



# MATE ROV COMPETITION 2018

## RANGER

**MATE  
INTERNATIONAL  
ROV COMPETITION  
2018**

**JET CITY:  
AIRCRAFT  
EARTHQUAKES  
AND  
ENERGY**

**JUNE 21 - 23, 2018  
WEYERHAEUSER KING COUNTY  
AQUATIC CENTER  
FEDERAL WAY, WASHINGTON, USA**

**MTS** marine technology society

**ROV** SOCIETY

**NSI**

**NORA** NATIONAL OCEANOGRAPHIC RESEARCH AND ASSOCIATED SERVICES

**OCEANEERING** UNIVERSITY of WASHINGTON



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**2018 MATE ROV COMPETITION:**  
*Jet City: Aircraft, Earthquakes, and Energy*

**RANGER CLASS COMPETITION MANUAL**

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

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## 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.

### RANGER CLASS – REGIONAL PARTICIPATION/DEMONSTRATION

**All companies participating in the RANGER class are required to take part in a regional event.**

Companies that win their regional event advance to compete in the RANGER class at the international competition. The total number of RANGER winners that advance to the international depends on the total number of individual SCHOOLS or ORGANIZATIONS (not teams) that participate in the regional (not just register, but show up and participate on contest day).

- Regionals must have a minimum number of 5 individual schools/organizations in order to send a team to the international.
- Regionals with fewer than 5 individual schools/organizations can send ONE team to the international provided that:
  - In addition to the product demonstration, the regional has required and scored at least 2 of the 3 Engineering and Communication components.
  - The team that advances has:
    - Passed the safety inspection
    - Achieved a demonstration score of at least 100 points, not including size and weight, safety, or organizational effectiveness
    - Achieved a combined Engineering and Communication score of at least 100 points, not including the company spec sheet or corporate responsibility
    - Successfully passes the RANGER video demonstration administered by the MATE Center
- Regionals with 5– 10 individual schools/organizations send the top ONE team to the international.
- Regionals with 11 – 20 individual schools/organizations can send the top TWO teams to the international.
- Regionals with 21+ individual schools/organizations can send the top THREE teams to the international.
- The regional hosting the international can send one additional team above their allotment to the international.

Companies will be assigned to the regional that is geographically closest to their location. If companies are located equidistant from two or more regionals, the MATE competition coordinator and the coordinators of those regionals will discuss with the company which regional is most appropriate.

RANGER class companies that are prohibitively far from a regional event should contact the [MATE Center](#) for information about conducting a [video demonstration](#).

NO RANGER class companies will be permitted to participate in the international competition without either 1) winning their regional event or 2) submitting a video demonstration that is then approved by MATE competition officials.

## PART 1: PRODUCT DEMONSTRATION

### OVERVIEW

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

**TASK #1: AIRCRAFT**

**TASK #2: EARTHQUAKES**

**TASK #3: ENERGY**

**NOTE:** Regional competitions may not include all 3 tasks of the product demonstration; regional competitions may also give companies more than one attempt at the product demonstration. Contact your [regional coordinator](#) or visit your regional contest's web site to determine what will take place your regional competition. Regardless, 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**

**NOTE:** Regional contests may not require all 3 of the Engineering & Communication components or offer the opportunity to earn points for JSAs and Corporate Responsibility. Contact your [regional coordinator](#) or visit your regional contest's web site for more information.

## 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 stop if a judge 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.).

Regional competitions may alter the set-up, product demonstration time, or demobilization time. Contact your [regional coordinator](#) or visit your regional contest's web site to verify the timing of your product demonstrations.

## 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-iUbpFV4A](http://www.youtube.com/watch?v=Tn-iUbpFV4A) for sound advice from MATE judge Marty Klein. He references 2015, but his words still hold true for this competition season!)



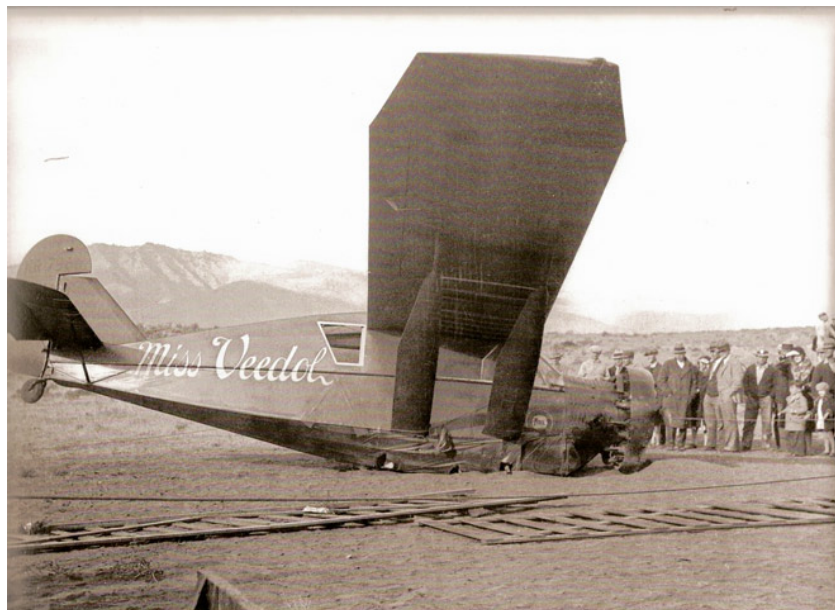
## REQUEST FOR PROPOSALS (RFP)

### 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. Its 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](https://en.wikipedia.org/wiki/Boeing_314_Clipper)

