plastic sheeting attached to a base of ½-inch PVC pipe. One of six potential aircraft will be in the product demonstration area. Companies will use the following distinguishing factors to differentiate between the six aircraft.

Aircraft	Tail Shape	Tail Markings	Tail ID Number
A	Triangle	Red Triangle	UH8
B	Triangle	Yellow Triangle	L6R
C	Triangle	Blue Triangle	G7C
D	Trapezoid	Red Rectangle	S1P
E	Trapezoid	Yellow Rectangle	JW3
F	Trapezoid	Blue Rectangle	A2X

The company's software must determine which of the six possible aircraft tails is located in the product demonstration area and display the proper identification on a video screen. Companies will receive 20 points when the proper symbol for the aircraft is output to a video screen and shown to the product demonstration judge. The EXPLORER Aircraft Identification Handbook has additional information on the six aircraft tails.

Aircraft	Output on video display
A	Red A or Red Triangle
B	Yellow B or Yellow Triangle
C	Blue C or Blue Triangle
D	Red D or Red Square/Rectangle
E	Yellow E or Yellow Square / Rectangle
F	Blue F or Blue Square / Rectangle

This output on the video display can be an image overlay of the letter or symbol on a video screen or a display on a different screen. Regardless, the software must output a symbol for the product demonstration judge to see. A company member is not allowed to verbally report the tail identification.

Prior to the competition, companies must demonstrate the effectiveness of their image recognition software. Companies are required to submit a data flow diagram of their image recognition software, an algorithm description document detailing the inputs to and outputs from the vision processing, and a library of code files. More information on the submission of image recognition documentation can be found at DOC-012.

At the competition, before the product demonstration, companies are required to demonstrate their image recognition software in a hands-free, "in air" test. Companies will be required to set up their vehicle and prepare their image recognition software. When ready, all company members must move away from the ROV and control board. A judge will then place an aircraft tail in the ROV view. The image recognition software must identify the tail without input from any company members. Note: This demonstration will take place in air; companies should design their software to identify aircraft tails both in air and underwater.

A schedule request for the test will be posted after May 24th.

Companies that do not submit their documentation or cannot pass the image recognition demonstration will not receive points for identifying the aircraft using the tail section.

Debris will cover a section of the wreckage, including its engine. Companies must attach a lift bag to the debris, inflate the lift bag to raise the debris off of the wreckage, move the debris so it is no longer covering the wreckage, then release the lift bag so the debris remains on the bottom.

See below for lift bag specifications.

The debris will be constructed from ½-inch PVC pipe and corrugated plastic sheeting. Weights will be attached for ballast. A #310 U-bolt will act as a grab point, but companies may attach their lift bag to the debris by any method they wish. Companies will receive 5 points for successfully attaching their lift

bag to the debris. Judges must be able to see the attachment of the lift bag to the debris through the company's video display. The lift bag must stay attached to the debris until it is purposefully released from the debris for the points to be awarded.

Once the lift bag is attached to the debris, companies must inflate it to raise the debris off of the wreckage. Companies will receive 5 points for successfully inflating their lift bag and raising the debris. Successfully lifting the debris off of the wreckage is defined as the debris no long in contact with the pool bottom or any part of the wreckage. Companies are required to inflate a lift bag to raise the debris; companies are NOT allowed to use only ROV thrust to lift the debris.

The debris will weigh less than 40 Newtons in water. Lift bag volumes should be calculated accordingly.

Once the lift bag has successfully raised the debris, companies must move the debris from the wreck area. The ROV must move the lift bag and debris and set the debris on the pool bottom so it is not in contact with any part of the wreckage or any other product demonstration props. Companies will receive 5 points for successfully placing the debris on the pool bottom. Companies may fully or partially deflate the lift bag to complete this step of the task.

After the debris has been moved, companies must release the lift bag. Companies are required to design and construct their own release mechanism for the lift bag. This can be a manual release, a magnetic/reed switch release, a wireless release, or a frequency selective acoustic release. Companies will receive up to 30 points for successfully releasing the lift bag from debris. Successfully releasing the lift bag is defined as the lift bag no longer attached to or in contact with the debris. The lift bag's attachment mechanism may remain attached to the debris, but the lift bag itself must be released. The attachment mechanism will not count as penalty points for leaving debris in the pool. However, divers should be able to easily detach the release mechanism from the debris.

Companies will receive up to 30 points for releasing the lift bag, depending on the method they use. See the chart below for the points awarded for each type of release method.

Release type	Definition	Point total
Manual release	Any device that requires the ROV to physically push, pull, bump, turn, or manipulate part of the OBS to execute the release.	5 points
Magnet/reed switch release∞	Any device that uses a magnet in close proximity to a magnetic reed switch or other similar device to complete an electrical circuit that executes the release of the OBS.	10 points
Wireless release* ∞	Any device that uses transmission of an electromagnetic signal that is received by the OBS and results in the release of the OBS. Bluetooth, WiFi and other such devices are included in wireless release.	20 points
Frequency-Selective acoustic release** ∞	Any device that transmits an acoustic pulse that is received by the OBS and results in the release of the OBS.	30 points

∞In order to use a magnet/reed switch, wireless, or frequency-selective acoustic release, companies must back away from the lift bag before activating the release mechanism. The ROV must not be touching any portion of the lift bag, debris, or attachment mechanism before activating this release. If your ROV is still touching the lift bag when it separates from the debris, the product demonstration judges will award points based on the use of a manual release.

*Note that in a freshwater environment, wireless signals travel approximately 6 to 8 cm. To avoid interference and rogue signals before deployment underwater, MATE recommends that companies using wireless transmission design their device to release only after it receives a special coded signal, unique for their company. Companies are responsible for WiFi protocol and design for both the transmitting and the receiving "end" of the WiFi release mechanism. More information on wireless signals in water can be found here.

**A frequency-selective acoustic release is defined as transmitting an acoustic pulse from the ROV that is received and results in the release of the lift bag. Any acoustic pulse must be transmitted from the ROV. Companies may not transmit the pulse from a device on the surface. Note that acoustics travel well underwater; pools with multiple ROVs can be a noisy environment. MATE recommends that companies design a mechanism that only releases the lift bag when a unique, multi-tone, variable frequency signal is received.

Companies are limited to one type of primary release, but are permitted to include a back-up manual release if their primary release fails. Companies that abandon their primary release in favor of a back-up manual release will only receive 5 points. Companies must include information about their back-up manual release on their one page description and must also inform the product demonstration judges if/when they are planning to use their back-up manual release.

Companies will not receive points if the lift bag releases from the debris prematurely (e.g. before the debris is placed on the bottom and before the company has activated the release). Companies must trigger the release with their ROV; any signal (Bluetooth, WiFi, or acoustic) transmission must originate on the ROV. Companies should inform the product demonstration judge when they are about to release the lift bag. MATE recommends building a robust release mechanism that can only be triggered by one specific method. Companies will not receive points for a lift bag that releases prematurely due to rough handling, ambient noise, or stray signals.

Companies that use a mechanism other than a manual release may need to power their lift bag release mechanism. Therefore, a company-built release will be classified under the Non-ROV device power specifications. See Non-ROV Device Power for more information.

After the debris has been removed from the wreckage, companies must return the aircraft's engine to the surface. The engine will be constructed from a milk crate. Weights inside the milk crate will act as ballast. A simulated propeller will be constructed from ½-inch PVC pipe. A #310 U-bolt will act as a grab

point, but companies may attach their lift bag to the aircraft engine by any method they wish. Companies will receive 10 points for successfully attaching their lift bag to the engine and inflating the lift bag to raise the engine from the bottom. Judges must be able to see the attachment of the lift bag to the engine through the company's video display. The lift bag must remain attached to the engine until it is returned to the surface for the points to be awarded.

The aircraft's engine will weigh less than 60 Newtons in water.

After lifting the engine from the bottom, companies must return the engine to the surface, side of the pool. Companies will receive 10 points when the engine is returned to the surface, side of the pool and placed on the pool deck. The ROV must return the engine to the side of the pool; it cannot be pulled in by a tether, power cable, rope, or other device.

Any lift bag deployed in the water must be returned to the surface, side of the pool. Companies will receive 5 points when all of their lift bags have been successfully returned to the surface, side of the pool and placed on the pool deck. The lift bag will not be considered debris, but companies will need to remove any lift bags from the water to receive points. The lift bag's attachment mechanism can remain in the pool, attached to the debris, but the lift bag itself must be removed from the water.

Lift bag specifications:
Companies are responsible for constructing their own lift bag(s) to remove the debris and return the engine to the surface. MATE will provide compressed air at each product demonstration station at the international competition. EXPLORER regional competitions may or may not provide compressed air; contact your regional coordinator or visit your regional contest's web page for more information. Companies planning to use an air compressor (including the one provided by MATE at the international competition) MUST pass the fluid power quiz. Companies using a manual powered pump are not required pass the fluid power quiz. For more information, see 3.6 Fluid Power and 3.6.7 Fluid Power Quiz.

Lift bags must be independent from the ROV. Lift bags may be held by the ROV, but should not be hard connected to the ROV. Companies may choose to incorporate a variable buoyancy system on their ROV, but that system is not considered a lift bag.

For this product demonstration task, points are awarded for inflating the independent lift bag. Companies may not simply use motor power, or the ROV's variable buoyancy system to lift the debris and/or engine. However:

- **Debris** (picking up debris from aircraft and setting the debris back on the bottom): Companies may use ROV motors to assist in lifting the debris, but the independent lift bag must be partially filled with air.
- **Engine** (lifting the engine to the surface): Air in the lift bag must be the only lifting force for the engine. Companies must be completely detached from their lift bag as it moves to the surface. Companies that are dragged to the surface with the engine will be penalized 5 points.

Companies may use different lift bags to move the debris and lift the engine, or companies may use the same lift bag for both tasks.

Air for inflating the lift bag must come from the surface. Companies may not use a compressed gas source on the ROV or chemical reactions that generate gases to inflate the lift bag. Any airline tubing to inflate the lift bags must be incorporated into the tether. An independent inflation system not incorporated into or attached to the ROV is not allowed.

Lift bag(s) will not be included in the size and weight measurements. However, airline tubing or other components attached to the ROV will be included in size and weight.

Companies are required submit a one page document outlining their lift bag and its release mechanism. If the lift bag release uses power, companies must also submit a SID detailing the powered release. See DOC-004 for more information. The MATE Center will evaluate the submission for any safety issues and address any concerns in the initial safety and documentation review.

TASK 2: EARTHQUAKES

This task involves the following steps:

- **Prior to the competition, developing a inductive coupling connector capable of providing power at 5 volts, 1 amp, 5 watts to an ocean bottom seismometer (OBS).**
- **During the competition – up to 25 points**
    - **Inserting the power connector into the port on the OBS – 5 points**
    - **Lighting the power indicator LED – 20 points**
- **Prior to the competition, developing a device capable of receiving WiFi data.**
- **During the competition – up to 55 points**
    - **Leveling the OBS using data transmitted by one of the following:**
        - **The OBS via WiFi data – 25 points**
        - **A bubble level – 5 points**
    - **Receiving and accurately displaying a seismograph data transmitted by the OBS via WiFi – up to 30 points**
        - **Receiving a seismograph data via WiFi – 10 points**
        - **Displaying the seismograph on a video monitor – 10 points**
        - **Seismograph display is accurate – 10 points**

Total points = 80

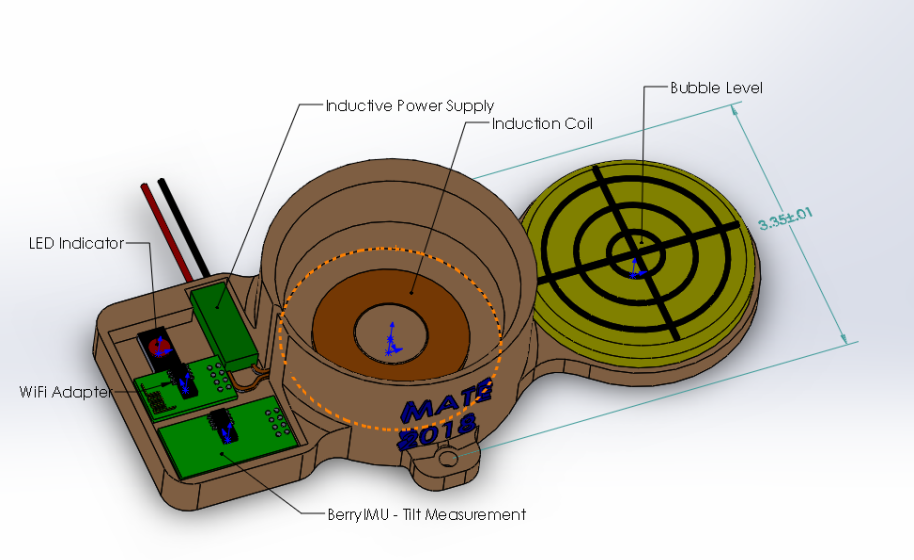
Product Demonstration Notes:

Companies must attempt to power the OBS before attempting to level it. Companies unable to power the OBS may not come back and attempt to power it at a later time. Companies must level the OBS,

either via WiFi data or bubble level, in order to receive seismograph data. The OBS will not transmit seismograph data until the OBS is level. Companies unable to level the OBS will not be able to receive seismograph data.

