2012 MATE ROV Competition Manual

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OVERVIEW

The **MATE Center** and the **Marine Technology Society's ROV Committee** coordinate an underwater robotics (remotely operated vehicle or ROV) competition that includes an international event and a network of 21 regional contests that take place around the world. Students from elementary through college level are welcome to participate in the competition, which includes three different "classes" of vehicles that vary depending on their complexity and the mission requirements.

This year's competition theme highlights the role that ROVs play in evaluating World War II shipwrecks and the potentially hazardous material that they may still contain. Resting on the ocean bottom for nearly 70 years, the hulls of these shipwrecks have no doubt deteriorated; if they still contain fuel oil, these wrecks pose the very real threat of an environmental disaster. Assessing the condition of the shipwrecks and determining what to do with any hazardous material that remains on board is the very real world challenge facing this year's competition teams.

2012 marks the 11th year of international competition. The event is being held at the YMCA Aquatic and Family Center in Orlando, Florida, June 21 – 23, 2012.

Employers (industry, businesses, government agencies, and research organizations) and working professionals are contributing to the event by donating funds, building materials, equipment, and facilities in support of the teams competing in both the international and the regional events. Working professionals are also volunteering their time and technical expertise as mentors, technical assistants, and competition judges.

GOALS

The MATE Center uses underwater robots as a way to get students excited about science, technology, engineering, and math (STEM) and help them to see the practical applications of these subjects. In this way, the MATE Center is working to encourage and motivate students to study STEM and pursue careers in ocean STEM fields.

Specifically, the MATE competition's goals are to:

- Increase the awareness and visibility of marine technical fields, educational and career opportunities, and potential employers.
- Help students develop the skills necessary to enter careers in technical fields. These skills include the ability to problem solve, think critically, troubleshoot, communicate effectively, and manage projects. These also include "entrepreneurial" skills – the ability to see the "bigger picture" context of their work and to tackle problems in creative and innovative ways. In addition, students develop interpersonal skills as they work together to solve problems and address challenges in a non-confrontational environment.
- Connect students and educators with employers and working professionals. Working professionals have the opportunity to share their knowledge and experience as team

mentors, complementing what students are learning in the classroom. Employers are able to evaluate students as potential employees. Students can explore potential careers.
- Increase students' understanding of the role that ROVs play in assessing World War II shipwrecks and addressing the threat of any hazardous cargo that they still contain.

COMPETITION COMPONENTS

Each year the competition focuses on a new theme in order to expose students and educators to the many different aspects of the ocean workplace and the scientific and technological advancements that are taking place.

Regardless of the theme, the competition consists of the following components:

- **Underwater mission tasks**
- **Technical reports**
- **Engineering presentations**
- **Poster displays**

Information about the **EXPLORER and RANGER** underwater missions can be found within the **Competition Missions** document, while the **Engineering & Communication** document contains information about the report, presentation, and display. The **Design & Building Specifications and Competition Rules** document contains information about ROV specifications and competition rules.

Information about the **SCOUT** missions, design and building specifications, competition rules, and engineering and communication can be found within the **SCOUT Class Competition** document.

COMPETITION CLASSES

There are three classes in which teams can compete – **EXPLORER, RANGER, and SCOUT**. (Note that the SCOUT class is not currently available at all of the MATE regional contests. See **REGIONAL CONTESTS** below for more information.) The specific eligibility information for each of these classes is included below.

PARTICIPATION FEE FOR EXPLORER AND RANGER TEAMS

Teams registering for the 2012 MATE competitions are required to pay a participation fee. This fee is for EXPLORER and RANGER class ONLY (not SCOUT) and is your team's commitment to participate in the competition. The fee will be returned to your team in the form of lunches, trophies, and prizes at your regional or international competition event.

The participation fee is $50 per team and is due when your registration has been approved. Once your registration is approved, you will receive an e-mail confirmation with a link that will take you to the payment page (and more information about your registration). Teams participating in regionals that take place outside of the U.S. may be exempt from this fee (the payment page will tell you). MATE accepts VISA and MasterCard, checks made out to MATE/MPC, and money orders. The address where to send checks and money orders is included on the registration form.

Participation fees will be fully refunded if your team withdraws 2 (or more) weeks prior to your competition. ("Withdraw" is defined as notifying your regional competition coordinator of your

decision not to participate.) Fees will not be refunded if your team withdraws within 2 weeks of the event (this includes "no-shows" on competition day). Regional winners moving on to the international competition are NOT required to pay another registration fee UNLESS they have not already done so.

ELIGIBILTY – GENERAL

(See below for eligibility as it applies to specific competition classes)

- Open to middle school (grades 5-8), high school (grades 9-12), community and technical college, and four-year university students as well as home-schooled students of comparable grade levels.
- Elementary school (grades K-4) students are eligible to participate, but only in the SCOUT class and only if their regional event can accommodate their participation. Contact the regional coordinator in your area for more information.
- Middle school students are eligible to compete in the SCOUT and RANGER classes ONLY. High schools that have previously participated in the RANGER class may apply to compete in the EXPLORER class (see the registration form for more details).
- Graduate students are NOT eligible to compete as student team members, but are welcome to serve as team mentors or lead instructors. Graduate students are encouraged to contribute to the team via advice and technical assistance.
- Students can participate in the competition as a part of a school course, afterschool program, club, or community organization. However, regardless of how the team is formed, it must demonstrate that 1) the participating students fall within the eligible grade levels and 2) if minors, the students are working under the supervision of a responsible adult mentor.
- Teams must have at least three students with at least one faculty member or adult mentor involved in the process. One student should be designated as the team captain/company CEO.
- The role of the faculty member or adult advisor must be limited to educational and inspirational support. Actual construction of the vehicle, particularly in the complex electrical and software areas, must be completed by the students. Students will be questioned extensively by the judges on their role in designing and building the ROV.
- Individuals from industry, businesses, research organizations, and/or government can act as mentors during the design and building process. The role of these individuals must be limited to technical guidance. Industry mentors should not participate in the actual construction of the vehicle.
- Teams competing in the EXPLORER and RANGER classes are discouraged from using complete, commercially available, off-the-shelf, plug-and-play systems. Teams will not be disqualified from competing for using these types of systems, but the engineering evaluation and technical report score sheets will reflect MATE's efforts to discourage their use. See the **Design & Building Specifications and Competition Rules** document for specific information.
- All team members, including instructors/mentors, are required to register or update their information on the MATE AlumniWeb site (www.marinetech.org/alumni) as a condition of participating in the competition. AlumniWeb helps the MATE Center to keep track of students and educators who have participated in its ROV competitions and to demonstrate the impact of the competition program to its funding agencies. The information entered is kept strictly confidential and is only viewed by MATE Center staff and MATE's independent evaluator.

See the ***Technical Report*** section within the EXPLORER and RANGER **Engineering and Communication** document and the **SCOUT Class Competition** for more information.

The competition organizers will review the registration forms. Students and/or instructors may be asked to verify that students are of eligible grade level and, if minors are participating, that the team is working under the supervision of a responsible adult mentor who understands the liability that he/she is taking on by overseeing the project.

EXPLORER class eligibility

Grade level

- Participation in the EXPLORER class is open to students in community and technical colleges and four-year universities.
- High school students (and students of comparable grade levels) participating in the MATE ROV competition for the first time are NOT eligible to compete in the EXPLORER class.
- High school students (and students of comparable grade levels) who have previously competed in the RANGER class can apply to compete in the EXPLORER class.
- High school students (and students of comparable grade levels) who have previously competed in the EXPLORER class must also apply, making sure to indicate the total number of returning team members. See the competition registration form for details.
- Elementary and middle school students are NOT eligible to compete in the EXPLORER class.

Number of teams

- Two teams per school are permitted provided that they come from different departments and/or campuses and that there are no common mentors or students (i.e., faculty can only mentor one team and students can only participate on one team).
- Schools with two (or more) teams that do not meet these criteria are encouraged to hold an in-school run-off to determine which team will represent their school at the international competition.
- High schools are not permitted to enter more than one team per school even if they do meet the above criteria.

EXPLORER class demonstration requirement

EXPLORER class teams are required to demonstrate that their vehicle can 1) maneuver under its own power and 2) complete the RANGER class (yes, RANGER) simulated sonar scanning component of mission task #1 prior to the international competition (see the **Competition Missions** document for details).

EXPLORER class teams must attend the regional contest geographically closest to them on the date of the event to demonstrate to the regional coordinator (or other designated competition official) that their vehicle can accomplish the tasks described above. If teams are located equidistant from two or more regionals, the MATE competition coordinator and the coordinators of those regionals will discuss with the team which regional is most appropriate.

Prior to the contest, the regional coordinator will contact the EXPLORER class teams within his or her region to arrange a time during the regional event for this demonstration to take place. The regional coordinator will then submit an e-mail to the MATE competition coordinator verifying that

the team's vehicle can (or cannot) accomplish the tasks listed above. If the team's vehicle cannot accomplish these tasks, the team is not eligible to participate in the international competition. There are no second attempts for demonstrations.

International teams that are not located near a regional event should contact the MATE competition coordinator at jzande@marinetech.org so that other arrangements can be made for their demonstration.

Regardless of where the demonstration takes place, the water depth for the demonstration must be greater than 1.5 meters.

Note: EXPLORER class ROVs must conduct their demonstrations at 48V and follow all EXPLORER class power specifications. EXPLORER class teams conducting their demonstrations using an impartial individual must provide their own 48V power source for this demonstration; teams conducting their demonstrations at regional events may or may not be required to provide their own power and should discuss this with their respective regional coordinators.

In addition, on the day of their demonstration EXPLORER class teams must submit – in both hard copy and electronic form – a copy of their Company Spec Sheet to the regional coordinator or impartial individual overseeing their demonstration. Teams must submit an electronic copy of their spec sheet to the MATE competition coordinator at jzande@marinetech.org on the day of their demonstration. See the **Engineering and Communication** document for more information about this spec sheet and its required information.

Teams that modify their vehicles between the time of their demonstrations and the international competition must submit a list that describes the specific modifications along with their revised **Company Spec Sheet** to the MATE competition coordinator 4 weeks prior to the international competition. (See the **Engineering and Communication** document for more information about this submission.) These teams must also be prepared to explain their modifications to the safety check officials and the judges presiding over their engineering presentation during the international event.

RANGER class eligibility

Grade level

- Participation in the RANGER class is open to students in middle (grades 5-8) and high (grades 9-12) schools as well as students in home schools, afterschool programs, clubs, and community organizations of comparable grade levels.
- Students attending community and technical colleges and four-year universities competing for the first time are also eligible to participate in the RANGER class. Note that "first time" is defined as students AND instructors/mentors who have not participated previously.

Number of teams

- Two (or more) teams per school/instructor are permitted provided that the regional contest in which these teams are participating has the resources to host more than one team AND that there are no common students (i.e., students can only participate on one team).

- Where the regional event cannot host more than one team per school/instructor, teams are encouraged to hold an in-school run-off to determine which team will represent their school/instructor at the regional contest.

ALL RANGER TEAMS MUST PARTICIPATE IN A REGIONAL

All teams participating in the RANGER class are required to take part in a regional event. Teams that win their regional event can move on to compete in the RANGER class at the international competition. (See **REGIONAL CONTESTS** below for information on the number of winners that move on from each regional.)

Teams will be assigned to the regional that is geographically closest to their location. If teams are located equidistant from two or more regionals, the MATE competition coordinator and the coordinators of those regionals will discuss with the team which regional is most appropriate. International teams competing in the RANGER class that are not located near a regional event must participate in a demonstration requirement similar to the EXPLORER class. Contact the MATE competition coordinator ASAP if your team falls into this category.

SCOUT class eligibility

See the **REGIONAL CONTESTS** below for a listing of those events that offer a SCOUT class competition.

Grade level

- Participation in the SCOUT class is open to students in elementary (grades K-4), middle (grades 5-8), and high (grades 9-12) schools as well as students in home schools, afterschool programs, clubs, and community organizations of comparable grade levels.
- Note that elementary school students may only participate if their respective regional coordinator approves their registration. Also, in regions that have different school grade configurations, the SCOUT class age requirement may vary. Contact the regional coordinator in your area for more information.

Number of teams

- Two (or more) teams per school/instructor are permitted provided that the regional contest in which these teams are participating has the resources to host more than one team AND that there are no common students (i.e., students can only participate on one team).
- Where the regional event cannot host more than one team per school/instructor, teams are encouraged to hold an in-school run-off to determine which team will represent their school/instructor at the regional contest.

Please see the **Competition Missions** and **Design & Building Specifications and Competition Rules** documents for detailed information about the EXPLORER and RANGER competition classes. Information about the SCOUT class rules, specifications, and missions can be found within the **SCOUT Class Competition** document. You can also visit the competition's web site at www.materover.org (look under the COMPETE tab).

INTERNATIONAL COMPETITION VENUE

The 2012 international competition is being held at the YMCA Aquatic and Family Center located at 8422 International Drive in Orlando, Florida. Photos of the venue will be posted to the MATE

Flickr account. You can also visit www.ymcacentralflorida.com.

Detailed information about room and board as well as transportation, shipping, local resources (such as hardware and electronics stores), and more will be posted to the competition web site at www.materover.org (under the COMPETE tab) as it becomes available.

REGIONAL CONTESTS

In 2012, the MATE Center is supporting and helping to organize 21 regional contests in the U.S., Canada, Hong Kong, Scotland, Japan, and Egypt. These regionals serve as feeders into the international competition's **RANGER** class, with the top one or two teams from each regional contest "winning" the opportunity to advance to the international competition.

For example, the top ONE team from regionals with 10 or less individual SCHOOLS PARTICIPATING ON CONTEST DAY can advance to the international competition, while the top TWO teams from regionals with more than 10 individual SCHOOLS PARTICIPATING ON CONTEST DAY can advance to the international competition.

The regional contest "hosting" the international competition can send one additional team to the international competition. For example, if the regional has less than 10 individual schools participating, they would send one plus one additional team, for a total of two, to the international event.

Several regional contests also offer a **SCOUT** class competition. These are indicated by an asterisk (*) below.

The following regional events are currently scheduled to take place in 2011:

▼ **Big Island** (Hilo, Hawaii)*
▼ **Carolina** (Myrtle Beach, South Carolina)
▼ **Florida** (Cocoa, Florida)*
▼ **Great Lakes** (Alpena, Michigan)*
▼ **Oahu** (Honolulu, Hawaii)*
▼ **Hong Kong** (Hong Kong)
▼ **Mid-Atlantic** (Hampton, Virginia)*
▼ **Monterey Bay** (Monterey, California)*
▼ **New England** (Buzzards Bay, Massachusetts)*
▼ **Newfoundland & Labrador** (St. John's, Newfoundland and Labrador)*
▼ **Nova Scotia** (Halifax, Nova Scotia)
▼ **Pacific Northwest** (Seattle, Washington)*
▼ **Philadelphia** (Philadelphia, Pennsylvania)*
▼ **Scotland** (Aberdeen, Scotland)
▼ **Shedd Aquarium-Midwest** (Chicago, Illinois)*
▼ **Southern California** (Long Beach, California)*
▼ **Southeast** (Savannah, Georgia)*
▼ **Texas** (Houston, Texas)*
▼ **Wisconsin** (Milwaukee, Wisconsin)
▼ **Japan** (Tokyo, Japan)
▼ **Egypt** (Cairo, Egypt)

For more information about the regional contest nearest you, visit www.materover.org (under the COMPETE tab > Regional Contests).

KEY MILESTONES AND SCHEDULE OF EVENTS FOR THE INTERNATIONAL COMPETITION*

Key milestones:

- December 2nd – general information, design specs, and competition rules posted
- December 2nd – on-line registration form posted
- **December 12th – mission tasks and engineering and communication requirements posted**
- February 1st – on-line registration deadline
- April 1st – application for travel assistance posted
- May 24th – deadline for submitting application for travel assistance
- May 24th – technical reports due to MATE competition coordinator
- June 21st – 23rd – international competition held at the YMCA in Orlando, Florida
    - Engineering & poster presentations due

***Note:** These are milestones that apply to the international competition **only**. Regional contests are held prior to the international event and may have their own sets of key milestones, including registration deadlines. See www.materover.org (under the COMPETE tab > Regional Contests) for information specific to the regional contests.

*****Example***** **schedule of international competition events:**

- Wednesday – teams arrive & check-in
    - Vehicles shipped or hand-carried to competition venue
- Thursday – set-up & pool practice day
    - Welcome & introductions in morning
    - Set-up team workstations & posters, competition arena, and repair station
    - Practice time available
    - Evening social mixer/reception **(attendance required)**
- Friday – engineering presentations & underwater missions
    - Engineering evaluation interviews
        - Teams have scheduled time slots
    - Underwater mission challenges begin
        - Teams have scheduled time slots
    - Free time and optional facility tours when not competing
- Saturday – underwater missions & awards
    - Underwater mission challenges continue
        - Teams have scheduled time slots
    - Free time and optional facility tours when not competing
    - Evening awards ceremony
- Sunday – teams depart

FUNDING AND BUDGET

There is no limit to the amount of money, time, and technical expertise that can go into designing and 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 complete the mission tasks.

The MATE Center offers each team the following support:

- **Opportunity to apply for financial assistance (up to $500).**
  Teams participating in the international competition can apply for funds (up to $500) to help offset the cost of travel and lodging for STUDENT team members. The application for financial assistance will be posted to the competition web site by April 1st, 2011.

  Note: Travel funds and/or lodging accommodations may be available for teams competing in regional events; teams should contact the regional contest coordinator in their area for more information.

