2004 MATE Center/MTS ROV Committee ROV Competition for High School & College Students

www.marinetech.org/rov_competition/index.php

Competition Challenges and Design & Building Specifications

The 2004 ROV competition focuses on the excitement and challenges of sanctuary science and exploration. We invite you and your teammates to take part in this program of technical innovation and discovery. This is the third annual competition and promises to be one of the most technically challenging to date.

Competition Challenges

There are two competition classes in which teams can compete – ***Explorer*** and ***Ranger***. Your challenge is to build an ROV to accomplish **one** of the two following missions:

Explorer Class

Explore Mystery Reef and perform a multi-faceted set of scientific measurement and recovery mission tasks within 30 minutes.

Ranger Class

Explore Mystery Reef and perform a set of 7 scientific and recovery mission tasks within 25 minutes.

Which competition class is appropriate for your team?

The ***Explorer* class** is suitable for those who are willing to design and construct an advanced, multi-functional ROV with a sophisticated control and payload system. ***Explorer* class** vehicles have a higher power limit, and are usually more costly to build.

The ***Ranger* class** is suitable for those who have limited budgets and/or prefer to work with "hardware store" technology. This class is by far the most popular with high school students – but don't be fooled. The ***Ranger* class** mission tasks are equally as challenging.

Look over both missions and decide which one you would like to tackle. **Your team can only compete in one competition class.**

Regional Ranger Competitions:

Teams in the New England, Houston, Texas, Southern California, and Northern California areas interested in competing in the ***Ranger class*** are asked to participate in the regional event in their area before moving on to the national competition. The top two winners from each regional will move on the national event. Teams outside of these areas interested in competing in the ***Ranger* class** can register directly with the national competition.

See the **General Information** document for details about the regional events or, for information about the ***Ranger*** regional contest near you, contact:

New England
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Scoring

While the focus of the competition is on the science and exploration mission, it would be unfair to judge the merits of team's efforts solely their performance in the water. Each team will put a tremendous effort into the process of designing, constructing, and testing its ROV. This undertaking should be rewarded.

To that end, the scoring for the competition is divided into two categories:

- **Mission** score – **110** points (max)
- **Engineering & Communication** score – **120** points (max)

The Engineering & Communication score is divided into two categories:

- Engineering – **80** points
- Communication – **40** points

  Communication is subdivided into two categories:
  - Technical Report – **25** points
  - Poster – **15** points

Total possible score = 230

Mission Logbook

A three-ringed logbook will be given to each team at the competition venue. **This will be the most valuable piece of information that you will receive at the competition.** You will need this logout throughout the event. It will be your responsibility to maintain it and have it on hand at all times. Bring it with you to all competition events.

The mission logbook will contain score sheets for:

- Technical report
- Poster display
- Engineering presentation
- Mission challenge

Other items that are relevant to the competition event may also be included, such as:

- The scheduled times and locations where your team is to compete
- Venue meetings and lectures
- A list of competing teams and team rosters
- Names of the judges officiating at each specific event
- A list of other officials
- Where to get lunch

The main purpose of the mission logbook is to provide teams with instant feedback on their performances. At each competition activity, your team will remove the appropriate score sheet from your logbook and hand it to the group of judges evaluating that particular portion of the competition. After they have completed their evaluation and filled in the score, the judges will initial the score sheet. This is called **confirmation**.

The team captain will also initialize the score sheet as confirmation that the team has witnessed the score. (**NOTE:** the judges will also record this score onto the master score sheet.) The judges will then hand the score sheet back to your team to place into your mission logbook. **Only the engineering presentation score sheet will not be returned to your team immediately.** The judges will keep this score sheet until all of the scores are entered and the final scores are tallied. It will be returned to you at the awards banquet.

Your team must be able to produce this logbook for any judge or official who requests it. While the judges will keep a master score sheet, this logbook will contain the only available detailed record of your performance. If there is a question about your team's

score or a comment on which you want clarification from a judge, you will need your team's logbook to present your case. Keep it available and keep it safe.

Explorer Class Mission

"Accept the challenges so that you may feel the exhilaration of victory."
–George S. Patton

Mission Objective

Explore Mystery Reef and perform a multi-faceted set of scientific measurement and recovery mission tasks within 30 minutes.

This competition scenario and mission tasks will test your engineering skills. You will need to design and construct an ROV to explore Mystery Reef, an imaginary underwater reef located in the Straits of Florida near NOAA's Florida Keys National Marine Sanctuary. Mystery Reef is made up of features that could be found on one or more of the many different types of reefs found within our national marine sanctuaries. The NOAA exploration expedition described in the scenario has just completed preliminary side scan sonar, sub-bottom profiler, and drop camera surveys of Mystery Reef. The expedition team found that there is a wreck resting on a ledge, but could not identify the wreck since it is deteriorated and covered in marine growth. The survey data also indicated there might be caverns within the reef. Most exciting of all are the methane seeps that energize the unique ecosystems clustered around them.

You have the exciting and challenging job of collecting specimens, identifying the wreck, finding the source of the methane gas, and exploring the caverns. For an added test of your resourcefulness and tenacity, you have to recover that *very expensive* towfish that Nancy and Leah lost on the survey track that led to the discovery of this reef.

This is an exploration mission. Exploration means discovery of the new – and the unexpected. This competition will push your imagination and technical skills. Enter the event with the spirit of the men and women explorers who have set out into the unknown. Take on the challenges with gusto, enthusiasm, and excitement. Design your ROV to be robust, reliable, and multi-functional so that it can perform the varied mission tasks. Do your research, document your work, pay attention to detail, and learn from your mistakes.