Companies must design an inductive coupling connector capable of providing power at 5 volts, 1 amp, 5 watts to a simulated ocean bottom seismometer.

The OBS will contain a port with the power receiver module of a wireless charger. The port will be oriented vertically and the receiver will be located inside at the center. Less than 2 mm of waterproofing coating will cover the receiver. The port will be 3D printed, round, approximately 3 cm deep, and have an inside diameter of 6 cm. Information about the port, including the 3D printing files, can be found on the here. Companies are responsible for developing and building their own power connector using the transmitter module of a wireless charger. Companies will receive 5 points for successfully inserting their power connector into the port on the OBS. Successful insertion of the power connector is defined as the company-built connector remaining inside the port once it has been released from the ROV.



3D model of the EXPLORER port, including components for leveling the OBS.

The inductive coupler will be used to power an LED attached to the receiver module. When companies connect their transmitter to the receiver in the port, the LED will turn from red to green, indicating that the OBS is receiving power via inductive coupling. Companies will receive 20 points for turning the LED from red to green. The station judge must be able to see the green LED light on a video screen.

The company-built transmitter module will not constitute debris if left in the pool at the end of product demonstration time.

Companies may choose to power their transmitter module from the surface or from batteries on-board the transmitter. The transmitter will be considered a Non-ROV device, and must follow the Non-ROV

device power specifications. If surface power is used, companies may choose to power the transmitter device from ROV power, or may run the wires independent of their ROV.

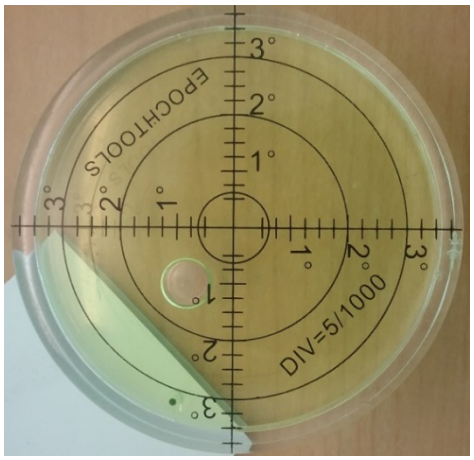
Note: MATE will provide stations at the pool so companies can test their inductive coupling connection. The testing stations will be identical to the actual product demonstration stations, but will be located in shallow water.

Companies must level the OBS. The OBS will be located in an area on the pool bottom that will not be level; portions of the bottom may be up to 5 cm above the floor of the pool. The frame of the OBS will be constructed from ½-inch PVC pipe. Each of the four corners of the frame will have a ½-inch PVC tee. Rotating the tee will raise or lower that corner of the OBS. A compass leveling sensor and WiFi module will be attached to the 3D-printed power port. These devices will be connected to an Arduino, which will be connected to the surface. Companies will use the data being broadcast by the WiFi module to level the OBS. The wireless device will transmit data for both the X axis and the Y axis of the OBS.

Additional information on the MATE Wifi and power set up, including all the parts used, will be included in the building instructions.

Companies must build a WiFi receiver to collect the data then use that data to level the OBS. To level the OBS, companies will turn handles on each corner of the OBS. The handles will be constructed from ½-inch PVC tees. A 3/8-inch-16, 6-inch bolt will be attached to each handle. Rotating the handle will move the bolt through a 3/16-inch nut, raising or lowering that corner of the OBS. Companies will receive 25 points when they use the WiFi data to successfully level the OBS. Successfully leveling the OBS is defined as both the X axis and the Y axis within one degree of level, with level being 0^{o}. The WiFi data will inform companies when each axis is within one degree. The station judge must be able to see data on a video screen, and both axes must be within the tolerance (i.e., one degree) for companies to receive points. When displaying the data to the station judge, the ROV should not be touching or holding any part of the OBS.

Companies unable to receive the WiFi data may attempt to level the OBS using the bull's eye bubble level attached to the OBS. Companies using the bubble level will only receive 5 points when the OBS is successfully leveled. Successfully leveling the OBS is defined as the bubble touching any part of, or inside of, the small center circle of the bubble level. The station judge must be able to see the bubble level through a video display; when displaying the bubble level within the 1 degree circle, the ROV should not be touching or holding any part of the OBS.



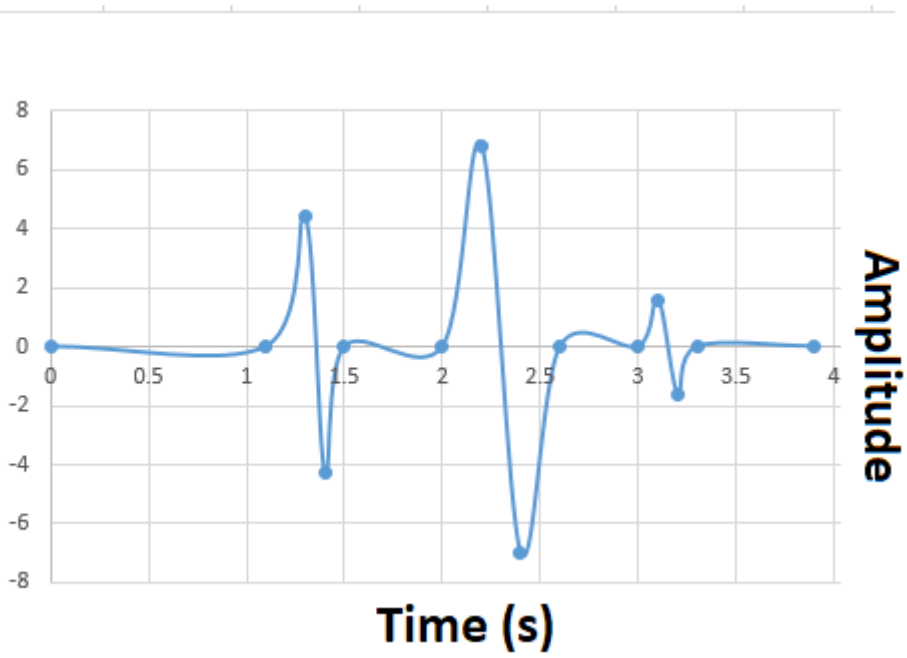
The bubble level. To receive 5 points, the bubble must be touching any part of, or inside of, the small center circle. In this photo, the bubble is not touching the center circle, so companies would still need to level the OBS.

The data transmitted by WiFi will be updated to include the seismograph data when the OBS is level (within tolerances for the X and Y axis). Companies receiving the seismograph data will receive 10 points. The station judge must be able to see the seismograph data on a video screen for companies to receive points.

Note: Companies that use the bubble level to successfully level the OBS may or may not be within the tolerances of the compass level sensor. The bubble touching, or inside of, the 1° ring of the bubble level may not initiate transmission of the seismograph data.

The seismograph data will include 14 data points, each of which includes a time and amplitude. These 14 data points must be plotted on a graph. Companies must plot the points (Y axis of graph) over time (X axis of graph) using a computer program. Companies must show their seismograph to the station judge on a video display; companies may not create their seismograph by hand. Companies will receive 10 points when they show the station judge their seismograph. Station judges will evaluate the seismograph for accuracy. Companies with an accurate seismograph will receive 10 points.

Time	Amplitude
0	0
1.1	0
1.3	4.4
1.4	-4.3
1.5	0
2	0
2.2	6.8
2.4	-7
2.6	0
3	0
3.1	1.6
3.2	-1.6
3.3	0
3.9	0



Example of 14 data points on the left. Graph of data points on the right. Companies will receive the data on the left and use that to plot the seismograph on the right.

Note: MATE will provide stations at the pool so companies can test their WiFi receiver. The testing stations will be able to be tilted so companies can vary the leveling data received. The WiFi data will be updated to include an example of seismograph data when the test station is level (both X axis and Y axis within tolerance).

TASK 3: ENERGY

This task involves the following steps:

- **Using tidal data and nautical chart to determine the optimum location for a tidal turbine – up to 20 points**
  - **Determining the optimum location – 10 points**
  - **Using tidal current data to calculate the maximum possible megawatt generation at this location – 10 points**
- **Installing a tidal turbine in the optimum location – up to 15 points**
  - **Installing the base on the bottom – 5 points**
  - **Installing the turbine onto the base – 5 points**
  - **Latching the turbine in place – 5 points**
- **Installing an Intelligent Adaptable Monitoring Package (I-AMP) to monitor the area – up to 10 points**
  - **Transporting the I-AMP to its stand – 5 points**

    - **Locking the I-AMP onto the stand – 5 points**
- **Placing a mooring a given distance from the base of the tidal turbine – up to 15 points**
    - **Measuring the given distance from the base – up to 10 points**
        - **Distance is within 10 cm – 10 points**
        - **Distance is not within 10 cm – 0 points**
    - **Placing the mooring on the bottom – 5 points**
- **Suspending an Acoustic Doppler Velocimeter (ADV) at a given height on the mooring line – up to 20 points**
    - **Measuring the given distance from the bottom – up to 10 points**
        - **Distance is within 10 cm – 10 points**
        - **Distance is not within 10 cm – 0 points**
    - **Attaching the velocimeter to the mooring line – 10 points**

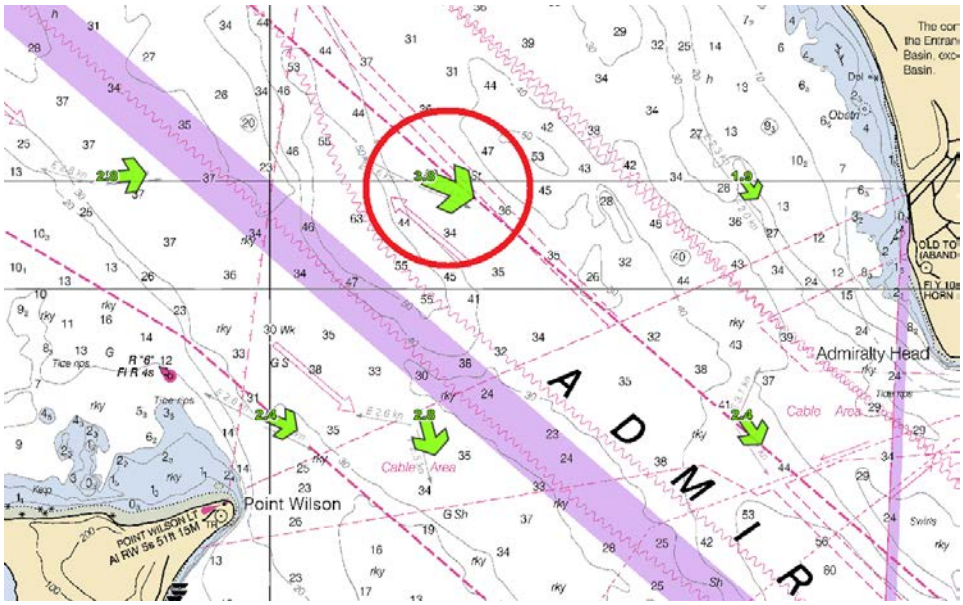
Total points = 80

Product Demonstration Notes:

Companies may complete the majority of the steps of this task in any order. However, before installing any equipment, companies must use the tidal data and nautical chart to determine the optimum location. Companies that cannot complete this step may move on to install the equipment, but cannot return to this step at a later time. The equipment, base, array of tidal turbines, I-AMP, and mooring can be installed in any order, although the mooring must be installed before the ADV can be attached to it.

Companies will use the DeepZoom website (www.deepzoom.com) to get real-time data on tidal currents in Puget Sound. If website information is not accessible at the competition, a printed copy of the tidal data will be provided. Companies must use the data provided to determine the optimum location for placement of the array of tidal turbine. Companies will receive 10 points when they successfully determine the optimum location, which is defined as the area with the highest flow over 24 hours that is not within a zone marked "Cable Area" on the chart. If a company fails to identify the optimum location, they will not receive points for this step, but can continue on to other steps of this task.

For example, there are six DeepZoom data points near Point Wilson, just north of Port Townsend, WA, at the north end of Admiralty Inlet, which is at the north end of Puget Sound. Over the course of 24 hours, the point 1.4 miles northeast of Point Wilson shows the highest overall currents (indicated by the largest green arrow). Therefore, that location has the highest flow rate and is not in the zone marked "Cable Area."



The highest flow rate is at the point 1.4 miles northeast of Point Wilson, circled in red.