- **Meals – kick-off reception, lunches, and awards banquet.**
  A kick-off reception, lunches two days (first and second day) of the event, and an awards banquet will be provided to student team members, instructors, and mentors attending the international competition. Parents, spouses, siblings, cheerleaders, etc. will be able to purchase tickets for the reception and awards banquet (but **NOT** lunches) in advance.

  Note: Meals may be provided to teams competing in regional events; regional teams should contact the regional contest coordinator in their area for more information.

- **Special offers from competition sponsors.**
  Several companies offer their products, materials, supplies, and/or access to equipment and facilities to competition teams at no or reduced costs.

  For example, VideoRay's "MATE ROV Competition Store" is available to competition teams **only**. This on-line store offers discounts on cameras, tethers, and, possibly, thrusters, among other items. Carrillo Underwater Systems (CUS) offers a scholarship for free and/or discounted products, and Sound Ocean Systems, Inc. offers free umbilical cable provided teams cover shipping costs.

  SolidWorks provides student edition versions of its software to ALL student members of MATE ROV teams at no cost. Igus, Inc. offers a range of its products at no-cost, while VANTEC, Lights Camera Action LLC, and Parallax offer discounts on certain products.

  Information about these offers and others is included within the "teams' only" section of the competition web site (see the bullet below for more information about how to access this site).

- **Resources and "teams' only" sections of the ROV competition web site.**
  The resources section of the ROV competition web site located at www.materover.org (under the LEARN tab) contains information on where to purchase building materials, and lists of helpful web site and books, among other resources.

  The URL for VideoRay's on-line store, CUS scholarship program, etc., and other information and support available only to MATE competition teams are posted within the teams only

section. Information on potential funding sources at both the international and regional level (e.g., local Rotary Clubs, American Association of University Women, etc.) is also included there. Teams will receive the username and password to access the teams' only section once their registration has been accepted.

- **Access to industry mentors.**
  The MATE Center and the regional coordinators work to connect students with industry professionals willing to donate their time and technical expertise as team mentors. Several regionals have developed extensive mentor networks utilizing members of their local MTS section, for example. Contact the MATE Center or the regional coordinator in your area if you are interested in connecting with an industry mentor.

- **Additional costs.**
  Teams are encouraged to organize their own fundraising activities to cover building materials and travel, housing, and meal costs above and beyond what the MATE Center provides. The teams' only section of the ROV competition web site includes fundraising tips as well as "tools" (e.g. the MATE logo, a press release template, etc.) that teams can use to support their fundraising activities.

  In addition, the following items are your team's responsibility:
  - The participation fee.
  - Shipping your ROV system and tools to competition venue.
  - Costs associated with fundraising or presentations to community.
  - Miscellaneous expenses for photocopying, phone calls, shipping costs associated with ordering ROV components, mailings, courier, etc.

DESIGN & BUILDING SPECIFICATIONS AND COMPETITION RULES

This document contains information relevant to the **EXPLORER and RANGER** classes; the **SCOUT Class Competition** document contains information relevant to the **SCOUT** class.

COMPETITION CLASSES

The MATE Center's ROV competition is divided into three classes – **EXPLORER, RANGER, and SCOUT**. See the **General Information** document for more information about each of the competition classes.

EXPLORER class ROVs operate at a nominal 48 Volts DC, 40 amps.
RANGER class ROVs operate at a nominal 12 Volts DC, 25 amps.

DESIGN & BUILDING SPECIFICATIONS

Note: The design and building specs for EXPLORER and RANGER teams are the same **EXCEPT** for power and mission capabilities. Please review the power and mission task specifications for each competition class carefully.

SAFETY COMES FIRST

Safety is the competition's primary concern and guiding principle. Any system that is deemed unsafe by competition officials will not be allowed to compete. If a safety concern is identified, teams are permitted to modify their system and have it re-inspected. Re-inspection is limited to two attempts, at which point the ROV is disqualified from the underwater competition portion of the event. There are NO APPEALS once your ROV has been disqualified.

NUMBER OF VEHICLES

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

POWER

Teams participating in the MATE ROV competition can utilize both **ELECTRICAL** and **NON-ELECTRICAL** power sources. These sources and the specific differences (or similarities) between the EXPLORER and RANGER class are described below.

ELECTRICAL POWER – GENERAL

MATE will provide the necessary power to each competition class. All power provided to your system through an external connection for any purpose during the competition must be obtained from the MATE competition power supply for your class of vehicle. This includes dedicated lines for cameras, manipulators, and any other devices. This is a singular point of connection; all power to your competition ROV must pass through the MATE-provided fuse. Laptops (two maximum) are permitted for command, control, and communications (C3) purposes. All other power (mechanical, chemical, or electrical) contained within the ROV system must comply with and not exceed the regulations specified here.

Exposed connections: ROVs with electrical connections that are exposed to water and not sealed are not permitted to enter the water. "Disposable motors" are also not permitted; these are exposed motors with no waterproofing.

Nominal voltage: Throughout this and other MATE competition specifications, references are made to the voltages of 12V and 48V. Teams should plan their systems to handle fully charged lead acid batteries. In the RANGER class, a fully charged 12V lead acid battery has a voltage as high as 14 Volts due to surface charge. In the EXPLORER class, four fully charged lead acid batteries in series can have a voltage as high as 56V due to surface charge. Any power supplies used will be set at 12.7±0.3 Volts (RANGER) and 50.8±0.3 Volts (EXPLORER).

Allowed voltages and currents: The following voltages and currents are allowed through your ROV's tether:

- Low voltage AC or DC control signals. Low voltage is defined as a voltage equal to or less than the maximum supply voltage per class specification.
- DC main-supply as per class specifications.

EXPLORER CLASS ELECTRICAL POWER

Voltage: EXPLORER class power supply connections will be 48 Volts DC ONLY. **Teams are free to use any voltage desired up to 48 Volts, but any conversion to a lower voltage must be made on board the ROV.** Teams will not be permitted to operate an ROV that reduces the voltage on the shore-side/topside end of the ROV tether.

Note: The voltage limits set by the MATE Center are for safety purposes. Voltages in excess of the class parameters set forth in the MATE competition rules are not allowed on the system at any time other than the brief moment of back electromotive forces (back EMF) from collapsing magnetic motor fields typical in any electrical motor situation.

Current: The amperage may never exceed 40 amps. MATE's power supply includes a 40-amp fuse. In the event that your ROV blows two of MATE's fuses, your mission run will be over and you will not be able to earn any additional points.

The MATE competition does not guarantee or promise performance limits beyond the maximum specified current for your particular class. However, any ROV causing a variance of current beyond the maximum that does not "blow" the fuse will be allowed to continue competing. Competitors should keep in mind, however, that vendors as well as tolerances in manufacture may vary and fuse performance in testing may not be representative of fuse performance in the competition setting.

Connections: Power supply connections will be via terminal posts –a 1/4" bolt with a wing nut. Your ROV tether must have proper cable-lugs with 1/4" ring connectors for these posts to obtain power.

Suggestions for converting 48 Volts to lower voltages

EXPLORER class teams whose ROVs do not use 48 Volts will need to find ways to reduce the voltage for their vehicles. There are many creative ways to accomplish this task. Here are a few methods suggested by MATE competition judges:

- DC to DC converters work (but can be expensive).

- A 48-Volt H-bridge and pulse width modulation will work and can be designed to give your vehicle occasional "super boosts."
- Circuitry design to allow a positive and negative bus, dividing 48 Volts into two 24-Volt busses.
- Teams can use a resistor rated for the current draw of their vehicle.
- Teams can step up to higher voltage motors. For example, 32-Volt bilge pump motors are available from West Marine.

RANGER CLASS ELECTRICAL POWER

Voltage: Maximum supplied power at pool-side will be a nominal 12 Volts DC. Voltage may not be increased anywhere in the ROV system.

Current: Maximum current is 25 amps. MATE's power supply includes a 25-amp fuse. In the event that your ROV blows two of MATE's fuses, your mission run will be over and you will not be able to earn any additional points.

The MATE competition does not guarantee or promise performance limits beyond the maximum specified current for your particular class. However, any ROV causing a variance of current beyond the maximum that does not "blow" the fuse will be allowed to continue competing. Competitors should keep in mind, however, that vendors as well as tolerances in manufacture may vary and fuse performance in testing may not be representative of fuse performance in the competition setting.

Connections: Power supply connections will be via standard banana plugs. Your ROV's tether must have male banana plugs to obtain power.

Note: RANGER Teams concerned about how voltage loss will affect their camera(s) should consider adding a separate line in the tether to supply the camera from the main power source. This dedicated line for cameras is permitted, provided that it, along with the other lines of the tether, passes through the ONE fuse and carries 12V DC.

EXPLORER AND RANGER CLASS CIRCUIT PROTECTION

All teams must demonstrate the presence of an appropriately-sized fuse on the positive side of their vehicle's electrical circuitry in order to pass the safety inspection. The MATE power supply provided at each pool station includes an in-line fuse, but each team needs to protect their system with an additional fuse. **If your vehicle is not protected with a fuse in addition to the fuse provided on the MATE power supply, YOUR VEHICLE WILL NOT PASS THE SAFETY INSPECTION and will not be allowed to compete.** Circuit breakers may be used in place of or in addition to fuses. The type of circuit protection (fuse or circuit breaker) must be documented and included in your technical report.

EXPLORER AND RANGER CLASS POWER SOURCES

Depending upon the competition event (i.e., regional or international), power for each class may be provided by batteries or isolated power supplies. If power supplies are used, they may be a fixed output voltage and will not be "turned down" to accommodate other than the specified voltage for the class. Taps will not be made off of batteries to provide other than the specified voltage for the class.

IMPORTANT CHANGE FOR 2012!!!!

EXPLORER AND RANGER CLASS ONBOARD ELECTRICAL POWER
(i.e., power not provided by the tether)

Onboard battery powered devices are NOT allowed under any circumstance.

Water leaking into a closed battery container can result in the generation of hydrogen gas. This gas can build up inside a pressure housing and create an unsafe situation. For this reason, onboard batteries are NOT allowed under any circumstance.

Any device that needs power must obtain that power directly from the ROV tether. For devices that operate at a voltage other than the tether voltage, an onboard ROV converter may be included. The converter must be sealed and not exposed to water.

This rule includes commercial "watertight" battery containers; no battery of any type is permitted on any competition vehicle.

Teams looking to make voltage sources other than 12V (i.e., 9V, 6V, 5V) should look for simple linear regulators such as the LM317, LM7809, LM7805. These are simple three terminal regulators that with the addition of input and output capacitors (and resistors for LM317) can provide lower voltage power supplies as needed.

POWER SHUTDOWN REQUIREMENT (applies to both EXPLORER and RANGER)
For safety purposes, any ROV that is disconnected from the surface supply must stop functioning in less than 5 seconds. **This applies to electrical, pneumatic, and hydraulic power sources.** Any filters, capacitors or accumulators must be sized accordingly to meet this specification.

FLUID POWER – GENERAL (applies to both EXPLORER and RANGER)
Hydraulic fluid: Water or biodegradable food-grade fluid, only.

- A Material Safety Data Sheet (MSDS) must be provided at the safety inspection showing the type of fluid used and its compatibility with the Biodegradable Food-Grade specification. Teams using water do not need to provide an MSDS.
- Maximum pressure allowed: 10.33 bars (150 psig)
- Hydraulic system: All lines, fittings, and hydraulic devices must be rated for a minimum pressure of two (2) times the maximum supply pressure.

The following fluids are approved for use in hydraulic systems:

1. Water
2. Mineral oil
3. Biodegradable Food-Grade Hydraulic Oil ISO Grade 32/46, SAE Grade 20, McMaster-Carr part# 3499K22

Pneumatic: Compressed air or inert gas.

- Maximum pressure allowed: 2.75 bars (40 psig)
- Pneumatic system: All lines, fittings, and pneumatic devices must be rated for a minimum pressure of two and a half (2.5) times the maximum supply pressure. For

example, if an 83 bar (1200 psig) tank is regulated to 2 bars (30 psig), then all system components must have a minimum rating of 5.17 bars (75 psig).

Surface power: MATE will provide one GFI-protected outlet with a nominal 115 Volts AC (60 Hertz) and 15 amps maximum. This outlet is intended to provide power for pumps and other surface support equipment (e.g. video monitors & control boxes). This AC power source CANNOT be used to directly or indirectly power the vehicle. If hydraulic or pneumatic power is used for vehicle thrust, the power for the pump must come from the MATE supplied DC power supply for that class.

In addition to electric pumps, hydraulic, and pneumatic systems can be powered by manual pumps (e.g. bicycle tire pump) or supplied from a pre-pressurized cylinder.

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

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

Pressure storage devices (pressure accumulators): Pressure storage devices are allowed on the ROV if they do not exceed 1L in total storage and do not store pressure higher than the allowed pressure for air or hydraulics. It is recognized that a team might not be able to purchase a pressure accumulator that has the proper rating and fits in the space needed. In that case, the team must show that their designed accumulator is capable of withstanding the specified pressures without rupture.

FLUID POWER QUIZ

Teams planning to use hydraulics and/or pneumatics (i.e., fluid power) are required to take and pass an online quiz. The quiz was developed by MATE Center technical support staff and competition judges and is designed to ensure that teams understand basic information on these topics and can apply that knowledge to safe practices. The intention is not to add yet another “requirement,” but rather to provide a safe and successful learning experience and competition environment.

A link to the quiz will be circulated and posted to the MATE web site in mid January. The quiz can be completed by one (or more) STUDENT team members. The team’s instructor or mentor

can provide guidance and advice, but the questions should be answered by the students participating on the team.

The quiz will be scored and the results provided almost instantaneously. A score of 100% is considered a passing grade. Teams can take the quiz as many times as they need to achieve this score.

The quiz must be completed with a passing grade at least 4 weeks prior to the international competition and/or 2 weeks prior to a regional event. (See www.materover.org under the COMPETE tab > Regional Contests for a listing of regional contests and their respective dates.) Teams failing to complete this quiz within the given time frame will NOT be permitted to use fluid power during their competition event.

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

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

IMPORTANT NOTE FOR 2012!!!

The MATE Center will provide an air compressor at each EXPLORER class mission station. The outlets will be ¼-inch industrial style air couplers. Teams should come with a male industrial plug on their end of their hose. The following link is an example of both components: http://www.homedepot.com/Tools-Hardware/h_d1/N-5yc1vZarnk/R-202220663/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053

EXPLORER class teams that do not pass the fluid power quiz OR choose not to take the fluid power quiz may not use MATE's (or their own) air compressor. However, these teams may use manually powered air pumps (foot pumps, hand pumps, etc.) that they supply themselves.

The MATE Center will provide a manual air pump (bicycle pump) and air line tubing at each RANGER class mission station. (Unlike EXPLORER teams, RANGER class teams do NOT need an air compressor.) The diameter of the air line tubing will be 3/16-inch (internal diameter). RANGER class teams that choose to use their own air line tubing must provide an adapter that can connect to the 3/16-inch air line tubing provided by the MATE Center at the mission station. RANGER class teams may use MATE's manual air pump to complete other tasks and/or ROV systems' operations.

COMMAND, CONTROL & COMMUNICATIONS (C3)

For Command, Control & Communications (C3) purposes, teams are limited to a maximum of three monitors or display screens, such as computers that display video and ROV status information. These devices may be made up of any combination of TVs, monitors, laptops,

and/or computer displays. These devices may be powered by the MATE provided GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source described in the **Surface Power** section above. In addition, teams' C3 station may include devices like video recorders. All C3 devices must be able to run on the single AC power outlet provided or on its own internal battery power. Any device plugged into this AC power outlet can only provide C3 functions and cannot provide power to the ROV.

MATE will provide ONE video monitor at each control station that may be used by teams. This monitor will be powered by the GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source described in the **Surface Power** section above. This monitor will have both RCA and RF inputs. (Teams should assume that only NSTC monitors will be available at the international competition.)

Teams must supply any additional monitors (including monitors for practice sessions*), video recorders, etc. These additional video devices and/or any repair tools (but NOT ROV payload tools) can be powered by the GFI-protected power strip described in the **Surface Power** section above. Only video monitors, video recording devices, and repair tools can use this AC power.

*MATE cannot guarantee that the practice area will have power for your video monitor.

SIZE RESTRICTIONS

The mission team must be able to personally transport the vehicle and associated equipment to the mission station and to the engineering evaluation room. At the international competition, engineering evaluation rooms may be located at a nearby building and not within the pool venue. In this case, your team must be able to transport the vehicle and associated equipment from the pool venue to the building.

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

OPERATING ENVIRONMENTS

SALINITY/WATER CHEMISTRY

Your vehicle must be able to function in fresh, chlorinated water. The water should be considered conductive of electrical currents.

DEPTH/TETHER LENGTH

EXPLORER class ROVs must be capable of operating in a maximum pool depth of 5.2 meters (17 feet). RANGER class ROVs must be capable of operating in a maximum pool depth of 3.7 meters (12 feet). All underwater missions will take place within 10 meters from the side of the pool. The mission station will be no more than 2 meters from the side of the pool. Tether length should be calculated accordingly.

Note: Regional competitions may be held in pools with a shallower minimum depth and/or greater maximum depth. Contact the coordinator in your area to determine the maximum mission depth at your regional competition.

VISIBILITY

Visibility in the pool is unlimited. The pool will not be covered or purposefully darkened in any way, although the specific mission tasks may require that your ROV operated in low-light conditions.

CURRENT

There will be no water currents intentionally created. However, depending on the venue, pressurized pool filtration system outlets may cause unexpected currents.

OTHER ENVIRONMENTAL PARAMETERS

The international competition pool may have a sloped bottom or small bottom features. Teams should be prepared to deal with small bottom topography. At the international venue, RANGER class missions will take place on a shallow slope. Teams should be prepared to operate their ROV on a sloping pool bottom.