Mission Overview

The event takes place in a swimming pool. The water may be up to 5.5 meters (m) deep. A mock-up of Mystery Reef will be on the bottom of the pool; a launch station area called the **control shack** will be just above the mock-up. Here teams will set up to fly their ROV into the mock-up and perform the mission tasks. ***(See Control Shack below.)***

This is a timed event. Your team has 5 minutes to move your gear to the competition control shack and set up your ROV system, conduct a systems check, fine tune the ballast, and ensure that all safety protocols are completed by the judges, which include having the judges' multi-meter connected to measure your system's voltage and amperage. The judges will use the following safety checklist:

- AC power supplies, power bars, and extension cords are secured and clear of any water or potential areas where water might collect on the deck.
- Fuses are present and operational.
- Auxiliary power sources are secure and safe to use. For example, compressed air cylinders are securely supported in an upright or prone position (i.e., laying flat on the deck); the cylinders have had recent hydro and VIP inspections; hoses and valves are in good repair; the high pressure connection from the cylinder to delivery device is rated 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 are on potentially hazardous devices.
- No danger of hazardous gases or chemicals leaking onto the pool deck, in the water, or into the atmosphere.
- Any other safety concern the judges may have about your ROV system and its operation.

At the end of the 5-minute set up period, your ROV should be in the water alongside the control shack pool deck and ready to dive.

At the "go" signal from the judges, the timer will be started and your team's mission performance period begins. You will have 30 minutes to dive the ROV to the mock-up of the reef and complete the mission tasks. Your ROV can surface and return to the reef as many times as you need to in the 30-minute time frame. Your team's mission performance period ends when the 30-minute period is up, or when you have successfully completed all of the mission tasks faster. At the end of the mission, you must have your ROV alongside the control shack with a team member touching it (it is not necessary to remove it from the water).

If your ROV is not alongside the control shack at the end of the 30-minute mission performance period, your team will lose 1 time point for every minute you are late. No points are awarded for any samples brought back to the deck after the mission clock has stopped.

You will then have a 5-minute period in which you must demobilize your gear and clear the control shack for the next team. Make sure that the judges have recorded your score on the master score sheet and that both the judges and your team's captain have confirmed that all your tasks completed (i.e., initialized your mission score sheet). Be sure that you take your initialized score sheet and place it back into your logbook. Divers will take any recovered samples from the deck and place them back into the mock-up for the next team.

We ask teams who have completed their missions not to disclose their knowledge of the reef to the other competing teams.

The judges may ask the divers to randomly reposition objects related to the mission tasks to other locations on the wreck for the next competing team.

Mission Tasks and Score

The mission score is determined by tasks worth 75 points and time points worth 35 points. The tasks can be performed in any order.

Task 1: Measure depth.
You must measure the depth of a designated point on the "periscope" of the U-boat. The periscope will be represented by a PVC pipe approximately 30 to 60 centimeters (cm) in length. It will be attached so that it is vertical and at right angles to the top of the U-boat's conning tower ***(see PERISCOPE illustration)***. There will be a mark on the pipe. You must take a depth measurement at this mark. To do this, you must maneuver your ROV close to the pipe and align the depth sensor that you have mounted on your ROV with the mark on the pipe. When you are satisfied that your ROV is aligned with the mark on the pipe, call out "MARK" and read your depth gauge. Ask the judge(s) to observe while you are doing this. The judge(s) should be able to see your depth readout on your ROV's video monitor or as a digital readout on your control panel. The judge(s) will confirm your result on the mission score sheet and assign a score based on the accuracy of your depth measurement compared to the known depth **(called the benchmark)** of the mark on the pipe.

Task 1 scoring – 10 points
Hover at the mark on the periscope prior to measuring the depth at the mark – 5 points
Accuracy – up to 5 points

- Depth measurement accurate to within 5cm of the benchmark – 5 points
- Depth measurement accurate to within 10cm of the benchmark – 4 points
- Depth measurement accurate to within 15cm of the benchmark – 3 points
- Depth measurement accurate to within 20cm of the benchmark – 2 points
- Depth measurement accurate to within 25cm of the benchmark – 1 point
- Depth measurement greater than 25cm of the benchmark – 0 points

Task 2: Measure the temperature of cold-water spring.
Located inside one of the caverns is a cold-water spring. You must measure the temperature of this water with a temperature sensor either mounted on or "carried" by your ROV. To recognize the cold-water spring, look for signs of low velocity, upward-moving currents ***(see COLD SPRING illustration)***. We recommend you design your temperature sensor to measure a range of 0 to 40 degrees Celsius (C).

To take the measurement, maneuver your ROV so that you can extend your temperature sensor into the stream of cold water. When you are satisfied that you have measured the temperature of the cold water, call out "MARK." Ask the judge(s) to observe while you are doing this. The judge(s) should be able to see your temperature readout on your ROV's video monitor or as a digital readout on your control panel. The judge(s) will confirm your result on the mission score sheet and assign a score based on the accuracy of your temperature measurement compared to the readout on the judges' temperature gauge **(called the benchmark gauge).**

Task 2 scoring – 10 points
Find the cold-water spring – 5 points
Accuracy – up to 5 points

- Temperature reading within 1.0 degrees C of the benchmark gauge – 5 points

- Temperature reading within 2.0 degrees C of the benchmark gauge – 4 points
- Temperature reading within 3.0 degrees C of the benchmark gauge – 3 points
- Temperature reading within 4.0 degrees C of the benchmark gauge – 2 points
- Temperature reading within 5.0 degrees C of the benchmark gauge – 1 point
- Temperature reading greater than 6.0 degrees C of the benchmark gauge – 0 points

Task 3: Sample the fluid from the leaking barrel.
With mysterious red liquid leaking out of one of the barrels, the U-boat poses a potential environmental problem. During the drop camera survey, the camera operator noticed that the barrels were not only leaking fluid, but were also badly corroded. Attempting to raise the barrels to the surface could result in disaster; Leah and Nancy need more data about the chemical composition of the mysterious liquid in order to determine the best course of action for dealing with this potential environmental threat. Your task is to obtain a 500 millimeter (ml) sample from one of these barrels and bring it back to the surface for chemical analysis.

Two barrels of red-colored liquid will be located on the bottom of the reef structure in the vicinity of the U-boat's bow section (the barrels will NOT be located inside of the reef). Each barrel will be made out of a plastic container and will have a ½" PVC schedule 40 pipe protruding 15cm from its top ***(see BARREL illustration)***. Each barrel will contain more than 1 liter (L) of a colored saline solution. You must attach a device that will draw this colored saline solution out of the barrel. The barrel is designed to compensate for the vacuum produced when removing liquid from it so you will not have to contend with low pressure forming in the container.