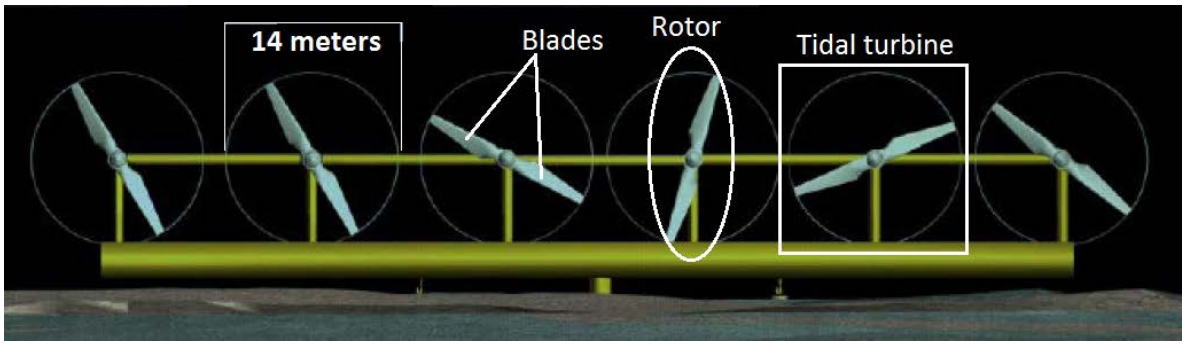
www.deepzoom.com

Once the optimum location has been determined, companies must use a power generation equation for the specific array of tidal turbines being used in this scenario to determine the maximum possible megawatt generation at this location on the given day. The equation for turbine power generation is:

$$P = N.\frac{1}{2}(\rho.A.V^3.Cp)$$

P is power generated in watts
N is the number of turbines in the array
ρ is density of seawater, 1025 kg/m^3
A is the swept area of one rotor in m^2
V is the velocity of the water in ms^{-1} (meters per second)
Cp is the efficiency of the turbines

Companies will use data from the DeepZoom website to determine the maximum flow rate (velocity) for the location on the given day. Note that the DeepZoom website velocity is given in knots. Companies will be provided with the diameter, in meters, of the turbine blades and the efficiency of the turbines at the start of the product demonstration. Note: The actual diameter of the four propellers on the MATE turbine array prop is 15 cm. That diameter of the rotor provided to teams will reflect that of a real tidal turbine. The length can be used to calculate the swept area of the rotor, using πr^2 to determine the area. Companies will receive 10 points when they successfully calculate the expected actual maximum power generation for the array of turbines at the optimum location. Companies are required to show their math; they cannot guess. Companies should be within 1% of expected value.



An array of six tidal turbines.
https://www.researchgate.net/publication/307478018_Tacoma_Narrows_Tidal_Power_Feasibility_Study_-_Final_Report

For example, using the above array of tidal turbines, if the maximum tidal current seen on the given day is 4.5 knots, the diameter of each rotor is 14 meters, and the turbine has an efficiency rating of 35%, the expected actual power generation at this location, at the maximum tidal current, will be 2.06 MW.

Companies must install the base unit for the array of tidal turbine on the pool bottom. The base will be constructed from ½-inch and 2-inch PVC pipe. The 2-inch PVC pipe will be set vertically in the center of the base unit. The array will mount into the 2-inch PVC pipe. Companies must place the base in the designated area, which will simulate the optimum location. The designated area will be a 41 cm square of ½-inch PVC pipe painted red. Companies will receive 5 points when they successfully install the base in the designated area. Successful installation is defined as the legs of the base completely inside the ½-inch pipe of the designated area, and the 2-inch PVC mounting pipe positioned vertically. No portion of the legs may be on top of the ½-inch PVC pipe of the designated area.

The base will weigh less than 10 Newtons in water.

Once companies have installed the base, the array of tidal turbines must be installed onto the base. The array will be constructed from ½-inch PVC pipe. Plastic airplane propellers, 15 cm long, will simulate the rotors. The array will have four rotors. A #310 U-bolt on top of the tidal turbine can be used as a grab point, but companies may transport the tidal turbine by any method they wish. Companies must install the 1/2-inch pipe at the bottom of the tidal turbine inside the 2-inch PVC pipe rising vertically out of the base. Companies will receive 5 points when the tidal turbine is successfully installed in the 2-inch vertical pipe of the base unit. A section of the 1/2-inch pipe at the bottom of the tidal turbine will colored red. Successful installation of the tidal turbine is defined as the colored PVC on the bottom of the tidal turbine completely inside the 2-inch pipe of the base.

The tidal turbine array will weigh less than 10 Newtons in water.

After the tidal turbine has been successfully installed, companies must latch it in place. A latching mechanism, constructed from ½-inch PVC pipe, will be attached to the base. Companies must turn a

handle, also constructed from ½-inch PVC pipe, to rotate the latching mechanism 90° to hold the tidal turbine in place. Companies will receive 5 points when they successfully latch the tidal turbine in place. Successfully latching the turbine in place is defined as the latching mechanism remaining in place against the tidal turbine for at least five seconds after the ROV has disengaged and is no longer touching the latching mechanism, tidal turbine, or base.

The latch mechanism will take less than 10 Newtons to turn.

Companies must install an intelligent adaptable monitoring package (I-AMP) onto its stand near the tidal turbine. The stand for the I-AMP will be constructed from ½-inch, ¾-inch, and 2-inch PVC pipe and positioned approximately 1 meter from the designated area where the tidal turbine is installed. The I-AMP stand will be painted yellow and black. The I-AMP will be constructed from ½-inch PVC pipe. A #310 U-bolt will act as a grab point on the I-AMP, but companies may move the I-AMP by any method they wish. Companies will receive 5 points when they successfully transport the I-AMP and position it on the stand. Successful transport and positioning of the I-AMP is defined as the "feet" on the bottom of the I-AMP sitting on the 2-inch cradles of the stand.

The I-AMP will weigh less than 10 Newtons in water.

After transporting and positioning the I-AMP, companies must lock the I-AMP onto its stand. Companies will only be able to lock the I-AMP in place if its feet are positioned successfully in the cradles of the stand. The locking mechanism will be constructed from ½-inch PVC pipe, positioned inside ¾-inch tees. Companies will push the locking mechanism over the feet of the I-AMP to lock it in place. Companies will receive 5 points when they successfully lock the I-AMP in place. Successfully locking the I-AMP in place is defined as pushing the locking mechanism until the ½-inch tees at one end of the locking mechanism are flush with the ¾-inch tees on the stand. The mechanism must stay locked for 5 seconds after the ROV completely disengages from the I-AMP and its stand.

The locking mechanism will take less than 10 Newtons to push.

Companies must also place a mooring at a given distance from the base of the tidal turbine. Product demonstration judges will provide companies with the given distance during the 5-minute set up period. A vertical length of PVC pipe near one corner of the tidal turbine's designated area will be the zero mark from which measurements must be taken. A length of ½-inch PVC pipe will extend from corner of the designated area. Colored marks at variable distances along this length of pipe will allow station judges to verify the distance measurement taken by the company. Companies will receive 10 points when they successfully determine the proper distance, within 10 cm, from the zero mark on the designated area. The product demonstration judge must be able to see or evaluate the measurement taken by the company. No guessing is permitted. Companies that incorrectly measure the distance will be informed by the station judge that their measurement is incorrect. Companies may choose to re-measure the length or continue with the product demonstration. Companies that re-measure the length will receive 5 points if their measurement is correct, within 10 cm. Companies that incorrectly re-measure the

length, or choose not to re-measure the length, will receive 0 points. The station judge will then tell the company at what mark to place the mooring.

Companies must then place the base of the mooring on the bottom, at the proper mark determined by their measurement. The base of the mooring will be constructed from ½-inch PVC pipe with weight attached. The mooring line will be constructed from #100 black decorator chain and length of ½-inch PVC pipe with #310 U-bolt attached. A 3-inch ABS pipe with end cap and flotation inside will act as a buoy to hold the mooring up in the water column. A #310 U-bolt attached to the base of the mooring will act as a grab point, but companies may move the mooring by any method they wish. Companies will receive 5 points when they successfully place the mooring on the bottom. Successfully placing the mooring is defined as any part of the PVC base of the mooring adjacent to the measured mark. The chain should extend upwards to the buoy floating on the surface.

The base of the mooring will weigh less than 15 Newtons in water.
The flotation of the mooring will provide approximately 3 Newtons of lift in water.

Once the mooring is in place, companies must attach an Acoustic Doppler Velocimeter (ADV) at a given height. A U-bolt attachment point will be suspended partway up the chain of the mooring. Companies must measure the height above bottom of the attachment point, within 10 cm. The zero mark for the height measurement should be the bottom of the pool directly below the base of the mooring. Companies will receive 10 points when they successfully measure the height of the attachment point, within 10 cm. Companies must show the station judge their distance measurement or inform the station judge how the height measurement was determined. Companies may not guess at the height. Companies that do not successfully measure the height cannot get points for this step, but can continue on and attach their ADV to the mooring.

After the height measurement, companies must attach the ADV to the mooring line. Companies are tasked with building their own simulated (non-working) ADV. The ADV can be constructed out of any material and must:

- Measure at least 20 cm long
- Include a means to connect to the #310 U-bolt on the mooring line
- Not touch the surface or bottom of the pool after attachment to the mooring line

The attachment points will be constructed from a #310 U-bolt set in ½-inch PVC pipe. The ADV must attach to the #310 U-bolt. Companies will receive 10 points for successfully attaching the ADV to the mooring line. Successfully attaching is defined as the ADV remaining attached to the U-bolt for at least 10 seconds after it is released from and no longer in contact with the ROV.

The turbine base, the turbine, the I-AMP, and the mooring will be located on the surface, side of the pool at the start of the product demonstration. Companies may lower the turbine stand, the I-AMP, and the mooring into the water at the side of the pool during the 5 minute set up period, or during the 15 minute product demonstration run. Companies may retrieve these items from the bottom and move

them to their designated locations. Companies are not allowed to "toss" or throw these items out into the pool; they must be released at the side of the pool. Companies are required to transport the tidal turbine array from the surface with their ROV; companies may not lower the turbine into the water.

Time bonus:
If a company has successfully completed all product demonstration tasks and is returning to the surface with the aircraft engine and/or lift bags, the product demonstration time will stop when a member of the company touches the vehicle. The engine and/or lift bags may be set on the pool deck after the clock has stopped. If any of these items is subsequently dropped from the vehicle and sinks 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 Aircraft Identification Handbook contains identification information on the six unknown aircraft believed to be lost in Lake Washington.

PART 2: PRODUCT DEMONSTRATION PROP BUILDING INSTRUCTIONS & PHOTOS

The product demonstration prop building instructions and photos have been made their own, separate document. This document will be released with, but separate from, this competition manual.

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 (www.marinetech.org/forums/). 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-002R).

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 their regional coordinator, visit the regional contest's website to find out any specific requirements for your regional.

2.0 SAFETY

Safety is the competition's primary concern and guiding principle. Any system that is deemed unsafe by competition officials will not be allowed to compete. If a safety concern is identified during the initial inspection, companies are permitted to modify their system and have it re-inspected. Companies are permitted to have their vehicle re-inspected twice. If a company fails to pass its third and final safety inspection, it is disqualified from the underwater competition portion of the event. There are NO APPEALS once an ROV has been disqualified.

Examples of safety violations from previous ROV competitions include:

- The electrical SID included in the technical documentation did not show a main fuse.
- The ROV used pneumatics, but the technical documentation did not include a pneumatics diagram.
- The ROV used pneumatics, but the company had not passed the fluid power quiz.

2.1 Job Site Safety Analysis

Each member of the company is encouraged to read Oceaneering Americas Region HSE Employee Handbook, with emphasis placed on the following chapters.

Chapter 1 - Housekeeping
Chapter 9 - Hand Safety
Chapter 11 - Lifting and back safety
Chapter 12 - PPE
Chapter 17 - Tool Safety
Chapter 24 Electrical Safety
Chapter 29 - Employee Observation Program
Chapter 33 - JSEA
Chapter 37 - Working at Other sights

Job Site Safety Analysis (JSAs)

For companies advancing to the international competition, up to 10 additional points can be earned by creating a JSA and submitting it along with (but as a separate document from) the Technical Documentation.

A **JSA** describes job tasks in step-by-step fashion, identifies associated hazards at each step, and outlines proper hazard controls that minimize the risk of injury or illness to the individual(s) performing that task. JSAs are used extensively by the offshore industry.

For more information and examples, companies can visit the following web sites:

- http://ehs.berkeley.edu/how-do-i-write-and-update-job-safety-analysis-jsa
- www.safetyworksmaine.com/safe_workplace/safety_management/hazard_analysis.html

POTENTIAL HAZARDS

DESCRIBE JOB STEP (List the natural steps of the job. Do not make the steps too broad or too fine)	POTENTIAL HAZARDS (What are the potential hazards identified at this part of the job steps)	RECOMMEND RISK CONTROL MEASURES (describe how the identified hazards can be eliminated or reduced)	RESPONSIBLE PERSON (S) (Implementing control)	INITIAL (Of the responsible person/s)
Toolbox Talk	Miscommunication	**ANYONE can call ALL STOP at any point if an unsafe condition /act is perceived/observed.** **Cell phone use is PROHIBITED in test area while testing!** Ensure all participants are aware of procedures and roles within the procedure and sign JSEA acknowledging thusly. Ensure that all participants are wearing correct PPE (safety glasses, safety shoes, gloves, and hard hats if crane ops are being performed) Ensure participants/witnesses are wearing adequate clothing for weather conditions and to take breaks whenever necessary.		
Hydraulic Function Testing	Stored/Trapped Energy: Up to **12,000 PSI** Environmental Discharge Tubing/Hose Failure Line of Fire	Ensure all functions have pressure/flow reduced to 0 PSI when not being actively function tested. Ensure each circuit is setup correctly before increasing pressure. Ensure Vent hoses are properly connected to fluid containment reservoir. Ensure all hoses are whip checked before coming up on pressure. Ensure valves and actuators are in proper configuration before testing. Ensure relief valves are set to relieve at the proper setting.		

