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# 2003 MATE Center/MTS ROV Committee ROV Competition for High School & College Students

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***Competition Classes and Design & Building Specifications***

## Lost on the *Titanic*: Rusticles or Bust

### *Mission Scenario*

A tale of the *Titanic* by Harry Bohm and Vickie Jensen

***The North Atlantic: April 14th 1912, 11:40 pm***

*Fred Fleet stamped his feet to get some warmth back into his legs. He looked over at his crewmate Reginald Lee and smiled; only twenty more minutes of lookout duty before they went off watch at midnight. Despite the bitter cold, Fred liked it up here in the crow's nest. He savored the hypnotic swishing sound of the bow wave as this giant cleaved the water with her prow, and marveled at how the star speckled night sky was reflected in the mirror-flat sea. It felt as if this monster of a ship, barreling along at 20 knots, was flying.*

*Fred peered ahead at the faint haze they had spotted a few minutes earlier. A pair of binoculars would be helpful to make out if it were ice. But, in the rush to get this brand new ship to leave port on schedule, someone had misplaced them. Suddenly his blood went cold as an indefinite white shadow in the approaching mist suddenly took on a solid and menacing form. Years at sea taught him the importance of remaining calm in an emergency. By reflex he sounded the warning bell three times, picked up the phone to the bridge and calmly spoke to the sixth officer James Moody, " Iceberg right ahead." "Thank you," acknowledged Moody just as calmly.*

*The iceberg, about 60 feet high, was 500 yards dead ahead. At this speed, it would take only 43 seconds to close that distance. Fred and Reginald braced themselves for the impending impact. They heard the powerful engines reversing and observed the bow turning ever so slowly to port. But it wasn't enough. The steamship struck the rock-hard 'berg, resulting in a gashing blow along her starboard side. The lookouts, pitched about in the crow's nest, saw dislodged blocks of ice tumble onto the forward Well Deck. A few minutes later, the ship coasted to a stop. Fred and Reginald looked at the frigid dark water below them and wondered if they would be enjoying a warm bunk tonight or* *manning a lifeboat? But how could they even think the ship would go down! She was, after all, the greatest and mightiest ship ever built – the "unsinkable" Titanic.*

*Then, ever so slowly, the bow began to settle. Water cascaded through a long ragged gash below the waterline that ran almost one-third of her 882 foot length. Two hours and forty minutes later, she was plunging towards the sea floor over two miles below.*

*Titanic.* Her very name symbolizes both the power of technology and the tragedy of human arrogance. The largest ship of her time, she represented the unprecedented rapid and astounding feats of turn of the 20th century technological innovation. Massive at over 52,000 tons, she was as tall as an eleven-story building and stretched over a sixth of a mile in length. Her coal-fired steam engines delivered 50,000 horsepower to drive her at over 20 knots. The opulence of her accommodations, even in third-class, was beyond anything other ships of the time could boast and was a reflection of Anglo-American society. Her upper decks of promenades, lounges, ball rooms, and first class staterooms pampered and cocooned the rich and privileged; the middle second class decks berthed the comfortably well-off professors, doctors, clerks, and musicians. And down in the lower reaches, amongst the cargo holds, resided steerage passengers sharing third-class cabins. These were the poor laborers and immigrant families hoping to make a new life in America. Over 2000 people were aboard when she sailed from Ireland on April 11th, but by dawn on April 15th, only 705 survivors were plucked from the icy Atlantic. Fred Fleet and Reginald Lee were among them.

In the decades following that "night to remember," many stories, songs, books, and even movies have told and retold the events of that fateful voyage. Some stories were factual; others mixed fact with fiction and even the fantastic. Some stirred the reader with accounts of raising the *Titanic* and having her complete the final leg of her voyage to New York. Some even depicted subsea adventurers encountering the ghosts of those who died aboard wandering her decks. The *Titanic,* like the ancient city of Troy, the Devil's Triangle, and the sunken Atlantis, had become a legend lost in time. These kinds of lost legends pull at us like powerful magnets crying out to be discovered.

The first known plan to locate the wreck of the *Titanic* occurred only five days after the ship had sunk. One of the notable passengers on board was the wealthy 47-year-old John Jacob Astor, accompanied by his new pregnant eighteen-year-old wife, Madeline. These poor souls presumably went down with the ship. Hearing the news, John's son Vincent wanted to recover his father's body. He contemplated finding the wreck and then lowering dynamite charges to blow a passage way into his father's first class stateroom to retrieve the corpse. The plan was shelved when the remains of Astor was identified among the bodies floating on the sea. In the following year (1913), other well-to-do families hired a salvage company to see if the wreck could be raised, but the firm wisely determined it would be impossible to do so.

Finding and salvaging the *Titanic* was considered difficult, if not impossible, primarily because of its remote location in the North Atlantic and its extreme depth. A new type of technology would need to be developed before any serious attempt to locate it, let alone salvage it, would even be feasible. In 1953, the British marine salvage firm Risdon Beasley Ltd., armed with acoustic technology developed for geophysical surveys of the seabed, voyaged out to the *Titanic's* last known location. They detonated underwater explosives in order to create a series of low frequency acoustic pulses reasoning that if the sound pulses struck the *Titanic's* enormous hulk, they would "bounce" back towards the salvage vessel's hydrophones revealing her location on the sea floor. But even seasoned professionals with good gear can be beaten by the sea, and the ship remained undiscovered.

The fact that simply locating the *Titanic's* resting place would be a daunting endeavor did not deter imaginative "optimists" from devising far-fetched schemes to raise her. One plan called for nylon balloons to be attached to the hull and filled with air to lift her off the bottom and float her to the surface. Another proposed to freeze the water around her with liquid nitrogen, which would make her float. Another poorly thought-out scheme wanted to pump 180,000 tons of molten wax down into her hull. Still another called for a submarine outfitted with electromagnets to clamp onto the massive hull and raise her to the surface. But perhaps the most novel plan of all was to fill the *Titanic* with thousands of ping-pong balls in order to lift her. However, realists knew that it would take a well thought-out expedition with experienced crew, the right state-of-the-art technology, and lots of solid financing to even think one had a fighting chance to find this ship in over 12,000 feet of water. The next attempt to discover her didn't happen until 1980.

Jack Grimm, a Texas oilman and adventurer, who had previously organized expeditions to find the Loch Ness Monster, Bigfoot, and Noah's Ark, set up a serious scientific attempt to locate the *Titanic*. Using the *Sea MARC* side-scan sonar, Grimm's team ran systematic grids through a search area over the last reported position of the sinking. Although they discovered 14 potential wreck sites, the *Titanic* still eluded them. Grimm tried again in 1981 and one final time in 1983. Despite having the money, the right technology, and a good crew, he was again unsuccessful. However, Grimm's methodical, hi-tech efforts still made the news. It was only a matter of time before others would follow his lead.

In 1985, a joint French and American expedition headed by Jean-Louis Michel of the French National Institute of Oceanography (IFREMER) and Robert Ballard of the Woods Hole Oceanographic Institution (WHOI) went out to search the Atlantic waters. Using a newly developed French side scan sonar, called *SAR* (sonar acoustique remorque*)*, they "mowed the lawn" of a 400 square mile search grid. After 21 days of searching and covering 70% of the search area, the *Titanic* still had not been found. Transferring from the French ship *Le Suroit* to WHOI's vessel *Knorr*, the French-American team deployed a video system mounted on WHOI's towed search sled *Argo*. It took two tedious weeks of pulling the sled systematically over the bottom before they were rewarded for their efforts. On September 1, 1985 humans gazed on the image of the *Titanic* for the first time since 1912. Surprisingly, she was not in one piece but had broken into two huge sections that had come to rest some ways apart from each other when she plunged into the bottom. The dream of raising the *Titanic* intact and towing her to New York was never going to happen.

In the summer of 1986, Robert Ballard returned to the *Titanic* on WHOI's research vessel *Atlantis II.* Also onboard was the famous submersible *Alvin*. *Alvin* was outfitted with a specialized little ROV called *Jason Jr.,* or *JJ*. In 11 dives, *Alvin*'s crew filmed, photographed, and videotaped as much of the wreck as possible. *JJ* was deployed to explore inside the wreck where it was too dangerous or tight for the submersible. The images that were shown to the world revealed a ship that had the right to be inhabited by ghosts. The scattered pieces of intact china, passenger luggage, shoes, the ship's telegraph, and the dramatic, looming image of the bow were surreal. Denizens of the deep glided over the promenades where, in 1912, people had walked.