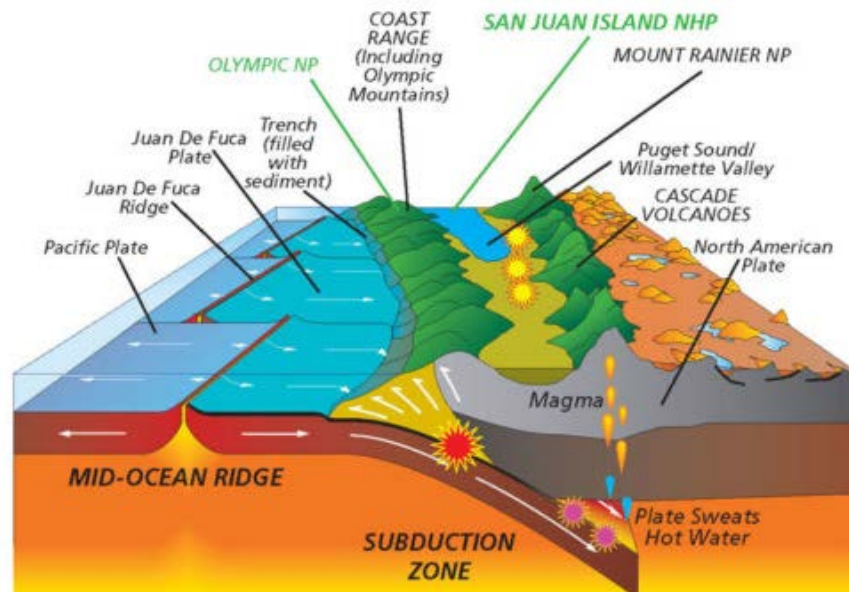
In addition to Boeing's planes, a number of other aircraft that saw service in World War II and subsequent wars flew in the skies over the Pacific Northwest. The Sand Point Naval Air Station, located at the northwestern end of Lake Washington, saw many of the take-offs and landings; at its peak during 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 ROV camera's video image of the tail structure can be used to identify the type of aircraft. Finally, after clearing debris from the wreckage, the vehicle 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. Helens' 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.

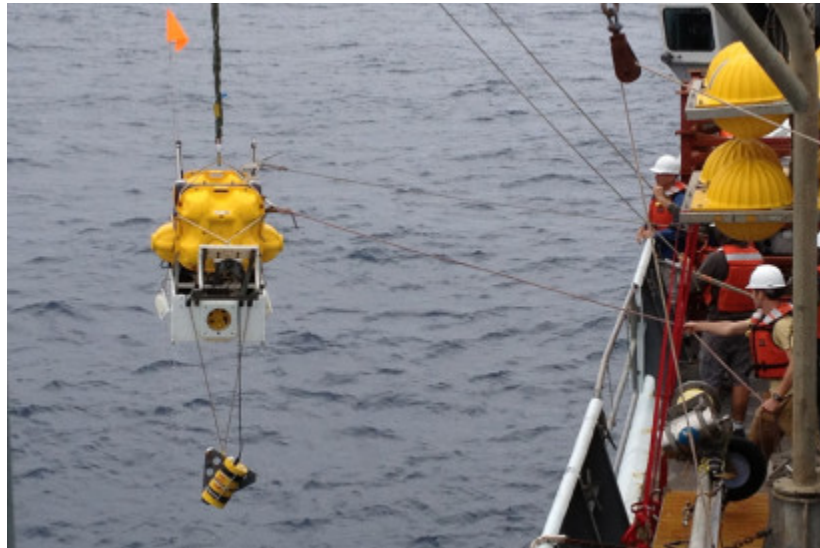
There is also evidence of accompanying tsunamis with most earthquakes in the subduction zone. One strong line of evidence is fossil damage from tsunamis in the Pacific Northwest and historical Japanese records of tsunamis.

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. In addition to OBSs for immediate deployment, the APL is calling for bids on an ROV that can recover OBSs and return them to the surface, as needed, for maintenance. Recovery will include disconnecting the OBS from the central power and communications hub and releasing it from its anchor so that rises to the surface. Once at the surface,

scientists on a research vessel standing by to retrieve it will rely on the ROV to help guide it to the ship.



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**

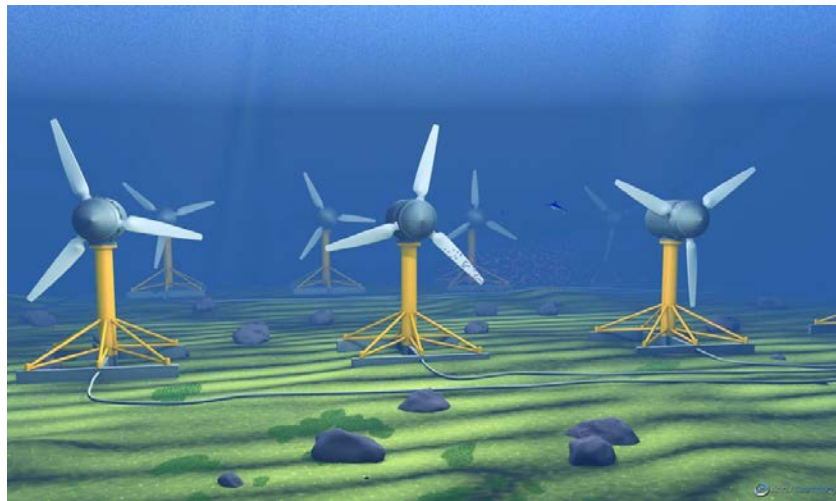
The Pacific Northwest has and continues to invest considerable resources in researching, developing, and implementing renewable energy systems. Part of what is driving this is Initiative 937, which was on the ballot passed by the voters of Washington in November 2006. The law requires that utilities 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](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. Finally, the vehicle will need to both collect samples of eelgrass for laboratory analysis to monitor its recovery and transplant eelgrass grown in the lab to help replenish the disturbed area.



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

- Building a simulated ocean bottom seismometer (OBS) with a release mechanism
- Disconnecting the OBS cable connector from the power and communications hub
- Placing the cable connector in its holder
- Closing the door of the power and communications hub
- Releasing the OBS from the anchor
- Returning the OBS to the side of the pool

## 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
- Eelgrass habitat monitoring and restoration

## 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.

During regional events, the company shall provide at least one day of technical support to resolve hardware, software, and operational issues. They shall provide at least three days of the same for the international event.