Example JSA task items courtesy of Oceaneering International

2.2 Safety Pre-Inspection

A safety pre-inspection will be completed before competition day. Companies will submit technical documentation, a company spec sheet, SIDs, lift bag release document, and a company safety review documentation to the MATE Center.

Once received, safety inspectors will conduct an **initial safety and documentation review** to identify potential safety violations. This review will be worth 20 points. Companies with violations will be notified via e-mail. Once notified, companies must:

a. Respond acknowledging receipt.
b. Layout a plan to address the violation.
c. Submit new documentation if required.

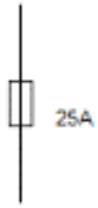
Safety inspectors will also compile a list of the safety violations and publish them to the competition web site. This is not done to "call out" or embarrass companies in any way. It is to emphasize the fact that EVERYONE is responsible and accountable for ensuring a safe, successful event. It also allows the company to correct the safety violations before arriving at the international competition.

2.2.1 Safety documentation requirements

DOC-001: SID Electrical: This must be an electrical diagram for all ROV systems. One section should focus on the systems above the waterline, and one section should focus on systems on the ROV (below the waterline). The SID:

- Should not exceed one page in length (both above and below water sections, as well as any other information, should be on one page).
- Must be drawn with a CAD (computer assisted drawing) program. Hand drawn figures are not permitted.
- All symbols used should be standard symbols as specified by ANSI, NEMA or IEC.
- The SID must include a FUSE SYMBOL using an ANSI, NEMA or IEC symbol.
- The SID must not be component level schematics, but a higher level interconnection block type diagram. Do not include individual pins on a board; the SID is a higher level diagram.
- Fuse calculations must be included on the SID.

The following ANSI and IEC fuse symbols are all acceptable for MATE documentation.

Item	ANSI	IEC
FUSE		

Examples of acceptable SIDs can be found here:

- www.marinetech.org/files/marine/files/ROV%20Competition/International%20Competition/2014%20tech%20reports/EXPLORER/EXPLORER/Memorial%20University/EER_Memorial_University_Newfoundland_Tech_Report_Final_2014.pdf, page 22

- www.marinetech.org/files/marine/files/ROV%20Competition/International%20Competition/2014%20tech%20reports/RANGER/RANGER/Cornerstone%20Academy/Cornerstone_Academy_Tech_Report_final.pdf, page 21

DOC-002: SID Fluid Power: Companies using fluid power must include a fluid power diagram using industry standard symbols, showing all items, regulators, and control valves. The diagram must document the components on the surface and the components located onboard the ROV. Fluid power diagrams must use ANSI, NEMA or IEC symbols. The fluid power diagram must also be drawn with a CAD program and should be a one page diagram. The fluid power diagram may be included on the main electrical SID or as a separate one page document.

DOC-003: SID Non-ROV Device: Companies utilizing an independent sensor or other electrically powered, non-ROV device to complete a product demonstration task must submit a SID for this device. Companies using power for their lift bag release mechanism must also submit a non-ROV device SID. The inductive coupling power for the OBS must also be included as a non-ROV device SID. These diagrams must be completed to the specifications listed in DOC-001. Each non-ROV device SID may be included on the main electrical SID or as a separate one page document.

DOC-004: Lift Bag Release Design: Companies will be required to submit a one page written and visual (photo) description of their lift bag release mechanism. If your company's lift bag release uses electrical power, you must also include a non-ROV device SID (see DOC-003). If your company's lift bag release uses onboard batteries, you MUST include the type of battery used.

DOC-005: Company safety review: All EXPLORER companies must submit a company safety review that demonstrates compliance with the following specifications:

- SBS50 Anderson Powerpole connectors are the main point of connection to the MATE supply (ELEC-010R).
- A properly sized fuse or breaker is within 30 cm of the main point of connection. The company must use a ruler to show this distance (ELEC-008E).
- Fuse calculations (ELEC-008E).
- The inside of the control box is does not have exposed wiring (ELEC-017E), the control box is neatly laid out with attention to workmanship (ELEC-022E), a separation and identification of 120VAC wiring from DC and control voltages (ELEC-023E). If AC wiring is not used in the control box, include a statement saying no AC is used.
- The tether leading to the ROV has proper strain relief (ELEC-024E).
- If hydraulics / pneumatics are used that the company has passed the Fluid Power Quiz (FLUID-014). If fluid power is not used on the vehicle, include a statement saying no fluid power is used.
- Hydraulic / pneumatic systems include 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 (FLUID-012, FLUID-013).
- Any watertight housing on the vehicle can withstand pressure at 5 meters (MECH-001).
- All propellers are shrouded (MECH-006).
- The ROV has no sharp edges or elements of the ROV that could cause damage (MECH-006, ELEC-017R).

The company safety review should include an explanation of how each system meets the safety specifications and include photographs of the relevant systems for review by the MATE Center staff.

Initial Safety and Documentation Review points

Penalty points will be deducted from the initial safety and documentation review if:

- Companies do NOT submit ALL the required documentation by the given date.
- The SID does not show a fuse, or the fuse does not use an ANSI, NEMA or IEC symbol.
- Fuse calculations are not show on the SID.

- The vehicle uses fluid power, but a fluid power diagram is not included.
- The lift bag release uses electrical power, but a non-ROV device SID is not included.
- The inductive coupling connector is not included as a non-ROV device SID.
- The technical documentation is not submitted in a searchable PDF format.
- The technical documentation is over 8MB in size.
- Other documents are over 2MB in size.
- The company safety review does not show compliance with all of the specifications.

The initial safety and documentation review rubric can be found here.

2.3 Onsite Safety Inspection

Companies must complete their onsite safety inspection before their vehicles enter the water.

At the international competition, companies must complete their safety inspection by the end of the first day of the competition. Companies must transport their vehicles to a designated room(s) where they will undergo their safety inspection. The inspector(s) will reference the list of violations as he/she conducts the safety inspection of the vehicle using the safety inspection rubric.

What follows is the safety inspection protocol used at the international competition.

2.4 Safety inspection protocol

1. Before entering the water for practice or a product demonstration run, the ROV system must go through a safety inspection. Once a company successfully passes inspection, they will turn in their safety inspection sheet to the safety inspector and receive a Green PASSED Card with their company number on it. Companies must present the Green PASSED Card to the pool practice/product demonstration coordinator before their vehicles are permitted to enter the water.
2. Competition staff will conduct a safety inspection of the vehicle using the safety inspection rubric.
3. If the safety inspector(s) identify a safety violation, companies will have the opportunity to address it. The pool practice or product demonstration run schedule will NOT change to allow companies more time.
4. If during the second safety review the
    a. violation has not been properly addressed or
    b. another violation is revealed

   companies will have ONE additional opportunity to address the issue.
5. If during the third safety review a violation still exists, companies will not be permitted to participate in the underwater product demonstration component of the competition. However, companies can still participate in the engineering and communication (technical documentation, product presentation, and marketing display) component.

6. Reminder: All companies must present the Green PASSED Card to the pool practice or product demonstration judge before placing their vehicles in the water. In addition, product demonstration station judges and competition officials can pause or stop a product demonstration run at any time if they feel that there is a potential safety concern.

REMINDER!!! Companies do not need to present their Green PASSED Card to the judges during their product presentation. Companies that have their product presentations scheduled for the first day do not require an early safety inspection in order to participant in their presentation.

2.5 Safety Inspection Points

The safety inspection is worth 30 points. Each time a company fails its safety inspection it loses 10 points. After a company fails its second inspection, it must meet with the chief safety inspector to discuss a plan of action prior to returning to its workstation. THREE STRIKES and a company

a. Receives 0 points for the safety inspections and
b. Is disqualified from the underwater product demonstration component

3.0 SPECIFICATIONS

The ROV system (or "system") must meet the following requirements:

3.1 Operational

3.1.1 Multiple Vehicles

OPER-001: MULTIPLE VEHICLES ARE NOT PERMITTED. Companies are required to design and build ONE ROV that can complete the necessary product demonstration tasks. "Floating eyeballs" or other vehicles that are not hard connected to the frame of the main vehicle are NOT permitted. Cameras designed to provide a "birds-eye view" are permitted provided that these cameras are hard connected to the frame of the main vehicle. "Hard connection" does not include the wiring between the camera and the ROV.

3.1.2 Environmental

OPER-002: The ROV system must be able to function in fresh, chlorinated water with temperatures between 15°C and 30°C. The water should be considered conductive of electrical currents.

OPER-003: The pool will not be covered or purposefully darkened in any way, although the specific product demonstration tasks may require that your ROV operates in low-light.

OPER-004: No water currents will be intentionally created. However, depending on the venue, pressurized pool filtration system outlets may cause unexpected currents.

OPER-005: The pool venue at the international competition has a smooth bottom.

Note: EXPLORER companies attending regional competitions should note that regionals may be held in pool venues with different environmental conditions than those listed here. If you are unfamiliar with the regional pool, contact the regional coordinator in your area.

3.1.3 Service Requirement

OPER-006: Companies shall provide a crew of at least 3 but not more than 6 people on the pool deck to operate the ROV System. Companies can send a larger crew complement, but no more than six can be on the deck at any time. More information about this "product demonstration team" is provided in the COMPETITION RULES.

3.1.4 Maintenance and Calibration Requirement

OPER-007: All measurement devices shall be calibrated according to manufacturer recommended calibration procedure and performed by company members only. Company mentors or advisors are not permitted to perform calibration procedures. More information about mentor restrictions is provided in the COMPETITION RULES.

OPER-008: System maintenance during field operations shall be conducted by ROV personnel at their workstations. Work of any kind must not be done by company mentors or advisors. All maintenance parts and equipment necessary to meet the operation requirements shall be provided by the company. More information about these regulations is provided in the COMPETITION RULES.

3.2 Mechanical/Physical

This section of the document provides specifications for the mechanical properties of the ROV system.

3.2.1 Materials

MECH-001: At the international competition, any electronics housings on the ROV shall be capable of operating to depths of 5.5 meters.

3.2.2 Size and weight

MECH-002: ROVs are limited to a maximum diameter of 92 cm. Vehicles above this size will not be allowed to compete. ROVs are limited to a maximum weight, in air, of 35 kg. Vehicles over this weight will not be allowed to compete. Companies must be able to personally transport the vehicle and associated equipment to the product demonstration station and to the product presentation room. ROV systems must be capable of being safely hand launched. Additional points will be given to smaller, lighter vehicles (see Size and Weight Restrictions).

3.2.3 Tether Length

MECH-003E: At the international competition, ROVs must be capable of operating in a maximum pool depth of 5.5 meters (18 feet). All underwater product demonstrations will take place within 8 meters

from the side of the pool. The product demonstration station will be no more than 3 meters from the side of the pool. Tether length should be calculated accordingly. EXPLORER companies attending regional competitions should note that regionals may be held in pool venues with different maximum depths than those listed here. If you are unfamiliar with the regional pool, contact the regional coordinator in your area.

3.2.4 Vehicle Deployment and Recovery

MECH-004: The ROV system must be launched and recovered manually; no powered winches or portable cranes can be used. Hand-powered lifts and levers may be used to launch and recover the vehicle. The vehicle and any associated equipment must not damage any part of the pool or pool deck.

MECH-005: Any hand-powered lift or levers that are used as a LARS must be detailed in the technical documentation and must be part of the safety inspection procedure. Any LARS equipment that is deemed as unsafe at the safety inspection will not be allowed. Ladders, tripods, or other bracing equipment are not permitted as part of a LARS.

3.2.5 Propellers

New in 2018!!!

MECH-006: Propellers must be shrouded and have thruster guards. ROVs that have propellers exposed without thruster guards will not pass the safety inspection and will not be allowed to compete. A shroud must completely encircle the propeller and extend at least 2 mm in front of and behind the propeller. Thruster guards must completely cover any openings on the thruster and should have a mesh size that meets IP-20 standards (solid particulate protection level 2). This IP code equates to a mesh size >12.5 mm. To pass safety inspection, the shroud and propeller guard should meet this standard. If your finger can touch the propeller, then it is not properly guarded.

Teams may construct thruster guards, 3D print thruster guards, or may purchase commercially available thruster guards. All motors on the ROV must be protected with shrouds and thruster guards.

See https://www.thingiverse.com/thing:1498338 for an example of an acceptable thruster guard.

3.3 Electrical

ELEC-001: All power provided to the ROV system through an external connection for any purpose during the competition must be obtained from the MATE competition power supply. This includes dedicated lines for cameras, manipulators, and any other devices. This is a singular point of connection; all power to the ROV must pass through the MATE-provided fuse AND the single in-line fuse as specified in this section.