The *Titanic* is a photographer's dream. Although it was now apparent that she could never be raised, perhaps a big screen camera could capture her poignant magnificence for a worldwide audience. In 1991 the documentary IMAX film "Titanica" did just that by setting up an IMAX camera inside the Russian *Mir* submersible's pressure sphere. This 90 minute film, shot through a tiny viewport, produced the first larger than life images that were incredibly clear and detailed. Because the twin *Mir* submersibles were available at a relatively "affordable" cost, going to the *Titanic* became commercially viable. Explorers, archeologists, artists, and even paying tourists were able to visit the wreck using the *Mirs.*

A number of years later a filmmaker visited the *Titanic* and made this already famous ship a household name around the world. James Cameron landed on the decks of the *Titanic* in 1995 to shoot scenes for his motion picture "Titanic." Although the story was fictional, the sets and underwater footage were detailed and realistic because the images were actually taken on the wreck. To film the *Titanic,* Cameron and his brother Michael developed a small 35 mm motion picture camera encased in a titanium housing. Mounted outside the submersible on a pan and tilt mechanism, this housing had to be compact in order to withstand 6000 psi of water pressure. Consequently, there was room for only 500 feet of film, enough for a very short 12 minute shooting session. Having such a small amount of film stock to take cinematic quality footage on a 16 hour dive was, as Cameron said, "…a little scary."

In addition to the film camera, they designed and built a small ROV with a video cam. Nested on the *Mir*, the ROV was sent exploring the corridors of *Titanic.* This expedition brought back footage that became the blueprint for the creation of the incredibly detailed sets of the feature. But it was not to be Jim Cameron's only journey to the *Titanic.* Years later those "ghostly" images would draw him back.

The summer of 2001 found Cameron drifting over the decks of the *Titanic*, this time to shoot an educational film with a difference: a 3-D, large-format ("IMAX") documentary film called "Ghosts of the Abyss." Partnered with Walden Media, Cameron wanted to "go one better" in the quality and quantity of images shot on the wreck. Michael Cameron used the resources of Sony, Panavision, Pace Technologies, and Phoenix Engineering to develop a unique 3-D imaging system. The system's heart was a high definition digital video so superior in resolution that, when transferred to 70 mm film stock, it would appear as if the scenes were shot by a motion picture camera. To get the 3-D effect, the camera used two lenses spaced 2.75 inches apart. Powerful lighting was supplied by a purpose-built ROV platform called *Medusa*. Piloted from a ship above, it followed the *Mirs* filming the watery gravesite. Its payload of underwater lamps bathed the ship in light, enabling long panoramic shots of the bow and stern sections as well as of the ship's debris field.

But the stars of the expedition were the two breadbox-sized ROVs affectionately dubbed *Jake* and *Elwood* (named after the Blues Brothers). Carrying high quality video cams, these ROVs made record setting penetrations inside the wreck, going to places were no one had gone since 1912 – except perhaps the spirits that might still pace those decks. "Ghosts of the Abyss" is scheduled for release in spring 2003.

Among the thousands of ghostly images captured by the many expeditions to the *Titanic* since its discovery, none is more dramatic and puzzling than the alien-like structures that seemed to ooze off her hull. These structures, called rusticles, are huge, rust-colored, icicle-like masses of oxidized iron formed by complex and puzzling biological processes. Simply put, certain types of bacteria and fungi can digest, chemically alter, and secrete the iron that is present in steel. These secretions result in the complex shapes found on the *Titanic*. Despite their size, the rusticle structures are very fragile and burst into red clouds of "dust" when lightly touched with the manipulator arms of a submersible or ROV. For every rusticle that these microbes form, a little bit more of the *Titanic's* structure deteriorates. Eventually, the *Titanic* will be reduced to a pile of red rust. How many years this will take is anyone's guess. However, before this happens, microbiologists are determined to study the microbial organisms and the process by which rusticles are formed.

One particularly adventurous team of researchers came up with a unique device to help unlock the mystery of these microbes. The team developed C-probes, miniature 6-inch long by ¾-inch diameter instruments that are able to electronically measure and store data on seawater temperature and conductivity. Each C-probe also collects small water samples so that chemical analysis of microbial activity can be carried out in a topside lab. In order to collect a scientifically significant amount of data, these researchers determined that they would need to place C-probes in numerous locations inside the wreck. In that way, each probe could collect and store data that, when uploaded and analyzed together, added to the understanding of these microbes and the rusticle growth process. The problem was how to get the probes inside the wreck and then collect them later. The answer was to build a special mini-ROV, one that the researchers affectionately named RUSTI. After more than a year of preparation and testing, they loaded RUSTI, the C-probes, and mountains of gear onto a small research vessel and sailed off to the *Titanic*.

The research vessel had been on site for a number of days, with the weather as fine as it gets in the unpredictable North Atlantic. The crew's mood was buoyant; RUSTI was performing beyond expectations and work was proceeding slightly ahead of schedule. The mission was going well – *maybe too well*. Word had come from the bridge officers that a sudden small but strong low-pressure front was quickly moving towards them and that the ROV should be back on board before the front blew up in the next few hours. The pilot, however, was confident that he could finish placing this batch of instruments in plenty of time to make a safe recovery before the storm hit.

RUSTI was working deep down inside an elevator shaft in order to gain access to some of the ship's staterooms. Having placed 20 C-probes inside several of these staterooms and corridors ahead of schedule, the pilot decided that he had time to check out a nearby first-class stateroom on the pretense that it could be a possible station site for more C-probes. In reality, the pilot was captivated by the legendary ship and wanted an excuse to go exploring. He had a suspicion that this particular stateroom belonged to the famous Molly Brown. He intended to verify this by finding the brass bed she claimed to have slept in. Allowing fifteen minutes for a quick look would still get RUSTI topside in plenty of time before the weather worsened, he reasoned.

RUSTI carefully nudged into the large cabin through a ragged opening rimmed with rusticles. The pilot threaded RUSTI through the loose debris to the farthest corner of the room. Disappointment – there was no brass bed, just a bunch of hanging wires, dangling rusticles, and a small stout box with a pad lock. Then, suddenly, the water alarm on the control panel shrilled, the video monitor went dark, and a red light flashed on the systems status monitor. The electronics can had flooded and all power to the ROV was down. RUSTI was powerless, heavier in the water by 10 pounds, and stuck inside the *Titanic*, with a storm about to charge down on the mother ship. Not a good situation. The only recovery option that the pilot had was to put a bit of tension on the tether with the winch and pray that RUSTI would ease clear of the wreckage.

Weather in the North Atlantic is difficult to predict and the low-pressure front came down on the research ship much quicker than anticipated. The seas grew higher as the crew tried desperately to free RUSTI. Soon the captain was warning that the vessel's dynamic positioning system, or DPS, would no longer be able to hold them in position over the wreck. With water sloshing up to their knees, the crew tried one last time to slowly take in the umbilical in the hopes of freeing RUSTI. Suddenly the deck tilted sharply and the ship veered. One of the bow thrusters had stalled. It was only non-functional for less than a minute but that was enough to put a tremendous strain on the tether. As the DPS computer jockeyed the ship back into position, the deck crew, fearing the worst, slowly spooled in the cable, hoping by some miracle that RUSTI was coming up. But only the severed and frayed end of RUSTI's tether was hauled back onboard.

RUSTI was imprisoned over 12,000 feet below, inside a first-class stateroom with about 6 feet of tether still attached to her. All the research team could do now was head back to port and hope to find an ROV that could recover RUSTI and gather up all the valuable C-probes they had deployed. It wouldn't be easy. RUSTI was specially built to work inside a wreck. Any other ROV would have to have the same capabilities and more. Because RUSTI was now heavier than neutral buoyancy and quite a bite larger than a C-probe, any rescue ROV would need to be small enough to get through the ragged gash and still be powerful enough to lift RUSTI's negative 10 pounds, drag it out the door, and bring it up to the surface. The other difficulty was that all those C-probes were in places with openings smaller than that of the first-class stateroom. Maybe two ROVs were needed; a powerful one to salvage RUSTI and another smaller and more nimble ROV to grab all of the C-probes. Finding ROVs of this caliber and functionality would be a tall order. Where would they find the talented, energetic, and eager minds to design, build, and operate an ROV to accomplish one of these challenging missions?

**Scenario story source material:**

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## *ROV Competition Challenge*

This year's ROV competition will have two competition classes – **Open** and **12-25** (named for its 12-volt, 25-amp limit). Your challenge is to design and build an ROV that can accomplish **one** out of the two following missions.

**Open:**

*Travel into the wreckage of the Titanic to recover an ROV called* RUSTI *that became disabled and trapped within one of the staterooms during a scientific mission.*

**12-25:**

*Maneuver through the wreckage of the Titanic to recover C- probes that had been placed there to take measures of water temperature, conductivity, and chemistry.*

**Which class is most appropriate for your team to compete in?**

The **Open** class is suitable for those who are willing to construct an advanced vehicle with higher voltage and amperage limits and greater thrust capabilities. The **12-25** class is suitable for those who are fairly new to ROV design and building and/or want to work with “hardware store” technology to build their vehicle. Look over both missions and decide which one you would like to tackle. **Your team can only compete in one class.**

Teams from schools in the New England area, Houston, Texas area, and southern California interesting in competing in the ***12-25*** class are asked to take part in the regional event in their area before moving on to the national competition. The top two or three teams from each region will advance to the national event. See the **General Information** document for more information about these regional events, including contact information for the regional coordinators.