## 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.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.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-17_Flying_Fortress)
- [https://en.wikipedia.org/wiki/Boeing\\_B-29\\_Superfortress](https://en.wikipedia.org/wiki/Boeing_B-29_Superfortress)

### b. EARTHQUAKES

- [https://en.wikipedia.org/wiki/Cascadia\\_subduction\\_zone](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://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](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](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=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/](http://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:
  - The simulated OBS
  - Lift bags

Vehicles will be measured and weighed in the 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

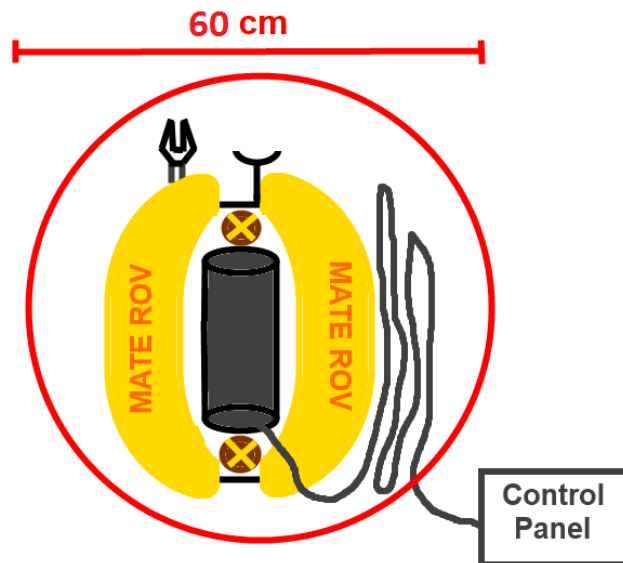
Size measurements will be made using the two largest dimensions of the ROV. Three rings with diameters of 60 cm, 75 cm, and 85 cm will be located on a table in the on deck circle. Companies will place their vehicles on the table and, when ready, ask a MATE Center competition official to make the size 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. In addition, 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 be included in the size or weight of the ROV. Tether management

systems that can be separated from the vehicle will also not be included in 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 in the product demonstration 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.



*A RANGER 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)	
< 60 cm diameter	+10 points	< 12 kg	+10 points
60.1 cm to 75 cm	+5 points	12.01 kg to 17 kg	+5 points
75.1 cm to 85 cm	+0 points	17.01 kg to 25 kg	+0 points

Vehicles above 85 cm in diameter, or greater than 25 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 – 5 points**
- **Removing debris from the engine using a lift bag – up to 35 points**
  - **Attaching the lift bag to the debris – 10 points**
  - **Inflating the lift bag to raise debris – 10 points**
  - **Moving the debris from the wreck area – 5 points**
  - **Releasing the lift bag from the debris – 10 points**
- **Returning the engine to the surface side of the pool using a lift bag – up to 25 points**
  - **Attaching the lift bag to the engine – 10 points**
  - **Inflating the lift bag – 10 points**
  - **Returning the engine to the surface, side of the pool – 5 points**
- **Returning all lift bags to the surface, side of the pool – 5 points**

**Total points = 80**

#### **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 them to the surface, side of the pool.

Companies will receive the aircraft's flight data and a map of Lake Washington with eight designated search zones at the start of the 15-minute product demonstration run. The flight data 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. The take-off location will be either Naval Air Station Sand Point or Renton airfield.

Companies will use the flight data to calculate three vectors: ascent, descent, and wind. Companies will combine these three vectors to determine the search zone for the wreckage. Companies will receive 10 points for successfully identifying the search zone. Companies must show their calculations, or explain to the judges how they determined each of the three vectors. Companies should display all three vectors on their map. The result of combining the three vectors will determine the proper search zone for the aircraft. Companies are not allowed to guess the proper search zone. Companies that misidentify the 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.

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 speed is 9.4 ms-1

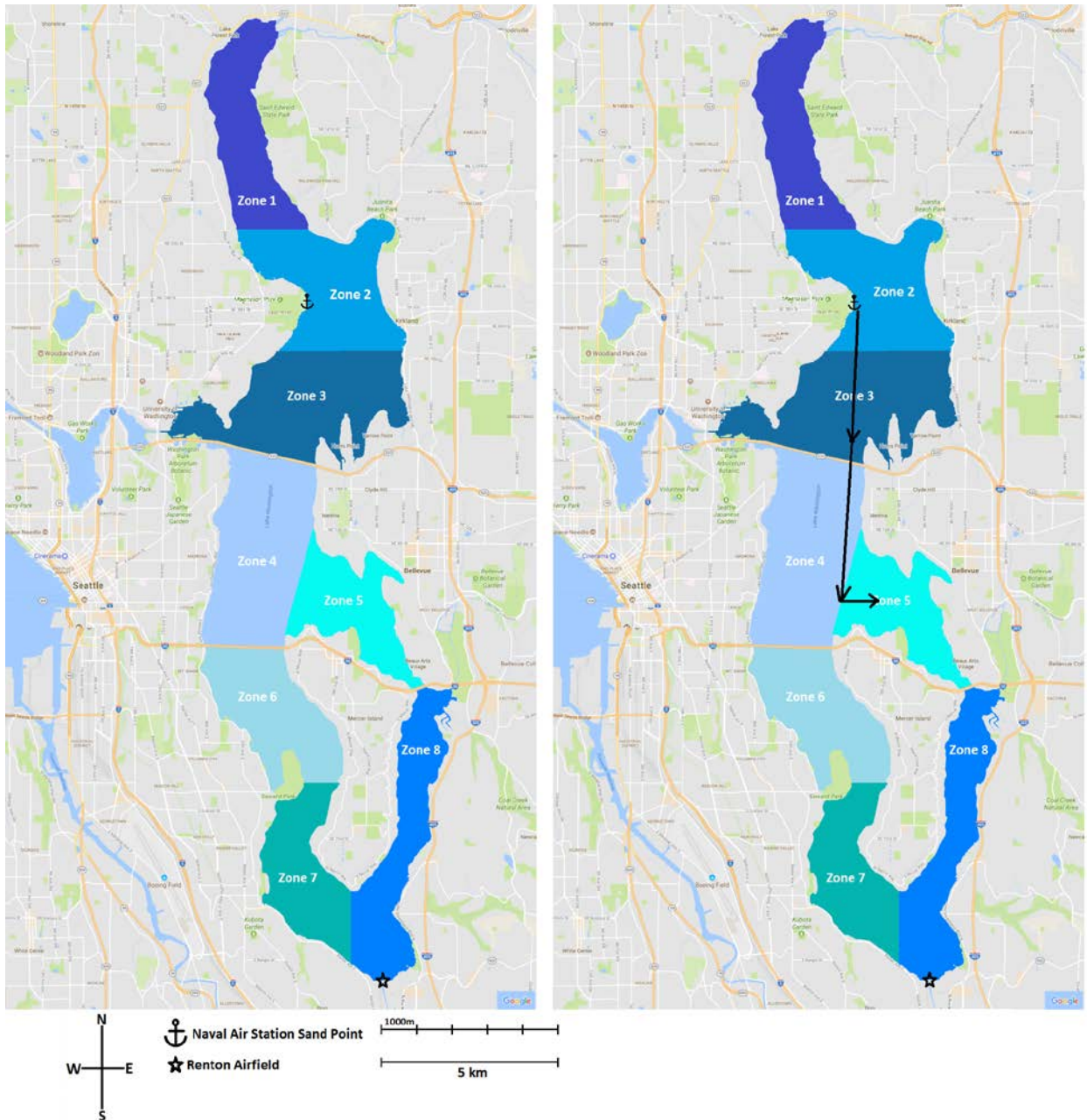
Companies can use this data to create an ascent vector, a descent vector and a wind vector. Companies should report the distance and direction of each vector and plot those on the map. Companies that use a computer program to calculate and display the vectors should display the distance and direction of each vector or report that information to the station judge. Using the above example, the following vectors would be:

Ascent vector: 3999 m at 184°.

Descent vector: 4587 m at 184°.

Wind vector: 1078 m at 90°.

Therefore the aircraft is in search zone 5.



Left: Map of Lake Washington with eight search zones defined.

Right: Map of Lake Washington with example flight shown.

[www.google.com/maps](http://www.google.com/maps)

Companies must identify the type of aircraft via a visual inspection of the tail structure. The tail structure will be constructed from ½-inch PVC pipe and corrugated plastic sheeting cut to a particular shape. Different tail shapes will correspond to different airplane types. A serial number will also be printed on one side of the tail. Companies must show the station judge, through their video display, an



image of the tail structure and inform the judge of the factors (e.g. tail shape and serial number) used to identify the aircraft. A copy of the [RANGER Aircraft Identification Handbook](#) will be provided at each product demonstration station. Companies will receive 5 points for successfully identifying the aircraft using the tail structure. Companies that incorrectly identify the aircraft, or choose not to complete this step of the task, can continue with the remaining product demonstration tasks, but 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 10 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 10 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 longer 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 30 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 will receive 10 points for successfully releasing the lift bag from the debris. Successful releasing 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 mechanism from the debris.

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. 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.

Once the lift bag is attached to the engine, companies must inflate their lift bag to raise the engine from the bottom. Companies will receive 10 points for successfully lifting the engine off the bottom. Successfully lifting the engine is defined as the engine no longer in contact with the pool bottom. Companies are required to fill a lift bag to raise the engine; companies are NOT permitted to use only ROV thrust to lift the debris.

The aircraft's engine will weigh less than 45 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 5 points when the engine is returned to the surface, side of the pool and placed on the pool deck.

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'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. 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 [3.6.6 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. Specifically:

- **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 permitted.

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.

## TASK 2: EARTHQUAKES

This task involves the following steps:

- **Prior to the competition, building an ocean bottom seismometer (OBS), cable with connector, anchor, and release mechanism as per specifications outlined below. The OBS, connector, anchor, and release will be deployed by divers before the product demonstration run – 20 points**
- **During the competition ...**
  - **Disconnecting the OBS cable connector from the power and communications hub – 5 points**
  - **Placing the cable connector in its holder – 5 points**
  - **Closing the door of the power and communications hub – 5 points**
  - **Releasing the OBS from the anchor using ...**
    - **A manual release – 10 points**
    - **A magnetic / reed switch release – 20 points**
    - **A WiFi or Bluetooth release – 30 points**
    - **A frequency-selective acoustic release – 40 points**
  - **Returning the OBS to the side of the pool – 5 points**

**Total points = 80**

### Product Demonstration Notes:

Prior to the competition, companies must build an OBS, cable with connector, anchor, and release mechanism as per the specifications outlined below. Divers will deploy these items before the production demonstration run.

During the competition, companies must complete the majority of the steps of this task in order. Companies must first disconnect the cable connector from the hub and place the connector in its holder

on the OBS. After the connector is placed on the OBS, companies must release the OBS from the anchor and return it to the surface, side of the pool. Closing the door of the power and communications hub can be done at any time after disconnecting the OBS cable connector.

Companies must construct their own **simulated** (non-operational) OBS. Companies can use whatever materials they wish to construct their OBS, provided that the materials do not violate any MATE design and building or safety specifications, and provided that they follow the specifications outlined below.

**OBS specifications:**

- Size: 25 cm to 60 cm in diameter and no more than 50 cm in height
- Durability: Capable of being transported by divers to the pool bottom
- Components:
  - an anchor
  - a simulated OBS that includes:
    - a holder/cradle for the cable connector
  - a cable connector with the following specifications:
    - a connector that is a combination of a 16 cm length of 1-inch PVC , a 6 cm length of 1-inch PVC connected with a 1-inch plus. Companies that cannot find 1-inch PVC may use larger diameter pipe (> 3 cm) or pipe made from other materials.
    - 2.5 or more meters of cable that attaches the connector to the OBS
  - a mechanism that will release the OBS from the anchor
- Performance:
  - the OBS, combined with its anchor, cradle, connector, and release mechanism, must be negatively buoyant
  - when released from the anchor, the OBS must be positively buoyant so that it floats to the surface

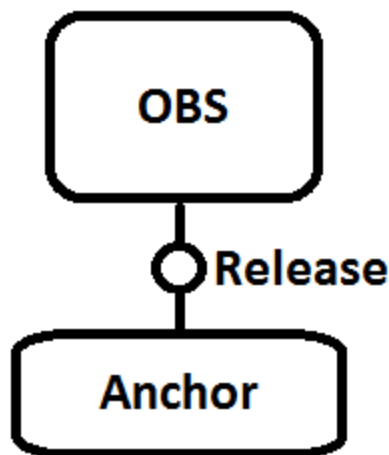


Diagram of OBS design

Companies must submit a one-page document outlining their OBS design, including its release mechanism(s), to demonstrate that it meets the specifications and does not violate any safety rules. This document must be submitted along with the technical documentation in advance of the competition. See [DOC-004](#) for more information. COMPANIES MUST SUBMIT THEIR OBS DOCUMENTATION OR THEY WILL NOT BE PERMITTED TO USE THEIR OBS DURING THE COMPETITION.