You can draw your sample of the red liquid from either of the two barrels on the reef. You are allowed to draw off more than 500 ml but will not gain a higher score for doing so (partial points are awarded for bringing back less than 500 ml). Return the sample to the control shack and ask the judges to confirm the color and amount of solution retrieved. The judges will compare the color of your sample with a vial that contains the "**standard**" color. The judges will then pour your sample into a graduated beaker to measure and confirm the amount of solution that you have collected. Make sure your sample is not contaminated with seawater (i.e., don't draw pool water that will dilute the saline solution. This will dilute your sample, making it a lighter color than the standard).

Make sure to leave enough time for the judges to score your sample. They will not score a sample returned after your 30-minute performance period is over. Your ROV does not have to stay on deck at the control shack while the judges score your sample; you can return the sample, remove it from your ROV, and then resume your mission while the sample is being scored. The judges will record and initialize your score on your mission task score sheet.

Task 3 scoring – 15 points
Find a barrel – 5 points
Collect and return the sample to the control shack deck – 5 points
Quantity – up to 5 points
- 500 ml or greater sample – 5 points
- 400 to 499 ml sample – 4 points
- 300 to 399 ml sample – 3 points

- 200 to 299 ml sample – 2 points
- 100 to 199 ml sample – 1 point
- 0 to 99 ml sample – 0 points

3 points will be subtracted for bringing back a diluted sample (i.e., a sample that is lighter in color when compared to the standard).

Task 4: Find and recover the U-boat captain's bell.
The commander of the U-boat was awarded a special commemorative bell for his navy service. Discovery of this bell will help to confirm the U-Boat's identity. You must find the bell and bring it back to the control shack deck. Before recovering the bell, ask the judges to confirm your discovery by observing the image of it on your ROV video monitor. If you drop the bell during recovery you are permitted to go back and retrieve it; no points are added or lost. However, the divers will not help you to recover the bell if it is lost in an inaccessible location on or inside of the mock-up.

Task 4 scoring – 10 points
Find the bell – 5 points
Return the bell to the control shack deck – 5 points

Task 5: Find and recover the lost towfish.
The side scan sonar "towfish" was lost on the reef during the initial survey. Your team must find and recover this *very expensive* towfish. You do not necessarily have to use your ROV to bring the towfish back to the surface and onto the deck at the control shack. For example, you can use your ROV to attach a line and your team members can pull it to the surface by hand. (You must bring your own line; the competition organizers will not provide one to teams competing in the *Explorer* class.) However, be prepared to use your ROV to disentangle the line if it gets caught on objects on the reef. The divers **WILL NOT** free the towfish if it becomes obstructed or tangled in any way.

The towfish will be made out of 2" black ABS plastic plumbing pipe and weigh no more than 9.8 Newtons (N) in air. It will be approximately 1m long ***(see TOWFISH illustration)***. The towfish's location on the reef may change between competing teams. However, it will never be placed inside the reef, nor will be obstructed in any way (i.e., your ROV will not need to remove debris in order to access and free it).

If your team drops the towfish on the way to the surface, you can choose to use your ROV to reattach the hook to the towfish in the place where it has landed and attempt to pull it back up to the surface. The divers will not reposition a dropped towfish. Make sure that the judges confirm that you have completed this task by initializing your mission score sheet.

Task 5 scoring – 10 points
Find the towfish – 5 points
Return the towfish to the control shack deck – 5 points

Task 6: Measure the length of the U-boat.
A standard investigative procedure used by underwater archaeologists is to measure the size of a shipwreck, including its length. The length of a wreck is crucial piece of data that, when combined with other clues, can help to confirm the wreck's origins, age, and identity. You must measure the length of the U-boat.

Two white marks will be located on the U-boat's hull; these indicate the length that you are to measure. At one mark there will be a 7cm long ½" PVC pipe with an end cap protruding at a right angle from the U-boat's hull. You can secure one point of your measuring device to this pipe, if you wish. You must measure the length between this pipe and the other, designated mark located on the length of the hull ***(see U-BOAT illustration)***.

The judges must confirm the measurement as you make it. Therefore, your measurement must be visible on either your ROV's video monitor, a display on your control panel, or some sort of recording device that you bring back to the surface for the judges to examine. The judges will compare your measurement with the known (**benchmark**) length. All measurements must be in meters. The U-boat mock-up **WILL NOT** be longer than 4m.

Task 6 scoring – 10 points
Position a measuring device to determine the length of the hull – 5 points
Accuracy – up to 5 points
- Measurement within 5cm of the benchmark length – 5points
- Measurement within 10cm of the benchmark length – 4 points
- Measurement within 15cm of the benchmark length – 3 points
- Measurement within 20cm of the benchmark length – 2 points
- Measurement within 25cm of the benchmark length – 1 point
- Measurement greater than 25cm of the benchmark length – 0 points

Task 7: Find and recover the pinger.
An acoustic pinger was thrown over the side in an attempt to mark the spot where Leah and Nancy lost the towfish. Your must find and recover this pinger and return it to the deck of the control shack.

A pinger is designed to emit a series of acoustic signals or clicks. These clicks can be detected by a directional hydrophone (an underwater microphone). The hydrophone can also be used to determine the bearing of the transmitted clicks. By following this bearing, an underwater vehicle can navigate to the pinger's location.

Standard ultrasonic acoustics do not work reliably in a swimming pool. The hard walls of the pool reflect the ultrasonic acoustic signals causing a phenomenon known as multi-pathing. This makes it difficult to discern the true direction of the pinger's transmission. Therefore, for this task a simulated pinger will be used to avoid multi-pathing problems **(*see Pinger illustration*)**.