## *Open Class Competition*

**Mission Objectives:**
***Travel into the wreckage of the Titanic to recover an ROV called*** **RUSTI** ***that became disabled and trapped within one of the staterooms during a scientific mission.***

Obviously, the **Open** class competition won’t be held at the actual site of the *Titanic*. However, the scenario illustrates a very real type of mission: an underwater recovery from inside a submerged wreck. Successfully accomplishing this challenging task will require your team to push the limits of its talents and energy. Are you prepared to meet this challenge? Here are the mission details.

**Competition Mission Overview:**
This event takes place in an indoor swimming pool. The water may be up to 15 feet deep. On the bottom of the pool is a mock-up of the *Titanic*; just above the mock-up is a launching station area. Here teams will set up to fly their ROVs down into the mock-up to recover RUSTI.

This is a timed event. Your team has 5 minutes to move your gear to the competition launching station area and set up your ROV system, conduct a systems check, fine tune the ballast, and ensure that all safety checks are completed by the judges, which includes connecting the judges’ multi-meter to measure your system’s voltage and amperage. At the end of the 5-minute set up period, your ROV should be in the water alongside the launching station and ready to dive.

At the “go” signal from the judges, the timer is started and the mission begins. You will have 20 minutes to dive your ROV down to the mock-up of the wreck, enter through the gash, move RUSTI out of the wreck through the same gash that you entered, and raise RUSTI to the surface. Your mission is completed when a team member touches the recovered RUSTI with his or her hand.

Once RUSTI has been touched or the 20-minute period is up, the clock is stopped and the judges will record your score. You will then have a five-minute period in which you must demobilize your gear and clear the launch station for the next team. Divers will take RUSTI and place it back into the mock-up for the next recovery attempt.

**Competition Rules:**

- The competition will take place in a chlorinated freshwater pool that is no deeper than 15 feet deep. It is recommended that your ROV have a minimum of 50 feet of tether from the control box to the vehicle. You should assume the water is as conductive as saltwater and engineer your ROV design accordingly. However, the density of the pool water will be closer to that of freshwater.

- Teams are required to bring their own power supply to the competition. You may choose to use batteries, AC to DC power supplies (converters), or alternative power sources (as long as they meet competition safety requirements) to supply power to your ROV system.

- Lead-acid storage batteries with liquid electrolyte MUST be carried and kept in a leak proof container to prevent accidental spillage of electrolyte if a battery is dropped.

- A fuse must be present within the electrical circuitry EVEN IF AN AC WALL UNIT AND CONVERTER ARE USED. In addition, competition officials will place a multi-meter in-line in order to monitor your ROV's voltage and amperage during the mission period.

- For those using AC to DC power supplies, a single 110/120-volts AC, 15-amp, 3-pronged receptacle with a GFI will be provided at the launching station. 220-volt AC and/or higher amperages is not available nor allowed.

- Make sure your AC power supplies can operate off a 110/120-volt, 15-amp GFI protected circuit. Some devices can operate without tripping the breaker on a non-GFI protected circuit but "spikes" generated by your power supply might trip a GFI protected circuit.

- AC to DC power supplies must be located at least 15 feet away from the pool edge.

- Teams will be provided with a separate GFI protected 110/120-volt, 15-amp, 3-pronged AC power receptacle to power plug AC devices such as repair tools, video monitors, and recorders. Your team must bring its own extension cords and power bars. These are not provided.

- A preview of your ROV's electrical schematic must be submitted to the competition coordinator 4 weeks in advance of the competition to confirm this. (**Note**: This schematic should be part of the **Documentation Portfolio** that all teams are required to submit. See below for more information about this portfolio.)

- Teams must demonstrate the presence of a fuse within their vehicle's electrical circuitry to competition officials during the safety check.

- Only DC voltages and low-voltage AC control signals are allowed down the tether from the control box to the vehicle.

- Maximum DC voltage is 48 volts.

- Maximum DC amperage is 40 amps.

- The mission is successful only if RUSTI brought to the surface launching station and touched by a team member. Thus, your ROV's recovery system has to allow a team member situated on the pool deck to touch RUSTI with his or her hand. Only his or her arm can be in the water; the judges must verify that this has been accomplished. Alternatively, once alongside the pool deck launching station and with the judges' permission, your team can lift your ROV, with RUSTI physically attached, onto the pool deck in order to complete the mission by touching RUSTI.

- Teams are permitted to use recovery devices that are auxiliary to their ROV, i.e., detach from their vehicle, float on the surface, such as a floating a hoist, etc., to accomplish this mission. However, at no time can team members pull on these devices – or their ROVs' tether – to lift their ROV, RUSTI, or RUSTI and their ROV to the surface. Any lifting using auxiliary equipment must be done with remotely controlled mechanical/electrical devices.

- Your ROV must be launched and recovered by hand, and only by the members of your team. No winches or portable cranes can be used to launch or remove your ROV from the water.

- The vehicle and all its associated equipment, including the tether, must either be hand-carried or stowed on a wheeled cart in order to transport it to the pool practice area and competition launching area. Your team must supply this cart.

- Your ROV vehicle system (this includes carts, tool boxes, tools, and any other items used to operate or maintain your ROV) must not damage any part of the pool deck and bottom tiles. Make sure any sharp hard (metallic) edges on the vehicle structure are covered with some sort of soft protective covering such as rubber or plastic to ensure the pool tiles are not damaged during set-up, launch, mission operations, recovery to the deck, and moving the unit around the pool deck for repairs, practice, or transport. Make sure any lead-acid storage batteries are in a leak proof case and cannot tip or fall off your workbench or cart.

- Your ROV can be constructed out of materials of your team's choice, as long as they meet the listed competition rules and safety regulations.

- Teams are required to bring their own video monitors. There are no limits on the number of video monitors to use.

- Other sources of "stored" power (e.g., hydraulic, pneumatic, or compressed air) and auxiliary equipment that uses this stored power are permitted as long as the vehicle and any and all associated equipment can be hand-carried to the site and operated off of the 48 volts and within the 40 amp limit allotted.

- All teams must submit the Documentation Portfolio **4 weeks** prior to the competition date.

- Officials may stop the competition at any time that they feel there is a safety issue.

**Documentation Portfolio:**
One of the responsibilities of an engineer or technician is to document his or her work. For this competition, teams are required to submit a **Documentation Portfolio**. This documentation portfolio consists of the following:

- **Project report**
  Guidelines and a format for this report will be provided shortly.
- **Photograph of your vehicle**
- **Budget/Expense sheet**
  This sheet is essentially a tally of monies available minus expenditures. A **Budget/Expense Sheet** will be provided shortly as an example of how to organize and report this information.
- **Electrical schematic**
  This schematic may be NEATLY drawn by hand or created using a CAD software program (e.g., OroCAD). An example of an electrical circuit will be provided shortly to help guide you.

  Minor modifications to vehicles' electrical circuitry between the time this schematic is submitted and the actual competition are permitted; however, you must maintain the presence of a circuit breaker.
- **Other suggested contents**
  Parts list, list of tools and equipment used, calculations and test data, and diagrams of sketches of specific ROV components, such as the propulsion system, retrieval mechanisms, or auxiliary equipment can also be included.

The documentation portfolio must be submitted, **IN HARD COPY**, to the competition coordinator 4 weeks prior to the competition date in order for the judges to evaluate the technical merits of the team's ROV design and construction and address any safety issues that may need to be resolved before the competition.