Companies must also present a copy of their one-page document to the size and weight judges who will evaluate companies' OBS and its release mechanism before each product demonstration run. Companies will receive 20 points when they demonstrate to the judges that their simulated OBS follows the specifications outlined above. Companies should arrive at the size and weight station at least 15 minutes before the start of their product demonstration time for size and weight measurements AND evaluation of their OBS.

Divers will transport the OBS to the bottom during the 5-minute set up period. The OBS must be robust and able to survive diver transport to the bottom of the pool. The divers are not responsible for the performance of your company's OBS.

Divers will connect the cable connector into a port on the power and communications hub. Companies must disconnect the cable connector from the hub. The hub will be constructed from a milk crate with a corrugated plastic sheet as a door. A handle, constructed from ½-inch PVC pipe, can be used to open the door. The port for the connector will be constructed from a 20 cm length of 2-inch PVC pipe. Companies will receive 5 points when they successfully disconnect the OBS cable connector from the hub. Successfully disconnecting the connector is defined as the connector no longer in contact with any portion of the hub or port.

Companies should design their connector using a 16 cm length and a 6 cm length of 1-inch diameter PVC pipe, inserted into opposite ends of a 1-inch plus. Companies unable to obtain 1-inch PVC pipe and connectors may use larger diameter pipe, or pipe not constructed from PVC. The connector MUST be able to be inserted 15 cm into the 2-inch port of the power and communications hub and remain in the port. Companies may include additional grab points for the connector, provided it can still be inserted 15 cm into the port. The cable connector must include 2.5 meters or more of cable that attaches it to the OBS. Companies can use whatever materials they wish to construct this cable, provided that the materials do not violate any MATE design and building or safety specifications,

Design note: This design is based on the 2017 entertainment power cable connector. Re-use of the 2017 connector is an acceptable OBS cable connector.

Once the cable connector has been disconnected from the hub, companies must close the door to the power and communication hub and return the cable connector to its holder/cradle on the OBS. The door will be constructed of corrugated plastic sheeting and attached by metal hinges to the milk crate power and communications hub. A ½-inch PVC handle will be attached to the door. A small piece of Velcro will hold the door closed. Companies will receive 5 points for closing the door of the hub. The

product demonstration station judge must see that the door is closed for companies to receive their points. Companies may close the door of the hub at any time after disconnecting the cable connector.

It will take less than 5 Newtons to close the door of the power and communications hub.

Once the cable connector has been disconnected from the hub, companies must place the cable connector in a holder or cradle on the OBS. This can be done before or after closing the door to the hub. The connector and cable must come to the surface with the OBS when it is released from the anchor. Companies will receive 5 points when they successfully place the cable connector in the holder/cradle. The connector MUST remain in the holder/cradle when the OBS is released and rises to the surface. If the connector falls out before the OBS is released, companies may attempt to place it in the holder again. If the connector falls out during the OBS’s ascent or after it is on the surface, the 5 points will be lost; however companies can continue with the other steps of the product demonstration.

After placing the cable connector in its holder, companies must release the OBS from the anchor. Companies will receive up to 40 points for releasing the OBS, 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.	10 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.	20 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.	30 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.	40 points

\*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 OBS. 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 OBS 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 10 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 OBS releases from the anchor prematurely (e.g. before the cable connector is placed in its holder 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 OBS. MATE recommends building a robust release mechanism that can only be triggered by one specific method. Companies will not receive points for an OBS that releases prematurely due to rough handling, diver movement, ambient noise, or stray signals.

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

After the OBS has been successfully released from the anchor, companies must return the OBS to the side of the pool. Companies will receive 5 points for returning the OBS to the side of the pool. The ROV must return the OBS to the side of the pool; it cannot be pulled in by a tether, power cable, rope, or other device. The side of the pool is defined as within the grasp of a company member at the side of the pool.

### **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 an array of tidal turbines in the optimum location – up to 15 points**
  - **Installing the base on the bottom – 5 points**
  - **Installing the array onto the base – 5 points**
  - **Latching the array 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**
- **Eelgrass habitat monitoring and restoration – up to 20 points**
  - **Collecting two samples of eelgrass for topside analysis – 5 points each, up to 10 points total**
  - **Transplanting two eelgrass frames to a previously disturbed area – 5 points each, up to 10 points total**