The simulated pinger will be housed in a small 2" PVC pipe approximately 10 to 20cm long (these dimensions are approximates only). Inside the pipe electronics will produce a click or tone transmitting at rate of 1 to 2 beats per second. The frequency of the sound

transmission will be in the human hearing range. Design your acoustic sensor so that it is able to determine the direction of the signal and use the signal's intensity to approximate the distance to it. (A sensitive audio microphone should be able to pick up the signal.) In order to design this device, you will need to research the basic concepts of acoustics and underwater direction finding. This should be a challenging sensor to construct.

In order to ensure that you are using an acoustic sensor to locate the pinger, four "dummy: pingers will be placed on the reef (in other words, one authentic pinger and four dummy pingers will be on the reef). These dummy pingers will look just like the real pinger but they will not emit a signal. Recovering a dummy pinger will result in a loss of points.

Ask the judges to confirm your discovery of the pinger by showing them its image on your ROV's video monitor. You must also show the judges that your acoustic sensor is functioning and that you have found the real pinger and not a dummy. The intensity of the acoustic signal will help to identify the pinger and its approximate the distance (i.e., the closer you are to the pinger the louder the clicks). In addition, the judges will visually confirm that you have recovered the real pinger when you return it to the deck of the control shack.

If you drop the pinger on the way to the surface, your ROV must go back down, recover it, and bring it to the deck of the control shack in order to score the recovery points. You will not lose discovery points for dropping the pinger – unless it is not the real pinger. Depending on the circumstance, the judges may ask the divers to recover the dropped pinger and bring it to the deck of the control shack in order to identify it. If it is a dummy pinger, then your ROV loses all discovery and recovery points.

Task 7 scoring – 10 points
Find ("discover") the real pinger – 5 points
Recover the real pinger – 5 points

0 points will be awarded for finding and recovering a dummy pinger.

Mission Time Points:

Your team will be awarded bonus points if you successfully complete all of the tasks in less than 30 minutes. The time bonus is calculated by subtracting the time it takes your team to complete the mission tasks from 35. For example, if your team took 15 minutes to complete the mission, then a bonus of 35 minutes – 15 minutes = 20 points will be awarded. Fractions of a minute are also calculated. For example, if it took your team 12 minutes and 30 seconds to complete the mission tasks, then a bonus of 35 minutes – 12.50 minutes = 22.50 points will be awarded. Teams' mission times will be subtracted from 35 so that each team receives at least a 5-point time bonus for getting in the water and attempting the mission regardless of whether or not it accomplishes the mission tasks. A 5-point time bonus will not be issued if a team is disqualified from the mission.

Reminder – Judge's Confirmation:
For many of the mission tasks, the judges must observe the task as it is being executed via your ROV's video monitor. Upon successful completion of the task(s), the judge will

assign a score(s) and record and initialize the entry on your mission task score sheet to confirm your results.

Engineering & Communication Score:

Engineering Score – 80 points

This is one of the most critical scores in the competition. It measures your team's theoretical and technical knowledge about your ROV.

The engineering evaluation (aka "design and construction interview") will take place the day before the mission portion of the competition event. Unlike previous competitions where teams were visited by roving groups of judges, this year teams give a formal, 15-minute presentation in front of a judges panel. After your presentation, the panel will ask your team members questions about your ROV, including its design, operation, and safety features.

Only the members, instructors, mentors, family members, and non-competing friends of the team being evaluated are permitted to attend this interview. We do understand and appreciate the value of sharing ideas and learning from other teams. However, our goal is to keep the competition as fair as possible. Teams being interviewed "first" won't know what questions to expect from the judges; if we allow other teams to attend the interviews, they will know what to expect, giving them an unfair advantage. We appreciate your understanding.

While they are permitted to attend, instructors and mentors are not allowed to participate in the interview process. If there is a critical question or issue that requires clarification and the student team members are unable to address it, the judges may decide to invite a mentor or instructor to answer.

Who presents?

All student members of your team must participate in this presentation. You can choose to delegate one team member to give the complete 15-minute talk or divide topics up amongst one, two, or all of your teammates. Audio visual aids, such as slide projectors, computer projection screens, white boards, etc. may or may not be available. We will update you on this once the venue for the competition is confirmed. You will be required to have your ROV in the room. A table will be on hand for you to set up your vehicle. During the question period, all team members must be present and prepared to answer any question a judge asks them to answer.

Each judge on the panel (there could be as many as seven) will award an engineering score based out of 80. These scores will then be averaged out to obtain your team's final engineering score. Engineering scores will be kept confidential until the concluding awards ceremony. At that time, the judges' engineering scores and comments will be returned to you.

Engineering evaluation:

In order to evaluate and score your team's engineering presentation, the judges' panel will focus on certain features of your ROV's design and the process that went into

building it. Here are some examples of questions that the judges may ask. (**NOTE: These are only examples and may not be the actual questions asked.)**

Structure

- How did you decide on the shape of the vehicle and the materials used to build it?
- What is the depth rating of your ROV? How did you test this?
- Did you use any pressure cans in your design? Explain how you designed and built these.
- What are o-rings and how do they work?
- How much did it cost to build your vehicle?
- How much does your ROV weigh?

Control system

- What type of control scheme have you used? Why?
- How does your control system work?
- How many conductors are in the tether?
- What devices/functions does your system control?
- Is there some unique feature of your control system that you would like to tell us about?
- How did you waterproof your underwater electrical connections?

Propulsion

- How many thrusters does your vehicle have? Why?
- How much thrust does each produce?
- How many watts does one thruster use at full rpm?
- How many amps does one thruster draw under full load?
- Explain how you measured thrust.
- How is power (watts) used by one thruster related to the thrust it produces?
- Do you know the forward speed of your ROV? How did you measure this?

Ballast System

- How does your ROV ballast system work?
- Explain what stability is. What is BG?
- Why is it important to consider stability in the design of ROVs?

Sensors

- What type of camera did you choose? How did you waterproof it?
- What is a CCD camera? Briefly explain how one works.
- What do your sensors measure or detect?
- What unique features are incorporated into your sensors?
- What additional sensors (other than a camera) have you put on your ROV? Why?

Payload Tools

- What kind of payload tool(s) did you design to accomplish the mission tasks? Why?
- Explain how this tool(s) works.