**Safety Regulations:**

1. All members of a competing team and their supporters are expected to conduct themselves in a professional and responsible manner during the duration of the competition.
2. All members of a team and their supporters must agree to follow the safety regulations of the pool facility.
3. All members of the team and their supporters must agree to follow the posted safety regulations of the ROV competition.
4. All devices using high voltage AC power must be on a GFI protected circuit. A GFI protected receptacle will be provided for your team's video monitors and recorders.
5. All high voltage AC to DC converters are to be located at least 15 feet away from the edge of the pool.
6. All ROV systems must be fused on the DC side of the system, i.e., the power that comes out of the control box and into the tether must only be DC voltages.
7. Only low-voltage AC control signals are allowed down the tether.
8. No team member shall enter the water to conduct a poolside recovery. Only arms and hands are allowed.
9. Team members may only enter the water with their vehicle during practice sessions and with the permission of the competition officials. All regulations regarding swimming activities posted by the pool facility are to be followed. Lifeguards may have to be present during any swimming activity.
10. Competition judges will conduct a physical inspection and safety check of the vehicle to ensure that it meets the design and building specifications and does not pose a risk to the integrity of the competition venue. This will take place during the 5-minute set up period and/or at the judge's discretion during the competition if deemed necessary.
11. Hazardous and/or non-biodegradable materials (e.g. hydraulic oil) may not be intentionally released into the competition waters or the atmosphere.
12. During the safety check, competition officials may disqualify any vehicle that they feel poses an unreasonable safety hazard (such as from leaking fluids or exposed electronics).
13. The **Documentation Portfolio** must be submitted **4 weeks** prior to the competition date in order to evaluate each team's design and built in safety devices and protocols. By submitting this in advance, any safety concerns of the judges can be addressed and remedied before the competition date.
14. Lead-acid storage batteries with liquid electrolyte MUST be transported and kept in a leak proof container to prevent accidental spillage of electrolyte if a battery is dropped. Plastic protective battery cases commonly found in automotive and marine supply shops are highly recommended.
15. Warning labels should be posted on potentially hazardous components of your ROV system. (i.e., high voltage warning labels on AC power supplies).
16. All teams must pass the safety check in order to compete in the recovery mission portion of the competition. This safety check will take place during your team's 5-minute set up time (see **Time Constraints** below).
17. **The competition organizers (the MATE Center and the MTS ROV Committee), competition presenters (Walden Media), and venue operators**

**are not liable for any injury or damage caused by any remotely operated vehicle system participating in the event.**

**Scoring:**
Although the focus of the competition is on the recovery mission, it would be unfair to judge the merits of teams' efforts solely on their underwater performance. Whether successful or not, each team had to put a tremendous amount of effort into the process of designing, constructing, testing, and operating their ROV before they even showed up at the pool. This undertaking should be rewarded. Thus, scoring for the competition is divided into two categories: **Engineering** and **Mission**. Engineering scores account for 50 % of the total and Mission scores for the remaining 50%. The combined total score will determine the winner of the event.

***Engineering***
- Communication – 25 points (max)
- Design and Construction – 25 points (max)

***Mission***
- Recovery – 25 points (max)
- Time – 25 points (max)

**Total:** Score out of 100 points (max)

**Engineering Scoring:**
Documentation is key to success in the real, working world and the marine workplace is no exception. Keeping an account of the design and building process, including budget information and expenses, is good practice, not to mention good project management. Communication is also extremely important. Being able to clearly and effectively explain how your vehicle systems function and why you constructed them the way you did will go a long way in helping you to sell your "product" to the "client" – in this case, the competition judges.

***Communication (25 points)***
Up to 25 points will be awarded for having a clear, concise, and informative poster display and project report. This evaluation takes place when your project report is submitted along with the **Documentation Portfolio** 4 weeks prior to the competition date, and during the poster session held the day(s) before the recovery mission. Your team can really add to your score with a well-documented project report, an interesting poster display of their vehicle system, and with each team member demonstrating a well-rounded knowledge of how and why their vehicle systems work. These points are awarded to encourage excellence in engineering and the communication of ideas.

It is important to have your project report completed 4 weeks prior to the competition. Any changes or additions made to your ROV system that differ from the project report you submitted can be presented to the judges at the poster session. The criteria that the judges will use to evaluate your team's project reports will be posted shortly.

***Design and Construction (25 points)***

Up to 25 points will be awarded for technical merit of your ROV construction and design. This judging will take place during the poster session held the day(s) before the recovery mission. The following is a general outline of what the criteria the judges will use to evaluate your team's poster; the final criteria will be posted shortly. Be advised that the judges may ask very specific questions that are not listed here about the technical details of your ROV system to determine the depth of your knowledge.

Points will be awarded for:

**Systems Design**

- Can the vehicle accomplish the mission?
- What are the strengths of the design?
- What are the weaknesses?
- Did the design address the constraints imposed by the competition?
- Do the safety systems work?
- Did the project meet their budget constraints?

**Originality**

- Does the design of the vehicle and its systems exhibit unique and/or original concepts?
- Are there any innovations or modifications that resulted in higher functionality and reduced costs?
- Are there any innovations that increased the safety of the vehicle's operation?

**Craftsmanship**

- What is the overall quality of craftsmanship?
- Are the system components well laid out and integrated?
- Are the electrical systems neatly run and wired?
- Are the vehicle and its sub-systems robust?
- Is it easy to access components for maintenance?
- Are warning labels and guards posted on potentially hazardous components?
- Are power supplies neatly/safely wired and set-up?
- Is the tether neatly bundled and protected?
- Does the vehicle look esthetically pleasing yet have practical functionality?

**Mission Scoring:**

The mission portion of the competition is scored in two ways: by the degree of progress you have made to raise the RUSTI during the 20 minute time period and the amount of time it takes you to accomplish the mission.

***Recovery Mission (25 points)***

Up to 25 points will be awarded for recovering RUSTI as follows:

1. Successfully raising RUSTI to the surface, bringing it alongside the launching station, and allowing it to be touched by one team member – all verified by a competition judge(s) within the 20-minute time limit.
   *25 points*

2. If you are unable to accomplish the complete mission in 20 minutes, partial points will be awarded by moving RUSTI progressively to the surface. 5 points are given for each stage accomplished and added together.

   **Stage 1:** Moving RUSTI towards the opening of the stateroom so that any portion of its frame partially hangs outside of the wreck.
   *5 points*

   **Stage 2:** Moving RUSTI completely clear of the stateroom and wreck.
   *5 points*

   **Stage 3:** Lifting RUSTI off of the bottom but not all the way to the surface.
   *5 points*

   **Stage 4:** Lifting RUSTI to the surface but not allowing a team member to touch it.
   *5 points*

   **Dropping RUSTI:** If RUSTI is dropped during the lift, no recovery points will be lost, but neither will any additional recovery points be awarded unless subsequent actions result in RUSTI being in position farther up from the point where it was when dropped. For example, if RUSTI is dropped halfway up to the surface, the team will be awarded 15 points. If, on a second attempt, the team makes a successful recovery of RUSTI within the 20-minute time frame, a total of 25 points will be awarded. However, if the team is unable to raise RUSTI past the point where it was first dropped, they will still be awarded 15 points.

***Time (up to 25 points)***
The scoring for the time taken to complete the mission is based on a total score of 25. After the 5-minute set-up time has expired, the judges will signal for the recovery mission to begin. Ready or not, the team has 20 minutes to recover RUSTI, bring it alongside the launching area pool deck, and allow a team member touch it with his or her hand. Points start at 25 and one point is deducted for every minute it takes the team to raise the vehicle. For example, if it takes a team 10 minutes to raise RUSTI, then 25 points – 10 minutes = 15 points are awarded to the team. Fractions of a minute also count. Thus if a team takes 20 minutes and 15 seconds the time score would be 25 points – 20.25 minutes = 4.75 points. The time stops at 20 minutes; therefore, every team that gets a vehicle in the water has a minimum score of 5 even if they do not recover RUSTI in the allotted time.

***Demobilization Time***

After the mission is completed or the 20 minute time period is up, your team has 5 minutes to demobilize your equipment and move it out of the launching station so that the next team can use it. No points are awarded for this activity.

**Penalty Points or Disqualification:**
Penalty points or disqualification may result if:

- A team member goes into the water to recover RUSTI from his or her ROV. Accidentally falling into the water during the competition may also lead to a disqualification. Only the arm(s) of the team members can be in the water for recovering and tagging RUSTI.
- The team's vehicle system does not meet the safety requirements.
- Disrespectful behavior towards the judges, officials, pool staff, audience, or other teams.
- Sabotaging, stealing, or pilfering the equipment of other teams.
- Cheating in anyway.
- If RUSTI is recovered by any team member(s) by pulling on the tether. **Note**: If your ROV attaches a line to RUSTI, it must not be raised by pulling on the line. A line attached to RUSTI can raise it only if this is done by a mechanically/electrically actuated remote controlled device that is a part of the ROV's recovery system.

**Disqualification and imposition of penalty points requires a consensus of the judging group that is officiating for the team.**

**Grievances will be heard by ROV competition officials and panel as the urgency of the circumstances dictate.**

**Safety Check:**
The judges will always keep the safe operation of your vehicle system in mind during the **Engineering** and **Mission** portions of the competition. Teams must pass all of the items on the safety checklist before they can compete in the recovery mission.

**Safety Checklist**

- Position of AC to DC power supply must be 15 feet from pool edge.
- AC power supplies, power bars, extension cords have to be clear of any water that might get onto the deck during operation of your ROV.
- Operation of fuses demonstrated to the satisfaction of the judges.
- Auxiliary power sources are secure and safe for use. For example, compressed air cylinders securely supported if in an upright position or laid flat on the deck and not rolling. Recent hydro and VIP inspection of cylinder. Hoses and valves in good repair. High-pressure connection from cylinder to device adequate to operate at the designated line pressure for that part of the system, etc.
- DC voltage and amperage does not exceed 48 volts and 40 amps.
- Warning labels on potentially hazardous devices, especially high AC voltage sources.