**Total points = 100**

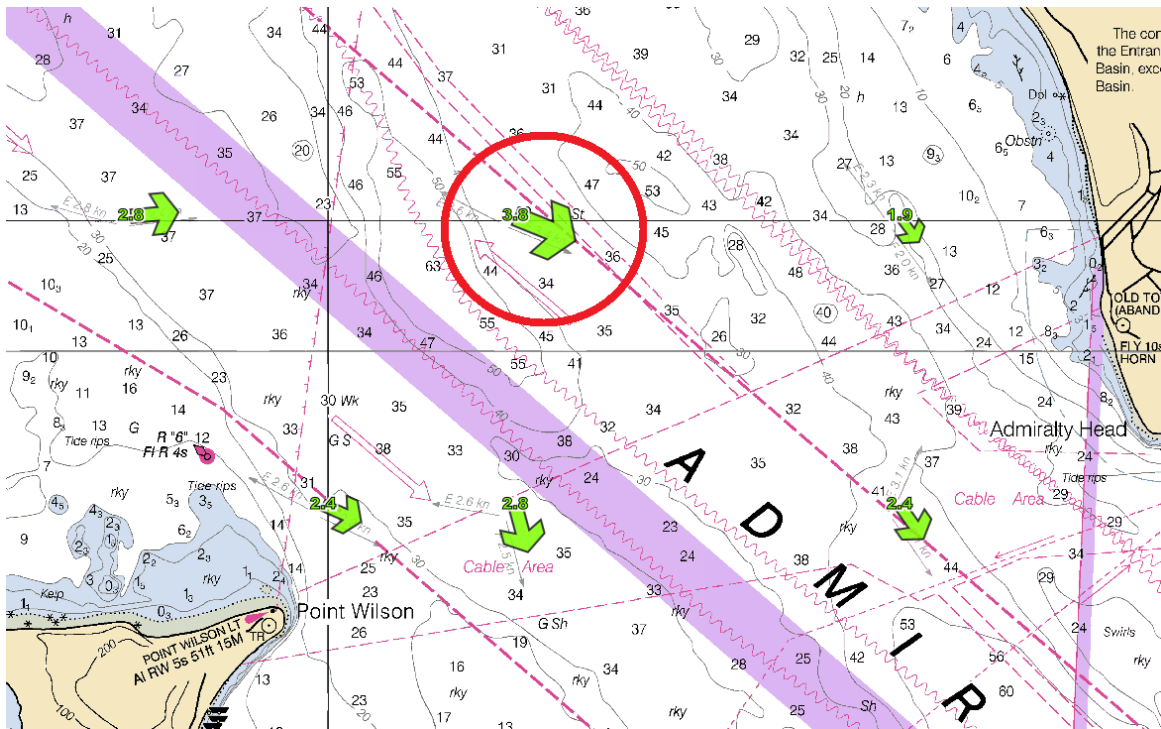
Companies may complete the majority of the steps of this task in any order. However, before installing any equipment, companies must use the tidal data and nautical chart to determine the optimum location. Companies that cannot complete this step may move on to install the equipment, but cannot return 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. The eelgrass habitat monitoring and restoration can be done at any time during the product demonstration.

Companies will use the DeepZoom website ([www.deepzoom.com](http://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](http://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:

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

P is power generated in watts

N is the number of turbines in the array

$\rho$  is density of seawater, 1025 kg/m<sup>3</sup>

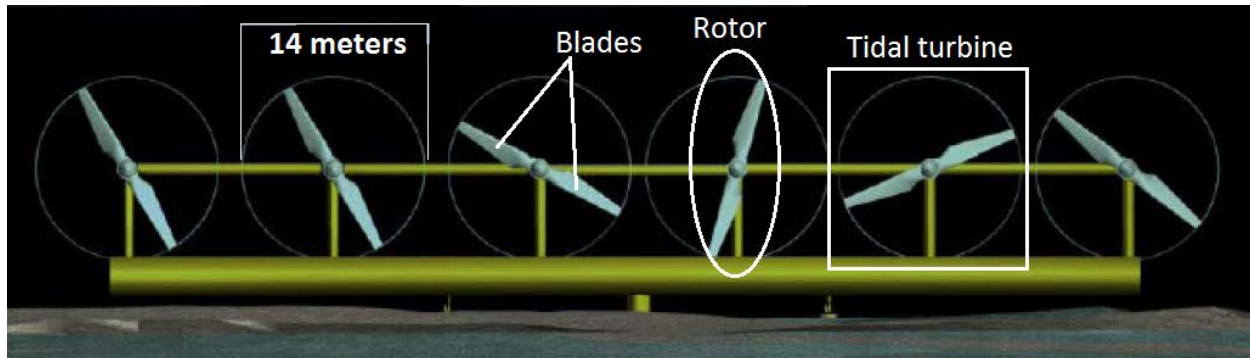
A is the swept area of one rotor in m<sup>2</sup>

V is the velocity of the water in ms<sup>-1</sup> (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  $\pi r^2$  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](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  $\frac{1}{2}$ -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  $\frac{1}{2}$ -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  $\frac{1}{2}$ -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  $\frac{1}{2}$ -inch PVC pipe of the designated area.

The base will weigh less than 5 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  $\frac{1}{2}$ -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  $\frac{1}{2}$ -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  $\frac{1}{2}$ -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 5 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 5 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 5 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 5 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.

Rebar is added inside the base to increase ballast.

The base of the mooring will weigh approximately 3.5 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.

Companies are also required to assist with eelgrass monitoring and restoration. Two samples of eelgrass will be located in the product demonstration area, and two transplant “frames” of eelgrass will be located on the surface, side of the pool. Both the eelgrass samples and the frames will be simulated by green foam sheets attached to ½-inch PVC pipe. Companies must collect the two samples on the pool bottom and return them to the surface. Companies will receive 5 points for each eelgrass sample they return to the surface, 10 points total. Companies must also transplant two frames of eelgrass from the surface to a previously disturbed area. The previously disturbed area will be a 41 cm square of ½-inch PVC pipe painted green. Companies will receive 5 points for each eelgrass frames transplanted into this disturbed area, 10 points total.

Eelgrass samples and frames will each weigh less than 5 Newtons in water.

The turbine stand, the turbine, the I-AMP, the mooring, and the two eelgrass frames 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, the mooring, and the eelgrass 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, lift bags, the OBS, and/or eelgrass frames, the product demonstration time will stop when a member of the company touches the vehicle. The engine, lift bags, OBS, and/or eelgrass onboard may be detached and set on the pool deck after the clock has stopped. If any of these items is subsequently dropped from the vehicle and sink to the bottom, the company will not receive points for returning the item to the surface, time will not restart, and the company will not receive a time bonus.

**PRODUCT DEMONSTRATION RESOURCES**

The [RANGER Aircraft Identification Handbook](#) contains identification information on the six types of 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/](http://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.