Note: Regional competitions may be held in pool venues with slopes or other bottom features. Contact the coordinator in your area to determine the bottom topography of the pool at your regional competition.

COMPETITION RULES

GENERAL

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

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

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

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

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

While at any MATE ROV competition (international and regional), **ALL** work done on the vehicle must be conducted by team members. Teachers, mentors, parents, and non-competing students are not permitted to work on the ROVs. They may provide advisory input, but they may not work on the ROV directly. This includes writing or editing software code. All mechanical electrical and software modifications and/or repairs to the ROV must be completed by student team members. Judges or other competition officials who observe unauthorized work by non-team members will deduct engineering or mission points or disqualify teams, depending upon the severity of the infraction. If teams choose to take their ROVs off the competition grounds for maintenance and repair, they are expected to observe this rule in the interests of the spirit of the competition.

- To encourage student participation at all levels, MATE is discouraging the use of "off-the-shelf" technology. The rationale is that engineering involves integrating existing technology into new systems. As such, students are encouraged to turn to commercially-available technology where available (and affordable). Individual discrete "components" obtained commercially are acceptable. However, as this is an educational event, students are strongly discouraged from using commercially available "plug-and-play systems" within their ROVs. These devices violate the spirit of the competition in that they remove many of the technical challenges of electrical and software engineering. Thus, they eliminate much of the educational value of the event. An extreme example would be a team that focused its efforts on fundraising and simply purchased one of the low-cost ROVs available commercially. Such an entry would not be permitted.

  In summary:
  Multiple commercial components are **ENCOURAGED**.

  Systems designed to perform multiple, complex functions from one "black box" or a series of components designed to integrate with each other are **DISCOURAGED**.

  Examples of "components" versus "systems" are provided below. If teams are uncertain about the commercially-available items that they plan to use, they should contact the MATE competition coordinator (jzande@marinetech.org) early in their design phase. All such questions (and answers) will be posted to the FAQs section of the MATE competition web site.

  The engineering evaluation and technical report score sheets will reflect MATE's effort to discourage the use of off-the-shelf systems. For example, both score sheets contain sections devoted to control systems. However, teams that demonstrate control systems constructed from "scratch" versus complete control system purchased from a commercial vendor will be awarded higher scores. In addition, the originality of design and teamwork sections will be weighted more heavily.

  Examples of commercially-sourced components:
  - Tethers
  - Thrusters
  - Radio control transmitters and/or receivers
  - RC servo and/or motor controllers
  - Pressure housings

- Watertight connectors
- Cameras with or without watertight housings
- Structural materials

Examples of commercially-sourced systems:

- "Black box" controllers that provide for multiple power and control signal interconnections and manipulations (e.g. FIRST Robotics controller systems)
- Thrusters, motor controllers, cabling, and control box designed and sold as a "system"

PROCEDURAL

- Teams must compete during their assigned time slots. Your team is **NOT** permitted to switch time slots with another team. Failure to show at the mission station* for your scheduled mission performance run or at the room assigned for your team's engineering evaluation interview will result in "no score" for that particular competition category. **No exceptions.** Assigned time slots will be sent out in advance so that any scheduling concerns can be addressed prior to the event.

  *Individual contests may refer to the mission station as the "control station" or "control shack."

- While there is no limit to the number of students who can compete as part of a team, **the pool mission team is limited to six students**. The mission team is defined as the team of students who operate the vehicle and its associated equipment during the mission performance period. Only six students will be allowed to launch, pilot, and perform the mission. Instructors, mentors, and/or non-student members cannot participate as part of the mission team. **Teams may alternate students on the mission team for the two mission attempts.** (All members of the team should participate in the engineering presentations; see the **Engineering & Communication** document for more information.)

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

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

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

- EXPLORER and RANGER class teams will compete in ONE mission that consists of two distinct mission tasks. These tasks, in turn, consist of several components. Both EXPLORER and RANGER class teams will get up to **TWO** attempts to complete this

single mission. The **higher** of the two scores will be added to the engineering and communication score to determine the total overall score for the competition.

Note: Regional contests may or may NOT offer teams two attempts at the mission tasks. Contact the coordinator in your area to determine if teams will receive one or two attempts.

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

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

- If your vehicle is completely disabled and/or its tether tangled and unable to free itself from the underwater environment, SCUBA divers can be called in to assist. However, the mission performance period time will NOT stop and **5** points will be deducted from the final mission score**.**

  Note: Some regional events may not provide SCUBA diver support. If that is the case, ROVs that become tangled and unable to free themselves or otherwise disabled will not be “rescued” by a SCUBA diver until the mission performance period is over. Unfortunately, that means that no additional mission points can be received. Contact the coordinator in your area to determine if your regional will have SCUBA diver support during your mission run.

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

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

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

- Communication using cell phones, text messaging, and online social media tools such as Skype, Facebook, Twitter, instant messaging, etc. is NOT permitted during the mission period, either between mission team members at poolside or between any mission team member and anyone outside of the mission station.

- At any time during the competition, mission judges and other competition officials will only communicate with the student team members. Judges and officials will NOT communicate with mentors, parents, or other non-student members regarding mission information, challenges, or other issues except during pre- and post-competition briefing sessions.

DESIGN & SAFETY CONSIDERATIONS

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

  "Safety practices and procedures" includes both how team members conduct themselves and how they design and build their vehicles. For example, can your ROV's propellers cut or injure someone in any way? If so, the judges will award points **only** if a safety mechanism to prevent harm is present. This is the type of safety consideration that teams should account for as they design and build their vehicles as this is the type of criteria that the judges will use in their evaluations.

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

  Teams will be informed immediately if their ROVs do not meet safety requirements. If a safety concern is identified, teams are permitted to modify their system (although they will not be given additional time to do so) and have it re-inspected. Re-inspection is limited to two attempts, at which point the ROV is disqualified from the underwater competition portion of the event. There are NO APPEALS once your ROV has been disqualified.

  The mission control officials will conduct a final safety check during the 5-minute set-up period. If they find a safety concern, teams are permitted to modify their system in the mission control area, but will not be given additional time to do so (the 5-minute set-up time will start on schedule). Teams unable to correct a safety issue will not be allowed to compete. Mission station judges and competition officials can pause or stop a mission run at any time if they feel that there is a potential safety concern.

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

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

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

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

- All teams must wear close-toed shoes and safety glasses or goggles. **No one will be allowed into the work station area without close-toed shoes and safety glasses or goggles**. **No one will be allowed on the pool decks without close-toed shoes.** This includes team members, parents, mentors, and guests. Safety glasses/goggles are also recommended when working with your vehicle on deck.

- Personal flotation devices (PFDs) may be required when launching and recovering your vehicles. Contact your regional coordinator or the international competition coordinator to determine if this is a requirement at your event. If PFDs are required, the coordinator will provide them.

COMPETITION MISSIONS

Diving into History: *The Role of ROVs in Exploring WWII Shipwrecks*

This document contains information about the EXPLORER and RANGER class missions. Information about the SCOUT class missions can be found within the **SCOUT Class Competition** document.

COMPETITION SCORING OVERVIEW

The competition consists of underwater missions, technical reports, engineering presentations, and poster displays with the following scoring breakdown:

- Mission
  - **EXPLORER** – 300 points (max), plus a time bonus
  - **RANGER** – 300 points (max), plus a time bonus
- Engineering & communication – 200 points (max)
  - Technical reports – 80 points (max)
  - Engineering evaluations – 80 points (max)
  - Poster displays – 40 points (max)
    - International competition teams ONLY – 5 bonus points for media outreach

THINK OF YOURSELVES AS ENTREPRENEURS

From deepwater oil drilling to shipwreck exploration, individuals who possess "entrepreneurial skills" are in high demand and stand out in the crowd of potential job candidates. What are entrepreneurial skills? They include the ability to understand the breadth of business operations (from finances to research and development to media outreach), work as an integral part of a team, and apply technical knowledge and skills in new and innovative ways.

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

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

- Who are your potential clients?

In this case, the MATE Center is your "client" and recently released a request for proposals. A request for proposals (RFP) is a document that an organization posts to solicit bids from potential companies for a product or service. The MATE Center's RFP focuses on the assessment of a fictional WWII shipwreck. In addition to surveying and mapping the wreck site, the RFP requires companies to develop and carry out a plan to remove hazardous material (fuel oil) that remains on board. In order to effectively respond to the RFP, companies must be prepared to design and develop specialized tools, including ROVs.

The specifics of your product design and rules of operation are included within the **Design & Building Specifications and Competition Rules** document. The specifics of the mission – that is, the tasks that you must accomplish – are described below.

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MISSION OVERVIEW

Both **EXPLORER** and **RANGER** class companies will compete in ONE mission that consists of the following two distinct tasks:

Task #1: Survey the shipwreck site (120 points)
Task #2: Remove fuel oil from the shipwreck (180 points)

Task #1 can be completed in any order. Task #2, removing fuel oil from the shipwreck, must be completed in order to receive full points. Task #2 can be attempted before task #1. See the mission task descriptions below for more details.

Your company will get up to **TWO** attempts to complete this single mission (contact your regional coordinator to confirm the number of attempts that you will receive). The higher of the two scores will be added to your engineering and communication score (see the **Engineering & Communication** document) to determine the total, overall score for the competition.

TIME

You will have 5 minutes to set up your system, 15 minutes to complete the mission tasks, and 5 minutes to demobilize your equipment and exit the control shack. During the 5-minute set-up, you may place your vehicle in the water for testing and/or trimming purposes, provided that a member of your company has a hand on the vehicle at all times and uses extreme caution. The 15-minute mission period will begin after the full 5 minutes of set up time expires, regardless of whether you are ready to start the mission.

At any time during the mission, you may pilot your ROV to the surface and remove the vehicle from the water for such things as buoyancy adjustments, payload changes, and trouble shooting, but the clock will only be stopped by a judge who determines it's necessary for reasons beyond your control. Otherwise, the clock will only stop after both mission tasks are successfully completed, the ROV has

returned to the surface under its own power so that it touches the side of the pool, and a member of your company at the launch station has physically touched the vehicle. Your ROV is not required to return to the surface between mission tasks.

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

TIME BONUS

Your company will receive a time bonus if you:

1) successfully complete both mission tasks;
2) return your ROV to the surface under its own power so that it touches the side of the pool; and
3) physically touch your vehicle before the mission time ends.

Your company will receive 1 point for every minute and 0.01 point for every second under 15 minutes remaining. Your mission performance period ends when your ROV has successfully completed THE TWO MISSION TASKS, returned to the surface under its own power so that it touches the side of the pool, and is physically touched by a member of your company. Time bonus points will be awarded accordingly.

GOOD LUCK!

The MATE Center would like to thank the Professional Marine Explorers Society, the OceanGate Foundation, and Global Diving & Salvage for their technical expertise and assistance with this year's mission scenario and tasks. The Center would also like to thank SUBSALVE USA for its donation of EXPLORER class lift bags. We appreciate the support of these organizations and their personnel!

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REQUEST FOR PROPROSALS (RFP)

Assessment of the *SS Gardner* and removal of hazardous material

1. Agency

The requesting organization is the Marine Advanced Technology Education (MATE) headquartered at Monterey Peninsula College in Monterey, California.

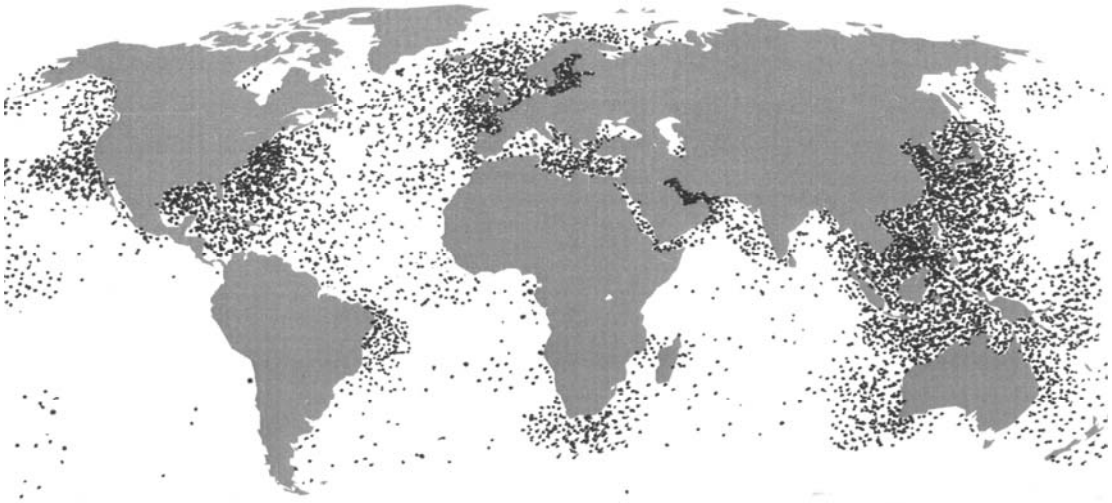
2. Objective

The MATE Center requires a remotely operated vehicle and the necessary associated systems and equipment to perform an assessment of the oil tanker *SS Gardner*. On December 25, 1942, the *SS Gardner*, loaded with a cargo of roughly 5 million gallons of bunker (fuel) oil, was hit and sunk by a German U-Boat as it traveled northward along Florida's east coast. The vessel now sits on the floor of the ocean at 84 fathoms (150 meters) approximately 30 nautical miles off of the east coast of Florida northeast of Cape Canaveral. The requirement is to complete an

assessment of the *SS Gardner* including: its current location and orientation on the seafloor; the debris field that surrounds it; the state of its hull and contents on board; and any other information necessary to develop and carry out a plan to remove any remaining oil. The assessment must be conducted no later than June 23, 2012 due to the arrival of hurricane season.

3. Background

Worldwide more than 8,500 oil-bearing ships lie at the bottom of the world's oceans and even in bodies of water like the Great Lakes. It is estimated that they contain between 0.5 and 4.3 billion gallons of oil and other hazardous cargo. More than 6,300 of them are from the World War II era.



Map of potentially polluting wreck sites

The wrecks are in various conditions. Some, like the battleship *USS Arizona* in Pearl Harbor, are leaking chronically. When the *Arizona* was hit by enemy fire it held approximately 1.5 million gallons of oil on board. Roughly a third of that amount leaked out during the bombing and caught fire; the ship burned for 2½ days. Over the last 70 years, about half of the remaining oil – 500,000 gallons – has been lost from the ship. The amount of oil that leaks each day varies and ranges from about 2 to 20 gallons per day.

The USS Arizona sinking after enemy air attacks on December 7, 1941

Other wrecks, like the *SS Jacob Luckenbach*, are leaking episodically. The *Luckenbach* was an oil tanker that collided with its sister ship and sank on July 14, 1953. This vessel, which was loaded with 457,000 gallons of fuel oil, sank in 180 feet of water approximately 17 miles west-southwest of San Francisco. It has been leaking sporadically over the years. In 2002, oil associated with several "mystery spills" was linked to the *Luckenbac*h. That summer, the U.S. Coast Guard, California Department of Fish and Game, United States Fish and Wildlife Service, National Parks Service, and National Oceanic and Atmospheric Administration (NOAA) removed much of the oil from the vessel and sealed the remaining oil inside.

The remaining wrecks can be viewed as either "having the potential to release oil in large amounts after a disturbance," relatively intact, or in a condition unknown. Unlike the *USS Arizona* whose condition is regularly monitored and the *SS Jacob Luckenbach* with its oil sealed inside, these other shipwrecks that have the potential to leak oil and those whose conditions are unknown are in need of assessment. Taking a proactive rather than a reactive approach to gathering information about these wrecks and mitigating the potential risks will not only save dollars in response costs, but will also reduce the threat of environmental and socioeconomic damages later on.

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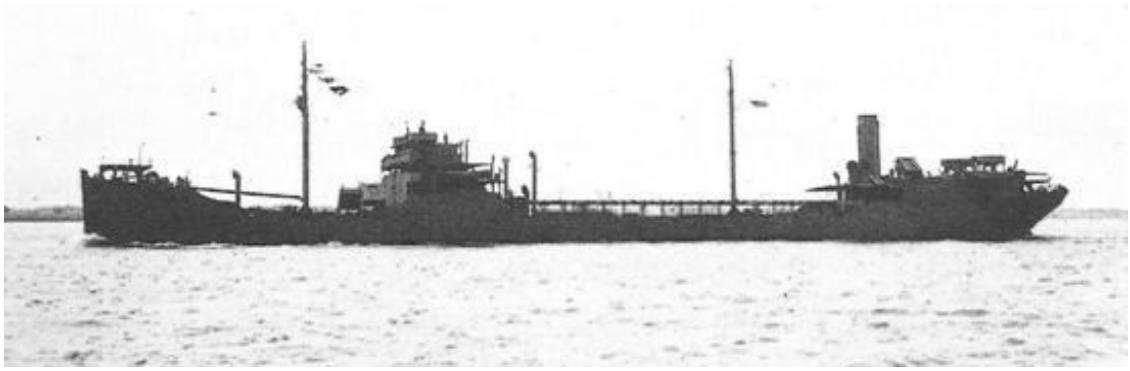
During World War II, American oil tankers made 6,500 voyages to carry 65 million tons of oil and gasoline from the U.S. and the Caribbean to the war zones and to U.S. Allies. They supplied 80% of the fuel used by bombers, tanks, jeeps, and ships during the War. Recognizing the important

role that they played in supporting war efforts, Allied oil tankers were often targeted by German U-Boats.



