

MATE ROV COMPETITION

NAVIGATOR MANUAL



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2019 MATE ROV COMPETITION:

Innovations for Inshore: ROV Operations in Rivers, Lakes, and Dams

NAVIGATOR CLASS COMPETITION MANUAL

For general competition information, including a description of the different competition classes, eligibility, and demonstration 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 ROV Competition and the Eastman Company 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.

PART 1: PRODUCT DEMONSTRATION

OVERVIEW

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

TASK #1: ENSURING PUBLIC SAFETY - DAM INSPECTION AND REPAIR

TASK #2: MAINTAINING HEALTHY WATERWAYS

TASK #3: PRESERVING HISTORY

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 website](#) to determine what will take place at 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)**
 - 200 points (max), plus a time bonus
 - Size restrictions
 - 10 points (max)
 - Product demonstration safety and organizational effectiveness
 - 20 points (max)
- **Engineering & Communication**
 - Technical documentation – 50 points (max)
 - Product presentations – 50 points (max)
 - Marketing displays – 50 points (max)
 - Company Spec Sheet – 10 points (max)
 - Corporate Responsibility – 10 points (max)
- **Safety** – 10 points (max)

TOTAL POINTS = 410

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

TIME

The time that your company will have to complete the product demonstration will depend on your regional event. Contact [your regional coordinator or visit your regional contest's website](#) to determine how your demonstration will be timed and how long you will have to set up, complete the tasks, demobilize, and exit the station.

At any time during the product demonstration you may pilot your ROV to the surface and remove it from the water for things such as buoyancy adjustments, payload changes, and troubleshooting. However, the product demonstration clock will NOT stop. The only time the clock will stop is if a judge determines that there is an issue that is 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 member of your company at the product demonstration station has physically touched the vehicle. Your ROV is not required to return to the surface between tasks.

TIME BONUS

Your company will receive a time bonus if you:

- 1) successfully complete 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 product demonstration time ends.

How the time bonus is calculated will depend on your regional event. Your regional coordinator will tell you this when he/she explains how your demos will be set up and how much time you'll have to complete them.

CONTEXT

Eastern Tennessee, USA, is probably best known for the Great Smoky Mountains (including the national park that bears their name), the cities of Gatlinburg (gateway to the park) and Pigeon Forge (home of Dollywood), and the University of Tennessee (go Volunteers!). Just northeast of these landmarks and attractions lies the city of Kingsport. Less than 5 miles from the Virginia border, Kingsport is home to Bays Mountain Park and Planetarium, the annual summer Fun Fest, and the Exchange Place Living History Farm, where, before it became a plantation and stagecoach horse "exchange" station, Daniel Boone, traveling along the Wilderness Trail, killed a bear and recorded the incident on a beech tree.



D. Boone killed a bear on this tree 1775.

In addition to hiking miles of mountain trails with picturesque views, Kingsport residents and visitors can walk, run, or bike along the South Fork Holston River. Like the Exchange Place, the river also has a place in history. On December 13, 1864, the Civil War Battle of Kingsport took place on its banks. Three hundred Confederate soldiers held off a much larger army of 5,500 Union soldiers for two days before surrendering.

Recreational opportunities as well as community events are also available at nearby Boone Lake, a reservoir that was formed when Boone Dam was built on the South Fork Holston River. Swimming, boating, water skiing, and fishing are popular activities on the lake. Each year the Boone Lake Association, one of the oldest environmental groups in the state of Tennessee, organizes the Boone Lake Clean-Up, where the local community helps to rid the lake of trash and debris, including old tires, tree limbs, and lumber.

Boone Dam has also gotten its share of community attention. Owned and operated by the Tennessee Valley Authority (TVA), this hydroelectric dam was built in the early 1950s as part of efforts to control flooding in the

Tennessee River watershed. In October 2014, a sinkhole was discovered near the base of the embankment, and water and sediment were found seeping from the riverbank below. While sinkholes are not uncommon in Eastern Tennessee, the locations of the sinkhole and the muddy discharge were indicators of potential issues with the safety of the dam. The TVA immediately began an inspection of the dam and continues to work on repairs and clean-up to this day, with regular updates on the “Boone Dam Project” going out to the community.

Along with plenty of opportunities to enjoy the outdoors, discover (or rediscover) American history, and become involved in the community, Kingsport is home to the corporate headquarters of a world-renowned Fortune 300 company. Eastman is a global specialty chemical company that produces a large variety of materials, specialty chemicals, and fibers that are found in products people use every day – from food storage containers to tires, clothing, and environmentally-friendly cleaning supplies. As a world leader in the variety of markets it serves, Eastman is focused on creating innovative and technology-based solutions while maintaining its commitment to safety and sustainability.

Eastman believes a truly sustainable company is one that creates more value in the world than the resources it uses. Whether it's through developing more efficient products and bringing innovative solutions to customers, working with world-class scientific institutions to help solve global challenges, or working with community partners to have a positive impact, Eastman is committed to improving the quality of life in a material way.

NEED

This year, Eastman is collaborating with the MATE ROV Competition and looking to its competitors to assist the company in doing “Good for Good.” Eastman has issued a request for proposals (RFP) for a remotely operated vehicle (ROV) and crew that can operate in the freshwater environments of Boone Lake, Boone Dam, and the South Fork of the Holston River. The specific tasks for the ROV and operators include:

- 1) Ensuring Public Safety – inspecting and making repairs to a hydroelectric dam. Eastman’s interest in the safety and security of Boone Dam goes beyond its company doors to the communities, cities, and state in which it makes its home.
- 2) Maintaining Healthy Waterways – monitoring water quality, determining habitat diversity, and restoring fish habitat. Eastman carries out studies of the South Fork of the Holston River on a regular basis to ensure the health of both the water and the species that live there.
- 3) Preserving History – recovering a Civil War era cannon and marking the location of unexploded cannon shells. Eastman recognizes the rich history of the area and the importance of preserving historical artifacts for generations to come.

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

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

REQUEST FOR PROPOSALS (RFP)

1. General

a. Ensuring Public Safety – Dam Inspection and Repair

Named for the famous frontiersman Daniel Boone, Boone Dam was built in the early 1950s. It was built to help control flooding in the Tennessee River watershed and to tap into the hydroelectric power potential of the South Fork Holston River. Boone Dam is 49 meter high, 467 meters long, and has a capacity to generate 81,000 kilowatts of power. The dam and its infrastructure were listed on the National Register of Historic Places in 2017.



An aerial photo of Boone Dam, with Boone Lake behind it and its waters spilling into the South Fork Holston River. (Photo credit: <https://tunnelingonline.com/nicholson-treviicos-jv-named-foundation-contractor-for-boone-dam-cutoff-wall/>)

During construction, the original designers and builders of Boone Dam found highly uneven bedrock known as “karst,” which consists of pinnacles separated by 6 to 9-meter deep crevices. Near the surface of the bedrock and within these pinnacles they came across voids and soft muddy soils. To limit water seepage underneath the dam, the dam’s engineers dug a deep “cutoff trench” to remove the voids and soft soils within the rock pinnacles. They also pumped grout into the foundation to fill any remaining voids beneath the dam’s embankment.

While this treatment of the dam’s foundation was state of the art in the 1950s, safety engineers now recognize that this type of construction has the potential to deteriorate.

In October of 2014, a sinkhole was discovered near the base of the dam's embankment. Water and sediment were seen seeping from the riverbank below. While sinkholes are not uncommon in Eastern Tennessee, the location of this sinkhole and the muddy water flow pointed to potential safety issues with the dam's foundation.

The TVA sprung into action. The authority assembled its safety engineers and called in a variety of experts to determine whether the safety of the dam may be compromised. It appeared that the wear and tear of time, together with the region's geology, had finally taken its toll. The conditions of the embankment were found to be favorable to internal erosion, a process in which voids form within a dam and/or its foundation because of flowing groundwater. If the situation is not dealt with, the water flow will continue to erode the foundation of the dam. This is a huge concern for public safety.

Because internal erosion is one of the leading causes of dam failures worldwide, TVA staff and experts took a number of actions to reduce the safety risk until they could find the best solutions for repairing the cracks and voids in the dam and its foundation. These actions included lowering the level of Boone Lake, which is behind the dam; installing an automated network of sensors to monitor the dam for pressure and temperature changes every 15 minutes and for movement every 30 minutes; assigning staff to be on site to continuously survey the dam; and putting together an emergency action plan for the surrounding community.