Your [regional coordinator](#), or your regional contest's website, will inform you of any specific requirements or changes 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](http://www.safetyworksmaine.com/safe_workplace/safety_management/hazard_analysis.html)

**POTENTIAL HAZARDS**

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

## 2.2 Safety Pre-Inspection

A safety pre-inspection will be completed before competition day. Companies will submit documentation to their regional coordinator; those advancing to the international competition will submit their documentation to the MATE Center.

Teams advancing to the international competition are required to submit the following:

- Technical documentation
- Company spec sheet
- SID
- OBS design document
- Company safety review

See 2.2.1 Safety documentation requirements below for more information.

Regionals may not require all of these documents. Contact your [regional coordinator](#), or visit your regional contest's web site, to determine the required documents as well as the date and proper format for submission.

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.

While your regional's safety inspectors will review your documentation for safety, they may or may not award points. Contact your [regional coordinator](#), or visit your regional contest's web site, for more information.


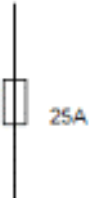


### 2.2.1 Safety documentation requirements

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](http://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](http://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 OBS release mechanism must also submit a non-ROV device SID. This diagram must be completed to the specifications listed in DOC-001. The non-ROV device SID may be included on the main electrical SID or as a separate one page document.

DOC-004: OBS Design: Companies will be required to submit a one page written and visual (photo) description of their OBS and its release mechanism. This description must also be provided to the size and weight judges before each run. If your company's OBS uses electrical power, you must also include a non-ROV device SID (see DOC-003). If your company's OBS uses onboard batteries, you MUST include the type of battery used.

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

- Anderson Powerpole connectors are the main point of connection to the MATE supply (ELEC-010R).
- A properly sized fuse is within 30 cm of the main point of connection. The company must use a ruler to show this distance (ELEC-008R).
- Fuse calculations (ELEC-008R).
- The inside of the control box is does not have exposed wiring (ELEC-017R), the control box is neatly laid out with attention to workmanship (ELEC-022R), a separation and identification of 120VAC wiring from DC and control voltages (ELEC-023R). If AC wiring is not used in the control box, include a statement saying no AC is used.
- Wires leading to the ROV and the control system both have adequate strain relief (ELEC-024).
- 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.
- Companies using only manually powered pumps should include information about the system.
- If 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 4 meters (MECH-001).
- All propellers are shrouded and have propeller guards (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 OBS uses electrical power, but a non-ROV device SID is not included.
- 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.

Companies advancing to the international competition 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. Consult your regional coordinator or visit your regional contest's web site for more information about the safety inspection process used at your regional.

### 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 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: Regional competitions 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 or visit your regional contest's web site.

### *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 to the event, 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: 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](#).

OPER-008: All measurement devices shall be calibrated according to manufacturer recommended calibration procedures 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](#).

## **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: Any electronics housings on the ROV shall be capable of operating to depths of 4 meters.

### *3.2.2 Size and Weight*

MECH-002: ROVs are limited to a maximum diameter of 85 cm. Vehicles above this size will not be allowed to compete. ROVs are also limited to a maximum weight, in air, of 25 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-003R: At the international competition, ROVs must be capable of operating in a maximum pool depth of 3 meters (10 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. Regional competitions 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 or visit your regional contest's web site.

### 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!!!**

Circuit breakers will not be allowed on the ROV system. Companies must use an inline fuse(s).

ELEC-002R: The ROV system must be capable of operating off the power provided by a MATE supply with a nominal voltage of 12 VDC. This voltage may be as high as 14.8 volts. At the international competition, power for the RANGER class will be provided by isolated power supplies. At regional competitions, power may be provided by isolated power supplies or batteries. Contact your regional coordinator or visit your regional contest's web site if you have questions about the type of power source being used. Your system should be designed to work with the maximum specified voltage of 14.8 VDC.

ELEC-003R: The ROV system may deliver any voltage to the ROV at or below the nominal supply voltage provided. Conversion of this voltage is allowed prior to it arriving at the ROV.

ELEC-004R: ROV systems may use any voltage desired up to 12 volts.

ELEC-005R: Voltage may not be increased above the nominal 12 volts anywhere in the ROV system.

ELEC-006R: Sonar or other systems that may have DC/DC conversion resulting in voltages above 12 V nominal are not permitted.

ELEC-007R: 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 OBS to operate using electrical power. In this case, the OBS will be considered a Non-ROV device and will operate under different power specifications than the ROV.

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.
- Under no condition should the housing be built with fasteners to hold the device together. At least one opening must serve as a pressure release.
- Utilization of pressure release valves is not acceptable as they cannot be tested at the competition site.
- The battery holder must be mounted in a manner that will allow the end cap to freely open if pressure develops inside the housing.

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.

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 any independent sensor that uses electrical power.

### *3.3.3 Current*

ELEC-008R: The ROV system must have a fuse 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 25 A maximum. The fuse 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 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 points deducted from the initial safety inspection and documentation review. Also, SIDS without fuse calculations will not pass safety inspection.

ROV Overcurrent Protection Example:

Four motors, 2.7 amps each = 10.8 amps.

Two cameras = 0.25 amps.

Two servo motors = 0.8 amps

One laser = 0.02 amps.

Total Amps: 11.87 amps X 150% = 17.8 Amps.

ROV uses a 20 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 25 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, time will stop, the demonstration run 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 are 15, 20, and 25 amps. Additional standard fuse sizes are 1, 3, 6 and 10 amps.

### *3.3.4 Power Connections*

ELEC-010R: Power supply connections will be Red/Black Anderson Powerpole Connectors. Companies' ROV system power wires must have proper connectors to obtain power. The Anderson Powerpole Connectors must be connected to the ROV power wires securely; use of a proper mechanical crimper 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 2018 International Competition.

<http://www.andersonpower.com/us/en/products/powerpole/pp15-to-45.aspx>

These are two-piece connectors as shown in the picture below.



Part specification and part numbers

Anderson Power Pole – Red and Black connector with 30 amp contacts

Red is connected to power supply positive.

Black is connected to power supply negative.

Since Anderson sells the connectors in 2500 and 200 piece quantities, these connectors are available from distributors.