New in 2018!!!

Companies **MUST** use one of the following inline fuse(s) that are rated for the voltages used on EXPLORER class ROVs. Circuit breakers will not be allowed on the ROV system.

30 amp fuse
25 amp fuse
20 amp fuse
Fuse holder

Companies may also purchase fuses and fuse holders from the SeaMATE store.

ELEC-002E: The ROV system must be capable of operating off the power provided by a MATE supply with a nominal voltage of 48 VDC. This voltage may be as high as 56 volts. Power supplies will be a fixed output voltage and will not be "turned down" to accommodate other than the specified voltage for the class. All references to 48 VDC in this document are the nominal voltage of 48 VDC, which must be within the ranges specified in this paragraph.

ELEC-003E: The ROV system must deliver the supply voltage to the ROV as provided and without modification. No conversion of this voltage is allowed prior to it arriving at the ROV system bus. Methods on the surface such as DC/DC converters, voltage drop resistors, and Pulse Width Modulation (PWM) are not allowed to be used between the ROV and the power source. ESCs and H-bridges are not allowed on the surface. Power supplies and conversion devices are not allowed on the surface if they operate the ROV.

MATE strongly urges companies to refrain from sending reduced voltage signals from the ROV back up the tether to power devices on the surface. This is not done by ROVs in industry and therefore discouraged by the MATE Center.

ELEC-004E: ROV systems may use any voltage desired up to 48 Volts, but any conversion to a lower voltage must be made on board the ROV. Companies will not be permitted to operate an ROV that reduces the voltage on the shore-side/top-side end of the ROV tether.

ELEC-005E: Voltage may not be increased above the nominal 48 volts anywhere in the ROV system.

ELEC-006E: Sonar or other systems that may have DC/DC conversion resulting in voltages above 48V nominal are not permitted.

ELEC-007E: Voltages in excess of the class parameters set forth in this specification are not allowed on the ROV system at any time other than any inductive spikes that are caused by the switching on/off of motors, solenoids and other inductive devices. Companies should design their systems to handle these voltage spikes but will not be penalized for the presence of these in a system. For additional information on this, companies can research back electromotive forces (back EMF), collapsing magnetic motor fields, and transient suppression.

NEW IN 2018!!!

3.3.1 Non-ROV Device Power Specifications

Companies are permitted to design their lift bag release to operate using electrical power. In this case, the lift bag release will be considered a Non-ROV device and will operate under different power specifications than the ROV. The inductive coupling power device may also operate as a non-ROV powered device if companies choose to power it from the surface or from on-board batteries.

ELEC-NRD-001: Non-ROV devices can be powered from the surface or from batteries onboard the device. Power is limited to 12 VDC maximum and 3 amps maximum.

ELEC-NRD-002: Any non-ROV device may not contain thrusters or cameras, and can only include systems relevant to the task it is completing.

ELEC-NRD-003: If powered from the surface, the device must have a 3 amp fuse within 30 cm of the power source and must use Anderson Powerpole connectors. The cable and Anderson Powerpole connections must be completely independent of the ROV control console. I.e. wires/cables from the non-ROV device must not touch the ROV control box or any wires/cables coming from the ROV control box.

ELEC-NRD-004: Onboard power is allowed for non-ROV devices. If onboard batteries are being used, the following specifications must be met:

- Batteries must be primary (non-rechargeable).
- AAA, AA, A, A23, C, D or 9V alkaline batteries are allowed. No other size or chemical composition is allowed. 12 volt, outdoor, rechargeable batteries are **NOT** allowed. High discharge LiPo batteries are **NOT** allowed.
- Batteries are mounted in a manner that they are not loose inside the container.
- A fuse (3 amps max) must be installed within 5 cm of the battery positive terminal.
- The enclosure housing must be designed so that it will open if the pressure inside the housing is greater than the outside pressure.
- The enclosure housing must be designed so that it will release pressure if pressure inside the housing is greater than the outside pressure. Under no condition should the housing be built with fasteners to hold the device together if there is no pressure release valve. At least one opening must serve as a pressure release. This can be achieved by:
    - The battery holder must be mounted in a manner that will allow the end cap to freely open if pressure develops inside the housing.
    - Battery containers utilize a pressure release valve AND a Schrader valve. The pressure release valve must be rated no more than 3 psi.

Companies using a pressure release valve for their onboard battery container provide specifications and factory cut sheets of the valve used to the Competition Technical Manager no later than March 16th, 2018 for review by the MATE safety committee.

Examples of acceptable methods for housing batteries include:

- A PVC pipe with wires penetrating one end and the opposite end plugged with a rubber stopper.
- Cylinder with batteries mounted inside. One end of the cylinder sealed with caps and O-rings, but no fastening devices holding the end cap on.
- Cylinder with both a properly rated pressure release valve and a Schrader valve.

ELEC-NRD-005: An SID must be submitted for any non-ROV device that uses electrical power.

3.3.2 Independent Sensors

Certain product demonstration tasks may require a sensor that is independent of the vehicle. These electrically powered sensors will operate under the following independent sensor rules.

ELEC-IS-001: Independent sensors must be powered from the surface; no onboard batteries are allowed.

ELEC-IS-002: Companies may use USB to connect their sensor to a computer. Companies may also use surface battery packs (limited to 12 volts maximum) or the MATE supply to provide power for their independent sensor.

ELEC-IS-003: The independent sensor may only contain the intended sensor; thrusters, cameras, or other systems MAY NOT be attached.

ELEC-IS-004: Companies that use an independent sensor must provide a 3 amp (or less) fast blow fuse on the positive side of their connection. If companies are using the 12 volt MATE supply to power their sensor, both the ROV and the sensor must run through the single fuse before splitting off to the 3 amp sensor fuse. Companies using USB only to power an independent sensor may utilize the built-in current limiting of USB and do not need to add an additional fuse.

ELEC-IS-005: An SID must be submitted for an independent sensor that uses electrical power.

3.3.3 Current

ELEC-008R: ROVs will be limited to 30 amps.

The ROV system must have a fuse (or circuit breaker) that is calculated based upon the maximum current draw of the ROV. This overcurrent protection must be calculated as follows: ROV Overcurrent Protection = ROV Full Load Current * 150%. The overcurrent protection value may be rounded up to the next standard fuse. Companies must use a fuse that is rated for overcurrent protection. In no case can that value exceed the 30A maximum. The fuse or circuit breaker must be installed in the positive power supply line within 30 cm of the power supply attachment point. The fuse may be a slow blow type. The SID and other electrical diagrams must show the fuse or circuit breaker and include the amperage of the overcurrent protection. In addition, the SID must show the calculations used in determining the

overcurrent protection value. SIDs without these calculations shown will have 5 points deducted from the initial safety inspection sheet. Also, SIDS without fuse calculations will not pass safety inspection.

ROV overcurrent protection example:

- Eight motors, 2.7 amps each = 21.6 amps
- Two cameras = 0.25 amps
- Two servo motors = 0.8 amps
- One laser = 0.002 amps
- Total Amps: **22.87 amps** X 150% = **33.98 amps**
- ROV uses a **30 amp** fuse

All information on overcurrent protection should be included on the SID. Show your work.

The MATE power supply will be protected by a 30 amp fuse; however, the ROV system must also have its own calculated fuse.

ELEC-009R: ROV systems are allowed one replacement fuse during the product demonstration. In the event that the ROV system blows the second fuse during the demonstration, the demonstration will be over and no additional points will be earned. Companies should have adequate replacement fuses on hand, MATE will not provide replacements. Standard sizes for fuses and fixed trip circuit breakers are 15, 20, 25 and 30 amps. Additional standard fuse sizes are 1, 3, 6, and 10 amps.

3.3.4 Power Connections

ELEC-010E: Power supply connections will be Anderson Power Connectors. Companies' ROV system power wires must have proper connectors to obtain power. The Anderson Power Connectors must be connected to the ROV power wires securely; use of proper (hydraulic) tooling is suggested. Hand crimp tools do not have the force necessary to ensure proper and safe connections. MATE will not provide companies with connectors or adapters at the 2016 International Competition.

http://www.andersonpower.com/products/multipole-sbs.html
Housing: Anderson SBS50BLU-BK
Pins: The proper pin for your tether conductors
12 or 10 AWG: Anderson 1339G3-BK
8 AWG: Anderson 1339G5-BK
6 AWG: Anderson 1339G2-BK

http://leeselectronic.com

MATE strongly discourages the use of Anderson Powerpole "knock-offs." These connectors do not meet electrical specifications and have the potential to melt under load. Companies unable to locate a source of genuine Anderson Powerpole connectors can purchase Anderson Powerpoles from the SeaMATE Store or should contact their regional coordinator.

New in 2018!!!
Companies not able to purchase Anderson powerpole SBS50 connectors in their area can purchase connectors from the SeaMATE store.

ELEC-011E: The power supply may be located up to 1 meter from the station table and may be located on either side of the table. MATE recommends a power cable long enough to reach the power supply up to 3 meters from your control system.

3.3.5 Tether Voltages

The signals in the tether must meet the following specifications:

ELEC-012E: Low voltage, low current AC or DC control or sensor signals. Low voltage is defined as a voltage equal to or less than the maximum supply voltage per class specification. Low current is defined as being less than 500mA.

ELEC-013E: DC main-supply at a nominal voltage of 48VDC as provided by the MATE power supply.

ELEC-014E: Ethernet, USB, or other ANSI or IEC accepted serial protocol signals.

All cameras, including USB cameras, must be powered by the MATE supply. Powering a USB camera from the MATE supply can be accomplished by using a USB repeater / extender that has a separate power input at the far (ROV) end. The ROV must convert the 48V to 12V or 5V as needed to power the device from the MATE 48 volt supply. This conversion must be done on the ROV. USB cameras plugged directly into laptops are not allowed.

ELEC-015E: NTSC or PAL Video signals

ELEC-016E: Fiber optic cabling of any type may be used.

3.3.6 Exposed connections and disposable motors

ELEC-017E: ROVs with electrical connections that are exposed to water and not sealed are not permitted to enter the water. Taping a connection with electrical tape only does not constitute a sealed connection. The process of sealing electrical connections must include methodologies such as, but not limited to, Silicone RTV, hot melt glue, epoxy, self-vulcanizing tape, and enclosure of the connections in a housing.

ELEC-018E: "Disposable motors" are not permitted; these are exposed motors with no waterproofing.

3.4 Onboard Electrical Power

ELEC-019E: Onboard electrical power (i.e., power not provided by the tether): Onboard battery power is not allowed on the ROV. See the Non-ROV device power specifications regarding onboard power for the lift bag release and the inductive coupling connector.

NOTE: Water leaking into a closed battery container can result in the generation of hydrogen gas. This gas can build up inside a pressure housing and create an unsafe situation. Any battery housing must be designed to open if the pressure inside the housing is greater than the outside pressure to meet the MATE safety standards. See the non-ROV device onboard battery rules (ELEC- NRD-004) for more information.

3.5 Power Shutdown

ELEC-020E: For safety purposes, any ROV system that is disconnected from the surface supply must stop functioning in less than 5 seconds. This applies to electrical, pneumatic, and hydraulic power sources. Any filters, capacitors or accumulators must be sized accordingly to meet this specification.

3.6 Fluid Power

3.6.1 Hydraulic Power

FLUID-002: Hydraulic fluid: Water or biodegradable food-grade fluid, only.

FLUID-003: If a biodegradable food-grade fluid is used, a Material Safety Data Sheet (MSDS) must be provided at the safety inspection. The MSDS must show the type of fluid used and its compatibility with the Biodegradable Food-Grade specification. Companies using water do not need to provide an MSDS.

FLUID-003: If a biodegradable food-grade fluid is used, a Material Safety Data Sheet (MSDS) must be provided at the safety inspection. The MSDS must show the type of fluid used and its compatibility with the Biodegradable Food-Grade specification. Companies using water do not need to provide an MSDS.

FLUID-004: The following fluids are approved for use in hydraulic systems:

a. Water
b. Biodegradable Food-Grade Hydraulic Oil ISO Grade 32/46, SAE Grade 20, McMaster-Carr part# 3499K22

All other bio-degradable food-grade fluids must be approved by the Competition Technical Manager by March 16th, 2018.

FLUID-005: Maximum Hydraulic pressure allowed: 10.33 bars (150 psig).

FLUID-006: Hydraulic system: All lines, fittings, and hydraulic devices must be rated for a minimum pressure of two (2) times the maximum supply pressure.

FLUID-007: Hydraulic pumps must be part of the safety inspection.
1. They must have a pressure relief valve with a maximum setting of 300 psig or less installed before the pressure regulator.
2. The pump must have a regulator in place and set to 150 psig or less.
3. Pumps with any sign of external rust or deterioration will not be accepted.
5. All wiring must be secure.
6. All guards must be in place.
8. Hydraulic pumps may run off of the 15A 115VAC outlet provided for command and control as long as the hydraulic fluid is not used to propel the ROV. The hydraulic fluid is to be used for grippers and actuators only.