The TVA and its external experts are currently evaluating potential solutions. These range from pumping in more grout, constructing a seepage barrier, building berms to strengthen the foundation, and – the extreme – removing the dam and constructing a new one.

In addition to locating and repairing cracks, voids, and other structural problems, the TVA is also conducting routine maintenance. One common issue with dams is damage to their trash racks. A trash rack is a metal structure that prevents debris – things such as tree branches and other vegetation, garbage – from entering the intake of the dam. In the course of doing their job, racks can become clogged with debris, so much so that the rack becomes damaged. While in some cases the rack can be repaired, in most others it must be removed and replaced.

Eastman has a vested interest in the inspection and repair of the dam infrastructure because of the proximity of the dam to Eastman's corporate headquarters. But its concern goes beyond its company doors to the local communities, cities, and towns where its employees make their homes, raise families, and enjoy the state's natural beauty. For Eastman, it's about providing a safe and secure working *and* living environment.

b. Maintaining Healthy Waterways

Since the 1960s, Eastman has hired world-renowned science institutions to study the rivers upstream and downstream of its major United States manufacturing sites to make sure that its operations are not negatively

impacting the environment. One of the largest river studies focuses on the South Fork Holston River, which runs through Eastman’s manufacturing site in Kingsport, Tennessee.



A river runs through it – “a river” being the South Fork Holston River and “it” being Eastman’s Kingsport, Tennessee manufacturing site. (Photo credit: <http://www.timesnews.net/News/2015/08/03/Eastman-Environmental-stewardship-is-important-to-us>)

The Philadelphia-based Academy of Natural Sciences of Drexel University, a private, nonprofit institution recognized as a leader in the assessment of the health of lakes, rivers, and bays throughout the U.S., performed the seventh study on the South Fork Holston River in July 2010. The study looked at the river’s water quality and the abundance and diversity of aquatic plants and animals and compared those results to previous studies.

The study measured water quality parameters, including temperature, dissolved oxygen, pH, phosphorous, and nitrogen, and organic carbon and sampled algae and aquatic plants, macroinvertebrates, such as aquatic insects, crayfish and snails, and fish. In addition to the number of individual species, the study also looked at overall species diversity as that is another indicator of water quality and environmental health. The study focused on selected zones of the South Fork Holston River as well as zones of the connecting Holston River and branching Horse Creek. The scientists compared the results for each zone to those of the other zones in order to gauge the overall health of the ecosystem. The results of the current study were also compared to previous studies to understand changes over time.



Examples of the macroinvertebrates (crayfish) and fish (rainbow trout) scientists found in the South Fork Holston River. (Photo credits: <https://researchingrivers.wordpress.com/> and <https://www.southeasternanglers.com/the-rivers/south-holston-river-watauga.html>)

The Academy's findings showed improvements in the South Fork Holston River over time. It reported major improvement in the numbers and types of aquatic insects, macroinvertebrates (such as crayfish, snails, and worms), and fish found in the river near Riverfront Park. For example, the 2010 study found 47 species of fish and 39 species of macroinvertebrates in one study location near Riverfront Park, compared to 46 and 34, respectively, in 1997. In addition, water chemistry parameters observed in 2010 continued to show improvement over the levels measured in studies during the 1960s and early 1970s.

It's time for another river study. In addition to measurements of water quality and species diversity in the South Fork Holston River, this year Eastman is investing in the restoration of fish species and habitat in Boone Lake, the reservoir that was created when Boone Dam was built. More than 1,500 rubber tires are currently on the lakebed. While the tires do provide habitat and attract fish and other species, over time the rubber has degraded. The tires are falling apart and, to maintain water quality as well as the health and safety of the lake's inhabitants, must be removed. The plan is to replace them with concrete reef balls. Once installed on the lakebed, the reef balls will provide additional habitat structure for fish species like the rainbow trout, which is also in the process of being "restored." Local fisheries biologists have been working to restock the lake with rainbow trout, to help increase both species diversity and the enjoyment of fishermen and women. These scientists have been raising trout fry (or baby trout) in the lab, and now the fry have grown large enough that they are ready to be released. To increase their chances for survival, including protection from birds flying overhead, the plan is to transport the trout fry offshore and release them at depth, near the bottom of the lake.

Eastman is committed to environmental stewardship – from monitoring water quality to maintaining healthy habitats and species diversity. These studies are just part of Eastman's efforts to operate sustainably and create more value in the world than the resources it uses. From both a company standpoint and a community perspective, it just makes good business sense.

c. Preserving History

At the outset of the American Civil War, Tennessee was one of the most divided states in the country. It was the last of the Southern states to declare secession from the Union as a large portion of the population was against secession. Most of those Tennesseans against secession lived in the eastern part of the state.

East Tennessee's loyalty to the Union came from its terrain and traditions. Because of its soil and rugged geography, the land wasn't suitable for large plantation estates. Most of the region's mountain farms were small, and cotton, important in the Deep South, wasn't a predominant crop. Because they didn't grow cotton, a labor-intensive crop, East Tennessee farmers didn't need or rely on slaves as much as farmers in other parts of the state.

East Tennesseans also had a strong antislavery tradition. Slavery was present but not prominent in comparison to other areas of the South. For example, about one-fourth of African-Americans living in Knoxville during the Civil War were free men or women. The first antislavery newspaper in the country was published in East Tennessee in 1819.

The Confederate attack on Fort Sumter, South Carolina on April 12, 1861 followed by President Abraham Lincoln's call for 75,000 volunteers to put the Southern states back in line and "preserve the Union" was the turning point for Tennessee. The state voted to secede. Angered by the withdrawal from the Union, East Tennesseans met in the cities of Greenville and Knoxville, eventually opting to secede from Tennessee and remain in the Union, much like West Virginia did in its split from Virginia. The state legislature, however, denied their petition and sent a 4,000-man force to stop them. Despite this, during the Civil War many East Tennesseans rebelled against the Southern cause by burning bridges, cutting telegraph wires, and spying.



Image from the Battle of Nashville, which took place December 15-16, 1864. (Photo credit: https://en.wikipedia.org/wiki/Battle_of_Nashville#/media/File:Battle_of_Nashville.jpg)

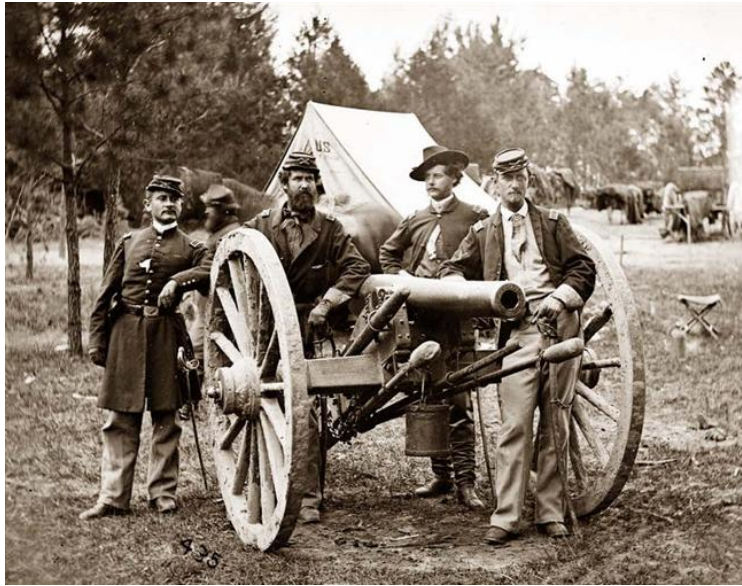
Because of Tennessee's location, both the Union and the Confederacy fought fiercely over the state. Tennessee's position in the Upper South led President Lincoln to describe the state as "the keystone of the Southern arch." The state linked the Eastern Theater of the war with the Mississippi River and early became a natural target for the Federal armies. Both sides wanted to control Tennessee's rich resources, especially the state's railroad and river routes. In the end, nearly 3,000 military battles were fought on Tennessee soil; only the state of Virginia saw more armed conflicts during the Civil War.