- Storage batteries safely contained to prevent accidental spillage of liquid electrolyte.
- Demonstration that there are no hazardous leakages of gases or chemicals on the pool deck, in the water or into the atmosphere.
- Any other safety concern the judges may have with your ROV system and its operation.

**Competition Arena:**
Here are the specifics of the competition set-up that will help you to design, build, and fly your ROV to recover RUSTI.

The competition arena will be organized as follows:
***Swimming Pool***

- The competition may be held in depths up to 15 feet.
- The pool contains chlorinated freshwater but should be considered conductive of electrical currents. It is recommended you design your ROV system as if it were operating in saltwater. However, the density of the pool water will be closer to the density of freshwater.

***Launching Station Area***
There will be one area marked and designated as the competition launching station. This will be set up along the edge of the pool. The launching station will include –

- For those using AC to DC power supplies, a 110/120-volt AC, 15-amp, 3-pronged GFI-protected power receptacle will be provided. Your power supply must be located at least 15 feet away from the edge of the pool.
- A separate 110/120-volt AC, 15-amp, 3-pronged GFI-protected power receptacle for you to use for repair tools, video monitors, and recorders. It will be located at least 15 feet away from the edge of the pool, but might be farther. Make sure your extension cords are at least 30 feet long so that they can reach a plug-in point.
- A table at least 6 feet long x 2 feet wide located within 4 to 6 feet of the pool edge for you to use to set up your ROV system.
- Three chairs for your team.
- A small table for the judges that is close to and in view of the ROV launching station.
- A mock-up of the *Titanic* wreckage at the bottom of the pool and immediately below the launch station.

***Titanic* mock-up details:**

- The entry point or "gash" of the wreckage is approximately 20 feet from the poolside launching station. The farthest point of the inside of the wreckage is 30 feet from the poolside launching station. Recommended minimum tether length is 50 feet.
- The mock-up is made of 1½-inch PVC pipe framework. The left and right sides and top are covered with 1-inch plastic mesh. The front is covered with solid

plastic sheeting. The rear of the mock-up has a removable mesh covering and framework struts.

- There may be an unknown amount of debris inside the mock-up. All of this debris can "pushed" out of the way by your ROV.
- Outside dimensions of mock-up are 8 feet x 5 feet x 5 feet.
- Inside dimensions are slightly less than 8 feet x 5 feet x 5 feet. There are no compartments inside the mock-up. It is one open "stateroom."
- The gash or jagged entryway is located on the front side of the mock-up. This opening is 4-feet wide x 4-feet high. The opening is not flush to the bottom of the pool. You will have to lift RUSTI over a sill to avoid becoming hung up on the sill. There may be some "debris" in front of the opening that you may have to move or fly over. This will make it difficult for you to just "drag" RUSTI out through the opening.
- The mock-up is anchored to the bottom of the pool with dive weights.
- Ambient light inside the mock-up may be greatly reduced compared to the light levels outside of it.

**RUSTI mock-up details:**
A mock-up of RUSTI will be located inside the mock-up of the wreckage.

- The RUSTI mock-up is made out of 1½-inch diameter PVC pipe with a lifting ring 1-inch in diameter attached to its central dorsal member.
- The bottom of the framework is covered in a screen mesh.
- RUSTI has an outside dimension of approximately 2 feet x 2 feet x 2 feet with the lifting eye extending 1 inch above the frame on the top dorsal member.
- 6 feet of tether remains attached to the ROV. This tether is ¾ inches in diameter and neutrally buoyant.
- Normally RUSTI would be neutrally buoyant; however, the flooded electrical can has made it negatively buoyant by 10 pounds. That means your ROV needs to be designed to lift a 10-pounds heavy-in-the-water RUSTI mock-up to the surface.
- The flooded electrical can may also have unbalanced RUSTI. Therefore, lifting RUSTI from its lifting ring may result in RUSTI tipping. However, the electrical can is well secured and will not shift its position if RUSTI is tipped during the lift.
- Remember RUSTI is 2 feet x 2 feet x 2 feet in size and may be canted at an angle when lifted. Allow for the possible cant angle in your ROV design in order to get RUSTI through the gash.

**ROV Design Details:**
Your ROV design is challenged by the following:

***Environmental Constraints***

- Your ROV must be able to operate and withstand water pressure at a depth of 15 feet freshwater.
- Your ROV will be operating in a swimming pool environment. The pool contains chlorinated freshwater but should be considered conductive of electrical currents. It is recommended that you design your ROV system as if it were operating in

saltwater. However, the density of the pool water will be closer to the density of freshwater.

- Your ROV should have at least 50 feet of tether to reach inside the mock-up from the launching station.
- Your team should be able to set up your ROV system within 5 minutes.
- Your team should be able to demobilize your ROV system within 5 minutes.

***Weight and Size Constraints***

Your ROV should be designed with the following weight and size constraints in mind:

- The gash has a minimal free opening of 4 feet high x 4 feet wide. The opening's edge will be jagged. There will be a low sill at the bottom edge.
- The vehicle and all of its accessories, as well as any auxiliary equipment that may be brought in and used to lift RUSTI, must fit within this opening.
- The vehicle and all associated equipment, including the tether, must either be hand-carried or stowed on a wheeled cart in order to transport it to the competition site. (Your team must supply this cart.)
- Your vehicle must be launched and recovered by hand and only by the members of your team. No winches or portable cranes that are not used as part of the recovery system of RUSTI can be used to launch and remove your ROV from the water. This will impose a natural limit on the vehicle weight.
- The vehicle system (this includes carts and any other items used to operate or maintain your ROV) must not damage any part of the pool deck and bottom tiles.

***Maneuvering and Navigation Constraints***

Your ROV must be able to accomplish the following:

- Travel down and into the *Titanic* mock-up.
- Maneuver through an opening 4 feet x 4 feet.
- Maneuver inside the mock-up.
- Move the RUSTI mock-up, which weighs 10 pounds in the water, to the surface and alongside the launching station.
- View objects electronically in clear water. Ambient light inside the mock-up may be greatly reduced compared to the light levels outside of it.

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***Structure and Ballast Constraints***

Your ROV's structure and ballast must satisfy the following:

- Your ROV must to fit through the 4-foot x 4-foot gash.
- The structure must be strong enough to lift the 10-pound weighted RUSTI mock-up in the water.
- The ballast system can consist of any materials and design.
- Air or gases used for controlling the ROV ballast system and any recovery system that might be used for raising RUSTI must meet the safety requirements of the competition rules.

***Propulsion System Constraints***

- Your ROV's propulsion system must operate on DC voltages.

*Power Constraints*

Your ROV's power system must comply with the following:

- The control system must supply only DC voltage to the ROV. Low-voltage AC control signals are permitted.
- Your power source can be supplied from storage batteries or an AC to DC power supply (converter).
- For those using AC to DC power supplies, a GFI-protected 110/120-volt, 15-amp, 3-pronged AC power receptacle will be provided. AC to DC converters must be located at least 15 feet from the edge of the pool.
- The maximum DC voltage your ROV can use is 48 volts.
- The maximum DC amperage your ROV can draw is 40 amps.
- The DC side of the system must be fused.
- A separate, GFI protected 110/120-volt, 15-amp, 3-pronged AC receptacle will be provided for you to use for repair tools, video monitors, and recorders. This is not considered part of your ROV's maximum power constraints.
  Other novel sources of power can be used as long as a verbal and written submission is sent to the ROV competition judging committee at least four weeks (but recommend submitting much earlier) before the competition date to evaluate if it meets safety requirements. Novel "out of the box" engineering is always encouraged as long as it is deemed safe to use.
- Your ROV system must meet all safety requirements stated in the competition rules.
- The judges officiating for your team will place a multi-meter in-line in order to monitor your ROV's voltage and amperage during the mission period.

*Time Constraints*

- Five minutes to set up your ROV system at the launching station, conduct pre-dive tests, allow the judges to complete safety checks, and place your ROV in the water alongside the launching station.
- Immediately after the 5-minute set-up period and upon the judges' signal, your ROV must attempt to recover RUSTI within a 20-minute period.
- After the 20-minute mission, you have 5 minutes to demobilize your ROV system and move it out of the launching station area in order to allow the next team to compete. The area must be left in a condition so the next team can set-up without impediment.

*Recovery System Constraints*

The recovery of the trapped RUSTI will require some sort of recovery tool, manipulator arm, or other lifting aid. Whatever recovery system you devise, it must be able to:

- Be carried down to the *Titanic* mock-up by your ROV.
- Move RUSTI from inside of the mock-up, out through the opening, and over a low sill to the outside.
- Lift the 10-pound RUSTI mock-up.