WWII oil tanker

Ships traveling off the coast of Cape Canaveral, Florida were especially vulnerable. Because ships needed to navigate around the cape, vessels traveling north or south along the coast would invariably pass close to one another. German U-boats took advantage of this bottleneck of ship traffic. Rather than actively hunting targets and expending their precious fuel supply to do so, U-boats patiently waited for the targets to come to them. It didn't take long. While more than 40 ships were sunk by enemy fire off of Florida, nowhere else is there a greater density of war casualties than the area between Port Canaveral and Sebastian Inlet.

The *SS Gardner* was targeted, hit, and subsequently sunk by a U-Boat as it traveled off of Cape Canaveral on Christmas Day 1942, just over one year after the attack on Pearl Harbor. Fortunately, all 43 members of the crew escaped on lifeboats, under minimal enemy fire. They were eventually picked up by an U.S. Navy destroyer and taken safely to shore in Fort Pierce, Florida.

While the survivors reported observing a slick of oil on the surface, there were no reports or records of a significant oil spill or leakage in the surrounding waters or along the coastline immediately following the disaster. To date, no sightings of oil by fisherman, beachgoers, or vessel personnel have been reported in the immediate vicinity of the wreck. Oil north of Cape Canaveral in the Gulf Steam has been reported sporadically, but its origins are unknown.

However, the effects of time and water corrosion have taken their toll on the shipwreck. A recent visual survey identified areas where the hull of the *SS Gardner* has deteriorated. While no signs of oil leakage were detected during the survey, there is growing concern that there could be a major hull breach in the near future, spilling whatever fuel oil that remains on board.

The effects of time and environmental conditions may have taken their toll on the oil and there are questions about its composition. For example, rather than a flowing liquid, it may have turned into a viscous, tar-like substance that's not easily pumped or suctioned from its tank.

As a result, the *SS Gardner* was recently identified by NOAA, the U.S. Coast Guard, and the U.S. Navy as a potential environmental and socioeconomic threat and designated as a "high risk sunken vessel." Funding was provided by these agencies to the MATE Center to develop and issue this RFP.

4. Technical Requirements

See the specific tasks (categorized as EXPLORER and RANGER) described below as well as the **Design & Building Specifications and Competition Rules** document.

5. Warranty and Technical Support

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

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

6. Delivery

Delivery of the ROV and associated systems and equipment shall be no later than the date of the geographically closest regional contest or by June 21, 2012, which is the start date of the international competition.

7. Evaluation Criteria

- Technical report
- Engineering presentation
- Poster display
- Performance

8. References

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- National Park Service – World War II valor in the Pacific www.nps.gov/valr/faqs.htm
- Personal communication with *USS Arizona* Memorial National Park Service personnel
- California Department of Fish and Game – *SS Jacob Luckenbach* Oil Spill www.dfg.ca.gov/ospr/Science/Luckenbach.aspx
- Overview of the *Wrecks of the World II: Evaluating and Addressing Potential Underwater Threats*. Conference sponsored by the American Salvage Association (ASA) and NAMEPA and held in Washington, DC, USA, June 6 – 7, 2011.
- Tankers built in the U.S. during WWII www.usmm.org/tankers.html#anchor406074
- Shipwrecks of Florida www.electricbluefishing.com/eb_sub_menu/shipwreck_list_of_florida.htm
- Uboat.net www.uboat.net
- Project Shiphunt http://discover.store.sony.com/shiphunt/index.html

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RANGER CLASS MISSIONS

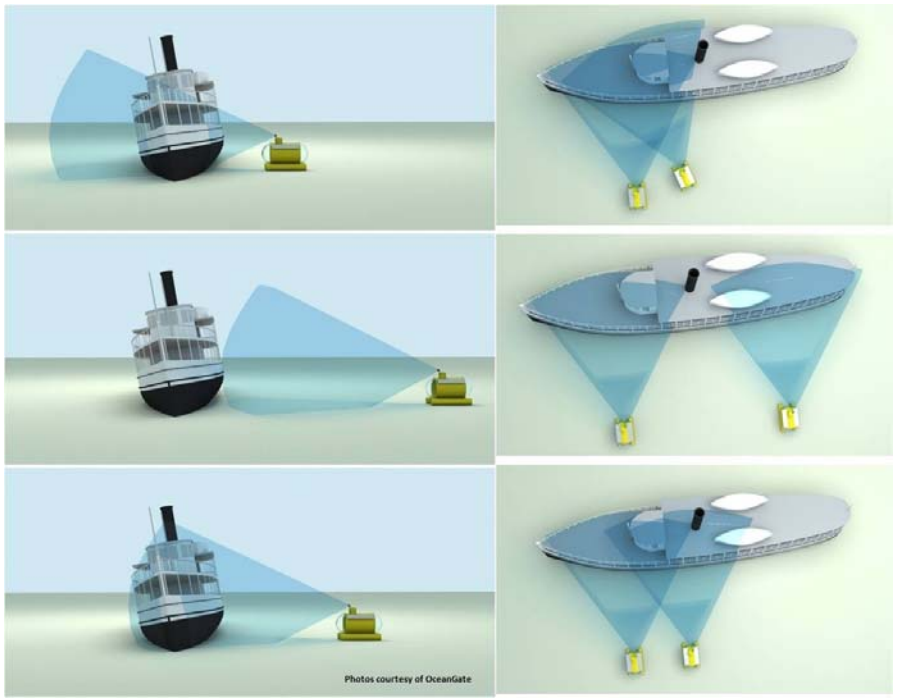
Task #1: Survey the shipwreck site

Your company is required to survey the *SS Gardner* and the wreck site. Surveying the wreck includes measuring the overall length of the ship, and determining the orientation of the ship on the seafloor. Your company must also examine the debris field alongside the wreck. The debris is overgrown with a thick layer of encrusting organisms and, from a visual standpoint, looks exactly like the encrusted rocky outcroppings found in the surrounding area. Your company must determine whether the objects in the debris field are metal, and hence part of the wreck site, or non-metal and therefore naturally occurring rocky outcroppings. Your company is then required to make a map of the wreck site based on your findings.

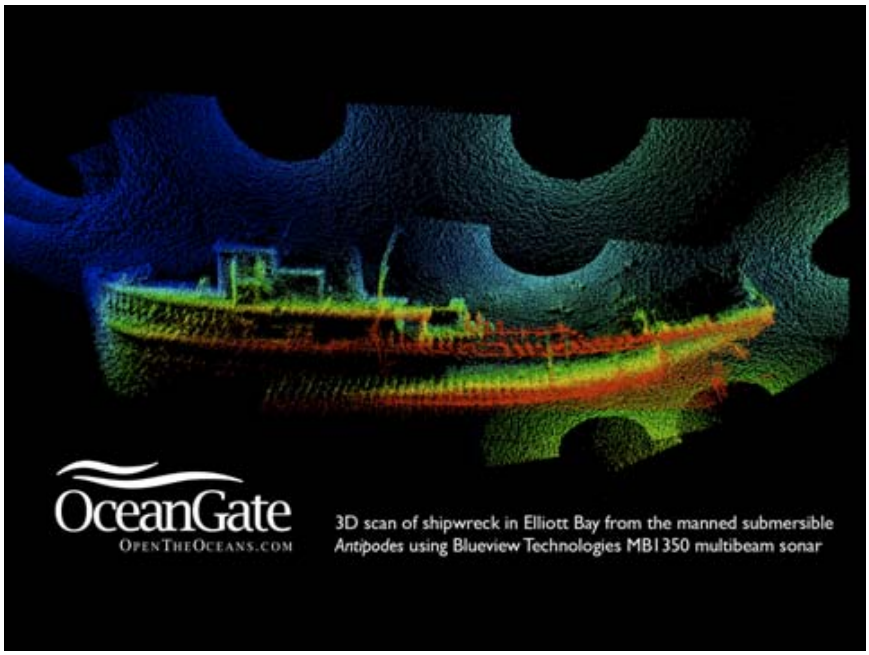
Your company must also scan the shipwreck with sonar. Today's multi-beam sonar is the best technology available for providing high quality, highly detailed images of shipwrecks and other submerged objects. By changing the angle of coverage and frequency of the sound produced by the sonar, the sonar can scan large areas with less detail, or smaller areas with extremely high detail. This,

along with your map, will help to document the wreck site and create a “snapshot” of the shipwreck at this moment in time.

Your company will simulate scanning the *SS Gardner* with a stationary multi-beam sonar. When scanning the shipwreck, distance matters. If your sonar is too far away, the beams will not reach the target. If your sonar is too close, the beams will survey a small area and miss much of the target. Spacing of the surveys is also important. Your sonar scans should be done so that there is minimal overlap of the scans. The figures below illustrate this concept.



Side view looking at the shipwreck *View looking down on shipwreck*



The result

This mission task involves:

- **Measuring the length of the wreck.**
- **Determining the orientation of the ship on the seafloor.**
- **Creating a map of the wreck site.**
- **Determining if debris piles are metal or non-metal.**
- **Scanning the shipwreck with sonar.**

RANGER class scoring – up to 120 points:

- Measuring the overall length of the wreck – up to 20 points
  - ≤ 5 cm off true length – 20 points
  - 5 cm to 30 cm off true length – 10 points
  - > 30 cm off true length – 0 points
- Determining the orientation of the ship on the seafloor – up to 20 points
  - ≤ 10^{o} off true orientation – 20 points
  - > 10^{o} to 20^{o} off true orientation – 10 points
  - > 20^{o} off true orientation – 0 points
- Creating a map of the wreck site that includes the following information – up to 25 points
  - Sketch of the shipwreck – 5 points
  - Length of the shipwreck – 5 points
  - Orientation of the shipwreck – 5 points
  - Location of debris piles – 10 points for placing all 5 debris piles in the correct grid squares

- Determining if debris piles are metal or non-metal – up to 25 points
    - Correctly identifying five objects as metal (M) or rock (R) – 5 points each (25 points total)
- Correctly "scanning" the ship at two target locations – 15 points for each target (30 points total)

Mission notes

Task #1 can be completed in any order. Companies must descend to the wreck site to create the map. Companies may alternate between task #1 and task #2.

The overall length of the shipwreck varies, but will range between 2.25 and 3.75 m. Different mission stations will have shipwrecks with different lengths.

RANGER class companies will determine the length between two designated points – one near the bow of the shipwreck and the other near the stern of the shipwreck. Each of these points will rise 16 cm above the top of the shipwreck. The point at the bow will be painted red; the point at the stern will be painted yellow. Like the shipwreck, these marks will be constructed from ½-inch PVC, with a ½-inch PVC connector at the top. The official length measurement must be taken from the center of the ½-inch PVC point on the bow to the center of the ½-inch PVC point on the stern (see **Constructing the shipwreck** within the **Mission prop specifications** below).

RANGER class companies should determine the orientation of the ship from the stern of the ship towards the bow of the ship. Both the regional competitions and the international competition will have a master compass or a designated north/south line for companies to calibrate their own compass or sensor. The orientation should be taken and reported relative to magnetic north.

A ½-inch PVC grid will be laid out on the pool bottom on one side of the shipwreck. The grid is 2.5 m long and 1.5 m wide and consists of fifteen squares, each approximately 0.5 m squared. The RANGER class mission area will have five (5) debris piles located within the grid.

During the five minute mission setup time, the mission station judge will hand your company a blank grid. Companies must create a map of the wreck site on this blank grid. In order to receive the full points for creating the map, companies will need to sketch the approximate location of the shipwreck and include the following information:

- sketch of the shipwreck
- length of the shipwreck
- orientation of the shipwreck
- location of each of the five debris piles

Companies will not be penalized if the length or orientation of the ship is incorrect on the map, but must include these measurements on the map in order receive points. RANGER class companies will not

receive full points if one (or more) of the five debris piles is not in the correct location. Companies cannot create the map by looking into the pool from the surface. Companies will not receive any points for creating a map if they do not descend to the wreck site.

Companies must determine whether these debris piles are constructed of metal or non-metal components. Any number of the five debris piles may be constructed from metal; debris piles made of metal and those made of non-metal will be visually identical. Companies will only receive points for those debris piles correctly identified.

RANGER class companies may not guess at which debris piles are metal and which are non-metal. Companies must show the mission station judge evidence that the sample is metal or non-metal. For example, companies can show the judges a sensor reading that allows them to determine whether the debris sample is metal or non-metal. This reading could be displayed on the company's video monitor.

All metal used in construction will be ferrous.

Companies should note that many pools have cement bottoms reinforced with metal rebar. Rebar in the cement could interfere with metal detectors deployed on the vehicle. To help differentiate between metal used in pool construction and the metal of the debris samples, the debris samples will be raised up off of the bottom of the pool with a brick. The center of the debris sample will be 10 cm above the bottom of the pool. Companies should take the metal rebar used in pool construction into consideration when designing their metal detector.

Companies will simulate scanning the ship with sonar by visualizing a target area. Each target area will consist of a black ring of 2-inch ABS pipe set inside a 2-inch white PVC end cap and a black mark set 25 cm to each side of the target. To effectively scan the shipwreck, an ROV must align a single camera so that the mission station judge can see on one video display the entire black ring within the end cap as well as both marks on either side of the target. The vehicle must maintain this alignment for 10 seconds. If at any time the mission station judge is unable to see the entire black ring or both colored marks, companies must realign their vehicle and start the scan again.

Targets will sit approximately 45 cm off the pool bottom.

RANGER class companies will scan two target areas. Both targets will be located on one side of the shipwreck.

Design note: Companies should consider the bottom topography of the regional and international competition venues. Do not assume that your ROV will be able to rest on a flat bottom to accomplish the scan.

Mission prop specifications

See the **RANGER Construction and Mission Prop Photos and SolidWorks Assemblies and Drawings** documents for visuals.

All PVC used in construction is DURA brand PVC. If items are unavailable or built to different specifications in your area, check online at www.duraplastics.com to purchase specific PVC pieces.

Constructing the shipwreck

The framework of the shipwreck is constructed out of ½-inch PVC. However, the exact diameter of the PVC framework is not important. Companies located outside of North America that do not have access to ½-inch PVC may substitute local PVC for ½-inch PVC pipe and connectors.

To construct the RANGER shipwreck, start construction at the stern of the ship.

1. Cut one 80 cm length, one 54 cm length, one 45 cm length, one 32 cm length, and four 38 cm lengths of ½-inch PVC pipe. Connect the 45 cm length of pipe and the 32 cm length of pipe by inserting them into the side openings of a ½-inch PVC tee.
2. Attach the middle opening of a ½-inch PVC tee to each of the ends of the 54 cm length, the 80 cm length, and the combined 45 cm and 32 cm length of pipe (six tees total). The 54 cm length of pipe is the bottom cross brace. The 80 cm length of PVC is the middle cross brace. The combined 45 cm and 32 cm length of pipe is the top cross brace. The four 38 cm lengths of PVC are the vertical braces.

See RANGER construction photo #1.

3. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the bottom cross brace (54 cm length of PVC). Attach a 90^{o} elbow to the other end of each 10 cm length of PVC pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert two of these 3 cm lengths of pipe into one side opening of each PVC tee on the middle cross brace (80 cm length of PVC).
5. Attach a side opening of a ½-inch PVC tee to the other end of each 3 cm length of PVC pipe. Insert the other two 3 cm lengths of PVC into the other side opening of the PVC tee. Attach a 90^{o} elbow to the other end of each 3 cm length of PVC pipe.
6. Cut two more 3 cm lengths of ½-inch PVC pipe. Insert these two lengths of 3 cm pipe into one side opening of each PVC tee on the top cross brace (the combined 45 cm and 32 cm length of PVC). Attach a 90o elbow to the other end of each 3 cm length of PVC pipe.

See RANGER construction photo #2.

7. Take two of the vertical braces (38 cm lengths of PVC pipe) and insert one end of a vertical brace into each of the open ends of the 90° elbow on the top cross brace. Insert the other ends of these vertical braces into the middle openings of both PVC tees on the middle cross brace (the 80 cm length of PVC pipe).
8. Take the remaining two vertical braces (38 cm lengths of PVC pipe) and insert them into the open ends of the 90° elbows on the middle cross brace. Insert the other ends of these vertical braces into the 90° elbows on the bottom cross brace (54 cm length of PVC pipe).
9. Adjust the angle of the 90° elbows on the middle cross brace and bottom cross brace so they are symmetrical. At this point, all six openings of the remaining PVC tees should be facing the same direction.

See RANGER construction photo #3.

Next, construct the center cross section of the shipwreck.

1. Cut one 80 cm length, one 54 cm length, one 44 cm length, one 23 cm length, one 10 cm length, and four 38 cm lengths of ½-inch PVC pipe.
2. Attach the side opening of a PVC tee to each end of the 10 cm length of PVC pipe. Attach the 23 cm length of pipe to the side opening of one of the PVC tees. Attach the 44 cm length of pipe to the side opening of the other PVC tee.
3. Attach the middle opening of a ½-inch PVC tee to each of the ends of the 54 cm length, the combination 23 cm, 10 cm, and 44 cm length and the 80 cm length of PVC pipe (six tees total). The 54 cm length of pipe is the bottom cross brace. The combined 23 cm, 10 cm, and 44 cm length of pipe is the middle cross brace. The 80 cm length of PVC is the top cross brace. The four 38 cm lengths of PVC are the vertical braces.

See RANGER construction photo #4.

4. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the bottom cross brace (54 cm length of PVC pipe). Attach the side opening of a PVC tee to the other end of each 10 cm length of PVC pipe.
5. Cut four 3 cm lengths of ½-inch PVC pipe. Insert all four of these 3 cm lengths of PVC pipe into the four side openings of the PVC tees attached to middle cross brace (80 cm length of PVC pipe). Attach the side opening of a PVC tee to each of the four 3 cm lengths of PVC pipe (four tees total).
6. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the top cross brace (remaining 80 cm length of PVC). Attach the side opening of a PVC tee to the other end of each 10 cm length of PVC pipe.

See RANGER construction photo #5.