One of those thousands of military battles took place on December 13, 1864 on the banks of the South Fork Holston River. During the Battle of Kingsport, 300 Confederate soldiers held off a much larger army of 5,500 Union soldiers for two days. Out-numbered, out-flanked, and discouraged by the bitter winter weather, the colonel leading the troops finally surrendered. The Confederates suffered 18 dead, and 84 prisoners of war were sent to a Union prison in nearby Knoxville.

While it was the last state to secede from the Union, Tennessee was the first state to rejoin after ratifying the 14th Amendment, which guaranteed citizenship rights to former slaves. Some credit this speedy reentry to Andrew Johnson, a Tennessean who became Abraham Lincoln's Vice President at the end of the war...

More than 150 years later, scientists hired by the Eastman Company to study the water quality of the South Fork Holston River discovered more than just a thriving benthic community of organisms on its muddy bottom. SCUBA divers conducting a video transect came across the muddied, iron-encrusted barrel of a cannon. Nearby, half-buried in the mud, are what look like shells or shell fragments – either that or some other, undeterminable type of debris.

Divers entered the water near the historical plaque that marks the site as the location where the first shot of the Battle of Kingsport was fired. Eastman scientists believe that the cannon and the shells are likely remains from this battle and are determined to recover the cannon in an effort to preserve the city's history and role in the Civil War. In addition, because the shells may be unexploded ordinance that pose a threat to public safety, Eastman is looking to confirm and mark any shells so that an EOD (explosive ordinance disposal) unit can come in and safely remove them.



While not from the Battle of Kingsport, this is an example of a cannon used during the Civil War. (Photo credit: www.gettysburgmuseumofhistory.com/wp-content/uploads/Artillery-Civil-War-0012.jpg)

THIS IS WHERE YOUR MISSION BEGINS.

d. Document Scope and Purpose

This and the following sections contain the technical specifications and requirements for ROV services needed to support Eastman. In 2019, ROV services include:

1) ENSURING PUBLIC SAFETY – DAM INSPECTION AND REPAIR

- Inspecting the foundation of the dam
- Inspecting and repairing a trash rack
- Inserting grout into the voids underneath the dam

2) MAINTAINING HEALTHY WATERWAYS

- Measuring the water temperature
- Collecting a water sample and measuring pH and phosphate levels
- Determining habitat diversity by examining benthic species underneath a rock
- Recording collected data on a data sheet
- Transporting and releasing trout fry
- Removing a degraded rubber tire
- Installing a new fish/reef ball

3) PRESERVING HISTORY

- Measuring and calculating the volume of the cannon
- Attaching a lift bag to the cannon and inflating
- Returning the cannon to the side of the pool

- Identifying and marking the location of cannon shells on the bottom

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 will guarantee the ROV for the duration of the product demonstrations. Repair or replacement will be at the company's expense. The company will provide at least one day of technical support to deal with any issues.

4. Shipping and Storage

Delivery of the ROV will be no later than the date of the nearest regional contest.

5. Evaluation Criteria

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

6. References

a. **ENSURING PUBLIC SAFETY - DAM INSPECTION AND CONSTRUCTION**

- https://en.wikipedia.org/wiki/Boone_Dam
- www.tva.com/Newsroom/Boone-Dam-Project
- www.youtube.com/watch?v=Fu8cJT-nEmc
- www.deeptrekker.com/clearing-trash-racks
- <https://epd.georgia.gov/safe-dams-program-faq-owner-inspections>

b. **MAINTAINING HEALTHY WATERWAYS**

- c. www.eastman.com/Company/Sustainability/features/Environment/Pages/River_Studies.aspx
- d. <https://boonelakeassociation.org>
- e. www.youtube.com/watch?v=AIQXPPJFbDI, www.youtube.com/watch?v=10rAjQT7uMM
- f. www.timesnews.net/News/2015/08/03/Eastman-Environmental-stewardship-is-important-to-us.html
- g. www.eastman.com/Literature_Center/P/P237.pdf
- h. www.timesnews.net/Local/2016/02/03/Raw-sewage-flows-into-Bluff-City-family-s-yard-possibly-Boone-Lake
- i. [MATE - Building a temperature sensor](#)

c. **PRESERVING HISTORY**

- https://en.wikipedia.org/wiki/Tennessee_in_the_American_Civil_War#Battles_in_Tennessee
- <https://www.quora.com/What-side-was-Tennessee-on-in-the-Civil-War>
- <https://www.knoxnews.com/story/news/2017/08/26/east-tennessee-civil-war-pro-union-divided/599123001/>
- http://www.tncivilwar.org/research_resources/battles_leaders
- http://www.tn4me.org/minor_cat.cfm/minor_id/1/major_id/5/era_id/5
- https://en.wikipedia.org/wiki/Field_artillery_in_the_American_Civil_War
- www.civilwarartillery.com
- <http://www.civilwarartillery.com/manufacturers.htm>
- www.waymarking.com/waymarks/WMKWW2_Civil_War_Battle_of_Kingsport_Tennessee

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

SIZE RESTRICTIONS

In light of some of the environments in which the ROVs will be operating, the Eastman Company 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 measurements will include the vehicle, all tools and components, and the tether. The following will NOT be included in the size measurement:

- The topside control system and 1 meter of tether going into the control system
- Lift bag (if separate from ROV)

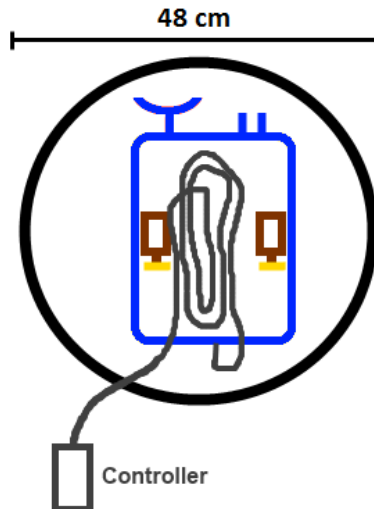
Vehicles will be measured in the on-deck circle 15 to 20 minutes prior to the company's product demonstration runs. Note that the vehicle will be measured before all product demonstration runs. The size bonus, if any, will be added into the product demonstration score.

2019 size parameters

Size measurements will be made using the two largest dimensions of the ROV. Two rings with diameters of 48 cm and 60 cm will be located on a table in the on deck circle. Companies will place their vehicles on the measuring table and, when ready, ask a MATE ROV Competition judge to make the size measurement. The vehicle measurement must include the vehicle, all manipulators/tools to be used in the product demonstration, and the vehicle's tether. The control system and 1 meter of tether may be outside of the

measurement circle. Companies must present their completely assembled ROV for measurement; companies may NOT detach manipulator arms or other equipment for the measurement.

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



A NAVIGATOR class vehicle, with tools attached and tether coiled on top, inside the 48 cm diameter ring. This vehicle would earn the company +10 bonus points on the product demonstration score.

Competition officials will use the following chart to award points:

Size	
< 48 cm diameter	+10 points
48.1 cm to 60 cm	+5 points

Vehicles above 60 cm in diameter will still be allowed to compete, but will receive 0 points for size.

Size Protocol

Only the four designated product demonstration company members will be allowed into the on-deck circle during and after the size measurement. Once a company's vehicle has been measured, 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 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, that 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: ENSURING PUBLIC SAFETY – DAM INSPECTION AND REPAIR

This task involves the following steps:

- Inspecting the foundation of the dam – 5 points each, 20 points total
- Inspecting and repairing a trash rack
 - Removing the damaged screen of the trash rack – 10 points
 - Installing a new screen – 10 points
- Inserting grout into four voids underneath the dam – 5 points each, 20 points total

TOTAL POINTS = 60 points

Product Demonstration Notes:

Companies may complete the steps of Task 1: Ensuring Public Safety – Dam Inspection and Repair in any order.

Companies must inspect the inside of four drain pipes for muddy flow, which indicates possible dam failure. The four drain pipes will be constructed from 3-inch PVC or ABS pipe. Each of the four pipes will be 50 cm long, will contain no bends, and will be capped on one end. The pipes will be positioned 20 to 50 cm above the pool bottom on a framework of ½-inch PVC pipe. Companies must pilot their ROVs so that their cameras can view the inside (open end) of each drain pipe to determine if there is muddy water flow inside the pipe. The muddy water flow will be simulated by 7 cm long strands of brown foam sheeting placed inside the pipe. Companies will receive 5 points when they successfully inspect each drain pipe, 20 points total. Successfully inspecting the drain pipe is defined as showing the station judge on a video display either the far capped end of the pipe (no muddy water flow) or the brown foam sheeting in the pipe (muddy water flow).