3.6.2 Pneumatic Power

FLUID-008: Pneumatic fluid: Compressed air or inert gas only

FLUID-009: Maximum pressure allowed: 2.75 bars (40 psig)

FLUID-010: Pneumatic system: All lines, fittings, and pneumatic devices must be rated for a minimum pressure of two and a half (2.5) times the maximum supply pressure. For example, if an 83 bar

(1200 psig) tank is regulated to 2 bars (30 psig), then all system components must have a minimum rating of 5.17 bars (75 psig)**.**

FLUID-011: Air compressors must be part of the safety inspection. .
1. They must have a pressure relief valve installed before the pressure regulator.
2. The compressor must have a regulator in place and set to 40 psig or less.
3. Compressors with any sign of external rust will not be accepted.
4. The tank drain valve must open.
5. If more than 5 ml of water exits upon opening the drain valve, the compressor will not be accepted.
6. All wiring must be secure.
7. All guards must be in place.
8. Air compressors may run off of the 15A 115VAC outlet provided for command and control as long as the air is not used for motor thrust. The air is to be used for buoyancy/ballast, grippers and actuators only.

3.6.3 Pressurized Cylinders

FLUID-012**:** Pressurized cylinders may be used, but must remain above the water surface and meet the following specifications:

a. Approved by US DOT (Department of Transportation) or TC (Transport Canada). For regional competitions taking place outside of the US, check with your regional coordinator for approval.
b. Have a current official inspection/test sticker and/or stamp.
c. Stamped with the maximum allowable pressure.
d. Contain a pressure relief safety device.
e. May be filled up to the maximum allowable pressure of the cylinder.
f. Must be regulated at its output to a maximum of 2.75 bar (40 psig).
g. Must have an easily accessible shut-off valve that is clearly marked with instructions.
h. May only be stationed on the surface, not on the ROV.
i. Must be secured in a safe manner such that they will not fall or roll around. If the judges feel that a cylinder is unsafe, they have the discretion to prevent its use.
j. SCUBA tanks are permitted. They must meet all the above specifications and have a current visual inspection sticker, or “fill permit” visible.

3.6.4 Pressure operated devices (PSO)

MATE will allow the use of soft-walled pressure operated devices in the competition provided they meet the following specifications:

- Device uses a pressure release valve of 7 psi maximum.

- Company provides specifications and factory cut sheets of the valve used to the Competition Technical Manager no later than March 16th, 2018 for review by MATE safety committee.

The intent of the exception to the pressure specifications is to allow the use of bladder type devices and flexible grippers that operate a few psi above ambient and would be destroyed if tested at full MATE pressure specifications. This exception does not apply to cylinders, pressure vessels or other pressure containment devices. If the device is tested to the 40 psi (pneumatic) or 150 psi (hydraulic) MATE specifications, a pressure release valve is not required.

3.6.5 Unpressurized cylinders

FLUID-013: Companies may fill containers on the ROV with air provided those containers never exceed ambient pressure. Any such container should have at least one ¼-inch (6.35 mm) hole drilled into the bottom of the container to allow excess air to spill out.

3.6.6 Pressure Storage Devices (Pressure Accumulators)

FLUID-014: Pressure storage devices are allowed on the ROV if they do not exceed 1.25L in total storage and do not store pressure higher than the allowed pressure for air or hydraulics. It is recognized that a company may not be able to purchase a pressure accumulator that has the proper rating and fits in the space needed. In that case, the company must show that their designed accumulator is capable of withstanding the specified pressures without rupture.

3.6.7 Fluid Power Quiz

FLUID-015: EXPLORER class companies planning to use hydraulics and/or pneumatics (i.e., fluid power) are required to take and pass an online quiz with a score of 100%. Companies ONLY using manual pumps and unpressurized containers are not required to take the Fluid Power Quiz, but must still submit documentation regarding their fluid power system.

NOTE: The quiz was developed by MATE Center technical support staff and competition judges and is designed to ensure that companies understand basic information on these topics and can apply that knowledge to safe practices. The intention is not to add yet another "requirement," but rather to provide a safe and successful learning experience and competition environment.

The quiz should be completed by the STUDENT company members. Each member of the company does NOT have to take the quiz; students can work together and make it a group effort. **ONLY ONE TEST PER COMPANY.** The company's instructor or mentor can provide guidance and advice, but the questions should be answered by the students participating on the company. The quiz will be scored and the results provided instantaneously. A score of 100% is considered a passing grade. Companies can take the quiz as many as 5 times to achieve this score.

The quiz must be completed with a passing grade by March 16th, 2018. Companies failing to complete this quiz within the given time frame will NOT be permitted to use fluid power during their competition event.

FEE TO TAKE THE FLUID POWER QUIZ! The fee to take the fluid power quiz is $15 for five attempts (no discounts for fewer attempts) and must be paid for at the time of registration. Companies will see an option to purchase the fluid power quiz when they register. Within five business days of receipt of payment, companies will receive a link, username, and password to take the quiz.

Note: The login information will be sent to the email address used when creating the team/company within the Active registration system – it must be an accurate and current email or you will not receive quiz access.

The following are sources of information on hydraulics and pneumatics. This is not intended to be an exhaustive list, but rather a starting point to encourage companies to seek out additional information and resources.

- Underwater Robotics: Science, Design & Fabrication, published by the MATE Center (see www.marinetech.org/underwater_robotics)
- http://www.fxsupply.com/pneumatics/psafety.html
- http://mining.state.co.us/safety/downloads/ppoint/HydraulicPressureIntensification.ppt
- National Fluid Power Association – http://www.nfpa.com/education/mini-book.asp
- Parker Hannifin Corporation – http://www.parker.com/ (look for technical literature links)

3.7 Control Systems

ELEC-021E: EXPLORER class ROVs are expected to utilize computer (or electronic) based control methodologies and H-Bridge or BLDC controllers for the thrusters. Systems using surface switch box controllers will not be permitted.

ELEC-022E: Surface control stations must be built in a neat and workmanship like manner. Loose components and unsecured wires will not pass safety inspection.

ELEC-023E: Surface control stations by nature combine 120VAC and 48VDC wiring. The surface control stations must be wired in a manner such that the 120VAC wiring is physically separated from the DC wiring, the 120VAC wiring is clearly identified from the DC and control voltages, and every conductor is insulated in a manner that no conductor is exposed. Identification can be through signage and/or wire color schemes. All 120VAC wiring colors must use ANSI, NEMA or IEC standard wiring colors appropriate to each voltage. There must be a sign inside the surface control station indicating which wiring standard is being utilized. Companies that do not have adequate separation of AC wires and components and DC wires and components will NOT pass safety inspection. It is recommended that separation be designed

into the control system to keep power systems separate. Wiring should be clear, neat and easy to follow by inspectors. Wiring "Rat's nests" or "spaghetti wiring" will not pass safety inspection.

New in 2018!!!

ELEC-024E: Companies must use proper strain relief and abrasion protection where wires and the tether enter the vehicle and the control box. The ROV should be capable of being lifted by the tether without damaging the tether connection to the ROV.

Examples of some acceptable strain reliefs for the ROV side include:
Hubbell Strain Relief 1
Hubbell Strain Relief 2
Strain relief grip
Kellums strain relief cord grip

ELEC-025E: Any connectors utilized in the surface control station and elsewhere in the ROV system must be properly type rated for their application. AC rated connectors must not be used for DC. The connectors must also be rated at or above the voltage and current used in their application.

3.8 Command, Control, & Communications (C3)

3.8.1 Power Provided

CCC-001: Surface power: MATE will provide one GFI-protected outlet with a nominal 115 Volts AC (60 Hertz) and 15 amps maximum. This outlet is intended to provide power for pumps and other surface support equipment (e.g. video monitors & control boxes). This AC power source CANNOT be used to directly or indirectly power the vehicle.

CCC-002: If hydraulic or pneumatic power is used for vehicle thrust, the power for the pump must come from the MATE supplied DC power supply.

CCC-003: In addition to electric pumps, hydraulic, and pneumatic systems can be powered by manual pumps (e.g. bicycle tire pump) or supplied from a pre-pressurized cylinder. Companies that are only using manual pumps do not need to pass the fluid power exam.

3.8.2 Displays

CCC-004E: Companies are not limited to the number of display screens used for video feeds or ROV status information. Display devices may be made up of any combination of TVs, monitors, laptops, and/or computer displays.

CCC-005E: These display devices may be powered by the MATE provided GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source described in CCC-001, Surface power.

CCC-006E: A company's C3 station may include devices like video recorders. All C3 devices must be able to run on the single AC power outlet provided or on its own internal battery power. Any device plugged into this AC power outlet can only provide C3 functions and cannot provide power to the ROV.

3.9 MATE Provided Equipment

MATE will **NOT** provide video monitors at the product demonstration stations.

3.9.1 Companies Sharing Equipment

Companies may share the following equipment during the competition event: monitors, joysticks, and compressors.

Companies may NOT share the following equipment during the competition event: control systems and payload tools (e.g. grippers, manipulators).

For companies attending an EXPLORER regional, contact your regional coordinator to determine if equipment can be shared at your regional event.

Companies that plan to share equipment during the international competition event must notify the Competition Technical Manager at least 4 weeks prior to the event so that this can be considered when creating the schedule. MATE will do its best to accommodate companies sharing equipment.

3.10 Laser Safety Rules

LASR-001: Companies using a laser at the international event must inform the MATE Center and provide the laser specifications by March 16th, 2018. Information and laser specifications should be sent to the Competition Technical Manager. Specifications will be forwarded to the MATE Center safety inspection team for evaluation. Once the laser specifications are reviewed, a notification will be sent to the company. If the laser is being used at a regional event or pool practice, notification will also be sent to the regional competition coordinator.

LASR-002: All lasers must operate in the visible range at either the 630-680 nm (red) or near the 532 nm (green) wavelength. All lasers must fall into the Class I, Class II, or Class IIIa category. Red lasers must operate at 5mW or less. Green lasers must operate at 1 mW or less.

LASR-003: Companies should include detailed specifications of their laser in their technical documentation as well as have that information ready and available during their safety inspection and product presentations.

LASR-004: Lasers must have an on/off switch. This switch must be on the surface controller.

LASR-005: All lasers must be powered by the MATE surface power supply. Batteries, including batteries for powering lasers, are not permitted on the vehicle.

LASR-006: Companies using lasers cannot increase the voltage or the current to increase the power of their lasers. Lasers must use the voltage and current set in their specifications.

LASR-007: When out of the water, the laser should have a shield or enclosed beam stop attachment within 30 cm of the laser. This means that the laser beam should not travel more than 30 cm before reaching the shield. This is a requirement at all times when the laser is out of the water. The shield does not need to be attached to the ROV while it is in the water. The shield must be painted with FLAT BLACK paint.

LASR-008: At no time should the laser be focused or deviate from a collimated beam.

LASR-009: When testing the laser at a workstation, companies must display a sign telling others that a laser is being operated.

LASR-010: Operators working with the laser while the ROV is out of the water should wear appropriate laser safety glasses at all times. This requirement is for all laser types. Search online to find laser safety glasses appropriate for the wavelength being used.

New in 2018!!!

Companies must forward the specifications of their laser safety glasses to the Competition Technical Manager by March 16th, 2018. A notification will be sent to the company when the laser safety glasses are approved. Companies must also bring a copy of their laser safety glasses specifications to their safety checks. If more than one brand of glasses are used, a copy of each specification sheet should be provided.

PART 4: COMPETITION RULES

4.1 GENERAL

- All members of the company and their supporters must follow the safety regulations of the ROV competition, pool facility, and event venue.

- All company members and their supporters are expected to conduct themselves in a professional and responsible manner during the competition. Disrespectful behavior towards the judges, officials, pool staff, audience, or other companies will lead to penalty points or disqualification.

- Sabotaging, stealing, or pilfering equipment of other companies will lead to disqualification. Companies found cheating will also be disqualified.

- The MATE ROV competition is, at its core, designed to be an educational and inspirational event for **STUDENTS**. It is designed to challenge them to apply the physics, math, electronics, and engineering skills they are learning in the classroom to solving practical problems from the marine workplace. (See the MATE Competition Philosophy.)

  It is expected that all "adults" (non-students; e.g. teachers, mentors, parents) involved in the competition limit their input to educational and inspirational roles. Actual construction of the ROV (particularly in the complex electrical and software areas) must be completed by the students. Adults should teach and advise students about design, electronics, software, and construction, but not complete the work for the students. Throughout the process adults are encouraged to focus on benefits to the students from the process and not simply winning. If it becomes apparent that adults exercised more than an advisory role, judges reserve the right to deduct points or, in extreme cases, disqualify companies from the competition.

  ALL work done on the vehicle must be conducted by company members. This includes any work done at home, at school, or during the MATE ROV competition (international and regional). Teachers, mentors, parents, and non-competing students are not permitted to work on the ROVs. They may provide advisory input, but they may not work on the ROV directly. This includes writing or editing software code. All mechanical, electrical, and software modifications and/or repairs to the ROV must be completed by students.