Distributor Part Number:

Connector & Pins: Powerwerx WP30-10 (This is a kit with 10 connector sets and 30 amp pins for approx \$12 USD)

Recommended Crimper: TRICrimp

<http://www.powerwerx.com/crimping-tools/tricrimp-crimping-powerpole-contacts.html>

Connector Sources:

<http://www.powerwerx.com/anderson-powerpoles/powerpole-sets/30-amp-permanently-bonded-red-black-anderson-powerpole-sets.html>

<http://www.aesham.com/power-distribution/powerpoles/powerwerx-wp30-10/>

[http://www.gigaparts.com/Product-Lines/Power\\_2/Powerwerx-WP30-10.html](http://www.gigaparts.com/Product-Lines/Power_2/Powerwerx-WP30-10.html)

<http://www.hamradio.com/detail.cfm?pid=71-001833>

### **Powerpole related links**

Powerpole Data Sheet

[http://www.andersonpower.com/\\_global-assets/downloads/pdf/ds-pp1545.pdf](http://www.andersonpower.com/_global-assets/downloads/pdf/ds-pp1545.pdf)

Powerpole Description

[https://en.wikipedia.org/wiki/Anderson\\_Powerpole](https://en.wikipedia.org/wiki/Anderson_Powerpole)

Powerpole Assembly Instructions

<http://www.powerwerx.com/assembly.asp>

<http://www.wb3w.net/powerpoleinst.htm> (see the section on using the TriCrimp tool)

YouTube video for Assembly

Part 1: [https://www.youtube.com/watch?v=8\\_DPPuQN8R4](https://www.youtube.com/watch?v=8_DPPuQN8R4)

Part 2: <https://www.youtube.com/watch?v=EsSsr2zGFqI>

ELEC-011R: 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-012R: 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 500 mA.

Note: Companies concerned about how voltage loss will affect their camera(s) should consider adding a separate line in the tether to supply the camera from the main power source. This dedicated line for cameras is permitted, provided it runs through the single fuse.

ELEC-013R: DC main-supply at a nominal voltage of 12 VDC as provided by the MATE power supply.

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

All cameras, including USB cameras, must be powered by the MATE supply. Power 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 would then provide the power to the device from the MATE supply. USB cameras directly plugged into laptops or surface computers are not allowed.

ELEC-015R: NTSC or PAL Video signals

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

### *3.3.6 Exposed Connections and Disposable Motors*

ELEC-017R: 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-018R: "Disposable motors" are not permitted; these are exposed motors with no waterproofing.

### 3.4 Onboard Electrical Power

ELEC-019R: 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 OBS.

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-020R: 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-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 16, 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 15 A 115 VAC 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 15 A 115 VAC 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 Unpressurized Containers*

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.

#### *3.6.5 Pressure Storage Devices (Pressure Accumulators)*

FLUID-014: Pressure storage devices are allowed on the ROV if they do not exceed 1.25 L in total storage and do not store pressure higher than the allowed pressure for air or hydraulics. It is understood that companies 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.

#### *3.6.6 Fluid Power Quiz*

FLUID-015: RANGER 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 16<sup>th</sup>, 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.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-021R RANGER companies are not limited to the type of control system they may use provided it complies with the other MATE design and safety specifications.

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

ELEC-023R: Surface control stations by nature may combine 120 VAC and 12 VDC wiring. The surface control stations must be wired in a manner such that the 120 VAC wiring is physically separated from the DC wiring, the 120 VAC 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 120 VAC 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 the 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.

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

ELEC-025R: 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-004R: Companies are limited to a maximum of three video display screens. Companies may use an additional two displays for ROV status or sensor information.

CCC-005R: 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-006R: 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

For companies advancing to the international competition, MATE will NOT provide video monitors at the product demonstration stations. Contact your [regional coordinator](#) visit your regional contest's web site as to whether video monitors will be provided at your regional competition.

#### 3.9.1 Companies Sharing Equipment

Companies may be allowed to 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).

Contact your [regional coordinator](#) or visit your regional contest's web site 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 16<sup>th</sup>, 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 16<sup>th</sup>, 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.

\*Regional contests may refer to the product demonstration station as the control “station” or “shack.”

- 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. Contact your [regional coordinator](#) or the [MATE Center \(jzande@marinetech.org\)](#) for more information.
- 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:** Regional competitions *may not* offer two attempts at the product demonstration. Regional 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 your regional competition. 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 OBS 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. 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: 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](http://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:
  - o Developing a list local media contacts
  - o Writing a press release about your participation in the MATE ROV competition
  - o Distributing it to your media contacts
  - o Following up with your media contacts to see if they’re interested in your company and its ROV
  - o 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), OBS design specifications, and a company safety review. In addition, companies may submit a JSA as well as documents supporting their corporate responsibility efforts.

**Regional competitions may not require all documentation.** Contact your [regional coordinator](#) or visit your regional contest's web site to determine what documentation must be submitted for your regional and the date it is due.

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], OBS 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.

DOC-009: For the international competition, due date for the required documentation and the JSAs is 11:59 PM, Hawaii Time Zone, on May 24, 2018.

DOC-010: Companies will lose points on their initial safety and documentation review if documents:

- 4) Are submitted late
- 5) Exceed the size limit
- 6) Use improper naming conventions
- 7) Are not submitted on ONE form

### 6.1.1 Corporate Responsibility Documentation

DOC-011: Corporate responsibility efforts should be submitted to: –

<https://www.emailmeform.com/builder/form/D6bW4p353aY>

DOC-012: 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-013: 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.** 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 16<sup>th</sup>, 2018: Last day to PASS the fluid power quiz
- March 16<sup>th</sup>, 2018: Last day to submit laser specifications
- March 16<sup>th</sup>, 2018: Last day to submit hydraulic fluid information
- May 11, 2018: [Video demonstration](#) submission deadline for teams prohibitively far from a MATE regional.
- May 24, 2018: Submission deadline for:
  - Technical documentation
  - Company spec sheet
  - SIDs (including electrical, fluid, Non-ROV Device)
  - OBS release design document
  - Company safety review



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