Resources

- Did the project meet the budget?
- What equipment/building supplies were donated, built, or bought?
- Did you economize yet produce a functional and robust vehicle?

System Design
- Can the vehicle accomplish the mission tasks?
- What are the strengths of the design?
- What are the weaknesses?
- Do the safety systems work?

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

Workmanship
- What is the overall quality of the workmanship?
- Are the electrical systems neatly run and wired?
- Is it easy to access components for maintenance?
- Are warning labels and guards posted on potentially hazardous components?
- Is the tether neatly bundled and protected?
- Does the vehicle look aesthetically pleasing yet have practical functionality?

Your team must be prepared to answer questions other than those examples listed above. The judges will ask for more details.

Preparing for your engineering presentation and evaluation:
Standing in front of a group of judges and convincing them that your team has a worthy vehicle can be very stressful. It is difficult to predict exactly what questions the judges will ask. The old Boy Scout motto "be prepared" is your team's best strategy for reducing the stress and meeting this challenge successfully.

Here are some suggestions for how to "be prepared:"
- Make sure that every member of your team has a good, general working knowledge of your vehicle, even though they may have specialized in one specific aspect of its design and construction.
- Every member should have a project notebook. Project notebooks or journals are a requirement in all scientific and technical work. They are the daily, detailed notes that you keep when developing and building your project. They are also useful as the primary reference and source of information when creating your team's technical project report (***see Technical Report below***). Write relevant technical and procedural issues down throughout your design and building process.
- Research the specifications of the components that you use in your vehicle. For example, look up the specs of your ROV's CCD camera and be familiar with such numbers as the amount of propulsive force the thrusters produce, the weight of your ROV, etc.

- Freely share information amongst your team members.
- Produce clear, simplified diagrams that you might be able to use in your presentation.
- Make sure that your vehicle is in complete and in working condition when you present.
- Write a concise technical report and make sure all the members of your team have contributed to it. Ask every member of the team to read it over to catch any errors, omissions, or typos. This will help to familiarize all team members with all aspects of the project.
- Practice your presentation. Each team member should practice what he/she is going to say. You'll be surprised how fast 15 minutes will pass. Generally, you will have more to say about your ROV than can be presented in fifteen minutes. That is why it is critical to organize your material and practice communicating it. Ask your instructors or mentors to give you feedback. Practice your presentation more than once so that you become comfortable speaking in front of other people in a coherent and organized way.
- When your team is prepared and knows the material well, you will all be more comfortable and confident. This will come across favorably to the judges.

Communication Score – 40 points

This component of the competition is a great way to earn up to 30 points towards your team's total score before you even show up at the event!

Your team is required to submit a **Technical Report** and create a **Poster Display** that describes your ROV and your design and building process. Up to 20 points will be awarded for having a clear, concise, and informative technical report; up to 10 points will be awarded for having a poster display that provides a good, overall visual presentation of your vehicle and the work that went into creating it.

Technical Report – 25 points:

The technical report is essentially an extension of your engineering score. As such, your team should make an effort to do a good job on this report and not relegate it to the back burner. If your team has been keeping a project notebook(s), then writing this report should be relatively easy. Your team's project notebook(s) will provide you with content and reference information, as well as help you to organize your report.

The technical report must be submitted to the competition coordinator 2 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. Any changes or additions that you make to ROV system that differ from the information the project report that you submit can be presented to the judges as part of your poster display and/or during your team's engineering presentation. **The judges will not review and rescore revised versions of your project report at the competition venue.**

THE REPORT SHOULD BE SENT ELECTRONICALLY AS A PDF FILE ATTACHED TO AN E-MAIL OR AS A PDF FILE SAVED ON A CD-ROM OR DISC AND SNAIL-MAILED TO THE COMPETITION COORDINATOR.

Examples of technical reports from previous years' competitions are posted on the competition web site at www.mpcfaculty.net/jill_zande/report_examples.htm. The guidelines and required components for the report are:

- **Length is less than 20 pages**
- **All measurements are in SI units (metric)**
- **Title page** that includes:
  - Your project/ROV name
  - School/club name
  - Team name (if applicable)
  - List of team members (you can also include degree/area of study and expected graduation date)
  - Names of your instructor(s) and/or mentor(s)
- **Abstract (250 words or less)** that is concise and clearly summarizes the project.
- **Photograph(s) of your completed ROV**
  You are permitted to make modifications that may change the look of your vehicle between the time you submit your report and the competition, however this must be a photo(s) of your completed, intact vehicle, not a photo of individual systems and/or payload.
- **Budget/expense sheet**
  Keep an accounting of your monies and expenditures. In addition to funds, list any items (building materials, equipment, etc.) that were donated, the organization that made the donation, and an estimate of the item's value. A sample expense/budget sheet will be provided shortly as an example of how you can organize and report this information.
- **Electrical schematic**
  Make sure to highlight safety features such as circuit breakers and fuses. This schematic may be NEATLY drawn by hand or created using a CAD software program (e.g., OroCAD).
- **Design rationale** presented in a clear and logical manner.
- **Description of at least one challenge** that your team faced and what methods were used to overcome it. These can include both technical and those challenges related to working as a team, such as team dynamics and dealing with individual personalities.
- **Explanation of troubleshooting technique(s)** used to overcome technical problems.
- **Description of at least one lesson learned or skill gained** during the design and building process.
- **Discussion of future improvements**
- **How ROVs are currently being used to explore and understand our national marine sanctuaries (500 words or less).** You can focus on one sanctuary or include information about ROV missions in a number of different sanctuaries. These missions can be related to science, exploration, conservation, or policy issues. Reference at least 3 sources for your information, and include photographs and/or graphics where appropriate.
- **Acknowledgements**

Please recognize the companies, organizations, professionals from industry, and/or mentors who helped to support your team by donating funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise.

The score sheet for your technical report will be returned to your team after your engineering presentation for you to place into your mission logbook. Please keep this score sheet available at all times. The judges may ask to see it at anytime during the competition. An electronic as well as a hard copy of your team's technical report will be on hand at the competition in case there is a question, concern, or issue requires the judges to view the actual document.