7. Take the middle cross brace (combined 23 cm, 10 cm, and 44 cm lengths of PVC pipe with six PVC tees) and insert the four vertical braces (38 cm lengths of PVC pipe) into the four available middle openings of the PVC tees. The 23 cm length in the combined pipe should be positioned toward the starboard side of the ship. The vertical braces closer to the stern should be facing upwards; the vertical braces closer to the bow should be facing downwards.
8. Attach the ends of two of the vertical cross braces to the middle openings of the two tees of the bottom cross brace (54 cm length of PVC pipe). Attach the ends of the other two of the vertical cross braces to the middle openings of the two tees of the top cross brace (80 cm length of PVC pipe).
9. Adjust the angle of the 90° elbows on the middle cross brace and bottom cross brace so that they are symmetrical. The top and bottom cross braces should be set so that all the remaining openings of the PVC tees are aligned, with six side openings facing the stern of the ship and six side openings facing the bow of the ship.

See RANGER construction photo #6.

Next, construct the bow of the shipwreck.

1. Cut two 80 cm lengths, four 38 cm lengths, and two 26 cm lengths of ½-inch PVC pipe. Connect the two 26 cm lengths of pipe by inserting both into the side openings of a PVC tee.
2. Attach a 90° elbow to the other end of each 26 cm length of pipe. Attach the middle opening of a ½-inch PVC tee to each of the ends of both 80 cm lengths of PVC pipe (four tees total). The two 26 cm lengths of pipe connected with a tee are the bottom cross brace. The two 80 cm lengths of PVC are the middle cross brace and the top cross brace. The four 38 cm lengths of PVC are the vertical braces.

See RANGER construction photo #7.

3. Cut two 3 cm lengths of ½-inch PVC pipe. Insert these two 3 cm lengths into the open end of the 90° elbows on the bottom cross brace (two 26 cm lengths of pipe). Attach the side opening of a PVC tee to the other end of each 3 cm length of PVC pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert all four of these 3 cm lengths of PVC pipe into the four side openings of the PVC tees attached to middle cross brace (80 cm length of PVC pipe). Attach the side opening of a PVC tee to two of these 3 cm lengths of pipe. Attach a 90° elbow to the other two of the 3 cm lengths of PVC pipe.
5. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the top cross brace (remaining 80 cm length of PVC). Attach the side opening of a PVC tee to the other end of each 10 cm length of PVC pipe.

See RANGER construction photo #8.

6. Insert a vertical brace (38 cm length of pipe) into each of the two middle openings of these PVC tees. Insert the other ends of these two vertical braces into the openings on the two 90° elbows on the middle cross brace. Insert the other two vertical braces (38 cm lengths of pipe) into the middle openings of the PVC tees on the middle cross brace. Insert the other ends of these two vertical braces into the middle openings of the PVC tees on the bottom cross brace.
7. Adjust the angle of the 90° elbows on the middle cross brace and bottom cross brace so that they are symmetrical.

See RANGER construction photo #9.

8. Cut one 104 cm length, one 57 cm length, one 51 cm length, one 3 cm length, and two 25 cm lengths of ½-inch PVC pipe. Connect the 51 cm length of pipe and the 3 cm length of pipe by inserting them into the side openings of a ½-inch PVC tee.
9. Insert the two 25 cm lengths of PVC pipe into the side openings of the PVC tees on the top cross brace. Attach a 45° elbow to the other end of each 25 cm length of pipe.
10. Insert the 57 cm length of PVC pipe into the open end of the 45° elbow on the port side of the shipwreck. Insert the combined 51 cm and 3 cm length of pipe into the open end of the 45° elbow on the starboard side of the shipwreck, with the PVC tee close to the bow. Attach a single ½-inch PVC sideout to the ends of the 57 cm pipe and the 3 cm pipe, inserting the ends of the pipe into the two slip ends of the PVC sideout. Insert a ½-inch male adapter into the threaded opening of the ½-inch sideout.
11. Cut a 3 cm length of ½-inch pipe and insert it into open end of the male adapter. Attach a 45° elbow to the other end of this 3 cm length of pipe. Insert the 104 cm length of PVC pipe into the open end of the 45° elbow. Insert the other end of the 104 cm pipe into the middle opening of the tee in the center of the bottom cross piece. The bow of your shipwreck is now complete.

See RANGER construction photos #10.

Design note: Depending on your construction and assembly, you may need to slightly adjust the lengths of PVC on the shipwreck for the wreck to fit together properly.

To complete the shipwreck, add lengths of pipe to connect the bow to the center area, and the center area to the stern. The overall length of the wreck will be variable and must be measured by RANGER class companies.

1. Cut six equal lengths of PVC pipe to connect side openings of the tees in the bow to those in the center of the shipwreck.
2. Cut six equal lengths of PVC pipe to connect the side openings of the tees in the center of the ship to those in the stern of the shipwreck.

The overall length of the shipwreck should be between 2.25 m and 3.75 m.

3. Cut two 12 cm lengths of ½-inch PVC.
4. Attach a ½-inch PVC coupling to one end of each 12 cm length of pipe. Wrap approximately 3 cm of the other end of the pipe with tape.
5. Spray one length of pipe and connector with red spray paint. Spray the other length of pipe with yellow spray paint.
6. Once the paint has dried, remove the tape and insert the yellow colored pipe into the middle opening of the PVC tee on the top stern cross brace. Remove the tape and insert the red colored pipe into the middle opening of the tee located at the very bow of the ship.

Design note: RANGER class companies will measure the overall length of the shipwreck between the yellow and red colored markers.

Add a cradle to the middle of the ship.

1. Remove both lengths of PVC pipe that run from the middle cross brace at the center of the shipwreck to the middle cross brace at the stern of the shipwreck. Cut 4 cm from each of the PVC pipes removed from the shipwreck.
2. Cut an additional 20 cm from one of the removed pipes and insert both the 20 cm length of pipe and the remaining length of pipe into the side openings of A PVC tee. This overall length should match the length of the remaining lengths of pipe running between the middle and stern of the shipwreck.
3. Repeat this procedure on the other removed length of pipe.
4. Reinsert these lengths into the shipwreck, running between the middle cross brace at the center of the shipwreck to the middle cross brace at the stern of the shipwreck. The 20 cm length of pipe should be at the center of the shipwreck.
5. Cut one 44 cm length, one 23 cm length, and one 10 cm length of ½-inch PVC pipe.
6. Attach the side opening of a PVC tee to each end of the 10 cm length of PVC pipe. Attach the 23 cm length of pipe to the side opening of one of the PVC tees. Attach the 44 cm length of pipe to the side opening of the other PVC tee.
7. Insert this combined length of pipe into the middle openings of the PVC tees just behind the middle cross brace in the center of the shipwreck. The 23 cm length of PVC pipe should go into the tee on the starboard side of the shipwreck.

This creates a second middle cross brace approximately 31 cm behind the original middle cross brace at the center of the shipwreck.

8. Cut three 10 cm lengths of ½-inch PVC pipe. Connect them with a pair of 45^{o} PVC elbows. Turn the PVC tees that are on both middle cross braces, approximately 26 cm from the starboard side of the shipwreck, so they face towards each other and down at a 45^{o} angle.

9. Insert the ends of this combined length into the middle openings of the PVC tees 26 cm from the starboard side of the shipwreck.
10. Cut one 26 cm length of ½-inch PVC. Insert it into the middle opening of the two PVC tees remaining on the middle cross braces. A 5-gallon bucket should fit tightly inside this cradle.

See RANGER construction photo #11 and #12.
See RANGER construction photos #13 and #14.

Plastic sheeting is added to one side of the shipwreck to provide a working area. Plastic sheeting is comprised of 1/8-inch black ABS sheets and corrugated plastic sheets.

To construct the working areas of the shipwreck:

1. Place one 61 cm x 46 cm (24inch x 18inch) of 1/8-inch black ABS sheeting along one side of the shipwreck. Position one 61 cm edge of the sheet along the top of the frame, near the center section of the shipwreck. The 61 cm edge should reach from 15 cm behind the center top cross brace towards the bow of the ship. The rough side of the ABS sheet should be facing outwards.
2. Use screws to fasten the corners of the ABS sheet into the PVC framework of the shipwreck.
3. Attach two 5 cm x 5 cm squares of Velcro hooks to ABS sheet. These 5 cm x 5 cm squares should be located approximately 15 cm to 20 cm apart from each other, half way up the ABS sheet.
4. Place a 61 cm x 46 cm (24 inch x 18 inch) of corrugated plastic sheeting along the same side of the shipwreck. The first corrugated plastic sheet should be adjacent to the black ABS sheet but located closer to the bow.
5. Use screws to fasten the corners of the corrugated plastic sheet into the PVC framework of the shipwreck.
6. Place a 61 cm x 46 cm (24inch x 18inch) of corrugated plastic sheeting along the same side of the shipwreck. This corrugated plastic sheet should be closer to the stern of the shipwreck. Leave a 15 cm gap between the 46 cm edge of the black ABS sheet and the 46 cm edge of the stern corrugated plastic sheet.
7. Use screws to fasten the corners of the corrugated plastic sheet into the PVC framework of the shipwreck.

Design note: Check sign-making/printing stores for black plastic ABS sheeting and corrugated plastic. Alternatively, Plexiglas, Lexan, or other flat plastic sheeting may be substituted. The working area of the shipwreck (black ABS sheet) should be able to withstand impacts from and ROV.

Design note: At the regional and international competitions, different colors of corrugated plastic will be used to differentiate the shipwrecks.

Metal/Non-metal debris:

The base of the debris samples is a red brick (Home Depot online part #M2501PPSM011, Home Depot SKU #393126). The brick is 19 cm x 9 cm by 5.5 cm (8-inch x 4-inch x 2 ½-inch). The metal/non-metal sample is attached with cable ties to the 19 cm x 9 cm face of the brick.

To construct the metal sample:

1. Purchase a ¾-inch x 5-inch galvanized steel pipe nipple that is threaded on both ends (Home Depot part #564-050HN, Home Depot SKU# 182664). Attach a ¾-inch 90° elbow to each end of the galvanized pipe, completely covering the threads on either end.
2. Spray paint the entire debris sample, but not the brick, multiple times to completely disguise the metal galvanized pipe.
3. Drill a pair of holes in the side of each 90° elbow that does not contain the galvanized pipe. Use cable ties through these holes to secure the sample to the brick.

To construct the non-metal sample:

1. Cut an 11.5 cm length of ¾-inch PVC pipe. Attach a ¾-inch 90° elbow to each end of the PVC pipe.
2. Spray paint the entire debris sample, but not the brick, multiple times to completely disguise the PVC pipe.
3. Drill a pair of holes in the side of each 90° elbow that does not contain the ¾-inch pipe. Use cable ties through these holes to secure the sample to the brick.

Design note: Use a black primer spray paint to give a heavy base coat to the debris samples. Finish with a heavy coat of red paint. When the samples are painted, the metal sample and the non-metal sample should be visually identical.

See RANGER construction photo #15.

Grid:

The RANGER class grid is constructed of ½-inch PVC. The grid is 2.5 m long and 1.5 m wide and consists of 0.5 m x 0.5 m squares.

To construct the RANGER class grid:

1. Cut sixteen 46 cm lengths of ½-inch PVC pipe.
2. Using the side openings of four ½-inch PVC tees, connect five of these 46 cm lengths of PVC in a line. Repeat this process, connecting five more lengths of pipe with four more PVC tees.
3. Using the side openings of two ½-inch PVC tees, connect three 46 cm lengths of PVC in a line. Repeat this process, connecting three more lengths of pipe with two more PVC tees.

These combined lengths form the outer edge of the grid. The longer lengths should be 2.5 m long. The shorter lengths should be 1.5 m long.

See RANGER construction photo #16.

4. Attach four ½-inch PVC 90° elbows to the end lengths of PVC on both 2.5 m edges of the grid.
5. Attach the ends of the combined PVC lengths together to form a rectangle approximately 2.5 m long by 2 m wide. All the middle openings of the PVC tees should face inwards.
6. Use two lengths of 2.46 m PVC pipe to connect the tees facing each other on the 1.5 m sides of the rectangle. Use four lengths of 1.96 m PVC pipe to connect the tees facing each other on the 2.5 m sides of the rectangle.

The five debris piles will be placed randomly within the fifteen 0.5 m x 0.5 m squares created by the grid.

See RANGER construction photo #17.

Targets:
RANGER class targets are constructed from a white, 2-inch PVC end cap with a ring of black, 2-inch ABS set inside the end cap.

1. Cut a 1 cm length of 2-inch black ABS pipe. Use a saw or heavy wire cutters to cut a 1 to 2 mm section from ABS ring.
2. Insert this ABS ring into the end cap, as close to the bottom as possible.

See RANGER construction photo #18.

Design note: If ABS is unavailable in your area, cut a 1 cm length of 2-inch PVC and paint it black before inserting it inside the 2-inch PVC end cap.

3. Use screws to fasten the target onto the shipwreck 45 cm from the bottom. Drill a 1/8-inch hole in the center of the PVC end cap and a 1/8-inch hole though the corrugated plastic into a length of PVC 45 cm off the bottom. Use a ¾-inch screw to attach the 2-inch end cap to the PVC pipe.

25 cm to each side of the target will be a black mark. These marks will be 1 cm wide and 4 cm tall and located on the colored corrugated plastic sheet.

4. Use a black Sharpie or permanent marker to draw the 1 cm x 4 cm mark on the corrugated plastic, 25 cm to each side of the center of the target.

See RANGER construction photo #19.

Task #2: Removing fuel oil from the shipwreck

Your company must clear the worksite of debris before attempting to determine if fuel oil remains on board. Clearing the worksite involves removing one of the *SS Gardner*'s masts that had fallen onto an area of the hull above the fuel tanks. Once the mast is removed from the worksite, your company must then clear the hull of encrusting organisms in order to provide a clean, unobstructed working surface. However, one of the organisms is an endangered species of coral. These corals cannot be decimated but rather must be transplanted to a new location.

Examples of coral

Once the hull is clear, your company must confirm the presence of oil within the underlying fuel tank. To accomplish this, your company will use two simulated sensors – an ultrasonic thickness gauge and a neutron backscatter device. The ultrasonic thickness gauge works by measuring the amount of time it takes for sound waves to travel through the hull and back. It then calculates the thickness based on the speed of the sound through the hull. The readings are instantaneous.

The thickness of the hull is used to calibrate the neutron backscatter device. To assist with calibration, the MATE Center constructed a test or calibration tank and placed in on the bottom near the shipwreck. This tank is filled with oil and water. Based on historical records of the *SS Gardner*, the MATE Center calculated a range of potential thicknesses and constructed the tank so that each wall is a different thickness. The readings from the ultrasonic thickness gauge will determine which wall of the tank should be used to calibrate the neutron backscatter device.

Once calibrated, your company must place the neutron backscatter device on the hull to test for the presence of oil. The device works by emitting high energy neutrons. When a fast neutron collides with a hydrogen atom it releases energy and becomes a slow or thermal neutron. The thermal neutrons are scattered in all directions. Some of these thermal neutrons are scattered back towards and counted by the device. The more hydrogen atoms present in a substance the more thermal neutrons are created and can be detected. Therefore, high readings indicate the presence of oil.

After you complete this task, you can assume that there is oil on board.

Your company must then penetrate the hull to collect a sample of the fuel oil. The sample must be returned to the surface so that it can be tested to determine the quality and condition of the oil.

References

- Coral photos http://na.oceana.org/en/category/blog-free-tags/deep-sea-coral and www.esablawg.com/esalaw/ESBlawg.nsf/d6plinks/KRII-7B66S7
- Ultrasonic thickness gauge http://ultrasonicthicknessgauge.org/
- Neutron backscatter device www.scanningtech.com/Neutron_Backscatter.html

This mission task involves:

- **Transporting and attaching a lift bag to a fallen mast.**
- **Inflating the lift bag to remove the fallen mast from the worksite.**
- **Removing endangered encrusting coral from the ship's hull.**
- **Transplanting the coral.**
- **Using two simulated sensors, determine if fuel oil remains inside the fuel tank.**
- **Removing a sample of fuel oil from within the tank by drilling a hole into the hull.**
- **Resealing the hole.**
- **Returning the sample to the surface.**

RANGER class scoring – up to 180 points:

- Transporting and attaching a lift bag to the U-bolt on a fallen mast – 10 points
- Inflating the lift bag so the mast ascends to the surface – 20 points
- Removing endangered corals from the hull– 5 points each (10 points total)
- Transplanting the corals to an unoccupied square within the grid – 10 point each (20 points total)
- Using two simulated sensors, determine if fuel oil remains inside the fuel tank – up to 30 points
    - Placing the ultrasonic thickness gauge sensor on the hull – 10 points
    - "Calibrating" the neutron backscatter device by placing it on the calibration tank – 10 points
    - Placing the neutron backscatter device on the hull – 10 points
- Simulating drilling a hole into the fuel tank by penetrating a layer of petroleum jelly and removing a sample of fuel oil from within the fuel tank so that it is in possession of your ROV and no longer in the container – 30 points
- Resealing the drill hole with a simulated magnetic patch – 20 points
- Returning a volume of sample to the surface side of the pool so that a member of your company can retrieve the sample – up to 40 points
    - > 100ml – 40 points

- 50 – 99 ml – 20 points
- 25 – 49 ml – 10 points
- < 25 ml – 0 points

5 points will be deducted for returning a diluted sample (i.e., a sample that is lighter in color when compared to the standard).

Mission notes

Task #2 must be completed in order. Companies may alternate between task #1 and task #2, but task #2 must be completed in order. Companies may skip any part of task #2, but will not receive points if they complete that part at a later time. Companies may choose to return the volume of liquid to the surface before resealing the drill hole or may reseal the drill hole before returning the sample to the surface. All tasks must be completed in order to receive a time bonus.