Companies should be prepared for low light levels inside the 50 cm pipe.

Companies must inspect and repair a trash rack by removing the damaged trash rack screen. The trash rack will be constructed from ½-inch PVC pipe. The damaged screen will also be constructed of ½-inch PVC pipe, with a #310 U-bolt as a grab point for the screen. The bottom of the damaged screen will be inside a cradle and the top of the screen will be placed at an angle against the PVC framework of the trash rack. Companies will receive 10 points when they successfully remove the damaged screen of the trash rack from the pool. Successfully removing the damaged screen is defined as returning the damaged screen to the surface, side of the pool and placing it on the pool deck.

After removing the damaged trash rack screen, companies must install a new screen into the designated area. The new trash rack screen will be constructed of ½-inch PVC pipe, with a #310 U-bolt as a grab point for the screen. One new screen will be located at the surface, side of the pool and may be attached to the ROV during the set up period. Companies will receive 10 points when they successfully install the new screen onto the trash rack. Successfully installing the new screen is defined as the ROV no longer in contact with the screen, both sides of the bottom edge of the screen inside the PVC cradle of the trash rack, and the top of the screen

placed at an angle against the PVC framework at the top of the trash rack. The new screen must stay in place for 10 seconds after being released from the ROV.

The damaged screen will weigh less than 10 Newtons in water.

The new screen will weigh less than 10 Newtons in water.

Companies will need to remove the damaged screen from the trash rack before installing the new one, but companies may return the damaged screen to the surface side of the pool after installing the new screen.

Companies must also insert grout into four voids underneath the dam. Grout will be simulated by ½-inch PVC tees painted black. The voids will be simulated by a grid of four PVC squares painted black. Companies must insert one piece of grout into each of the four squares of the PVC grid. Ten black painted tees will be available on the surface at the beginning of the product demonstration. Companies will receive 5 points when they successfully insert one piece of grout into one void, 20 points total. Successfully inserting grout is defined as a black tee on the pool bottom completely within one of the PVC squares. If a company drops one of the four black tees outside the square, or inserts the grout into a square that already has a black tee, they may pick it up and attempt to move it into the vacant square, or return to the surface for another piece of grout.

TASK 2: MAINTAINING HEALTHY WATERWAYS

This task involves the following steps:

- **Monitoring water quality**
 - **Measuring the water temperature – up to 10 points**
 - **Temperature measurement is within 2°C of benchmark – 10 points**
 - **Temperature measurement is between 2.01°C and 4°C of benchmark – 5 points**
 - **Temperature measurement is not within 4°C of benchmark – 0 points**
 - **Collecting a water sample from the bottom – 10 points**
 - **Using a water monitoring kit to**
 - **Measure the pH of the water sample – 5 points**
 - **Measure the phosphate levels of a water sample – 5 points**
- **Determining habitat diversity**
 - **Lifting a rock from the bottom – 5 points**
 - **Examining the benthic species underneath the rock**
 - **Using a handbook to determine the number and type of benthic species – 5 points**
 - **Recording the date, time, temperature, pH, phosphate, and species diversity on a data sheet – up to 10 points**
 - **Recording 1 or fewer data points: 0 points**
 - **Recording 2 or 3 data points: 5 points**
 - **Recording all 4 data points: 10 points**
- **Transporting and releasing trout fry – 5 points each, 10 points total**
- **Restoring fish habitat**
 - **Removing degraded tire(s) – 5 points each, 10 points total**

- **Installing new fish/reef ball(s) – 5 points each, 10 points total**

Total points = 80 points

Product Demonstration Notes:

Companies may complete the steps of Task 2: Maintaining Healthy Waterways in any order.

Companies are required to provide their own sensor to measure the temperature of the water near the water sample collection point. A MATE temperature sensor, used as a benchmark, will be located within a 1-inch PVC coupling. Companies should take their measurement as close to the MATE sensor as possible. Companies must show the station judge their temperature reading display; companies may not guess at the temperature. Companies will receive 10 points if their temperature reading is within 2°C of the MATE benchmark reading. Companies will receive 5 points if their temperature reading is between 2.01°C and 4°C of the MATE benchmark reading.

MATE will provide a calibration testing station at the competition so that companies can compare their temperature reading to a MATE temperature reading.

Companies must collect a water sample from the bottom of the pool and return it to the surface. The water sample will be inside a length of 1-inch PVC pipe with a threaded end cap on one end. One end of the pipe will unscrew to allow access to the sample inside. A length of rope will act as a grab point on the 1-inch pipe. Companies will receive 10 points when they successfully collect the sample. Successful collection is defined as returning the water sample to the surface, side of the pool.

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

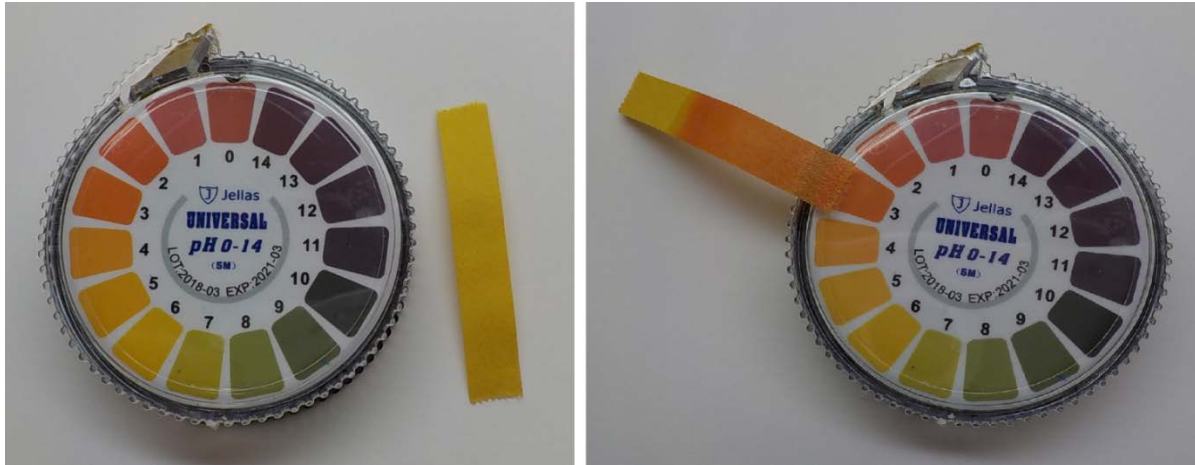
Companies must use a test kit to measure the pH and phosphate levels of the water sample. MATE will supply the test kit for each station; companies do not need to supply their own water quality test kit. MATE will use the following test kits:

[Jellas Universal pH Test Kit With Paper Strips Roll](#)

[LaMotte Insta-Test Low Range Phosphate Test Kit](#)

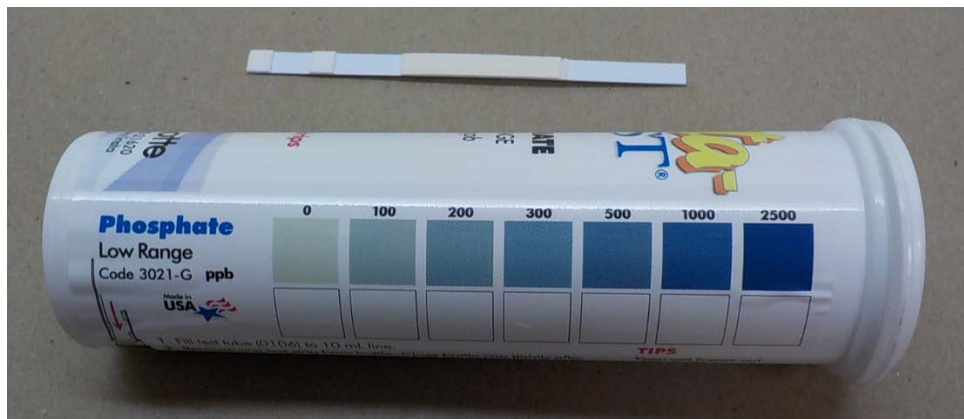
Your regional competition may use a different type of test kit. Your regional coordinator will provide you with the details of the kit.