Poster Display – 15 points:

Creating an informative, clear, and concise visual presentation that effectively explains 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.

Your team's poster will be evaluated and scored by a group of judges during the competition. The score sheet for your poster display will be returned to you once the judges have evaluated all of the posters and recorded the scores onto the master score sheet. Your team may not receive your poster score sheet until after your mission performance period, but it will be returned to you before the awards banquet. You should place it into your mission logbook. The score sheet must be available at all times; the judges may ask to see it at anytime during the competition.

Competition officials will provide each team with one 3-panel, freestanding presentation display board (although you may bring your own). Each display board is:

- Made out of black, corrugated cardboard
- Free-standing; no easels or stands are required
- 36" tall with a total width of 48"
- Comprised of three panels
    - One 24" wide by 36" tall center panel
    - Two 12" wide by 36" tall side panels

For more details about the display board, including a photo, visit www.staples.com and search for project display board item #922528. Competition officials will also provide scissors, tape, glue sticks, adhesives (e.g., Velcro), and other means of attaching display items to the presentation board, although you are also welcome to bring your own.

The guidelines and required components for the poster display are:

- **Font size that is clearly legible from a distance of 1.5 m**
- **All measurements are in SI units (metric)**
- **Your school/club and team name (if applicable)**
- **Images AND captions**
    - Team photo
    - Photo of your ROV
    - Photo(s) of any special features of your vehicle and building photo(s)
- **Description of your vehicle and why you built it the way that you did**

- **Answers to the following questions:**
  - What was the most rewarding part of this experience?
  - If you were to do this again, what would you do differently?
- **How ROVs are currently being used in national marine sanctuaries**
  Use the information that you included in your technical report (***see Technical Report above***) to create a brief summary paragraph of ROV missions taking place in sanctuaries. Include a photograph or other graphic.
- **Acknowledgements**
  Please recognize any companies, organizations, professionals from industry, and/or mentors who helped to support your team by donating funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise.
- **Other items that you may use in your poster or have on display include:**
  - Diagrams or sketches (CAD drawings, for example)
  - Photo journals
  - Copies of your team's technical report
  - Resumes of individual team members
    Note: This year we are planning to circulate the resumes of students nearing graduation and/or interested in applying for a MATE Center Technical Internship to competition sponsors and other potential employers (think JOBS!). More information about this process, as well as guides to resume writing, will be set out to teams in January 2004. There is no obligation to participate.

Recommendations for your poster display:
We recommend using Microsoft PowerPoint or Publisher slide presentation program to create your team's poster presentation. PowerPoint will allow you to include both text and photos, which should make creating your presentation relatively easy. Once you've created your slide presentation in PowerPoint, you can print out each individual slide and tile the slides along the presentation board. For example, the two side panels will hold four 8 ½" x 11" pieces of paper; the center panel has room for eight. You may want to use 24-lbs. or higher stock, such as cardstock, paper for text and photographic paper for images to ensure presentation quality display materials.

Your team will be required to submit a copy of your team's poster presentation materials, so please bring two sets – one to display on the presentation board and one to turn in to competition officials. Please place the materials in a folder with your school/team name.

Awards

A complete list of the award categories will be posted to the competition web site shortly. The award categories will be similar to those from last year. For last year's competition awards and the teams who won them, visit www.mpcfaculty.net/jill_zande/2003_winners.htm.

Competition Arena

The Reef Mock-Up

The tasks that make up the *Explorer* class mission will require your team to fly your ROV outside and inside of the reef structure. The exact location of these mission tasks is

not known. Be prepared to fly your vehicle through simulated methane seeps (air bubbles), dash through twisting passages inside the reef, search the U-boat for the leaking barrel and bell, explore the reef for collecting/tagging tasks, and search for the lost towfish. You should have a minimum of 15m of tether from the control box to your ROV. No single object that your ROV has to recover and bring to the surface will weigh more than 9.8 Newtons (N) in air.

Structure of Reef
The Mystery Reef mock-up is a 5m long x 5m wide x 3m high structure. The frame is constructed of ¾" schedule 40 PVC pipe and fittings with a black landscaping cloth covering the framework. It will be placed in 3 to 5.5m of water, but it may be deeper depending on the venue pool. It will be located directly below and somewhat in front of the edge of the pool below the control shack (***see Control shack below***).

U-Boat structure
The mock-up of the U-boat will be located outside and on top of the reef. The U-boat will be approximately 4m long x 1.5m in diameter, with a conning tower about 1m high. A periscope will also extend form the top of the conning tower. (**NOTE:** The U-boat dimensions may change slightly from those stated above; however, you can consider these its minimum size dimensions). The U-boat mock-up will be divided internally with bulkhead compartments (***see U-BOAT illustration***).

Caverns
The reconnaissance survey showed that the reef has a cavern system with a number of entrances, the exact number of which is unknown. The minimum size of any entrance (which may be circular or square in shape) will be no less than 1m in diameter. The inside passages of the caverns can be likened to a maze with blind alleys, twists, and turns. The exact layout of the maze system is unknown; your team will have to explore it. Light levels inside the caverns will be reduced but not be completely dark.

Cold-Water Spring
The cold-water spring will be simulated by cold water coming from a hose that runs from the pool deck down into the reef mock-up. The hose will be anchored to the bottom of the pool. To find this spring, look for signs of low velocity, upward-moving currents inside one of the caverns.

Methane Seep
The methane seep will be simulated by air bubbles. An air compressor located on the pool deck will create the bubbles. An airline will run from the deck into the reef mock-up. A bubble diffuser or air stone like those used in aquaria will be located at the end of the air line in order to break the bubbles into a fine stream. To accomplish some of the mission tasks, your ROV may have to pass through or fly in the bubble stream, so design accordingly. Rest easy; the simulated methane bubbles are not explosive.

We apologize for the artificial look of the reef (i.e., plumbing pipe and landscaping cloth). You will have to use your imagination to see the reef's complex diversity and beauty, and the unique place that reefs have in our ocean ecosystems.