- Lift RUSTI up to the surface. **You are not permitted to pull on your ROV's tether or any other line attached to RUSTI to move it from the bottom to the surface or from the surface to the side of the pool.**
- Move the surfaced RUSTI to the launching station area.
- Meet the safety requirements of the competition rules.

The mission is successful only if RUSTI is touched by a team member once on the surface. Thus, the recovery system must allow a team member situated on the pool deck to touch RUSTI with his or her hand. Only his or her arm(s) can be in the water. The judges must verify that this has been accomplished.

Alternatively, once alongside the pool deck and with the verbal permission of the judges, the team can lift their ROV with RUSTI physically attached onto the deck in order to complete the mission by touching RUSTI.

Teams are permitted to use recovery devices that are auxiliary to their ROV, i.e., detach from their vehicle, float on the surface like a floating a hoist, etc., to accomplish this mission.

***Safety Constraints***
It is important to look over the safety regulations to make sure these constraints are addressed in your ROV design. The AC power issues and fuses are of particular importance, so make sure you meet these requirements in your design. These constraints have been detailed in the posted constraints and safety regulations.

**Funding:**
While the MATE Center will provide each team with $500 for ROV building materials and supplies, there is no limit to the amount of money, time, and technical expertise that can go into building your team's vehicle. However, the following funding issues may challenge your budget:

- Travel costs for the team members to the competition venue. **Note**: The MATE Center will provide each team with a travel stipend up to $1,500.
- Shipping of ROV system and tools to competition venue.
- Costs associated with fund raising or event presentations to community.
- Miscellaneous expenses for photocopying, phone calls, shipping costs associated with ordering ROV components, poster session materials, mailings, courier, etc.

## *12-25 Class Competition*

**Mission Objectives:**
*Maneuver through the wreckage of the Titanic to recover C- probes that had been placed there to take measures of water temperature, conductivity, and chemistry.*

Obviously, the **12-25** class competition won't be held at the actual site of the *Titanic*. However, the scenario illustrates a very real type of challenging mission: an underwater recovery from inside a submerged wreck. Are you prepared to meet this challenge? Here are the mission details:

**Competition Mission Overview:**
This event takes place in an indoor swimming pool. The water may be up to 15 feet deep but more than likely only around 8 feet. In the bottom of the pool is a mock-up of the *Titanic*; just above it is a launch station area. Here teams will set up to fly their ROVs down into the mock-up and recover the C-probes.

This is a timed event. Your team has 5 minutes to move your gear to the competition launching station area and set up your ROV system, do a systems check, fine tune the ballast, and ensure that all safety checks are completed by the judges, which includes connecting the judges' multi-meter measure your system's voltage and amperage. At the end of the 5-minute set up period, your ROV should be in the water alongside the launching station and ready to dive.

At the "go" signal from the judges, the timer is started and the mission begins. You will have 20 minutes to dive the ROV down to the mock-up of the wreck, enter through the topside opening, move through the two levels of decks and corridors, enter the staterooms, and grab as many C-probes as possible. Your ROV can surface with recovered C-probes, remove them and dive back down into the wreck as many times as needed to accomplish the mission in the 20 minute period. The deeper and/or farther a C-probe is located inside the wreck, the higher its individual point value. Your mission is completed when the 20-minute time period is up, or you have recovered all 20 of the C-probes to the launching station.

Once the 20-minute period is up, the clock is stopped and the judges record your score. You will then have a 5-minute period in which you must demobilize your gear and clear the launching station for the next team. Divers will take the recovered C-probes and place them back into the mock-up for the next recovery attempt.

**Competition Rules:**

- The competition will take place in a chlorinated freshwater pool that is no deeper than 15 feet deep. It is recommended that your ROV have a minimum of 30 feet of tether from the control box to the vehicle. You should assume that the water is as conductive as saltwater and engineer your ROV accordingly. However, the density of the pool water will be closer to that of freshwater.

- Teams will be provided with a DC power source that will supply 12 to 13.5 volts and 25 amps. There is no need to bring batteries to the competition to power your ROV system. Connections to the battery will be via standard banana plugs. The banana plugs will be on the terminal ends of two wires – one red that will lead to the positive battery terminal and one black that will lead to the negative battery terminal. A 25-amp fuse will be placed in-line between the positive battery terminal and the vehicle to ensure that the ROV operates within the 25-amp limit.

(**Note**: Banana plugs are available at your local Radio Shack or through electronics supply companies such as Digikey or Newark.)

- Teams will be provided with a GFI protected 110/120-volt, 15-amp, 3-pronged AC power receptacle to power plug AC devices such as repair tools, video monitors, and recorders. Your team must bring its own extension cords and power bars. These are not provided.

- The judges officiating for your team will place a multi-meter in-line in order to monitor your ROV's voltage and amperage during the mission period.

- A preview of the electrical schematic must be submitted to the competition coordinator 4 weeks in advance of the competition to confirm this. (**Note**: This schematic should be part of the **Documentation Portfolio** that all teams are required to submit. See below for more information about this portfolio.)

- Teams must demonstrate the presence of a fuse within their vehicle's electrical circuitry to competition officials during the safety check.

- Only DC voltages and low-voltage AC control signals are allowed down the tether from the control box to the vehicle.

- Maximum DC voltage is 13.5 volts.

- Maximum DC amperage is 25 amps.

- Your team's score is based on the value of the C-probes brought back to the surface launching station, removed from your ROV by one of your team members, and placed in the designated container at the launching station. Time bonus points will also be awarded if a team recovers all of the C-probes in less than 20 minutes.

- A lottery may be used to determine the order in which teams will compete.

- Your ROV must be launched and recovered by hand, and only by the members of your team. No winches or portable cranes can be used to launch or remove your ROV from the water.

- The vehicle and all associated equipment, including the tether, must either hand-carried or stowed on a wheeled cart in order to transport it to the pool practice area and competition launching area. Your team must supply this cart.

- Your ROV vehicle system (this includes carts, tool boxes, tools, and any other items used to operate or maintain your ROV) must not damage any part of the pool deck and bottom tiles. Make sure any sharp hard (metallic) edges on the vehicle structure are covered with some sort of soft protective covering such as rubber or plastic to ensure the pool tiles are not damaged during set-up, launch, mission operations, recovery to the deck, and moving the unit around the pool deck for repairs, practice, or transport.

- Your ROV can be constructed out of materials of the team's choice, as long as they meet the listed competition rules and safety regulations.

- Teams are required to bring their own video monitors. There are no limits on the number of video monitors to use.

- Other sources of "stored" power (e.g., hydraulic, pneumatic, or compressed air) and auxiliary equipment that uses this stored power are permitted as long as the vehicle and any and all associated equipment can be hand-carried to the site and operated off of the 12 volts and within the 25 amp limit allotted.

- All teams must submit the Documentation Portfolio **4 weeks** prior to the competition date.

- Officials may stop the competition at any time that they feel there is a safety issue.

**Documentation Portfolio:**
One of the responsibilities of an engineer or technician is to document his or her work. For this competition, teams are required to submit a **Documentation Portfolio**. This documentation portfolio consists of the following:

- **Project report**
  Guidelines and a format for this report will be provided shortly.
- **Photograph of your vehicle**
- **Budget/Expense sheet**
  This sheet is essentially a tally of monies available minus expenditures. A **Budget/Expense Sheet** will be provided shortly as an example of how to organize and report this information.
- **Electrical schematic**
  This schematic may be NEATLY drawn by hand or created using a CAD software program (e.g., OroCAD). An example of an electrical circuit will be provided shortly to help guide you.

  Minor modifications to vehicles' electrical circuitry between the time this schematic is submitted and the actual competition are permitted; however, you must maintain the presence of a circuit breaker.
- **Other suggested contents**
  Parts list, list of tools and equipment used, calculations and test data, and diagrams of sketches of specific ROV components, such as the propulsion system, retrieval mechanisms, or auxiliary equipment can also be included.

The documentation portfolio must be submitted, **IN HARD COPY**, to the competition coordinator 4 weeks prior to the competition date in order for the judges to evaluate the technical merits of the team's ROV design and construction and address any safety issues that may need to be resolved before the competition.