The fallen mast will be located against the hull of the shipwreck. RANGER class companies must attach a lift bag to the U-bolt on the mast. One lift bag will be provided to RANGER class companies at the mission station during the five minute set-up period. A manual pump and 40 feet of air line tubing will also be provided to the companies during set up. RANGER class companies **MAY NOT** use air compressors or compressed air tanks to fill the lift bags. The lift bags MUST be filled from the manual pump provided by the competition officials.

Note: RANGER class companies do not have to pass the fluid power quiz to use the manual air pump.

The lift bag will be constructed from 3-inch ABS pipe with 1/8-inch rope holding a hook at the bottom. The hook will have a diameter of 1.7 cm. Only one lift bag will be provided to RANGER class companies. If the bag is dropped, companies must retrieve it with their vehicle.

Lift bags must be completely empty of air before the ROV descends. Companies may evacuate air and fill their lift bag with water during the 5-minute set up period.

Details of the air line tubing and the manual air pump are detailed in the mission prop specifications below.

The mast is constructed from ¾-inch PVC. Weights inside the bottom-most ¾-inch PVC pipes will provide ballast. A U-bolt will be the attachment point for the lift bag.

Companies will receive points when the 3-inch ABS lift bag breaks the surface. If the lift bag is still rising as the mission time ends, companies will not receive points for completing this task.

After removing the mast from the worksite, RANGER class companies must remove encrusting corals from the hull of the shipwreck. These endangered corals must be transplanted into an open grid square.

An open grid square is considered a grid square that does not have a debris sample within it. Two corals will be growing on the black ABS sheeting attached to the side of the shipwreck. Both corals will be held onto the side of the hull by Velcro. Both corals must be removed from the hull and placed in an open grid square in order to receive full points for this step and to be eligible for a time bonus. Corals may be placed in the same grid square or different grid squares as needed. Corals do not need to be placed upright within the grid square in order to receive full points. To successfully transplant a coral, no portion of the coral should be touching any part of the PVC grid.

Corals will require less than 1 Newton to detach from the hull of the shipwreck. Corals will weigh less than 1 Newton in water.

After removing both corals from the hull of the ship, companies must gauge the thickness of the hull, use the thickness to calibrate their neutron backscatter device against a calibration tank, and determine if oil remains in the fuel tank using the calibrated neutron backscatter device. Both the ultrasonic thickness gauge sensor and the neutron backscatter device will be simulated.

RANGER class companies must create their own simulated sensors. Both simulated sensors may be combined into one unit. Guidelines for creating the sensor are that it must be able to touch the vertical hull of the ship and calibration tank. The sensor must be at least 12 cm long and at least 2 cm in diameter or at least 2 cm x 2 cm square. The sensor should be labeled and identified to the mission station judge during the 5-minute mission set up time.

Once both corals are removed from the hull of the ship, companies must maneuver their vehicle so that the ultrasonic thickness gauge is touching the working surface of the hull of the shipwreck. The working surface of the hull is defined as the 61 cm x 46 cm black ABS sheet. The mission station judge must be able to see through an ROV camera that the ultrasonic thickness gauge sensor is touching this area of the hull for a continuous five seconds. If the sensor comes off of the hull during those five seconds, companies must reposition their vehicle and restart the five second time period. Companies should inform the mission station judge that they are attempting this task and ask the mission station judge to count off the five seconds.

Companies must then pilot their vehicle to the calibration tank to calibrate their neutron backscatter device. The calibration tank is a standard milk crate, approximately 32 cm long, 32 cm wide, and 28 cm tall. The calibration tank will be positioned on the pool bottom within one meter of the working area on the hull of the shipwreck. Companies must maneuver their vehicle so that the neutron backscatter device is touching the wall of the milk crate. The mission station judge must be able to see through an ROV camera that the neutron backscatter device is touching the calibration tank for a continuous five seconds. If the sensor comes off of the calibration tank during those five seconds, companies must reposition their vehicle and restart the five second time period. Companies should inform the mission station judge that they are attempting this task and ask the mission station judge to count off the five seconds.

Once the neutron backscatter device is calibrated, companies can return to the working area of the hull. Companies must maneuver their vehicle so that the neutron backscatter device is touching the working area of the hull of the shipwreck. The mission station judge must be able to see through an ROV camera that the neutron backscatter device is touching the hull for a continuous five seconds. If the sensor comes off of the hull during those five seconds, companies must reposition their vehicle and restart the five second time period. Companies should inform the mission station judge that they are attempting this task and ask the mission station judge to count off the five seconds.

RANGER class companies are also tasked with removing a sample of fuel oil, which is simulated by green saltwater, from inside a tank.

RANGER class companies will simulate drilling through the hull by penetrating a layer of petroleum jelly. The petroleum jelly will be located at the end of a 1 ½-inch to 1-inch PVC reducer bushing. The layer will be approximately 1 cm to 2 cm thick, will be 3.3 cm in diameter and located 1 cm to 3 cm deep into the reducer bushing. Companies must design a device to puncture through the petroleum jelly seal in this reducer bushing.

No sharp objects are permitted on the vehicle to puncture through the petroleum jelly. Hypodermic needles, knives, razor blades, etc. are not allowed.

The reducer bushing will be set into a 1 ½-inch PVC coupling that is attached to the top of a 5-gallon bucket lid. The bucket lid is attached to a 5-gallon bucket which rests on its side near the center-stern of the shipwreck.

The outside edge of the 1 ½-inch to 1-inch reducer bushing will be covered with Velcro loops.

Design note: Velcro loops are the soft, “wool” side of Velcro.

Any petroleum jelly removed by the vehicle may be left in the pool or returned to the surface with the ROV.

Once the layer of petroleum jelly is penetrated, RANGER class companies must retrieve a sample of fuel oil from within the tank and return it to the surface. The fuel oil is simulated by green saltwater comprised of water, salt, and green food coloring.

The sample of fuel oil must be returned to the surface so that it may be retrieved by a member of your company and handed to the mission station judge. To receive points for returning a sample to the surface, the ROV must be within the grasp of a member of your company before the 15-minute mission time period has ended. Companies that have a fuel oil sample on board, but are still in the pool when the mission time ends, will receive points for collecting the sample, but will not receive points for

returning the sample to the surface. If companies have completed all other mission tasks and have the fuel oil sample on board, their mission time will end when a member of their company grasps the vehicle at the surface, side of the pool. In this case, companies may retrieve the sample from their vehicle and hand it to the mission station judge after the mission time has ended. Once the clock has stopped, if a company member drops the sample, or the company feels the sample size is insufficient or too diluted, they may not return to the water to retrieve a second sample. If the sample size is not >100 ml, companies will be unable to receive a time bonus.

Companies that return their fuel oil sample before completing other mission tasks may ask the mission station judge to measure the volume of the sample or compare it to the standard to determine if it is too dilute. Time will not stop while the judge is making the measurements. Companies may elect to retrieve an additional sample if they feel that the sample size is insufficient or the sample is too dilute.

Once your company is satisfied with the fuel oil sample, you must use a magnetic patch to reseal the drill hole. Magnetic patches will be simulated by Velcro. RANGER class companies must place a Velcro patch over the simulated drill hole.

Note: Once the Velcro patch is placed over the drill hole, companies may not attempt to remove it to obtain a sample of liquid.

The Velcro patch will have a diameter of 7.3 cm. The patch must completely cover the entire 5.3 cm diameter of the reducer bushing to successfully reseal the drill hole.

RANGER class companies will be provided with two patches at the mission control shack. If one patch is dropped, the vehicle can attempt to retrieve it from the bottom of the pool, or may return to the surface for the second patch. If a second patch is dropped, companies will have to retrieve one of the patches from the bottom of the pool to complete this step of the mission.

Mission prop specifications

See the **RANGER Construction and Mission Prop Photos and SolidWorks Assemblies and Drawings** documents for visuals.

Mast:

The RANGER class mast is constructed from ¾-inch PVC. The mast is 65 cm tall and 45 cm wide. A 3 ½-inch U-bolt will be the attachment point for the lift bag. Six lengths of rope hang from the mast. Weights in the bottom of the mast will provide ballast.

To construct the mast:

1. Cut one 40 cm length, four 20 cm lengths, and one 15 cm length of ¾-inch PVC pipe.
2. Take the 15 cm length of ¾-inch PVC pipe and drill a pair of 7/16-inch holes all the way through the pipe. These holes should be spaced approximately 10 cm apart and be parallel along the

pipe. The distance between these two holes should correspond exactly to the length between the two ends of a 3.5-inch U-bolt. The RANGER class U-bolt is 8.6 cm (3.5-inches) wide (ACE Hardware part# 5007968: 3/8-inch x 3 ½-inch x 4 5/8-inch U-bolt). Push the U-bolt all the way through the ¾-inch PVC pipe so the ends are protruding from the bottom end. With this design, the RANGER U-bolt will stick 8.5 cm out from the mast. Use 3/8-inch lock nuts to secure the U-bolt in place.

Design note: The 15 cm length of PVC pipe with the U-bolt is recycled from the 2011 RANGER class missions. It was used in 2011 as the connection point for lifting the riser pipe off the oil well.

3. Insert two of the 20 cm lengths of pipe into opposite openings of a ¾-inch PVC cross. Insert the 40 cm length of pipe into another opening of the cross. Insert the 15 cm length of pipe with the U-bolt into the final opening of the PVC cross.
4. Attach a ¾-inch end cap to the other end of the 15 cm length of pipe.
5. Drill holes into the ¾-inch end cap to allow air to escape from the mast.
6. Attach the middle opening of a ¾-inch PVC tee to the other end of the 40 cm length of PVC pipe.
7. Insert the other two 20 cm lengths of pipe into the side openings of the ¾-inch PVC tee. Align these two lengths to match the 20 cm lengths of pipe above.

The RANGER class mast will weigh less than 11.5 Newtons (2.5 pounds) in water. Add weights into the bottom PVC pipe of the mast to achieve the proper weight.

1. Drill three 3/16-inch holes in each of the 20 cm lengths of 1 ½-inch PVC pipe (six holes total).
2. Cut six lengths of 1/8-inch braided nylon and polypropylene rope (Home Depot part #**140-287**, ACE Hardware part #75851). The lengths of rope should vary from 20 cm to 50 cm long. Insert one end of each length of rope into the holes drilled through the pipe and tie and overhand knot to secure them in place.

See RANGER construction photo #20.

Lift bag:

The lift bag is constructed from 3-inch ABS pipe with a 3-inch knockout cap (Home Depot part# 39102, SKU#508260, Home Depot online# 39102) at one end. A hook is attached by 1/8-inch rope to the other end of the 3-inch ABS pipe.

To construct the RANGER class lift bag:

1. Cut a 32 cm length of 3-inch ABS pipe.
2. Use 5-minute epoxy (or other glue) to secure and waterproof a 3-inch knockout cap to one end of the 32 cm length of ABS pipe. Use enough epoxy or glue so that air will not leak out the end.
3. Drill four 3/16-inch holes spaced evenly around the other end of the 32 cm length of ABS pipe.

4. Cut four 20 cm lengths of 1/8-inch braided rope. Insert the ends of the 20 cm lengths of rope into the four holes drilled, one rope per hole. Rope should be inserted from the outside of the pipe to the inside of the pipe. Tie an overhand knot to secure the rope inside the ABS pipe.
5. Cut 7.5 cm from a 6-inch J-hook (ACE Hardware part #57933). Keep the hook portion of the J-hook.
6. Use plastic/electrical tape and/or epoxy to secure the four loose ends of rope to the J-hook. Secure approximately 2 cm to 3 cm of rope to the top 3 cm of the J-hook.

See RANGER construction photo #21.

Design note: Companies that cannot find ABS in their area should check online sources.

Air pump:
RANGER class companies will be provided with a manual (hand-powered or foot-powered) pump at the mission station. The pump is connected to 40 feet of 3/16 (inner diameter) of air line tubing. The bottom end of the air line tubing is attached with a pair of cable ties to the outside of a 10 cm length of PVC pipe.

Companies may provide their own air line tubing. Companies that choose to use their own air line are responsible for providing a connector that will fit 3/16-inch air line tubing and are responsible for making the connection to the manual pump. Companies are allowed to connect their air line tubing during the five minute set-up period.

Design note: If 3/16-inch air line tubing is not available in your local hardware stores, check online sources for "3/16 inch air line" tubing.

Coral:
The coral is simulated using chenille stems (pipe cleaners) set into a ½-inch PVC end cap base.

To construct a coral:
1. Cut three 30 cm long, pink pipe cleaners into six 15 cm lengths. Cut four 30 cm long, white pipe cleaners into eight 15 cm lengths.
2. Drill an 1/8-inch hole 0.5 cm off center in the bottom of a ½-inch PVC end cap. Insert 4 cm of a white pipe cleaner through this hole. Twist the end of the pipe cleaner into an overhand knot so that it is secured in the end cap.
3. Drill a pair of 3/16-inch holes on opposite sides of the wall of the ½-inch PVC end cap. Insert a small cable tie through both holes on the side of the end cap, over the top of the end cap, and over the white pipe cleaner coming out the top of the end cap. Pull the cable tie to secure the pipe cleaner tightly against the surface of the end cap.
4. Take a 15 cm length of pink pipe cleaner and twist the middle of it twice around the white pipe cleaner, about 1 cm up from the end cap. 7 cm should extend from each end of the twist.

5. Take two 15 cm lengths of white pipe cleaner and twist the middle of each around either length of the pink pipe cleaner, about 1 cm up from the base.
6. Repeat until all 15 cm lengths of pipe cleaner are used.
7. Bend the ends of all pipe cleaners upwards, away from the end cap.
8. Cut a 3 mm by 4 cm length of Velcro loops. Attach the Velcro strip to the base of the end cap, placing one end approximately 1.5 cm inside the end cap, and the other end outside the end cap.

See RANGER construction photo #22.

Ultrasonic thickness gauge sensor and neutron backscatter devices:
RANGER class companies are tasked with building their own simulated ultrasonic thickness gauge sensor and neutron backscatter device. Both simulated sensors may be combined into one unit; in other words, one device can serve as both sensors. The sensor must be able to touch a flat, vertical surface. The sensor must be at least 12 cm long. The sensor must be at least 2 cm in diameter or at least 2 cm x 2 cm square.

RANGER class companies may attach the sensors to their vehicle by any method they choose.

Calibration tank:
The calibration tank will be simulated by a milk crate.

1. Use cable ties to attach a 34 cm x 34 cm length of colored corrugated plastic to the top of a milk crate.
2. Turn the milk crate on its side and add sufficient weight to secure it to the bottom of the pool.

The neutron backscatter device must be held to the 34 cm x 34 cm sheet of corrugated plastic surface for five seconds.

Design note: Check sign-making/printing stores for colored corrugated plastic sheeting. Alternatively use 1/8-inch black ABS sheeting, Plexiglas or Lexan.

Fuel tank:
The fuel tank is a 1-liter soft water bottle within a 5-gallon bucket. The soft water bottle design allows the container to collapse under pressure when a sample is removed with minimal mixing of the pool water. It is placed within a 5-gallon bucket for protection and weight. The nozzle of the water bottle extends from, and is secured to, the lid of the 5-gallon bucket. The water sample is accessed through a 1 ½-inch to ¾-inch reducer bushing.

The soft water bottle is a *Platypus* 1.0 liter bottle. Check REI or local camping stores for availability. It

can also be purchased from REI Online (Platypus SoftBottle with closure cap, 34flozs, Item #797977). Any 5-gallon bucket with lid can be used as the outer container.

To construct the fuel tank container:

1. Use a 1-inch hole saw to drill a hole in the center of the 5-gallon bucket lid. Alternatively, you can use a smaller drill bit and widen the hole with a file or knife blade. The hole should be large enough to allow ¾-inch PVC pipe to fit through it, but not large enough so a ¾-inch PVC coupling will fit through it.
2. Attach a ¾-inch PVC coupling over the mouth of the soft water bottle. Secure with a small screw or glue. Insert a 4.5 cm length of ¾-inch PVC pipe into the coupling.
3. Push the end of the 4.5 cm length of PVC through the hole in the 5-gallon bucket lid. Attach a 1 ½-inch to ¾-inch reducer bushing (Home Depot Part #437-210HC, Home Depot SKU #896-981, DURA online part #437-210) to the 4.5 cm length of pipe.
4. Attach a 1 ½-inch coupling to the reducer bushing. Insert a 1 ½-inch to 1-inch reducer bushing (Home Depot part # 437-211HC, Home Depot SKU #294-284, DURA part #437-211) into the other end of the coupling.
5. Add a layer of petroleum jelly (Vaseline) to the 1 ½-inch to 1-inch reducer bushing. The petroleum jelly should completely fill the entire diameter of the bushing and should be 1.5 cm to 2 cm thick.

Design note: Check pharmacies/drug stores for petroleum jelly.

6. Drill multiple ¼-inch holes in the 5-gallon bucket to allow flooding. Weights can be added inside the 5-gallon bucket to hold it on the bottom. Make sure the lid is tightly secured on the 5-gallon bucket. Use straps to hold the lid on if necessary.
7. Set the 5-gallon bucket into the cradle located behind the center of the shipwreck. The bucket lid should be facing the starboard side of the shipwreck. The 1 ½-inch coupling and reducer bushing should extend beyond the side of the shipwreck.

See RANGER construction photo #23.
See RANGER construction photo #24.

<u>Fuel oil</u>:
Add 125ml (1/2 cup) of salt and 4 drops of green food coloring per 1.0 liters of water. Mix well. Fill the 1 liter soft water bottle and all PVC pipes with the dense colored liquid.