Control shack

There will be one or more areas marked, roped off, and designated as the *Ranger* class control shack along the edge of the pool. The set up at the control shack will include:

- A tent-like structure with four walls that extend to the pool deck. Your team will set up inside this structure. The team member handling the tether will be positioned outside of the structure, but will not be able to look into the water to direct the pilot as to the position of your ROV.
- A 110/120-volt AC, 15-amp, 3-pronged GFI protected power receptacle for you to use for repair tools, video monitors, and recorders. This will be located at least 3m away from the edge of the pool but might be further. Make sure you're your extension cords are at least 10m long so that they can reach a plug-in point.
- A table located within 2m of the pool edge for you to use to set up your ROV system.
- Three chairs for your team members.
- A small table for the judges close to and in view of the ROV control shack.
- A mock-up of *Mystery Reef* at the bottom of the pool and immediately below the control shack.

Competition Rules

We have tried to develop these rules so that they are fair for each and every team. However, nothing human is ever perfect. If you have any concerns or questions regarding these rules, please let us know in advance of the competition and we will do our best to address them. During the competition, any dispute regarding the awarding of points, intent of the rules, omissions, inconsistencies, human error, etc., will be addressed by the chief judge and deliberated in consultation with the other judges, participants, and competition officials.

It is very important to review the following safety regulations and make sure that they are followed. Most of these safety rules will impact the way that your team will design, build, and operate your ROV.

General Safety

- All members of a competing team and their supporters are expected to conduct themselves in a professional and responsible manner throughout the duration of the competition.

- All members of a team and their supporters must agree to follow the safety regulations of the pool facility.

- All members of the team and their supporters must agree to follow the posted safety regulations of the ROV competition.

- 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 or bottom tiles. Make sure that any sharp hard (metallic) edges on the vehicle structure are protected with some sort of soft 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 your ROV around the pool deck for repairs, practice, or transport.

- Make sure that any power cords are not lying in pools of water on the deck.
- Secure any equipment so that it does not fall off the table, damage the deck, or cause in jury.
- Keep an eye out for tripping hazards in the control shack and in your team's workspace.
- 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.
- Hazardous and/or non-biodegradable materials (i.e., hydraulic oil) may not be intentionally released into the competition waters or the atmosphere.
- Officials may stop the competition at any time that they feel there is a safety issue.
- All teams must pass the safety check in order to compete in the mission. The safety check will take place at the control shack during the 5-minute set up period. Your team must pass each item on the checklist in order to compete. However, no points will be given or taken away during the safety check.
- The judges will always keep the safe operation of your vehicle system in mind throughout the event. They may ask you to explain and/or demonstrate some aspect of your vehicle that they feel is unsafe. Your team must comply with any such requests and address any concerns to the satisfaction of the judges.
- The competition organizers (MATE, the MTS ROV Committee, and NOAA's National Marine Sanctuary) and venue operators are not liable for any injury or damage caused by any ROV system participating in the event.

Electrical Safety

- Teams are required to bring their own power supply. Your team 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.
- During the safety check, teams must demonstrate the presence of a fuse within their vehicles' electrical circuitry. A fuse must be present even if an AC wall unit and converter are used. The DC side of the system, i.e., the power that comes out of the control box and travels into the tether, must also be fused.

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

- Maximum DC voltage is 48 volts.

- Maximum DC amperage is 40 amps.

- Only a single 110/120-volt, 15-amp AC receptacle with a GFI is provided by the competition at the launch station. All your AC power needs must be run from this source. 220V AC or higher amperages such as 20 amps, is not available, nor allowed. The team must bring extension cords and power bars. These are not supplied.

- For those teams using AC to DC power supplies, a single 110/120-volt, 15-amp, 3-pronged receptacle with a GFI will be provided at the control shack. 220-volt AC and/or higher amperages will not available or allowed.

- Make sure that your team's 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.

- Any AC to DC power supplies must be located at least 3m from the pool's edge and elevated off of the pool deck to prevent standing water from creating an electrical hazard.

Penalty Points or Disqualification

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

Grievances will be heard by competition officials and judges as the urgency of the circumstances dictate.

Penalty points or disqualification may result:

- A team member goes in the water to recover the team's ROV. Only the arms of the team members can be in the water to recovering the ROV and any associated equipment or sample.
- A team member accidentally falls into the water during the team's mission performance period.
- A team's vehicle system does not meet the safety requirements or fails to operate (i.e., complete systems failure that results in your vehicle being unable to move or submerge during the mission performance period).
- Disrespectful behavior towards the judges, competition officials, pool staff, audience, or other teams.
- Sabotaging, stealing, or pilfering the equipment of other teams.
- Cheating in anyway.

Procedural Rules

- Your team's technical report (***see Technical Report above***) should be submitted four weeks prior to the competition.

- Your ROV must be launched and recovered by hand and only by the members of your team.

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

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

- Inside the control shack, teams will be provided with a table located within 2m of the pool edge to set up their ROV system and associated equipment.

- The ROV's monitor and control panel will be set up to prevent the pilot and team members from looking at the ROV in or under the water except through the ROV monitor.

- The surface of the water near the control shack will be rippled to make it difficult to clearly see your vehicle or the reef below.

Who goes first - volunteers?!
This year we are asking for at least six teams to volunteer to go first. We recognize that this may put these teams at somewhat of a disadvantage as they will be the first to explore the reef and determine many of the unknowns of the mission tasks. Because underwater footage will be broadcast to big screens topside, the teams not competing at the time may be able to determine the layout of the reef and location of some of the mission tasks. However, as previously noted, divers will randomly reposition items related to the mission tasks between competing teams. In addition, ripples may be created by sprinkling water near the control shack, making it difficult for ALL of the teams, as well as the spectators, to get a good look at the reef below. These efforts will help to keep the playing field even, and ease any disadvantage/advantage a team might have. Once the first six teams have been assigned their competition time slot, the time slots for the remaining teams will be chosen by lottery.

When you submit your technical report 2 weeks prior to the competition, please indicate if your team would volunteer to go first.

Mission Team Rules

- "Mission team" refers to the student members who will actually launch, pilot, and perform the competition mission. Instructors, mentors, and/or non-student members cannot participate as part of the mission team.