**Safety Regulations:**

1. All members of a competing team and their supporters are expected to conduct themselves in a professional and responsible manner during the duration of the competition.
2. All members of a team and their supporters must agree to follow the safety regulations of the pool facility.
3. All members of the team and their supporters must agree to follow the posted safety regulations of the ROV competition.
4. All devices using AC power (i.e., repair tools, video monitors, recorders) must use a GFI protected receptacle. These receptacles will be provided.
5. All ROV systems must be fused on the DC side of the system, i.e., the power that comes out of the control box and into the tether must only be DC voltages.
6. Only low-voltage AC control signals are allowed down the tether.
7. No team member shall enter the water to conduct a poolside recovery. Only arms and hands are allowed.
8. Team members may only enter the water with their vehicle during practice sessions and with the permission of the competition officials. All regulations regarding swimming activities posted by the pool facility are to be followed. Lifeguards may have to be present during any swimming activity.
9. Competition judges will conduct a physical inspection and safety check of the vehicle to ensure that it meets the design and building specifications and does not pose a risk to the integrity of the competition venue. This will take place during the 5-minute set up period and/or at the judge's discretion during the competition if deemed necessary.
10. Hazardous and/or non-biodegradable materials (e.g. hydraulic oil) may not be intentionally released into the competition waters or the atmosphere.
11. During the safety check, competition officials may disqualify any vehicle that they feel poses an unreasonable safety hazard (such as from leaking fluids or exposed electronics).
12. The **Documentation Portfolio** must be submitted **4 weeks** prior to the competition date in order to evaluate each team's design and built in safety devices and protocols. By submitting this in advance, any safety concerns of the judges can be addressed and remedied before the competition date.
13. Warning labels should be posted on potentially hazardous components of your ROV system.
14. All teams must pass the safety check in order to compete in the recovery mission portion of the competition. This safety check will take place during your team's 5-minute set up time (see **Time Constraints** below).
15. **The competition organizers (the MATE Center and the MTS ROV Committee), competition presenters (Walden Media), and venue operators**

**are not liable for any injury or damage caused by any remotely operated vehicle system participating in the event.**

**Scoring:**
Although the focus of the competition is on the recovery mission, it would be unfair to judge the merits of teams' efforts solely on their underwater performance. Whether successful or not, each team had to put a tremendous amount effort in the process of designing, constructing, testing, and operating their ROV before they even showed up at the pool. This undertaking should be rewarded. Thus, the scoring for the competition is divided into two categories: **Engineering** and **Mission**. Engineering scores account for 50 % of the total and Mission scores for the remaining 50%. The combined total score will determine the winner of the event.

***Engineering***

- Communication – 25 points (max)
- Design and Construction – 25 points (max)

***Mission***

- Recovery – 50 points (max)

***Bonus Time Points***
Additional bonus points are awarded the team if all the C-probes are brought to the surface before the 20-minute time period is over.

**Total:** Score out of 100 points (max) plus any bonus time points

**Engineering Scoring:**
Documentation is key to success in the real, working world and the marine workplace is no exception. Keeping an account of the design and building process, including budget information and expenses, is good practice, not to mention good project management. Communication is also extremely important. Being able to clearly and effectively explain how your vehicle systems function and why you constructed them the way you did will go a long way in helping you to sell your "product" to the "client" – in this case, the competition judges.

***Communication (25 points)***
Up to 25 points will be awarded for having a clear, concise, and informative poster display and project report. This evaluation takes place when your project report is submitted along with the **Documentation Portfolio** 4 weeks prior to the competition date, and during the poster session held the day(s) before the recovery mission. Your team can really add to your score with a well-documented project report, an interesting poster display of their vehicle system, and with each team member demonstrating a well-rounded knowledge of how and why their vehicle systems work. These points are awarded to encourage excellence in engineering and the communication of ideas.

It is important to have your project report completed 4 weeks prior to the competition. Any changes or additions made to your ROV system that differ from the project report you submitted can be presented to the judges at the poster session. The criteria that the judges will use to evaluate your team's project reports will be posted shortly.

***Design and Construction (25 points)***

Up to 25 points will be awarded for technical merit of your ROV construction and design. This judging will take place during the poster session held the day(s) before the recovery mission. The following is a general outline of what the criteria the judges will use to evaluate your team's poster; the final criteria will be posted shortly. Be advised that the judges may ask very specific questions that are not listed here about the technical details of your ROV system to determine the depth of your knowledge.

Points will be awarded for:

**Systems Design**

- Can the vehicle accomplish the mission?
- What are the strengths of the design?
- What are the weaknesses?
- Did the design address the constraints imposed by the competition?
- Do the safety systems work?
- Did the project meet their budget constraints?

**Originality**

- Does the design of the vehicle and its systems exhibit unique and/or original concepts?
- Are there any innovations or modifications that resulted in higher functionality and reduced costs?
- Are there any innovations that increased the safety of the vehicle's operation?

**Craftsmanship**

- What is the overall quality of craftsmanship?
- Are the system's components well laid out and integrated?
- Are the electrical systems neatly run and wired?
- Are the vehicle and its sub-systems robust?
- Is it easy to access components for maintenance?
- Are warning labels and guards posted on potentially hazardous components?
- Are power supplies neatly/safely wired and set-up?
- Is the tether neatly bundled and protected?
- Does the vehicle look esthetically pleasing yet have practical functionality?

**Mission Scoring:**

The mission portion of the competition is scored in two ways: by the point value displayed on the C-probes your team has recovered and a time bonus if you have recovered all of the C-probes in less than the 20-minute mission period.

***Recovery (maximum 50 points)***
Up to 50 points will be awarded for recovering the C-probes. There are 20 C-probes located in various parts of the mock-up. C-probes with higher point value are deeper and/or farther inside the wreck. The mission is scored by the value of the C-probes that you brought back to the surface with your ROV. These must be removed by a team member alongside the launching station, and placed in the designated container at the launching station. The attached diagram shows the approximate locations of the C-Probes and their point value.

***Time Bonus***
A time bonus will be awarded if your team recovers all of the C-probes and returns them to the launching station in under 20 minutes. The time bonus is calculated by subtracting the time your team takes to complete the mission from the 20-minute mission time. For example, if your team took 15 minutes to recover all of the C-probes, a bonus of 20 minutes – 15 minutes = 5 points will awarded. Fractions of a minute are also calculated. For example, if it took your team 12 minutes and 15 seconds to complete the mission, a bonus of 20 minutes – 12.25 minutes = 7.75 points are awarded.

***Dropping C-probes***
If C-probes are dropped during the mission, no points will be lost, but neither will any points be awarded unless, on a subsequent try, the dropped C-probes are brought to the surface and placed in the designated container at the launching station.

***Out of Time***
If time runs out and your ROV is carrying C-probes but these probes have not been returned to the launching station, removed from the water, and placed in the designated container, the point value of these C-probes will not count towards your total score. Only the C-probes placed in the designated container at the launching station will count towards your total score.

***Demobilization Time***
After the mission is completed or the 20 minute time period is up, your team has 5 minutes to demobilize your equipment and move it out of the launching station so that the next team can use it. No points are awarded for this activity.

**Penalty Points or Disqualification:**
Penalty points or disqualification may result if:

- A team member goes into the water to recover C-probes from his or her ROV. Accidentally falling in the water during the competition may also lead to a disqualification. Only the arm(s) of the team members can be in the water for recovering the probes.
- The team's vehicle system does not meet the safety requirements.
- Disrespectful behavior towards the judges, officials, pool staff, audience, or other teams.
- Sabotaging, stealing, or pilfering the equipment of other teams.

- Cheating in anyway.
- If your ROV is recovered by any team member(s) pulling on its tether while it is performing the mission.

**Disqualification and imposition of penalty points requires a consensus of the judging group that is officiating for the team.**

**Grievances will be heard by ROV competition officials and panel as the urgency of the circumstances dictate.**

**Safety Check:**
The judges will always keep the safe operation of your vehicle system in mind during the **Engineering** and **Mission** portions of the competition. Teams must pass all of the items on the safety checklist before they can compete in the recovery mission.

**Safety Checklist**

- AC power supplies, power bars, extension cords have to be clear of any water that might get onto the deck during operation of your ROV.
- Operation of fuses demonstrated to the satisfaction of the judges.
- Auxiliary power sources are secure and safe for use. For example, compressed air cylinders securely supported if in an upright position or laid flat on the deck and not rolling. Recent hydro and VIP inspection of cylinder. Hoses and valves in good repair. High-pressure connection from cylinder to device adequate to operate at the designated line pressure for that part of the system, etc.
- DC voltage and amperage does not exceed 13.5 volts and 25 amps.
- Warning labels on potentially hazardous devices.
- Assurance that there are no hazardous leakages of gases or chemicals on the pool deck, in the water, or into the atmosphere.
- Any other safety concern the judges may have with your ROV system and its operation.

**Competition Arena:**
Here are the specifics of the competition set-up that will help you to design, build, and fly your ROV to recover the C-probes.

The competition arena will be organized as follows:
***Swimming Pool***

- The competition may be held in depths up to 15 feet but more than likely will take place in 8 feet of water.
- The pool contains chlorinated freshwater but should be considered conductive of electrical currents. It is recommended you design your ROV system as if it were operating in saltwater. However, the density of the pool water however will be close to the density of freshwater.