  With learning at its core, the MATE competition encourages students to utilize and build upon their skill sets to find creative solutions to designing and building their ROV. Students gain valuable skills and knowledge when creating a component from "scratch," which is apparent to judges as they review the technical documentation and engineering presentation. However, as they move through the process of analyzing their designs and identifying building materials, students may decide to either build a component from "scratch" or purchase it from a commercial vendor.*** So, while original solutions are encouraged, the use of commercial components is acceptable, provided 1) that the components adhere to the design and building as well as safety specifications for the particular competition class and 2) more importantly, that the students can provide a reasonable, logical explanation for buying versus building.

  The competition scoring rubrics are designed to reflect this; points are awarded based on students' abilities to explain and justify how all of the components and systems work together as an integrated ROV, regardless if they purchased them, pulled them from public libraries, or made them themselves.

  ***Note "commercial vendor" includes the SeaMATE store and other competition programs that sell educational robotics kits. SeaMATE kits were created to remove barriers to participation for

teachers and schools unable to easily 1) find parts and materials and 2) set up accounts with multiple vendors. The kits are part of a larger educational package offered by the MATE Center that includes curriculum materials, videos, and other resources to support and enhance learning. And learning is what students who use SeaMATE (or other) kits will be expected to demonstrate during and through the ENGINEERING & COMMUNICATION components.

It should be noted that purchasing and competing with complete, assembled, commercial ROVs is not permitted.

4.2 PROCEDURAL

- Companies must compete during their assigned time slots. Your company is **NOT** permitted to switch time slots with another company. Failure to show for your scheduled product demonstration or for your company's product presentation will result in "no score" for that particular competition category. **No exceptions.** Assigned time slots will be sent out in advance so that any scheduling concerns can be addressed prior to the event.

- Companies must complete their size and weight measurements before each product demonstration run. The size and weight measurements are included as part of the product demonstration score. Companies should be at the size and weigh in area at least 20 minutes before their scheduled product demonstration run.

- While there is no limit to the number of students who can compete as part of a company, **the product demonstration team (aka demo team) is limited to six students**. The demo team is defined as the team of students who operate the vehicle and its associated equipment during the product demonstration. Only six students will be allowed to enter the product demonstration station, launch, pilot, and perform the tasks. Instructors, mentors, and/or non-student members cannot participate as part of the demo team. **Companies may alternate students on the demo team for the two product demonstration attempts.** (All members of the company should participate in the engineering and communication components; see ENGINEERING & COMMUNICATION for more information.)

- Only the demo team members and judges are allowed at the product demonstration station during the product demonstration, which includes the set-up and demobilization periods. Other members of the company, instructors, mentors, audience members, and observers (press or special invited guests) must remain outside the product demonstration station or in designated viewing areas.

- Instructors, mentors, parents, and "fans" are **NOT** permitted at the safety inspection stations or repair tables. Two warnings will be issued before individuals not heeding this rule will be asked to leave the venue.

- In addition, instructors, mentors, parents, and fans are **NOT** permitted to work on the ROV. Individuals who are seen working on the ROV who are not student company members will be issued a warning. Two warnings will be issued before individuals not heeding this rule will be asked to leave the venue. If companies choose to take their ROVs off the competition grounds for maintenance and repair, they are expected to observe this rule in the interests of the spirit of the competition.

- To help enforce this, teachers, mentors, parents, and non-competing students MAY have limited access to the work station areas.

- Video devices may be used to record the underwater activities for entertainment and learning purposes **only**. Video will not be used as an instant replay to review judges' decisions or to challenge product demonstration timing.

- Product demonstration stations will be roped off and marked. Product demonstration stations will contain 2-3 chairs and one 6-foot table long table for companies to use. This table will be within 3 meters of the pool edge. Product demonstration stations will be set up to prevent the pilot(s) from looking at the ROV in or under the water except through the ROV cameras.

- Companies will compete in one product demonstration that will consist of three tasks. Companies will get TWO attempts at the one product demonstration. The higher of the two scores will be added to the engineering and communication score to determine the total, overall score for the competition.

- The product demonstration time consists of a 5-minute set-up period, a 15-minute performance period, and a 5-minute demobilization period. If the demo team and all of their equipment are not out of the product demonstration station at the end of the 5-minute demobilization period, the company will be **penalized 1 point for each additional minute**.

  Note: For companies attending an EXPLORER regional, those competitions may allow more or less time to complete the product demonstration. Contact the regional coordinator in your area or your regional contest's web site for more information.

- Manipulating the tether to free it from underwater obstacles is permitted. Pulling on the tether to speed up the recovery of items or to return your vehicle more quickly to the surface is not permitted and will result in penalty points. Judges will issue one warning if tether pulling occurs. Each future infraction will result in **5** points deducted from the final product demonstration score.

- SCUBA diver assistance will be available at the international competition. If help is required, the company CEO or pilot must ask a station judge and divers for assistance. Each diver assist will incur a 5 point penalty. The product demonstration clock will not stop if a company is receiving diver

assistance.

Diver assistance may not be available at regional competitions. Contact your regional coordinator or your regional contest's web site to determine if diver assistance will be available at your regional competition.

- Pilots can only leave the product demonstration station and move poolside to repair, adjust, or alter a vehicle if the ROV is surfaced and at the side of the pool.

- Companies are not permitted to leave debris in the pool. Any debris must be recovered by the ROV before time has expired or the company will be penalized. Debris is defined as pieces of the ROVs, weights, floats, or other items created by the company. Any lift bag release mechanism intentionally left on the anchor are not considered debris. Task props are also not considered debris. The product demonstration notes section may cover special items that can be left in the pool after time has expired.

- No demo team member shall enter the water to complete an object recovery. Only arms and hands are allowed into the pool to retrieve an object or to retrieve the vehicle. Companies will be disqualified or penalized depending on the severity of the infraction.

- Communication between demo team members at the pool edge and demo team members piloting the vehicle will be limited. Only tether management issues (e.g. how much tether is out, how much is remaining on the pool deck) can be discussed. Those team members at the pool edge cannot give any directional or product demonstration task information to the pilot. Judges will issue one warning regarding illegal communication. Each future infraction will result in **5** points deducted from the final product demonstration score.

- Communication using cell phones, text messaging, and online social media tools such as Skype, Facebook, Twitter, instant messaging, etc. is NOT permitted during the product demonstration, either between the demo team members at poolside or between any demo team member and anyone outside of the product demonstration station. The ROV and/or the ROV control system is not allowed to broadcast video or other information to anyone outside of the product demonstration area. No exceptions. Companies found broadcasting any data to those outside of the product demonstration area will be disqualified.

- **Product demonstration judges and other competition officials will only communicate with students.** Judges and officials will NOT communicate with mentors, parents, or other non-student members regarding product demonstration information, challenges, or other issues except during pre- and post-competition briefing sessions.

  Companies that wish to issue a challenge during the product demonstration run should immediately

communicate this challenge to the product demonstration judges. The judges will discuss and attempt to resolve the issue. If a decision cannot be made, the product demonstration judges will consult with the head judges and competition technical manager to resolve the issue.

4.3 DESIGN & SAFETY CONSIDERATIONS

- The competition coordinators and host venues stress the importance of safety practices and procedures to all companies. The score sheets and rubrics will reflect the MATE Center's efforts to encourage and reward companies that demonstrate exceptional safety practices and procedures.

- **ALL ROVS MUST PASS A SAFETY INSPECTION CONDUCTED BY COMPETITION OFFICIALS PRIOR TO ENTERING THE POOL.** These inspections will be conducted topside to ensure that ROV systems meet the design and building specifications and do not pose a risk to the integrity of the event venue. See VEHICLE DESIGN & BUILDING SPECIFICATIONS for additional information.

- Radio transmitters that operate on a separate battery are permitted. No batteries are permitted to be in or on the water. No exceptions.

  Companies should be aware of all the implications of these wireless devices. There is no assurance that an adjacent company's wireless controller will not interfere with your control systems. Adjacent wireless controllers with a battery that has a higher charge than the nearby controller have demonstrated the ability to "hijack" the nearby control signals. In addition, all wireless controllers are susceptible to external sources of electronic interference. Your system may work fine in your home environment, but not in the industrial environment of the competition. MATE will not stop the clock to resolve wireless control issues. Companies deciding to utilize wireless controllers do so at their own risk.

- Keep an eye out for tripping hazards in the product demonstration station and at your company's work station. Make sure power cords are not laying in pools of water on the deck.

- During your product demonstration, be sure to secure any equipment so that it does not fall off the product demonstration station table, damage the deck, or cause injury.

- Loose fitting clothing, jewelry, and long hair could all become safety issues. Consider securing long shirts or baggy pants, removing jewelry, and tying back long hair when working on or operating your ROV.

- ROVs may be constructed out of materials of your company's choice, provided they meet the design and building specifications and safety regulations. Warning labels should be posted on potentially hazardous components of your ROV system.

- Close toed shoes are required on the pool deck. Safety glasses are required when working on the vehicle.

- Personal flotation devices (PFDs) will not be required at the international competition. No personal flotation devices will be provided by MATE or the host venue. Regional events may require PFDs. For companies attending an EXPLORER regional, contact your regional coordinator to determine if PFDs will be necessary.

PART 5: ENGINEERING & COMMUNICATION

The ability to effectively communicate information about your vehicle and the design and building process is equally as important as how well your vehicle performs. Strong communication skills are an essential part of good business practices. To emphasize this point, the competition requires the following four engineering and communication components:

- Company Spec Sheet
- Technical Documentation (formerly known as the technical report)
- Engineering Presentation (formerly known as the product presentation)
- Marketing Display (formerly known as the poster display)

NOTE: For companies attending EXPLORER class regionals, regional contests may not require all of the Engineering & Communication components. Contact your regional coordinator or your regional contest's web site for more information.

The company spec sheet, technical documentation, and engineering presentation are components where you are communicating with technical audiences, such as potential future clients. (Examples of spec sheets and technical documentation from previous competitions can be found www.marinetech.org/tech-reports. Examples of engineering presentations can be found on MATE's Vimeo channel.) The marketing display should be thought of as part of your marketing (or sales) strategy and aimed at general (including non-technical) audiences.

TIPS FOR EFFECTIVE WRITTEN AND ORAL COMMUNICATION

Communicating ideas about how to solve a problem and evaluating those ideas against competing alternatives is a critical skill for anyone entering the workplace. It is a skill that is directly linked to decision making about whether or not to hire (or fund) us and our ability to influence the work that we do.

The key to a successful technical documentation and engineering presentation is the way that critical thinking and engineering reasoning are communicated. You can think of the process as technical "storytelling."

Technical storytelling includes the use of text, images, schematics, and data to effectively communicate the "story" of how your company brainstormed and evaluated ideas to come up with your solution (e.g. ROV, payload tools, and operational strategies) to the problem at hand (product demonstration tasks). It also involves organizing content to efficiently present your work and justify why you did what you did.

However, you should choose details with care. Each detail should help to answer the question "why is what you did the best solution for your company and for this competition?" Describe why a component in the system is critical and how you chose it. Include specifications or dimensions only if they help to explain the "why" and "how" you made choices. Keep in mind that a mechanical drawing with dimensions can replace a lot of text and in many cases do a better job telling details of the story than text.

That said, if something is hard to describe clearly and completely with two to three sentences, consider whether using an image may help. A good technical document balances text and images to provide lots of information concisely, which for a detailed understanding while being quick and easy to read. Remember that your reader is new to your design and needs to understand both what your design is and the process you used to get there. Present text and images in a logical order that helps readers follow your development process and results.

Maintaining a project notebook is a good business practice that will help to capture ideas and document your company's progress – including your research, designs, trade studies, experiments, data, vehicle specifications, testing, expenditures, and donations. The notebook is also a place to keep track of your company member's contributions (time, support, etc.).

Along with your notebook, here are some items to consider as you prepare to tell your story:

- What was your company's "work breakdown structure" (tasks, time, and people)?
- What were the greatest constraints (schedule, budget, equipment, labor, logistics, etc.) on your design process?
- How did the product demonstration tasks and rules influence your design and decisions?
- What systematic process, such as a tradeoff matrix, did you use to evaluate competing design solutions?
- What were the most important design decisions you made and why?
- How did you arrive at your final power budget? What concessions, if any, did you have to make and why?
- How do you calibrate your sensors?

- If your vehicle uses software, where does the code execute? Describe the flow and format of the data.
- Did you have a noteworthy troubleshooting experience? Any problem or procedure that takes more than 20 minutes to figure out is worth understanding and writing down.

NEW IN 2018!!!

Rather than specifications, this year your company should refer directly to the scoring rubrics posted on the MATE web site under Missions, Specs, and Scoring for details on what is required for your technical documentation, engineering presentation, and marketing display. The judges will use the rubrics to evaluate and score these engineering and communication components.

5.1 COMPANY SPEC SHEET

Your company is required to submit a one-page spec sheet; the specifications for what is required are included below. The goal of the spec sheet is to provide the judges with a "snapshot" of your company. It includes basic information about your company and vehicle.

Company spec sheets will be reviewed by MATE competition coordinators.