Companies will open the PVC water sample and pour some of the liquid inside the sample into a test container. Companies will use the pH test kit provided by MATE to measure the pH of the sample liquid. Companies must show the result of their pH test to the station judge; companies may not guess at the pH of the sample. The process for properly using the Jellas pH test kit will be detailed in the prop building instructions and photos document. Companies will receive 5 points when they successfully measure the pH of the water sample. A successful pH measurement is defined as within 1 range increment on the pH scale.



Left: pH test kit litmus paper. Right: Litmus paper after being dipped into the sample.

Companies must also measure the phosphate concentration of the liquid sample. Companies will use the phosphate test kit provided by MATE to measure the phosphate concentration. Companies must show the result of their phosphate test to the station judge; companies may not guess at the phosphate concentration of the sample. The process for properly using the Insta-test phosphate test kit will be detailed in the prop building instructions and photos document. Companies will receive 5 points when they successfully measure the phosphate concentration. A successful phosphate measurement is defined as within one range increment, measured in parts per billion (ppb) on the color measurement scale.



Insta-test phosphate test kit



Left: Preparing the test strip in the cap of the sample bottle.

Right: Phosphate concentration of 300 ppb.

Companies must lift a simulated rock from the bottom of the pool and determine the benthic diversity underneath the rock. The rock will be simulated by a ½-inch PVC framework covered with a corrugated plastic sheet. A section of the ½-inch PVC pipe will act as a handle to use as a grab point. Companies will receive 5 points when they successfully lift the rock from the bottom. Successfully lifting the rock from the bottom is defined as the simulated rock under control of the ROV and no longer in contact with the pool bottom or the contents underneath the rock. Companies may place the simulated rock on the bottom after successfully lifting it.

The simulated rock will weigh less than 5 Newtons in water.

Once the rock is lifted, companies will examine the benthic species underneath the rock. The benthic species, represented by insect stickers, will be located on the topside of a corrugated plastic sheet attached to a ½-inch PVC framework that rests on the bottom of the pool. Companies will use the NAVIGATOR Benthic Species Handbook to identify and count the number of each species. The handbook is posted on the [competition website](#). During the event, MATE will provide a handbook at each product demonstration for companies to reference; companies do not need to supply their own handbook. Companies must inform the station judge of the different species and how many of each species were found under the simulated rock. For example, companies would report four of species A to the station judge (using species A's name), one of species B, and three of species C. Companies will receive 5 points when they use the handbook to successfully identify the species under the rock and report that information to the station judge.

When companies have measured and reported the water temperature, pH of the water sample, the phosphate concentration of the sample, and the species underneath the rock, they will record that information, along with the date and time, on a data sheet. MATE will provide the data sheet with appropriate rows and columns for the data. MATE will also provide a pen or pencil to record the data. Companies will receive up to 10 points for recording their data. Companies that measured none or one of the four types of data (temperature, pH,

phosphate, benthic diversity) will receive 0 points for recording the data. Companies that measured two or three types of data will receive 5 points for recording the data. Companies that measured all four of the types of data will receive 10 points for recording the data. Companies should also record the date and time of the product demonstration attempt onto the data sheet. Companies should enter, and will get points for recording, the data points they measured or collected, even if those data points are outside the accepted range for that measurement. For example, if a company measured a temperature of 15.4°C, but the temperature of the water is 23.8°C, companies should still record 15.4°C temperature actually measured. Companies would not receive points for measuring the water within 4°C of the benchmark, but would receive points for recording this data point onto the data sheet.

Companies are required to transport two simulated trout fry (baby trout) and release them into a designated area. The trout fry will be simulated with [rubber fishing lures](#) whose hooks have been removed. The designated area will be constructed from ½-inch PVC pipe and painted green. Two simulated trout fry will be located at the station during the set up period. Companies must design a device to transport the trout fry without damaging or injuring the fish. Companies may not carry trout fry directly in a gripper that applies pressure to the body of the fish. The device must transport the trout fry to the designated location on the bottom then release (remove) the trout fry into the designated area. Companies may place the trout fry into the device during the set period of the product demonstration. Companies will receive 5 points for each trout fry successfully placed in the designated area, 10 points total. Successfully placing a trout fry into the designated area is defined as the rubber fishing lure no longer in contact with the vehicle, resting on the bottom of the pool, and completely within the designated area. If a fish is later displaced from the designated area because of motor prop wash, tether dragging along bottom, etc., companies will not lose points. If a fish exits the device at any time, companies may not attempt to re-capture the fish. If the escaped fish lands in the designated area, companies will receive points for successfully placing the trout fry in the designated area. If the escaped fish does not land in the designated area, the company will not receive points for placing that fish.

The two simulated trout fry (combined) will weigh less than 5 Newtons in water.

Companies must remove two degraded tires and return them to the surface. The degraded tires will be simulated with 16.5 cm diameter [plastic pool rings](#) painted black. Two degraded tires will be located on the bottom of the pool. Companies will receive 5 points for each degraded tire returned to the surface, side of the pool, 10 points total. Companies will receive points when the tires are removed from the water and placed on the pool deck.

Pool rings will weigh less than 5 Newtons in water.

Companies must install two reef/fish balls into the designated area. The reef/fish balls will be simulated with plastic O-balls. The designated area will be constructed from ½-inch PVC pipe and painted orange. The designated area used for installing the reef/fish ball will be located adjacent to the trout fry designated area. Two O-balls will be available on the surface, side of the pool. O-balls can be attached to the ROV during the set up time. Companies will receive 5 points for each reef/fish ball successfully installed into the designated area, 10 points total. Successfully installing a reef/fish ball is defined as the plastic ball no longer contact with the

ROV, resting on the pool bottom inside the designated area. If a reef/fish ball is later displaced from the designated area (motor prop wash, tether dragging along bottom, etc.), companies will not lose points.

TASK 3: PRESERVING HISTORY

This task involves the following steps:

- **Recovering the Civil War era cannon**
 - **Calculating the amount of force needed to lift the cannon**
 - **Calculate the volume of the cannon – up to 20 points**
 - **Length measurement**
 - **within 2 cm – 5 points**
 - **not within 2 cm – 0 points**
 - **Outer diameter measurement**
 - **Within 1 cm – 5 points**
 - **Not within 1 cm – 0 points**
 - **Bore diameter measurement**
 - **Within 1 cm – 5 points**
 - **Not within 1 cm – 0 points**
 - **Calculating the volume of the cannon – 5 points**
 - **Attaching a lift bag to the cannon and inflating the lift bag – 10 points**
 - **Returning the cannon to the side of the pool – 10 points**
- **Identifying and marking the location of metal cannon shells/non-metal debris – 5 points each, 20 points total**

Total points = 60

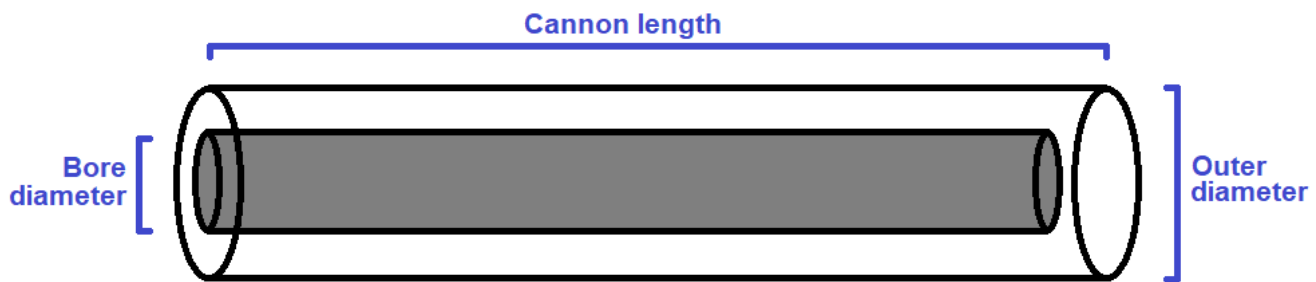
Product Demonstration Notes:

Companies must measure the dimensions and calculate the volume of the cannon before attaching a lift bag and returning the cannon to the surface, side of the pool. Companies may skip the measurements and math calculations if they desire, but cannot return to this step at a later time. Identifying the location of metal cannon shells may be done before or after calculating the volume.