<u>Patch</u>:
The contact surface of the patch is constructed from a 3-inch knockout cap (Home Depot part# 39102, SKU#508260, Home Depot online# 39102) covered with Velcro hooks.

To construct the patch:

1. Use heavy wire cutters or dykes to cut the pull tab from the 3-inch knockout cap.
2. Place the top of a ½-inch PVC end cap onto the center of the bottom side (non pull tab side) of a 3-inch knockout cap.
3. Use two #6 ½-inch sheet metal screws to secure the end cap onto the 3-inch knockout cap. The heads of the screws should be on the top side flat, 7.3 cm side of the knockout cap (the side the pull tab was removed from).
4. Cut an 8 cm length of ½-inch PVC and insert it into the end cap.
5. Drill a pair of 3/16-inch holes in the 8 cm length of pipe approximately 0.5 cm from the end.
6. Cut a 20 cm length of 1/8-inch braided nylon and polypropylene rope. Insert one end of the rope through a drill hole from the outside to the inside of the pipe. Tie an overhand knot to secure the rope inside the pipe. Insert the other end of the rope through the other drill hole, from the outside to the inside of the pipe. Tie an overhand knot to secure the rope inside the pipe.
7. Cover the entire top of the 3-inch knockout cap, including the heads of the sheet metal screws, with Velcro hooks.

See RANGER construction photo #25.

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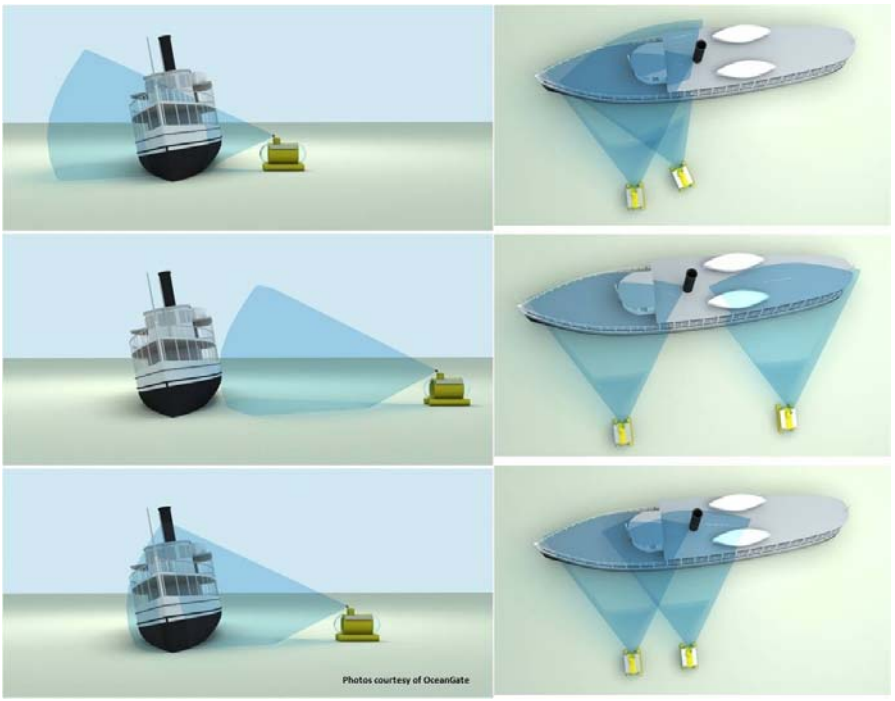
EXPLORER CLASS MISSIONS

Task #1: Survey the wreck site

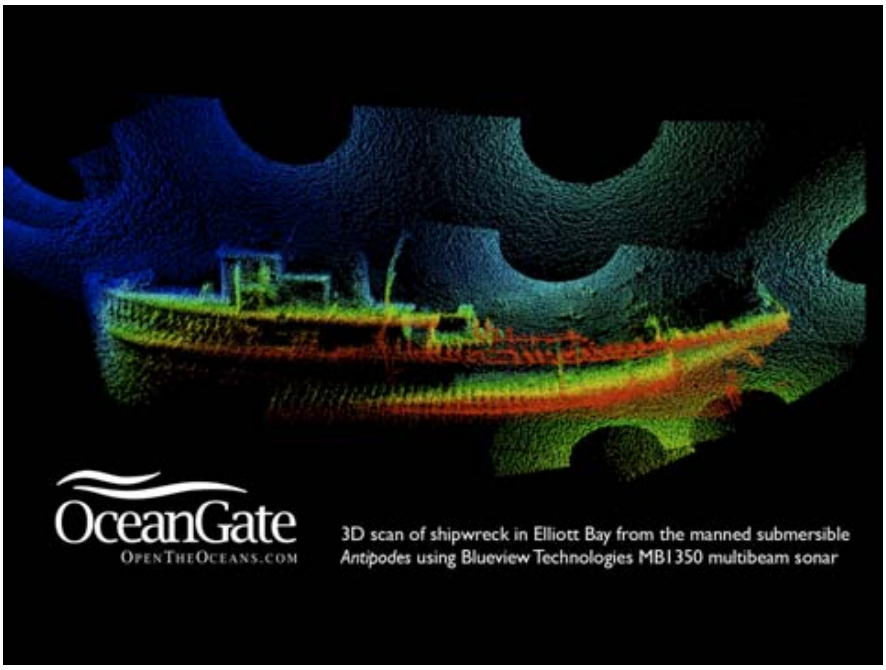
Your company is required to survey the *SS Gardner* and the wreck site. Surveying the wreck includes measuring the overall length of the ship, and determining the orientation of the ship on the seafloor. Your company must also examine the debris field alongside the wreck. The debris is overgrown with a thick layer of encrusting organisms and, from a visual standpoint, looks exactly like the encrusted rocky outcroppings found in the surrounding area. Your company must determine whether the objects in the debris field are metal, and hence part of the wreck site, or non-metal and therefore naturally occurring rocky outcroppings. Your company is then required to make a map of the wreck site based on your findings.

Your company must also scan the shipwreck with sonar. Today's multi-beam sonar is the best technology available for providing high quality, highly detailed images of shipwrecks and other submerged objects. By changing the angle of coverage and frequency of the sound produced by the sonar, the sonar can scan large areas with less detail, or smaller areas with extremely high detail. This, along with your map, will help to document the wreck site and create a "snapshot" of the shipwreck at this moment in time.

Your company will simulate scanning the *SS Gardner* with a stationary multi-beam sonar. When scanning the shipwreck, distance matters. If your sonar is too far away, the beams will not reach the target. If your sonar is too close, the beams will survey a small area and miss much of the target. Spacing of the surveys is also important. Your sonar scans should be done so that there is minimal overlap of the scans. The figures below illustrate this concept.



Side view looking at the shipwreck *View looking down on shipwreck*



The result

This mission task involves:

- **Measuring the length of the wreck.**
- **Determining the orientation of the ship on the seafloor.**
- **Creating a map of the wreck site.**

- **Determining if debris piles are metal or non-metal.**
- **Scanning the shipwreck with sonar.**

EXPLORER class scoring – up to 120 points:

- Measuring the length of the wreck – up to 20 points
  - ≤ 5 cm off true length – 20 points
  - 5 cm to 20 cm off true length – 10 points
  - > 20 cm off true length – 0 points
- Determining the orientation of the ship on the seafloor – up to 20 points
  - ≤ 10^{o}off true orientation – 20 points
  - > 10^{o} to 20^{o}off true orientation – 10 points
  - > 20^{o}off true orientation – 0 points
- Creating a map of the wreck site that includes the following information – up to 10 points
  - Sketch of the shipwreck, length of shipwreck, orientation of shipwreck – 5 points
  - Location of debris piles – 5 points for placing all eight debris piles in the correct grid squares
- Determining if debris piles are metal or non-metal – up to 40 points
  - Correctly identifying eight objects as metal (M) or rock (R) – 5 points each (40 points total)
- Correctly "scanning" the ship at three target locations – 10 points for each target (30 points total)

Mission notes

Task #1 can be completed in any order. Companies must descend to the wreck site to create the map. Companies may alternate between task #1 and task #2.

The overall length of the shipwreck varies, but will range between 2.25 m and 4 m. Different mission stations will have shipwrecks with different lengths.

EXPLORER class companies will determine the length of the shipwreck from the front tip of the bow to the stern most edge of the stern top cross brace (see **Constructing the shipwreck** within the **Mission prop specifications** below).

EXPLORER class companies should determine the orientation of the ship from the stern of the ship towards the bow of the ship. The international competition will have a master compass or a designated north/south line for companies to calibrate their own compass or sensor. The orientation should be taken and reported relative to magnetic north.

A ½-inch PVC grid will be laid out on the pool bottom on one side of the shipwreck. The grid will be 2.5 m long and 1.5 m wide and consist of fifteen squares, each approximately 0.5 m squared. The EXPLORER class mission area will have eight (8) debris piles located within the grid.

During the five minute mission setup time, the mission station judge will hand your company a blank grid. Companies must create a map of the wreck site on this blank grid. In order to receive the full points for creating the map, companies will need to sketch the approximate location of the shipwreck and include the following information:

- sketch of the shipwreck
- length of the shipwreck
- orientation of the shipwreck
- location of each of the eight debris piles

Companies will not be penalized if the length or orientation of the ship is incorrect on the map, but must include these measurements on the map in order receive points. EXPLORER class companies will not receive full points if one (or more) of the eight debris piles is not in the correct location. Companies cannot create the map by looking into the pool from the surface. Companies will not receive any points for creating a map if they do not descend to the wreck site.

Companies must determine whether these debris piles are constructed of metal or non-metal components. Any number of the eight debris piles may be constructed from metal; debris piles made of metal and those made of non-metal will be visually identical. Companies will only receive points for those debris piles correctly identified.

EXPLORER class companies may not guess at which debris piles are metal and which are non-metal. Companies must show the mission station judge evidence that the sample is metal or non-metal. For example, companies can show the judges a sensor reading that allows them to determine whether the debris sample is metal or non-metal. This reading could be displayed on the company's video monitor.

All metal used in construction will be ferrous.

Companies should note that many pools have cement bottoms reinforced with metal rebar. Rebar in the cement could interfere with metal detectors deployed on the vehicle. To help differentiate between metal used in pool construction and the metal of the debris samples, the debris samples will be raised up off the bottom of the pool with a brick. The center of the debris sample will be 10 cm above the bottom of the pool. Companies should take the metal rebar used in pool construction into consideration when designing their metal detector.

Companies will simulate scanning the ship with sonar by visualizing a target area. Each target area will consist of a black ring of 1 ½-inch ABS pipe set inside a 1 ½-inch white PVC end cap and a black mark set

25 cm to each side of the target. To effectively scan the shipwreck, an ROV must align a single camera so that the mission station judge can see on one video display the entire black ring within the end cap, as well as both marks on either side of the target. The vehicle must maintain this alignment for 10 seconds. If at any time the mission station judge is unable to see the entire black ring or both colored marks, companies must realign their vehicle and start the scan again.

Targets will sit approximately 45 cm off the pool bottom.

EXPLORER class companies will scan three target areas. Two will be located on one side of the shipwreck; one will be on the stern of the shipwreck. In addition, EXPLORER class companies are required to shine a high intensity light (**lasers are not allowed**) into the target area for a full 10 seconds. The back of the target area will be covered with reflective tape to help judges determine that this task is completed correctly.

Design note: High intensity lights may not use batteries as their power source. Companies must power these lights directly from tether power.

Design note: Companies should consider the bottom topography of the regional and international competition venues. Do not assume that your ROV will be able to rest on a flat bottom to accomplish the scan.

Mission prop specifications

See the **EXPLORER Construction and Mission Prop Photos and SolidWorks Assemblies and Drawings** documents for visuals.

All PVC used in construction is DURA brand PVC. If items are unavailable or built to different specifications in your area, check online at www.duraplastics.com to purchase specific PVC pieces.

Constructing the shipwreck:
The framework of the shipwreck is constructed out of ½-inch PVC. However, the exact diameter of the PVC framework is not important. Companies located outside of North America that do not have access to ½-inch PVC may substitute local PVC for ½-inch PVC pipe and connectors.

To construct the EXPLORER shipwreck, start construction at the stern of the ship.

1. Cut two 80 cm lengths, one 54 cm length, and four 38 cm lengths of ½-inch PVC pipe.
2. Attach the middle opening of a ½-inch PVC tee to each of the ends of the 54 cm length and both 80 cm lengths of PVC pipe (six tees total). The 54 cm length of pipe is the bottom cross brace. The two 80 cm lengths of PVC are the middle cross brace and the top cross brace. The four 38 cm lengths of PVC are the vertical braces.

See EXPLORER construction photo #1.

3. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the bottom cross brace (54 cm length of PVC). Attach a 90° elbow to the other end of each 10 cm length of PVC pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert two of these 3 cm lengths of pipe into one side opening of each PVC tee on the middle cross brace (80 cm length of PVC).
5. Attach a side opening of a ½-inch PVC tee to the other end of each 3 cm length of PVC pipe. Insert the other two 3 cm lengths of PVC into the other side opening of the PVC tee. Attach a 90° elbow to the other end of each 3 cm length of PVC pipe.
6. Cut two more 3 cm lengths of ½-inch PVC pipe. Insert these two lengths of 3 cm pipe into one side opening of each PVC tee on the top cross brace (the remaining 80 cm length of PVC).
7. Attach a 90° elbow to the other end of each 3 cm length of PVC pipe.

See EXPLORER construction photo #2.

8. Take two of the vertical braces (38 cm lengths of PVC pipe) and insert one end of a vertical brace into each of the open ends of the 90° elbow. Insert the other ends of these vertical braces into the middle openings of both PVC tees on the middle cross brace (the other 80 cm length of PVC pipe).
9. Take the remaining two vertical braces (38 cm lengths of PVC pipe) and insert them into the open ends of the 90° elbows on the middle cross brace. Insert the other ends of these vertical braces into the 90° elbows on the bottom cross brace (54 cm length of PVC pipe).
10. Adjust the angle of the 90° elbows on the middle cross brace and bottom cross brace so they are symmetrical. At this point, all six openings of the remaining PVC tees should be facing the same direction.

See EXPLORER construction photo #3.

Next, construct the center cross section of the shipwreck.

1. Cut two 80 cm lengths, one 54 cm length, and four 38 cm lengths of ½-inch PVC pipe.
2. Attach the middle opening of a ½-inch PVC tee to each of the ends of the 54 cm length and both 80 cm lengths of PVC pipe (six tees total). The 54 cm length of pipe is the bottom cross brace. The two 80 cm lengths of PVC are the middle cross brace and the top cross brace. The four 38 cm lengths of PVC are the vertical braces.

See EXPLORER construction photo #4.

3. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the bottom cross brace (54 cm length of PVC pipe). Attach the side opening of a PVC tee to the other end of each 10 cm length of PVC pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert all four of these 3 cm lengths of PVC pipe into the four side openings of the PVC tees attached to middle cross brace (80 cm length of PVC pipe). Attach the side opening of a PVC tee to each of the four 3 cm lengths of PVC pipe (four tees total).
5. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the top cross brace (remaining 80 cm length of PVC). Attach the side opening of a PVC tee to the other end of each 10 cm length of PVC pipe.

See EXPLORER construction photo #5.

6. Take the middle cross brace (80 cm length of PVC pipe with six PVC tees) and insert the four vertical braces (38 cm lengths of PVC pipe) into the four available middle openings of the PVC tees. The vertical braces closer to the stern should be facing upwards; the vertical braces closer to the bow should be facing downwards.
7. Attach the ends of two of the vertical cross braces to the middle openings of the two tees of the bottom cross brace (54 cm length of PVC pipe). Attach the ends of the other two of the vertical cross braces to the middle openings of the two tees of the top cross brace (54 cm length of PVC pipe).
8. Adjust the angle of the 90° elbows on the middle cross brace and bottom cross brace so that they are symmetrical. The top and bottom cross braces should be set so that all the remaining openings of the PVC tees are aligned, with six side openings facing the stern of the ship and six side openings facing the bow of the ship.

See EXPLORER construction photo #6.

Next, construct the bow of the shipwreck.

1. Cut two 80 cm lengths, four 38 cm lengths and two 26 cm lengths of ½-inch PVC pipe. Connect the two 26 cm lengths of pipe by inserting both into the side openings of a PVC tee.
2. Attach a 90° elbow to the other end of each 26 cm length of pipe. Attach the middle opening of a ½-inch PVC tee to each of the ends of both 80 cm lengths of PVC pipe (four tees total). The two 26 cm lengths of pipe connected with a tee are the bottom cross brace. The two 80 cm lengths of PVC are the middle cross brace and the top cross brace. The four 38 cm lengths of PVC are the vertical braces.

See EXPLORER construction photo #7.

3. Cut two 3 cm lengths of ½-inch PVC pipe. Insert these two 3 cm lengths into the open end of the 90° elbows on the bottom cross brace (two 26 cm lengths of pipe). Attach the side opening of a PVC tee to the other end of each 3 cm length of PVC pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert all four of these 3 cm lengths of PVC pipe into the four side openings of the PVC tees attached to middle cross brace (80 cm length of PVC pipe). Attach the side opening of a PVC tee to two of these 3 cm lengths of pipe. Attach a 90° elbow to the other two of the 3 cm lengths of PVC pipe.
5. Cut two 10 cm lengths of ½-inch PVC pipe. Insert these 10 cm lengths into one side opening of each PVC tee on the top cross brace (remaining 80 cm length of PVC). Attach the side opening of a PVC tee to the other end of each 10 cm length of PVC pipe.

See EXPLORER construction photo #8.