Companies will receive up to 20 points for submitting a spec sheet that is one page in length, follows the file size and naming specifications, and contains all of the following information:

COMPANY SPECS

- **Company and school, club, or community organization name**
- **Home state and/or country**
- **Distance required to travel to the international competition**
- **History of MATE ROV competition participation.** Be sure to specify if your company and/or the members of your company are "new" or "returning."
- **Company photo and caption indicating members' names and roles (e.g. CEO, CFO, Design Engineer, Pilot, etc.).** This photo should include all of the members of your company.
- **Range of grade/college levels represented by the members of your company**

ROV SPECS

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

If all of the above information is included, the specifications for length, size, and naming conventions are followed carefully, and the document is submitted on time, this is an "easy" 20 points!

5.2 TECHNICAL DOCUMENTATION

Your company is required to submit technical documentation that will be reviewed and evaluated by 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 engineering presentation!) The technical documentation is a means for your company to describe the design, operations, and features of your vehicle. Your clients should gain a good technical understanding of your vehicle and your company's capabilities in addressing your client's needs for an ROV.

Any changes or additions that you make to your ROV that differ from the information in the technical documentation that you submit should be presented to the judges during your company's engineering presentation. **NOTE: The judges will not review and rescore revised versions of your technical documentation during the competition.**

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.

Use the technical documentation scoring rubric posted here as the guideline for the required components for the technical documentation. This rubric will be posted by February 1, 2018.

5.3 ENGINEERING PRESENTATION

During the competition, your company is required to give a 15-minute oral 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.) Your presentation should describe the engineering behind your vehicle's design and operation and address any possible safety issues. It should also highlight any design innovations or creative solutions to solving the product demonstration tasks. 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.

All student members of your company must participate in this presentation and question and answer (Q&A) period. You are required to have your ROV with you.

NOTE: The engineering presentation is designed to be a face-to-face interaction where students and representatives from industry become engaged in conversation. MATE will not provide audio visual aids, such as slide projectors, computer projection screens, white boards, etc.; however, you are welcome to distribute handouts to help judges better understand the information that you are

presenting. **PowerPoint presentations are NOT permitted.** During the Q&A, all members of the company must be present and prepared to answer.

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. 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.**

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.

The judges will pay particular attention to whether or not the vehicle was built by the students from "scratch" or excessively uses complete, off-the-shelf systems. (The COMPETITION RULES includes more information on this topic). They will also be looking carefully at how the vehicle was designed and built specifically for the product demonstration tasks. Design originality and innovation as well as safeguards to prevent injury or damage to the underwater environment will be noted.

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 February 1, 2018. 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.

Preparing for your engineering presentation and Q&A

- Make sure that every member of your company has a good, general working knowledge of your vehicle, even though they may have specialized in one specific aspect of its design and construction.
- Research the specifications of the components that you use in your vehicle. For example, look up the specs of your ROV's camera and be familiar with such numbers as the amount of propulsive force the thrusters produce, the weight of your ROV, etc.
- Make sure that all the members of your company are familiar with your technical documentation. Ask every member to read it over to catch any errors or omissions. This exercise will help to familiarize everyone with all aspects of the project.
- Generally, you will have more to say about your ROV than can be presented in 15 minutes. That is why it is critical to organize your material and practice communicating it. However, avoid coming across as having memorized your presentation verbatim. Judges want to see that you are prepared and understand the information, not that you can simply regurgitate a rehearsed speech from memory. Ask your instructors or mentors to give you feedback.

Other important items

- If during the engineering presentation it becomes apparent that instructors, mentors, and other adults associated with your company exercised more than an advisory role, judges reserve the right to deduct points or, in extreme cases, disqualify companies.

5.4 MARKETING DISPLAY

Your company is required to create a display that will be showcased during the competition event. Your display should be an informative, clear, and concise presentation about your company and how you designed and built the specialized tools to effectively complete the product demonstrations. During 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.

While some judges will have a technical background, others will have a communications, marketing, or public relations background. In addition, there will be visitors to the competition who may not completely understand what an ROV is or how it is used. Think of these visitors as potential future clients who may authorize funding for your work, but have a limited understanding of the technology (i.e., you need to explain your technology, the tasks at hand, and "sell" them on YOUR products and services). Design your display to communicate to this type of audience.

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

****

INTERNATIONAL COMPETITION ONLY!

NOTE: The MATE Center will NOT supply display boards again this year.

You must provide your own display board. The space that the text and photographs/graphics occupy CANNOT exceed 36" tall by 48" wide. For example, company names CANNOT be mounted above the display board. NO EXCEPTIONS!

At the international competition, tables will be provided for the displays. Contact your regional coordinator to see if tables (easels or other) will be provided at your regional event.

MATE will continue to provide scissors, tape, glue sticks, adhesives, and other means of attaching display items to the presentation board, although you are also welcome to bring your own.

****

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 February 1, 2018.

Creating an effective marketing display:

- Address the theme and make real-world connections.
- Reflect your company's personality and mindset.

- Make key points and be concise.
- Keep the general public in mind.
- Make sure to label any and all figures, graphs, diagrams, and photographs and credit the source.
- Maximize the use of the 36" by 48" display space.
- Make sure that it is both informational and aesthetically pleasing.

Note: "Accessories" such as video footage, PowerPoint slide presentations running on laptop computers, video projections, etc. are permitted but should be used with discretion. Remember that the judges will have a limited amount of time to evaluate your marketing display and may find excessive use of audio or video presentations distracting.

However, if you do make a video of your ROV building or competition experience, please submit information about it to the MATE Center so that it can be shared via MATE's YouTube and Vimeo channels.

5.5 CORPORATE RESPONSIBILITY (formerly Outreach and Inspiration)

The MATE Center uses underwater robotics to inspire and encourage students' interest in STEM (science, technology, engineering, and math) education and careers. Recognizing that the students who participate in MATE competitions are powerful ambassadors for the program as well as effective leaders in raising awareness of important issues and bringing about positive change, companies have the opportunity to earn up to 10 points for "corporate responsibility."

Corporate responsibility includes, but is not limited to, the following:

- **Mentoring** consists of, for example, providing guidance to other students in your area who are designing and building an ROV for the competition or a science or other project.
- **Engaging the community** includes demonstrating your ROV and sharing information about your company at festivities and other community-wide events. Presenting to a Rotary Club or your school districts board of directors are other examples.
- **Media outreach** consists of:
    - Developing a list local media contacts
    - Writing a press release about your participation in the MATE ROV competition
    - Distributing it to your media contacts
    - Following up with your media contacts to see if they're interested in your company and its ROV
    - Compiling a summary of results

    Here are some general guidelines for working with the media. They are specific to the international competition, but can be easily modified for regional events.
- **Raising awareness of societal (including environmental) issues** includes, for example, the amount of plastics in the world ocean. A 2010 study estimated that 8 million tons of plastic trash ended up in the ocean from coastal communities – far more than the total that has been

measured floating on the surface in the ocean's "garbage patches." Even the deepest part of the ocean is not immune; a recent study published in Nature found that crustaceans collected at the bottom of the Marianas Trench had levels of plastic micro-particles at levels 50 times greater than that of the most polluted river in China. Read more – and take on the challenge!

Corporate responsibility efforts will be reviewed by competition coordinators and awarded 0 to 10 bonus points, depending on the number and scope of the outreach and awareness activity(s), i.e., the number of other students or members of the community engaged, the number of mentoring sessions, etc.

Make sure to include the following information in your write-up:

- Type of activity (e.g. mentoring, exhibiting at a community event, raising awareness)
- Locations, dates, and the amount of time spent on the activity
- Number of students or community members (if a large event, this can be an approximate) involved
- Description of your actions, outcomes, and other information that helps to demonstrate the quality of your time and efforts
- For media outreach, please submit a copy of your press release, a copy of your media contacts list, and a summary of news articles, TV or radio coverage, etc. that your company received. Include copies of articles and URLs, and list any television or radio coverage. Be sure to include name of outlet, date, and a summary of the coverage.

PART 6: SUBMISSION GUIDELINES AND KEY DEADLINES

6.1 Documentation

Companies advancing to the international competition are required to submit a technical documentation, a company spec sheet, a SID, a fluid power diagram (if fluid power is used), lift bag release design specifications, a SID for the inductive coupling connector, and a company safety review. In addition, companies may submit a JSA, information on image recognition, as well as documents supporting their corporate responsibility efforts.

For companies attending EXPLORER class regionals, regional contests may not require all of the documentation. Contact your regional coordinator or your regional contest's web site for more information.

DOC-006: All required documentation sent to the MATE Center MUST be in searchable PDF format (see https://fd4686477cb19f983f54-68abf00cbc1a2cc111562c013cb867db.ssl.cf1.rackcdn.com/SearchablePDFs.pdf for information about creating searchable PDFs.

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_2018.pdf, where DOCUMENT TYPE is technical documentation, spec sheet, SID [type – electrical or fluid], lift bag release design, company safety review, or JSA. They must be submitted via the form located here – https://www.emailmeform.com/builder/form/cU50v6e90Xd2G6FEOaec8P

Submit only your final documents and use only ONE form (multiple files can be attached to one emailmeform). 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.

6.1.1 Video Demonstration Documentation

DOC-009: Videos must be submitted no later than 11:59 PM, Hawaii time, May 11th, 2018. Videos must be submitted via the form located here – https://www.emailmeform.com/builder/form/IFKbdLUvk3e1V, using the following naming convention: School or organization name_company name_ video demonstration_2018.

DOC-010: Videos must be submitted as links to a YouTube or Vimeo post. Companies may submit the specification and product demonstration as two separate videos. Note that the product demonstration portion must be a complete, uncut video.

MATE competition organizers will review the videos and respond by May 22nd. Video submissions will NOT be accepted after May 11th – NO EXCEPTIONS. 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 international competition. No extensions past the due date will be given for any reason.

MATE strongly encourages companies to submit their videos well before May 11th. That way, if an issue is found, companies will have the opportunity to address the issue and submit an updated video before the May 11th deadline. Note that it may take MATE up to 5 working days to evaluate a video submission.

6.1.2 Image Recognition Documentation

DOC-011: Image Recognition: Companies are required to submit information to the MATE Center about their image recognition software. This document should detail how the company created their image recognition software and include the following items:

- Data flow diagram: A diagram showing the flow of data from the camera on the ROV to the output that identifies the aircraft.
- Algorithm description: A detailed description of the inputs to the vision processing and a detailed description of the output of the vision processing. A description of the algorithm should also be included, describing the method (shape and color recognition, letter recognition, etc.) used by the company to complete the task.
- A library of code files: A document of all the code used including header files, libraries, and a README describing each file.

Shape Overlay Resources:
C, C++, Java, Python, Cuda, Android, iOS: **https://opencv.org/**
Arduino: **https://www.open-electronics.org/a-video-overlay-shield-for-arduino/**
Matlab: **https://www.mathworks.com/help/vision/ref/insertshape.html**

Companies may choose to use other image processing algorithms as needed.

DOC-012: All documents should use the following naming convention: School or organization name_company name_DOCUMENT TYPE_2018.pdf, where DOCUMENT TYPE is data flow diagram, algorithm description, code file # (multiple code files can be uploaded). They must be submitted via the form located here – https://www.emailmeform.com/builder/form/IFKbdLUvk3e1V

Submit only your final image recognition documents and use only ONE form (multiple files can be attached to one emailmeform). This form should be submitted separately from emailmeform for technical documentation.

Image recognition documentation will be evaluated by MATE Center judges. Any potential issues or concerns will be discussed with the company until a resolution is found. Companies that do not submit image recognition documentation or do not resolve issues with the MATE Center judges will not be permitted to complete the identifying the aircraft step of Task 1: Aircraft.

DOC-013: For the international competition, due date for the required documentation, the image recognition documentation, and the JSAs is 11:59 PM, Hawaii Time Zone, on May 24, 2018.

DOC-014: Companies will lose points on their initial safety and documentation review if documents:
- Are submitted late
- Exceed the size limit
- Use improper naming conventions
- Are not submitted on ONE form

6.1.3 Corporate Responsibility Documentation

DOC-015: Corporate responsibility efforts should be submitted to: https://www.emailmeform.com/builder/form/D6bW4p353aY

DOC-016: The following naming convention should be used for corporate responsibility documentation: School or organization name_company name_Corporate Responsibility ##_2018, 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 emailmeform). 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 international competition, due date for the corporate responsibility documentation is 11:59 PM, Hawaii Time Zone, on June 7, 2018.

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

6.2 KEY DEADLINES

Below is a summary of key dates and deadlines for the 2018 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 web site for more information.

- December 1, 2017: Registration opens (note that individual regional registrations will open as regionals secure their location and date)
- March 16th, 2018: Last day to PASS the fluid power quiz
- March 16th, 2018: Last day to submit laser specifications
- May 11, 2018: Last day to submit EXPLORER qualification videos
- May 24, 2018: Submission deadline for:
    - Technical documentation
    - Company spec sheet
    - SIDs (including electrical, fluid, Non-ROV Device
    - Lift bag release specifications
    - Company safety review

    - Job site safety analysis (optional)
    - Image recognition documentation
- June 7, 2018: Submission deadline
    - Corporate responsibility documentation