The cannon will be constructed from PVC or ABS pipe and connectors. Companies must measure the overall length of the cannon, the outer diameter of the cannon, and the bore diameter of the cannon. NOTE: Although the cannon will be constructed from various lengths of pipe/connectors, companies should assume that both the outside of the cannon and the bore of the cannon is a cylinder. Companies should assume that the bore extends the entire length of the cannon.

Companies must measure:

- Overall length of the cannon
- Outer diameter of cannon
- Bore diameter



Companies must show each measurement to the station judge, they may not guess. Companies will receive the following points for each of the four measurements:

	Within 2 cm	Within 1 cm	Incorrect measurement
Cannon length	5 points	-	0 points
Outer diameter	-	5 points	0 points
Bore diameter	-	5 points	0 points

Companies only get one chance to correctly measure the lengths.

Once the company has made all three measurements, the station judge will provide the company with the exact dimensions (to one decimal place) of the cannon in centimeters. Exact measurements will be provided to assist companies in being successful in their calculations of the volume of the cannon. Small errors in measurements could lead to large differences in overall volume. Companies will use the provided dimensions to calculate the volume of the cannon. Companies will receive 5 points when they successfully calculate the volume of the cannon. Successfully calculating the volume is defined as the calculated volume within 50 cm³ of the actual value. Companies should show their calculations, or the program used to calculate the volume, to the station judge; companies may not guess at the volume. Companies that do not calculate the correct answer may attempt to recalculate the volume, or may skip the calculations and move on to recover the cannon. Companies cannot make any additional volume calculations once a lift bag is attached to the cannon. Companies are allowed to use calculators or computer programs to calculate the cannon volume, but must provide these devices themselves.

For example, if the cannon length was 130 cm, the outer diameter is 32 cm, and the bore diameter is 18 cm, the total volume of the cannon is 71,471 cm³.

After calculating the volume, companies must attach a lift bag to the cannon, inflate the lift bag to bring the cannon to the surface, and return the cannon to the side of the pool. Contact [your regional coordinator or visit your regional contest's website](#) for information about construction of the lift bag. Some regionals will provide the lift bag and air pump, while others will require companies to design and provide their own lift bags and supply their own air pump. Companies may attach the lift bag to their vehicle during the set up time.

The cannon will be constructed from 3-inch PVC or ABS pipe. A #310 U-bolt will act as a grab point on the cannon. Companies will receive 10 points when they successfully attach the lift bag to the cannon and inflate the lift bag to bring the cannon to the surface. Successfully attaching the lift bag and bringing the cannon to the surface is defined as the lift bag breaking the surface of the water with the cannon still attached.

The cannon will weigh less than 15 Newtons in water.

Once the lift bag has broken the surface with the cannon attached, companies must use the ROV to return the cannon to the side of the pool. The ROV must push the cannon and lift bag; companies may not pull on a rope or line to return the cannon to the side of the pool. Companies will receive 10 points when the cannon is returned to the surface, side of the pool and removed from the water.

Companies must examine four objects that may be unexploded cannon shells. The objects will be simulated by lengths of ¾-inch PVC or metal pipe. Each pipe will be completely wrapped in black plastic tape, making the two different types of pipe visually indistinguishable from each other. Each length of pipe will be attached to a non-ferrous weight and placed in a grid on the bottom of the pool. The grid will be constructed from ½-inch PVC pipe. Companies must design and create a sensor that can distinguish the metal pipes (metal cannon shells) from the PVC pipes (non-metal debris). Companies should explain to the station judge how they are identifying metal versus non-metal objects and show the station judge each object identified. Companies may not guess.

Once an object is identified as metal or non-metal, companies must place a colored marker near each object. Markers will be constructed from ½-inch PVC tees painted red or black. Multiple red and black tees will be available at each product demonstration station. Red tees will be used to mark objects identified as metal, black tees will be used to mark objects identified as non-metal. Companies will receive 5 points for each object successfully identified and marked, 20 points total. Successfully identifying an object is defined as showing the station judge the sensor determining the identity of the object. Successfully marking an object is defined as the proper colored tee placed in the grid square containing the object, and no other colored tee in that square. If a wrong colored tee is inadvertently dropped into the square, companies must remove it to receive points.

Time bonus:

If a company has successfully completed all product demonstration tasks and is returning to the surface with the old trash rack screen, degraded tires, and/or cannon, the product demonstration time will stop when a member of the company touches the vehicle. The old trash rack screen, degraded tires, and/or cannon 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 [NAVIGATOR Benthic Species Handbook](#) contains identification information for various benthic species found in local lakes and rivers.

An example of the [Maintaining Healthy Waterways NAVIGATOR Data Sheet](#). MATE will provide a data sheet at each station for NAVIGATOR companies.

NEW IN 2019!!! PRODUCT DEMONSTRATION RESPONSIBILITIES

Companies are responsible for providing their own temperature sensor. MATE will not provide one. Regionals may require NAVIGATOR companies to design and bring their own cannon lift bag and air pump or they may provide them. Contact [your regional coordinator or visit your regional contest's website](#) for more information.

MATE and your regional coordinator will provide all of the remaining product demonstration items, including the water quality test kits.

PART 2: PRODUCT DEMONSTRATION PROP BUILDING INSTRUCTIONS & PHOTOS

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

PART 3: VEHICLE DESIGN & BUILDING SPECIFICATIONS

1.0 GENERAL

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

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

[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 considered unsafe by competition officials will not be allowed to compete. If a concern is found during the first safety inspection, companies are permitted to attempt to correct it and have their ROV re-inspected. However, the competition schedule will NOT change to allow companies more time. Companies are allowed 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 your ROV has been disqualified.

Examples of safety violations from previous ROV competitions include:

- The ROV does not use Anderson Powerpole connectors to attach to main power.
- No SID was provided at the safety check.
- The ROV does not have a main fuse.
- The SID did not show a main fuse.
- The ROV used pneumatics, but the technical documentation did not include a pneumatics diagram.
- Sharp items, or potentially sharp items, (fishing hooks, glass bottles, Mercury thermometers) were included on the vehicle.
- The vehicle motors were not waterproofed.
- Propellers were not protected inside the framework or were not shrouded.

2.1 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 Blue PASSED Card with their company number on it. Companies must present the Blue 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 revealedcompanies 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 Blue 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.

Your regional competition may use a system other than a Blue PASSED Card, but all companies must pass a safety inspection before entering the water. Contact [your regional coordinator or visit your regional contest's website](#) to determine if a Blue PASSED Card or another system will be used for safety verification.

2.1.1 System Interconnection Diagram (SID)

To pass the safety inspection, companies must provide a system interconnection diagram (SID) of their vehicle control system. An SID is an electrical diagram of their wiring, including their control box, motors, and any other electrical systems on their vehicle. The SID should separate and show what systems are on the surface and what systems are on the vehicle. The SID must not exceed one page in length. **The diagram MUST show an ROV system fuse. SIDs that do not show a fuse, utilizing an ANSI, NEMA or IEC symbol, with the size of the fuse marked, will not pass their safety check.**

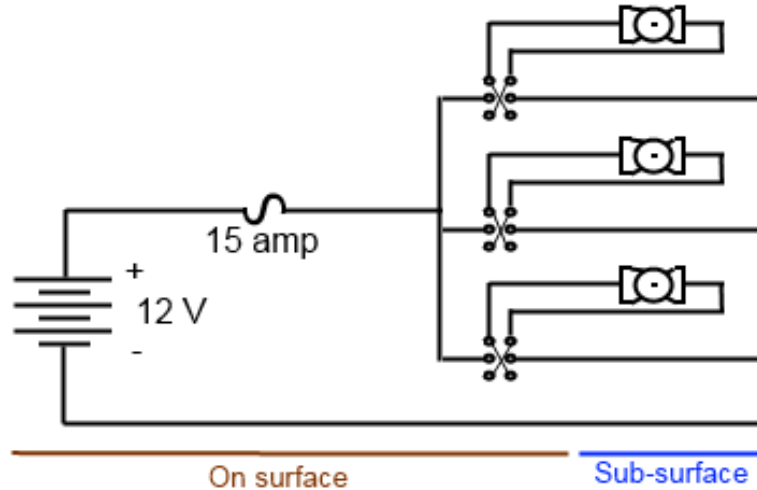


Diagram: An example of an acceptable SID.

Companies should create their own SID. Do not simply copy the above SID, or another SID produced by MATE. SIDs help to understand how electricity flows through your system and will provide a better understanding of ROV operations.