***Launching Station***

There will be an area marked and designated as the competition launching station. This will be set up along the edge of the pool. The launching station will include –

- A 110/120-volt AC 15-amp, 3-pronged GFI protected power receptacle for you to use for repair tools, video monitors, and recorders. It will be located at least 10 feet away from the edge of the pool but might be farther. Make sure your extension cords are at least 30 feet long so that they can reach a plug-in point.
- A table at least 6 feet long x 2 feet wide located within 4 to 6 feet of the pool edge for you to use to set up your ROV system.
- Three chairs for your team.
- A small table for the judges that is close to and in view of the ROV launching station.
- A mock-up of the *Titanic* wreckage at the bottom of the pool and immediately below the launch station.

***Titanic* Mock-Up Details:**

- The entry point of the wreckage is not more than 10 feet away feet from the poolside launching station. The farthest point of the inside of the wreckage is not more than 15 feet away from the poolside launching station. Recommended tether length is 30 to 40 feet.
- The mock-up is made of 1½-inch PVC pipe framework. The left and right sides are covered with 1-inch plastic mesh. The front and top is covered with solid plastic sheeting. The rear of the mock-up has a removable mesh or sheet covering and framework struts. The interior bulkheads and decking are made of plastic sheeting.
- There may be an unknown amount of debris inside the mock-up. All of this debris is light and can "pushed" out of the way by your ROV.
- Outside dimensions of mock-up are 8 feet long x 6 feet wide x 6 feet high.
- The interior of the mock-up consists of two inside decks (Deck A and Deck B) that are accessible through a 2 foot x 2 foot opening on the top of the mock-up that opens into a corridor on Deck A. There are two staterooms on Deck A each with 2 foot x 2 foot openings. On the corridor floor of Deck A is another 2 foot x 2 foot opening that leads down to a corridor on Deck B immediately below. Off the deck B corridor are two staterooms each with a 2 foot x 2 foot opening.
- The mock-up is anchored to the bottom of the pool with dive weights.
- There may be two mock-ups on opposite sides of the pool so two teams can compete at once without interfering with each other. Your team will only have to be concerned with negotiating one mock-up.
- Ambient light inside the mock-up may be greatly reduced compared to the light levels outside of it.

**C-Probe Mock-Up Details:**

C-probes are small cylinders approximately 6 inches long by ¾ inches outside diameter. They are simulated for the contest by using ½-inch PVC pipe, two ½-inch PVC end cap fittings, and a ¾-inch i.d. eyebolt fitted to the top as a "grab" loop. They have very little in-the-water weight – only 1 to 3 ounces. They are designed so that most of the interior weight is concentrated on the bottom of the cylinder; this causes them to stand upright.

They are painted to indicate their point value as follows:

| | | |
|---|---|---|
| White | = | 1 point |
| Red | = | 2 points |
| Yellow | = | 3 points |
| Orange | = | 4 points |
| Silver | = | 5 points |

The point value is also marked on each cylinder.

The cylinders are placed in 2-inch PVC end-caps that are fastened to the decks of the mock-up to prevent the C-probe from being displaced and to allow the positioning of each probe to be consistent for each team that competes. The C-probes are NOT fastened to the end-caps in anyway; they are simply placed upright inside them. The approximate dimensions of the end-caps are 3 inches in diameter x 1¼ inches in height.

There are 20 C-probes placed in various locations on the inside of the mock-up on the two different decks. C-probes with higher point values are located deeper and/or farther inside the interior of the mock-up.

**ROV Design Details:**
Your ROV design is challenged by the following constraints.

***Environmental Constraints***

- Your ROV must be able to operate and withstand water pressure at a depth of 15 feet freshwater.
- Your ROV will be operating in a swimming pool environment. The pool contains chlorinated freshwater but should be considered conductive of electrical currents. It is recommended that you design your ROV system as if it were operating in saltwater. However, the density of the pool water will be closer to the density of freshwater.
- Your ROV should have at least 30 feet of tether to reach inside the mock-up from the launching station.
- Your team should be able to set up your ROV system within 5 minutes.
- Your team should be able to demobilize your ROV system within 5 minutes.

***Weight and Size Constraints***

Your ROV should be designed with the following weight and size constraints in mind:

- You ROV must be able to fit through an opening 2 feet x 2 feet and operate in a space no larger than 4 feet long x 3 feet wide x 3 feet high. This is the smallest space inside the mock-up.

- Your vehicle and all associated equipment, including the tether, must either be hand-carried or stowed on a wheeled cart to transport it to the competition site. (This cart must be supplied by the team.)
- Your vehicle must be launched and recovered by hand and only by the members of your team.
- The vehicle system (this includes carts and any other items used to operate or maintain the ROV) must not damage any part of the pool deck and bottom tiles.

***Maneuvering and Navigation Constraints***

Your ROV must be able to accomplish the following:

- Travel down to the mock-up, pass through vertical and horizontal openings only 2 foot x 2 foot in size, turn and grab C-probes in spaces as small as 4 feet x 3 feet x 3 feet, maneuver back out of the mock-up with one or more C-probes on board, and travel back up to the surface launching station with the C-probes.
- View objects electronically in clear water. Ambient light inside the mock-up may be greatly reduced compared to the light levels outside of it. A camera and possibly a small light is recommended.

***Structure and Ballast Constraints***

Your ROV's structure and ballast must satisfy the following:

- Your ROV must be able to fit through a 2-foot x 2-foot opening and maneuver within a space as small as 4 feet x 3 feet x 3 feet.
- The ballast system can consist of any materials and design as long as they fall within the safety requirements of the competition rules.
- Air or gases used to control the ballast system must meet the safety requirements of the competition rules.

***Propulsion Constraints***

- Your ROV's propulsion system must operate on DC voltages.

***Power Constraints***

Your ROV's power system must comply with the following:

- Only DC voltage is allowed through the tether to the ROV. No AC current is allowed to travel down the tether to the vehicle other than low-voltage control signals.
- The maximum DC voltage the ROV can use is 13.5 volts.
- The maximum DC amperage the ROV can draw is 25 amps
- The DC electrical system must be fused.
- A 12 to 13.5 volt DC power source capable of 25 amps will be provided to operate your ROV during the competition and practice sessions. Connections to the battery will be via standard banana plugs. The banana plugs will be on the terminal ends of two wires – one red that will lead to the positive battery terminal and one black that will lead to the negative battery terminal. A 25-amp fuse will be placed in-line between the positive battery terminal and the

vehicle to ensure that the ROV operates within the 25-amp limit. (**Note**: Banana plugs are available at your local Radio Shack or through electronics supply companies such as Digikey or Newark.)

- The video monitor(s) and video recorder can be powered separately from a GFI protected AC receptacle and are not considered part of the ROV maximum power requirements. This GFI protected 110/120-volt AC 15-amp 3-pronged receptacle will be provided for you and located at least 10 feet away from the side of the pool.
- The judges officiating for your team will place a multi-meter in-line in order to monitor your ROV's voltage and amperage during the mission period.

***Time Constraints***

- Five minutes to set up your ROV system at the launching station, conduct pre-dive tests, allow the judges to complete safety checks, and place your ROV in the water alongside the launching station.
- Immediately after the 5-minute set-up period and upon the judges' signal, your ROV must attempt to recover as many C-probes as possible within a 20-minute time period.
- After the 20-minute mission, you have 5 minutes to demobilize your ROV system and move it out of the launching station area in order to allow the next team to compete. The area must be left in a condition so the next team can set-up without impediment.

***Recovery System Constraints***

Your team will need to devise a way to pick-up or grab C-probes. **Hint**: Your ROV should be able to grab more than one C-probe at a time. When designing this recovery system, keep the following in mind:

- Make sure your recovery system allows your ROV to bring the C-probes to the surface and alongside the launching station. A team member must be able to remove the C-probes from the vehicle. You can remove your ROV from the water to do this if necessary.
- Air or gases used for controlling the ROV ballast system and any recovery system that might be used for recovering C-probes must meet the safety requirements of the competition rules.

***Safety Constraints***

- Your ROV system must meet all safety requirements stated in the competition rules.
- It is important to look over the safety regulations to make sure these are followed.

**Funding:**

While the MATE Center will provide each team with $500 for ROV building materials and supplies, there is no limit to the amount of money, time, and technical expertise that can go into building your team's vehicle. However, the following funding issues may challenge your budget:

- Travel costs for the team members to the competition venue. **Note**: The MATE Center will provide each team with a travel stipend up to $1,500.
- Shipping of ROV system and tools to competition venue.
- Costs associated with fund raising or event presentations to community.
- Miscellaneous expenses for photocopying, phone calls, shipping costs associated with ordering ROV components, poster session materials, mailings, courier, etc.