- The names of the mission team members must be submitted to the judges the day before the mission portion of the competition begins.

- **The mission team is limited to six students.**

- The control shack will be clearly marked, roped off, and designated as the control shack.

- Only the mission team and judges are allowed at the control shack. Other team members, instructors, mentors, audience, and observers (i.e., press or special invited guests) must remain outside the control shack or in the designated viewing area during the mission period.

- Instructors, mentors, or other team members who are not part of the mission team are not allowed to pilot or assist in the setting up their ROV at the control shack. However, they can assist in bringing the ROV equipment to the **entrance** of the control shack.

- Mission team members are allowed to communicate with each other at the control shack. Coaching from the sidelines is discouraged. However, loud and enthusiastic cheering is greatly appreciated.

- The team can pull on the tether to bring the vehicle back to the control shack.

- Any mission team member(s) can recover the towfish and/or sample basket.

- Only mission team members are allowed at the control shack during the 5-minute demobilization time. Follow any instructions from the judges or competition officials as to where to take your equipment after you leave the control shack in order to keep the area clear for the next competing team.

- The competition organizers (MATE, the MTS ROV Committee, and NOAA's National Marine Sanctuary) and venue operators are not liable for any injury or damage caused by any ROV system participating in the event.

ROV Design and Operation Capabilities

Here are things to think about and take into consideration when designing and operating an ROV for the *Explorer* class mission tasks:

- The mission tasks are varied and complex. Plan and design your ROV so that it can multi-task.
- A well-engineered, robust ROV with a dexterous payload tool will make the job of piloting the vehicle much easier.
- Multiplexing your control system and designing an automatic depth-keeper might be good choices. You might even want to look at using a computer and internet

protocols (IP) control options. Whatever you decide to use for a control system, make sure it is robust yet flexible to control multiple devices.

- Having a thin tether will be an advantage.
- Put a KISS (Keep It Simple Stupid!) sign over your workbench to remind your team about the dangers of over-engineering. On the other hand, don't engineer your ROV too close to the mission specifications. Much of the information about the size and weight of objects are only approximates or maximums/minimums. Make sure you to design your ROV so that it has lots of clearance to transit entrances, lift weights slightly heavier than specified, and with enough vertical thrust to maneuver in air bubbles.
- The omissions and lack of information within the mission tasks are intentional. This is an exploration mission and not everything will be known when you launch your ROV. You may find some tasks may require you to "reach" into a space or object to measure it or to grasp it with your payload tool.
- Your ROV will have to cover a lot of bottom while completing the mission tasks. Develop a system for keeping track of where your ROV is and has been. Make notes of recognizable landmarks to use in navigating around the reef.
- Practice piloting and navigating your vehicle. This is the fun part, but often neglected because of "lack of time." Try to schedule (set milestones) your ROV project so that when you arrive at the venue you are confident that your vehicle is ready to compete.
- Have a team member act as a "scribe" to log your course changes, depth, and keep track of visual landmarks. You might even have a "co-pilot" to operate your payload tools.
- An acoustic sensor is required. Research the design and construction of this device carefully. The usefulness of your sensor design depends on its ability to work with ambient noise. The pool will not be acoustically quiet. Divers' bubbles, other ROVs, pool pumping systems, water hoses, methane bubbles, etc. will create interference with the pinger's transmissions. Test any detection devices that you create to make sure it/they are effective before mounting it on your ROV. For the final set of tests, mount it on your ROV and test it again in a noisy pool environment.
- There will be simulated methane bubbles on and inside the reef. You should be able to operate your ROV in a bubble stream.
- Temperature measurements are required. Make sure that your temperature sensor has the necessary 0.5 degree C accuracy.
- Some objects and samples will need to be brought to the surface. You should figure out a way to minimize the number of trips back and forth to the control shack during the mission performance period.
- Your ROV must be able to operate and withstand water pressure at a depth of 5m.
- The pool contains chlorinated, freshwater but should be considered conductive of electrical currents. Please waterproof your ROV components if possible.
- Your ROV should have at least 15m of tether to reach inside the mock-up from the control shack.
- Your team must be able to set up your ROV system at the control shack within the 5-minute set up period.

- Your team must be able to demobilize your ROV system and move it from the control shack within five minutes.

Funding and Budget

There is no limit to the amount of money, time, and technical expertise that can go into building your team's vehicle. However, keep in mind that a costlier vehicle does not necessarily mean that the vehicle will perform better or will be better able to successfully accomplish the mission tasks. In other words, spending more money does not always lead to competition victory!

This year the MATE Center will provide each team with $100 for building supplies and materials. This includes teams competing in the regional events as well as the national competition. Teams competing in regional events should contact the regional competition coordinator in their area in order to receive their ROV building supply and material funds. In addition, regional coordinators may have plans for other types of support, including workshops and access to mentors.

In addition, the Center is working with a number of companies to encourage them to offer their products, materials, supplies, and/or access to equipment and facilities at no or reduced costs. For example, VideoRay (www.videoray.com) is creating a "MATE ROV Competition Store" that will be available to competition teams **only**. This on-line store will offer discounts on cameras, tethers, and, possibly, thrusters, among other items. (The URL for this on-line store will be posted to a "teams only" section of the ROV competition web site. The "teams only" section is currently under construction; its URL and password will be sent as soon as it's completed.) Likewise, Carrillo Underwater Systems is again offering a scholarship for free and/or discounted products. Visit www.carrillounderwater.com/mate/ for more information, including how to apply.

The MATE Center will also provide information on potential funding sources at both the national and regional level (e.g., local Rotary Clubs, American Association of University Women, etc.). This information will be posted to the "teams only" section of the competition web site.

The Center also encourages teams to organize their own fundraising activities, including approaching local businesses (e.g., Home Depot) for donations of funds, building materials, equipment, etc.

In addition to supply and material costs, the following funding issues may also 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 of at least $1,500.
- Lodging and meal costs during the competition event. **NOTE:** The MATE Center will cover the cost of some housing and meals, the exact amount of which TBD.
- Shipping your 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.

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