DOC-004: Any electrical diagram should use ANSI, NEMA, or IEC symbols as often as possible; it is required for the fuse. They should be neatly hand drawn or created using a CAD software program.

Item	ANSI	IEC
FUSE		

ANSI: American National Standards Institute
 IEC: International Electrotechnical Commission
 2019 NAVIGATOR Class

NEMA: National Electrical Manufacturers Association

Note: Companies that do not hand draw their SID may use free drawing software such as [OpenOffice](#) to create their diagrams.

2.2 Safety Inspection Completed

Companies must complete their safety inspection before entering the water for practice or a product demonstration run on the day of the competition.

3.0 SPECIFICATIONS

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

3.1 Operational

3.1.1 Multiple Vehicles

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

3.1.2 Environmental

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

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

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

Contact [your regional coordinator or visit your regional contest’s website](#) to learn more about the environmental operating conditions of the competition pool. Some pools may have sloping bottoms or other features that could affect your ROV’s performance.

3.1.3 Service Requirement

OPER-005: Companies shall provide a product demonstration team of at least 3 but no more than 4 people to operate the ROV on the pool deck. Companies may have more than 4 people, but only 4 company members are allowed on the pool deck to operate the vehicle.

3.1.4 Maintenance and Calibration Requirement

OPER-006: 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-007: 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

MECH-002: ROVs are not limited to a maximum size, but 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 restrictions](#)).

3.2.3 Tether Length

MECH-003N: ROVs must be capable of operating in a maximum pool depth of 4 meters (13 feet). All underwater product demonstration 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.

Note: Many NAVIGATOR class competitions are held in water less than 4 meters deep. Contact [your regional coordinator or visit your regional contest's website](#) to determine the maximum depth of the NAVIGATOR competition.

3.2.4 Vehicle Deployment and Recovery

MECH-004N: The product demonstration team (up to 4 people) must be able to carry the entire vehicle by hand. The crew must be able to hand launch and recover the ROV. No lifts or levers may be used to launch the ROV.

3.2.5 Propellers

MECH-005N: Propellers must be enclosed inside the frame of the ROV or shrouded. Companies that have propellers protruding outside of their frame will not pass the safety inspection and will not be allowed to compete.

3.3. Electrical

ELEC-001N: All power provided to your ROV system must be obtained from the MATE competition power supply. This is a singular point of connection; all power to your ROV must pass through the MATE-provided fuse on the supply AND the single fuse in your wiring.

ELEC-002N: MATE will provide a nominal 12 volt power source at the product demonstration station. This power source may be a battery or a power supply. Nominal voltage may be as high as 14.8 volts.

ELEC-003N: Voltage may never be increased above the nominal 12 volts anywhere in the ROV system.

3.3.1 Current

ELEC-004N: ROVs will be limited to 15 amps.

The ROV **MUST** have a 15A maximum fuse in the positive power supply line within 30 cm of the positive Anderson Powerpole connector. The SID must show this fuse, using a proper fuse symbol, and include the amperage rating of the fuse.

NOTE FOR 2019!!!

ELEC-005N: ROV systems are allowed only one replacement fuse during the product demonstration run. In the event that the ROV system blows the second fuse during the product demonstration, time will stop, the product demonstration run will be over, and no additional points will be earned. Note: Companies must provide their own replacement fuses. MATE will not provide replacement fuses.

3.3.2 Power Connections

ELEC-006N: The MATE ROV Competition requires that all ROVs use Anderson Powerpole connections (<https://seamate.org/collections/power-related-products/products/seamate-angelfish-pufferfish-power-kit-with-powerpole-connectors>, <https://powerwerx.com/anderson-powerpole-connectors-30amp-bonded>). Power supply connections at all regional competitions will be red/black Anderson Powerpole Connectors.

Anderson Powerpole connections are two-piece connectors as shown in the picture below.



Part specification and part numbers

Anderson Powerpole – 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.

For those who want more information on Anderson Powerpole connectors:

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.hamradio.com/detail.cfm?pid=71-001833>

Powerpole related links

Powerpole Data Sheet

http://www.andersonpower.com/_global-assets/downloads/pdf/ds-pp1545.pdf

Powerpole Description

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

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

ELEC-007N: 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.

3.3.3 Tether Voltages

The signals in the tether must meet the following specifications:

ELEC-008N: 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 or circuit breaker.

ELEC-009N: DC main-supply at a nominal voltage of 12VDC as provided by the MATE power supply.

ELEC-010N: Ethernet, USB, or other ANSI or IEC accepted serial protocol signals.

NOTE FOR 2019!!!

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-011N: NTSC or PAL Video signals

ELEC-012N: Fiber optic cabling of any type may be used.

3.3.4 Exposed connections and disposable motors

ELEC-013N: All electrical components going into the water must be waterproofed. ROVs with electrical connections that are exposed to the water and not sealed will not be permitted to enter the pool. Disposable motors (motors with no waterproofing) are not permitted. Taping a connection with only electrical tape 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 enclosing the connection inside a housing.

ELEC-014N: “Disposable motors” are not permitted; these are exposed motors with no waterproofing.

3.4 Onboard Electrical Power

ELEC-015N: Onboard electrical power (i.e., power not provided by the tether): Onboard battery powered devices are NOT allowed under any circumstance.

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. For this reason, onboard batteries are NOT allowed under any circumstance. Any device that needs power must obtain that power directly from the ROV tether. For devices that operate at a voltage other than the tether voltage, an onboard ROV converter may be included. The converter must be sealed and not exposed to water. This rule includes commercial “watertight” battery containers; no battery of any type is permitted on any competition vehicle.*

3.5 Power Shutdown

ELEC-016N: 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

NEW FOR 2019!!!

Companies may choose to use powered air compressors or hydraulic pumps that meet MATE’s fluid power safety standards. Companies using compressors or electrically powered air pumps must take and pass the 3.6.7 FLUID POWER QUIZ and meet all the safety standards in the fluid power section. Companies may still use manually powered pumps as well. Companies using manually powered pumps do not need to take the fluid power quiz, but must still comply with all the MATE fluid power safety rules.

Any vehicle using fluid power must provide a fluid power diagram. Fluid power is defined as hydraulic pumps (water) or pneumatic pumps (air) on the vehicle or on the surface. NOTE: Companies are not required to submit a fluid power diagram if they are only using the MATE-supplied manual pump and airline tubing for Task 3: Preserving History. If your regional requires companies to bring their own manual pump and lift bag to complete this task, companies SHOULD include a fluid power diagram.

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 April 1, 2019.

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

NOTE FOR 2019!!!

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.
7. 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)

NOTE FOR 2019!!!

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).

Note: Aquarium tubing is not generally rated for the pressures associated with compressed gas systems and should not be used in a pressurized pneumatic system.

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.

NOTE FOR 2019!!!

Electronic housings and other enclosures on the ROV must operate at surface pressure. Companies may not pressurize their electronics housing.

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 Chemical Creation of Gases

The chemical creation of gases is not permitted.

3.6.7 FLUID POWER QUIZ

FLUID-015: NAVIGATOR 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 ROV Competition 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 April 1st, 2019. Companies failing to complete this quiz within the given time frame will NOT be permitted to use fluid power during their competition event. **Note: No fluid power quizzes will be issued between March 10th and March 26th. It may take five working days for your fluid power quiz to be issued after purchase. Companies should plan accordingly.**

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 and MATE Inspiration for Innovation – (see www.marinetech.org/underwater_robotics)
- <http://www.fxsupply.com/pneumatics/psafety.html>
- <http://mining.state.co.us/safety/downloads/ppoint/HydraulicPressureIntensification.ppt>
- National Fluid Power Association – <http://www.nfpa.com/education/mini-book.asp>
- Parker Hannifin Corporation – <http://www.parker.com/> (look for technical literature links)

3.7 Control Systems

ELEC-017N: NAVIGATOR 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-018N: Surface control stations must be built in a neat and workmanship like manner. Loose components and unsecured wires will not pass safety inspection.

ELEC-019N: 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-020N: 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.

3.8 Cameras and monitors

CAM-001N: Companies are limited to ONE video display screen. This display screen may be powered by the MATE provided GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source described in CAM-002, Surface power.

CAM-002: 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 the video monitor. This AC power source CANNOT be used to directly or indirectly power the vehicle.

3.8.1 MATE Provided Equipment

MATE will not provide monitors at NAVIGATOR product demonstration stations this year. Companies are responsible for providing their own video monitor.

3.9. Lasers

NAVIGATOR class companies may NOT use lasers on their vehicle.

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. . Contact [your regional coordinator](#) at least four

weeks before the competition if you know you have a scheduling concern.

- Companies must complete their size measurements before each product demonstration run. The size measurements are included as part of the product demonstration score. Companies should be at the size in area at least 15 to 20 minutes before their scheduled product demonstration run. Regional competitions may not require size measurements or may change the size measurement process. Contact [your regional coordinator or visit your regional contest's website](#) for more information on the size process and scoring.
- 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 four students**. The demo team is defined as the team of students who operate the vehicle and its associated equipment during the product demonstration. The product demonstration is held at a “product demonstration station.” Only four 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. If a regional offers two product demonstration attempts, **companies may alternate students on the demo team for the two product demonstrations. See below for additional information about the number of 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 following 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 following 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.
- 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.

- Companies will compete in ONE product demonstration that consists of three distinct tasks. Companies may get up to **TWO** attempts to complete each product demonstrations. If that is the case, 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 contests may or may NOT offer companies two attempts at the product demonstration tasks. In addition, the product demonstration time frames for set-up, performance period, and demobilization may be different at your regional contest. Contact [your regional coordinator or visit your regional contest's website](#) 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.
- If your vehicle is completely disabled and/or its tether tangled and unable to free itself from the underwater environment, SCUBA divers can be called in to assist. However, the product demonstration time will NOT stop and **5** points will be deducted from the final product demonstration score.

Diver assistance may not be available at your regional competition. Contact [your regional coordinator or visit your regional contest's website](#) 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. Task props are 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 ROV Competition'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.
- **ROV MOTORS MUST BE WATERPROOFED!** No exceptions. You may use already waterproofed motors (bilge pump motors, etc.) or you may choose to waterproof small electrical motors. Methods for waterproofing electric motors can be found on the competition web site

www.marinetech.org as well as in the little yellow book “Build Your Own Underwater Robot and Other Wet Projects.”

- Propellers must be enclosed inside the frame of the ROV or shrouded. **Companies that have propellers protruding outside of their frame will not pass the safety inspection and will not be allowed to compete.**
- 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.

- Safety must also be a priority when operating your ROV poolside. Keep an eye out for tripping hazards. Make sure that your connections to the battery or power supply are not lying in pools of water on the deck. During your product demonstration, be sure to secure any equipment so that it does not fall, 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.
- **Closed-toed shoes are required on the pool deck and anytime you are working on your ROV.** Safety glasses or goggles should be worn when working on your ROV.
- Personal flotation devices (PFDs) may be required when launching and recovering your vehicles. Contact [your regional coordinator or visit your regional contest’s website](#) to determine whether this is a requirement at your regional event. If PFDs are required, they will be provided by the regional coordinator.

PART 5: ENGINEERING & COMMUNICATION

NEW IN 2019!!! MATE is creating an ROV Competition Marketing Kit that includes logos and guidelines for their use. When available, this kit will be posted [here](#).

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)

IMPORTANT NOTE: Regional contests may not require all of the Engineering & Communication components. Contact [your regional coordinator or visit your regional contest's website](#) for more information.

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

TIPS FOR EFFECTIVE WRITTEN AND ORAL COMMUNICATION

Communicating ideas about how to solve a problem and evaluating those ideas is a critical skill for anyone thinking about a career in marine technology. It is a skill that is directly linked to decision making about whether or not to hire (or fund) us and our ability to affect the work that we do.

The key to a successful technical documentation and product 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, diagrams, and data to communicate the “story” of how your company brainstormed and evaluated ideas to come up with your solution (e.g. ROV, payload tools) to the problem at hand (tasks). It also involves organizing the information to efficiently present your work and justify why you did what you did.

However, 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, giving 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 keep track of 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 write down 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 via your documentation and presentation:

- What was your company's "work breakdown structure" (tasks, time, and people)?
- What were the greatest limitations (schedule, budget, equipment, labor, logistics, etc.) on your design process?
- How did the product demonstration and rules influence your design and decisions?
- What 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?
- 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.

NOTE FOR 2019!!!

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 (ONE PAGE ONLY)

The goal of the Company Spec Sheet is to provide the judges with a "snapshot" of your company. It includes basic information about your company and vehicle.

Companies must submit their spec sheets to their [regional coordinator](#), along with (but as a separate document from) their technical documentation (see below).

Companies will receive up to 10 points for submitting a spec sheet that is one page in length and 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 regional 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 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.

Each judge will evaluate and award a score (50 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 March 1, 2019. In the meantime, companies may refer to the previous year's rubrics posted [here](#) for a general idea of the categories and points.

5.3 ENGINEERING PRESENTATION

During the competition, your company will present to a panel of working professionals – individuals who represent science, exploration, government, and industry. .) 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 5 to 10 minutes to ask the members of your company questions about your ROV. The judges will evaluate both your presentation and responses to their questions and award a score (50 points max) based on your presentation and how you answer 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. Be sure to organize your information and practice your presentation in advance. Ask your instructors, mentors, and parents for feedback. Practicing will help you to work out any "kinks" and be more comfortable talking in front of the judges.

Depending on your regional, this may be a presentation and a question and answer period OR a question and answer period ONLY. Either way, you should be prepared to talk about your vehicle and answer questions about it and your company.

NOTE: The product presentation is designed to be a face-to-face interaction between students and industry professionals. 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.**

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 March 1, 2019. In the meantime, companies may refer to the previous year's rubrics posted [here](#) for a general idea of the categories and points.

Judges may ask questions regarding any of these topics not covered in the presentation as well as other questions about the vehicle, the mission theme, or the company.

Preparing for your product presentation

- 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. Be familiar with such numbers as the amount of propulsive force the thrusters produce, the weight of your ROV, etc.
- Encourage each member of your company to keep a project notebook. Before the competition, set up a time where you compare notebooks. One member might have written more information about your ROV's electrical system, while another might have included details about buoyancy that others forgot. This exercise will help to refresh everyone's memory about the design and building process. If your company submitted technical documentation, make sure all company members have read it and are familiar with it. 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 5 or 10 minutes. That is why it is critical to organize your material and practice communicating it. However, avoid coming across as having memorized your presentation. Judges want to see that you are prepared and understand the information, not that you can simply recite 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.

Each company will have a space approximately 3-feet x 3-feet for its display. Depending on your regional, tables may or may not be provided. Contact [your regional coordinator or visit your regional contest’s website](#) for more information.

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 March 1, 2019. In the meantime, companies may refer to the previous year’s rubrics posted [here](#) for a general idea of the categories and points.

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 ROV Competition 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 spokespeople for the program as well as 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 changed for regional events.

- **Raising awareness of societal (including environmental) issues** includes, for example, ensuring access to clean water around the globe and monitoring water quality and restoring fish habitat, as is featured within Task 2: Maintaining Healthy Waterways.

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: DOCUMENTATION AND KEY DEADLINES

Companies are required to submit a system interconnection diagram (SID) of their vehicle control system. Your regional may also require you to submit technical documentation and a company spec sheet.

Contact [your regional coordinator or visit your regional contest's website](#) to determine what documentation must be submitted for your regional and the date it is due.

DOC-001: Technical documentation: A technical document or engineering notebook about your vehicle that will be reviewed by a panel of judges. See the [technical documentation](#) section for more information on the contents required for the technical documentation.

DOC-002: Company spec sheet: A one page document that provides a snapshot of your company and ROV. See the [company spec sheet](#) section for more information on the requirement for the company spec sheet.

DOC-003: SID Electrical: Companies must provide a [system interconnection diagram \(SID\)](#) of their vehicle control system during their safety inspection.

DOC-004: Fluid power SID: Companies using fluid power (hydraulics or pneumatics) must provide a fluid power diagram. The diagram should separate and show what systems are on the surface and what systems are on the vehicle. A fluid power SID for simple syringe hydraulics would consist of a syringe box on the surface connecting to a syringe box on the vehicle.

The fluid power SID can be incorporated into the Electrical SID or can be a separate, one page document.

DOC-005: Documents may be due before the competition or the day of the competition. Regardless, companies MUST bring a SID of their ROV systems in order to pass the safety inspection!

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