6. Insert a vertical brace (38 cm length of pipe) into each of the two middle openings of these PVC tees. Insert the other ends of these two vertical braces into the openings on the two 90° elbows on the middle cross brace. Insert the other two vertical braces (38 cm lengths of pipe) into the middle openings of the PVC tees on the middle cross brace. Insert the other ends of these two vertical braces into the middle openings of the PVC tees on the bottom cross brace.
7. Adjust the angle of the 90° elbows on the middle cross brace and bottom cross brace so that they are symmetrical.

See EXPLORER construction photo #9.

8. Cut one 104 cm length, two 57 cm lengths, and two 25 cm lengths of ½-inch PVC pipe.
9. Insert the two 25 cm lengths of PVC pipe into the side openings of the PVC tees on the top cross brace. Attach a 45° elbow to the other end of each 25 cm length of pipe.
10. Insert the two 57 cm lengths of PVC pipe into the open ends of the 45° elbows. Attach a single ½-inch PVC sideout to both ends of the 57 cm pipes, inserting the ends of the pipe into the two slip ends of the PVC sideout. Insert a ½-inch male adapter into the threaded opening of the ½-inch sideout.
11. Cut a 3 cm length of ½-inch pipe and insert it into open end of the male adapter. Attach a 45° elbow to the other end of this 3 cm length of pipe. Insert the 104 cm length of PVC pipe into the open end of the 45° elbow. Insert the other end of the 104 cm pipe into the middle opening of the tee in the center of the bottom cross piece. The bow of your shipwreck is now complete.

See EXPLORER construction photo #10.

Design note: Depending on your construction and assembly, you may need to slightly adjust the lengths of PVC on the shipwreck for the wreck to fit together properly.

To complete the shipwreck, add lengths of pipe to connect the bow to the center area and the center area to the stern. The overall length of the wreck will be variable and must be measured by EXPLORER class companies.

1. Cut six equal lengths of PVC pipe to connect side openings of the tees in the bow to those in the center of the shipwreck.
2. Cut six equal lengths of PVC pipe to connect the side openings of the tees in the center of the ship to those in the stern of the shipwreck.

The overall length of the shipwreck should be between 2.25 m and 4m.

See EXPLORER construction photo #11 and #12.

Plastic sheets are added to one side of the shipwreck to provide a working area. Plastic sheeting is comprised of 1/8-inch black ABS sheets and corrugated plastic sheets.

To construct the working areas of the shipwreck:

8. Place one 61 cm x 46 cm (24inch x 18inch) of 1/8-inch black ABS sheeting along one side of the shipwreck. Position one 61 cm edge of the sheet along the top of the frame, near the center section of the shipwreck. The 61 cm edge should reach from 15 cm behind the center top cross brace towards the bow of the ship. The rough side of the ABS sheet should be facing outwards.
9. Use screws to fasten the corners of the ABS sheet into the PVC framework of the shipwreck.
10. Attach two 5 cm x 5 cm squares of Velcro hooks to ABS sheet. These 5 cm x 5 cm squares should be located approximately 15 cm to 20 cm apart from each other, half way up the ABS sheet.
11. Place a 61 cm x 46 cm (24inch x 18inch) of corrugated plastic sheeting along the same side of the shipwreck. The first corrugated plastic sheet should be adjacent to the black ABS sheet but located closer to the bow.
12. Use screws to fasten the corners of the corrugated plastic sheet into the PVC framework of the shipwreck.
13. Place a 61 cm x 46 cm (24inch x 18inch) of corrugated plastic sheeting along the same side of the shipwreck. This corrugated plastic sheet should be closer to the stern of the shipwreck. Leave a 15 cm gap between the 46 cm edge of the black ABS sheet and the 46 cm edge of the stern corrugated plastic sheet.
14. Use screws to fasten the corners of the corrugated plastic sheet into the PVC framework of the shipwreck.

Design note: Check sign-making/printing stores for black plastic ABS sheeting and corrugated plastic. Alternatively, Plexiglas, Lexan, or other flat plastic sheeting may be substituted. The working area of the shipwreck (black ABS sheet) should be able to withstand impacts from an ROV.

Design note: At the international competition, different colors of corrugated plastic will be used to differentiate the shipwrecks.

Metal/Non-metal debris:
The base of the debris samples is a red brick (Home Depot online part #M2501PPSM011, Home Depot SKU #393126). The brick is 19 cm x 9 cm by 5.5 cm (8-inch x 4-inch x 2 ½-inch). The metal/non-metal sample is attached with cable ties to the 19 cm x 9 cm face of the brick.

To construct the metal sample:

4. Purchase a ¾-inch x 5-inch galvanized steel pipe nipple that is threaded on both ends (Home Depot part #564-050HN, Home Depot SKU# 182664). Attach a ¾-inch 90° elbow to each end of the galvanized pipe, completely covering the threads on either end.
5. Spray paint the entire debris sample, but not the brick, multiple times to completely disguise the metal galvanized pipe.
6. Drill a pair of holes in the side of each 90° elbow that does not contain the galvanized pipe. Use cable ties through these holes to secure the sample to the brick.

To construct the non-metal sample:

4. Cut an 11.5 cm length of ¾-inch PVC pipe. Attach a ¾-inch 90° elbow to each end of the PVC pipe.
5. Spray paint the entire debris sample, but not the brick, multiple times to completely disguise the PVC pipe.
6. Drill a pair of holes in the side of each 90° elbow that does not contain the ¾-inch pipe. Use cable ties through these holes to secure the sample to the brick.

Design note: Use a black primer spray paint to give a heavy base coat to the debris samples. Finish with a heavy coat of red paint. When the samples are painted, the metal sample and the non-metal sample must be visually identical.

See EXPLORER construction photo #13.

Grid:
The EXPLORER class grid is constructed of ½-inch PVC. The grid is 2.5 m long and 1.5m wide and consists of 0.5 m x 0.5 m squares.

To construct the EXPLORER class grid:

7. Cut sixteen 46 cm lengths of ½-inch PVC pipe.
8. Using the side openings of four ½-inch PVC tees, connect five of these 46 cm lengths of PVC in a line. Repeat this process, connecting five more lengths of pipe with four more PVC tees.

9. Using the side openings of two ½-inch PVC tees, connect three 46 cm lengths of PVC in a line. Repeat this process, connecting three more lengths of pipe with two more PVC tees.

These combined lengths form the outer edge of the grid. The longer lengths should be 2.5m long. The shorter lengths should be 1.5 m long.

See EXPLORER construction photo #14.

10. Attach two ½-inch PVC 90° elbows to the end lengths of PVC on one of the 2.5 m edges of the grid. Attach the side opening of a PVC tee to the end lengths of PVC on the other 2.5 m edge of the grid.
11. Attach the ends of the combined PVC lengths together to form a rectangle approximately 2.5 m long by 2 m wide. All the middle openings of the PVC tees should face inwards.
12. Use two lengths of 2.46 m PVC pipe to connect the tees facing each other on the 2 m sides of the rectangle. Use four lengths of 1.96 m PVC pipe to connect the tees facing each other on the 2.5 m sides of the rectangle.
13. Cut two 1.5 m lengths of PVC pipe. Insert these lengths of pipe into the side openings of the tees at two of the corners of the PVC grid. This 2.5 m edge will be closest to the shipwreck.

The eight debris piles will be placed randomly within the fifteen 0.5 m x 0.5 m squares created by the grid.

See EXPLORER construction photo #15.

Targets:
EXPLORER class targets are constructed from a white, 1 ½-inch PVC end cap with a ring of black, 1 ½-inch ABS set inside the end cap. The back inside surface of the 1 ½-inch end cap will be covered with 1-inch wide, yellow reflective tape (REI online part# 634417, also available at bike shops).

5. Cut a 1 cm length of 1 ½-inch black ABS pipe. Use a saw or heavy wire cutters to cut a 1 mm to 2 mm section from ABS ring.
6. Cut a 4 cm length and two 0.5 cm lengths of 1-inch reflective tape. Attach these lengths of reflective tape to the back, inside surface of the 1 ½-inch PVC end cap.
7. Insert this ABS ring into the end cap, as close to the bottom as possible.

See EXPLORER construction photo #16.

Design note: If ABS is unavailable in your area, cut a 1 cm length of 1 ½-inch PVC and paint it black before inserting it inside the 1 ½-inch PVC end cap.

8. Use screws to fasten the target onto the shipwreck 45 cm from the bottom. Drill a 1/8-inch hole in the center of the PVC end cap and a 1/8-inch hole though the corrugated plastic into a length of PVC 45 cm off the bottom. Use a ¾-inch screw to attach the 1 ½-inch end cap to the PVC pipe.

25 cm to each side of the target will be a black mark. These marks will be 1 cm wide and 4 cm tall and located on the colored corrugated plastic sheet. The marks on the stern of the ship will be black marks on the stern middle cross brace, which is built of ½-inch PVC. The marks will be located 25 cm on either side of the target.

9. Use a black Sharpie or permanent marker to draw the 1 cm x 4 cm mark on the corrugated plastic, 25 cm to each side of the center of the target. Use a black sharpie or permanent marker to draw the mark 25 cm to each side of the target on the stern middle cross bar.

See EXPLORER construction photo #17.

Task #2: Removing fuel oil from the shipwreck

Your company must clear the worksite of debris before attempting to determine if fuel oil remains on board. Clearing the worksite involves removing one of the *SS Gardner*'s masts that had fallen onto an area of the hull above the fuel tanks. Once the mast is removed from the worksite, your company must then clear the hull of encrusting organisms in order to provide a clean, unobstructed working surface. However, one of the organisms is an endangered species of coral. These corals cannot be decimated but rather must be transplanted to a new location.

Examples of coral

Once the hull is clear, your company must confirm the presence of oil within the underlying fuel tank. To accomplish this, your company will use two simulated sensors – an ultrasonic thickness gauge and a neutron backscatter device. The ultrasonic thickness gauge works by measuring the amount of time it

takes for sound waves to travel through the hull and back. It then calculates the thickness based on the speed of the sound through the hull. The readings are instantaneous.

The thickness of the hull is used to calibrate the neutron backscatter device. To assist with calibration, the MATE Center constructed a test or calibration tank and placed in on the bottom near the shipwreck. This tank is filled with oil and water. Based on historical records of the *SS Gardner*, the MATE Center calculated a range of potential thicknesses and constructed the tank so that each wall is a different thickness. The readings from the ultrasonic thickness gauge will determine which wall of the tank should be used to calibrate the neutron backscatter device.

Once calibrated, your company must place the neutron backscatter device on the hull to test for the presence of oil. The device works by emitting high energy neutrons. When a fast neutron collides with a hydrogen atom it releases energy and becomes a slow or thermal neutron. The thermal neutrons are scattered in all directions. Some of these thermal neutrons are scattered back towards and counted by the device. The more hydrogen atoms present in a substance the more thermal neutrons are created and can be detected. Therefore, high readings indicate the presence of oil.

After you complete this task, you can assume that there is oil on board. You can also assume that, because of the deteriorated condition of the hull, you have made the decision to remove the oil. However, it is more complicated than that. Removing the oil is likely to collapse the hull, which could potentially result in damage to the endangered corals and the wreck itself. The survivors and their families are very passionate about the shipwreck. It is your responsibility to keep the wreck site as intact as possible while mitigating the threat of an oil leak.

Your only option is to replace the oil with the surrounding seawater. Your company must penetrate the hull to access the fuel tank, remove the oil, and replace it as you are removing it with seawater. As you are accomplishing this, oil must NOT leak into the environment.

References

- Coral photos http://na.oceana.org/en/category/blog-free-tags/deep-sea-coral and www.esablawg.com/esalaw/ESBlawg.nsf/d6plinks/KRII-7B66S7
- Ultrasonic thickness gauge http://ultrasonicthicknessgauge.org/
- Neutron backscatter device www.scanningtech.com/Neutron_Backscatter.html

This mission task involves:

- **Transporting and attaching a lift bag to a fallen mast.**
- **Inflating the lift bag and removing the fallen mast from the worksite.**
- **Removing endangered encrusting coral from the ship's hull.**

- **Transplanting the coral.**
- **Using two simulated sensors, determine if fuel oil remains inside the fuel tank.**
- **Simulating drilling two holes into the hull and underlying fuel tank by penetrating a layer of petroleum jelly.**
- **Removing fuel oil from within the tank and replacing it with simulated seawater.**
- **Resealing the drill holes with a simulated magnetic patch.**

EXPLORER class scoring – up to 180 points:

- Transporting and attaching a lift bag to the U-bolt on a fallen mast – 10 points
- Inflating the lift bag so that the mast is lifted off the bottom of the pool – 10 points
- Moving the fallen mast so that it does not drag along the bottom of the pool and placing it in a designated area – 10 points
- Removing endangered corals from the hull – 5 points each (10 points total)
- Transplanting the corals to an unoccupied square within the grid – 5 points each (10 points total)
- Using two simulated sensors, determine if fuel oil remains inside the fuel tank – up to 30 points
    - Placing the ultrasonic thickness gauge sensor on the hull – 10 points
    - "Calibrating" the neutron backscatter device by placing it on the calibration tank – 10 points
    - Placing the neutron backscatter device on the hull – 10 points
- Simulating drilling holes into the fuel tank by penetrating layers of petroleum jelly and replacing the fuel oil in the tank with seawater– up to 80 points
    - Seawater begins to flow into the fuel tank – 20 points
    - All of the fuel oil is removed from the fuel tank – 40 points
    - The fuel oil is captured so that it does not leak into the pool – 20 points
- Resealing the drill holes by placing a simulated magnetic patch over each hole – 10 points each (20 points total)

Mission notes

Task #2 must be completed in order. Companies may alternate between task #1 and task #2, but task #2 must be completed in order. Companies may skip any part of task #2, but will not receive points if they complete that part at a later time. All tasks must be completed to receive a time bonus.

The fallen mast will be located against the hull of the shipwreck. EXPLORER class companies must attach a lift bag to a U-bolt on the mast and move the fallen mast to a designated area.

Note: The MATE Center, with support from SUBSALVE USA (www.subsalve.com), will provide a professional SUBSALVE 25 pound lift bag to any EXPLORER class company that requests one. Alternatively, companies are free to engineer or purchase their own lift bag to lift and move the mast to the designated area.

The mast is constructed from1 ½-inch PVC. Cement inside the 1 ½-inch PVC pipe will provide ballast. A U-bolt will be the attachment point for the lift bag.

Once the lift bag is attached, EXPLORER class companies must move the mast and place it in a designated area. The designated area is located on either side of the 2.5 m x 1.5 m grid. When transporting the mast to the designated area, EXPLORER class companies must lift the mast so that it does not drag along the bottom, but do not have to bring the mast all the way to the surface. To successfully move the fallen mast into the designated area, no part of the mast may be touching the grid or shipwreck.

If any part of the mast drifts out of the designated area after being successfully placed, the mission task will be considered incomplete and companies will lose the 10 points that they had been awarded. Companies may attempt to return the mast to the designated area, without penalty, to regain these 10 points. Companies that successfully return the mast to the designated area may still receive a time bonus.

Lift bags must be empty of air before the ROV descends. Companies may evacuate air and fill their lift bag with water during the 5-minute set up period.

The EXPLORER class mast will weigh between 50 and 75 Newtons (between 11 and 16.5 pounds) in water.

After removing the mast from the worksite, EXPLORER class companies must remove encrusting corals from the hull of the shipwreck. These endangered corals must be transplanted into an open grid square. An open grid square is considered a grid square that does not have a debris sample within it. Two corals will be growing on the black ABS sheeting attached to the side of the shipwreck. Both corals will be held onto the side of the hull by Velcro. Both corals must be removed from the hull and placed in an open grid square in order to receive full points for this step and to be eligible for a time bonus. Corals may be placed in the same grid square or different grid squares as needed. Corals do not need to be placed upright within the grid square in order to receive full points. To successfully transplant a coral, no portion of the coral should be touching any part of the PVC grid.

Corals will require less than 1 Newton to detach from the hull of the shipwreck. Corals will weigh less than 1 Newton in water.

After removing both corals from the hull of the ship, companies must gauge the thickness of the hull, use the thickness to calibrate their neutron backscatter device against a calibration tank, and determine if oil remains in the fuel tank using the calibrated neutron backscatter device. Both the ultrasonic thickness gauge sensor and the neutron backscatter device will be simulated.

EXPLORER class companies must create their own simulated sensors. Both simulated sensors may be combined into one unit. Guidelines for creating the sensor are that it must be able to touch the vertical hull of the ship and calibration tank. The sensor must be at least 12 cm long and at least 2 cm in diameter or at least 2 cm x 2 cm square. The sensor should be labeled and identified to the mission station judge during the 5-minute mission set up time.

Once both corals are removed from the hull of the ship, companies must maneuver their vehicle so that the ultrasonic thickness gauge is touching the working surface of the hull of the shipwreck. The working surface of the hull is defined as the 61 cm x 46 cm black ABS sheet. The mission station judge must be able to see through an ROV camera that the ultrasonic thickness gauge sensor is touching this area of the hull for a continuous five seconds. If the sensor comes off of the hull during those five seconds, companies must reposition their vehicle and restart the five second time period. Companies should inform the mission station judge that they are attempting this task and ask the mission station judge to count off the five seconds.

Companies must then pilot their vehicle to the calibration tank to calibrate their neutron backscatter device. The calibration tank is a standard milk crate, approximately 32 cm long, 32 cm wide, and 28 cm tall. The calibration tank will be positioned on the pool bottom within one meter of the working area on the hull of the shipwreck. Companies must maneuver their vehicle so that the neutron backscatter device is touching the wall of the milk crate. The mission station judge must be able to see through an ROV camera that the neutron backscatter device is touching the calibration tank for a continuous five seconds. If the sensor comes off of the calibration tank during those five seconds, companies must reposition their vehicle and restart the five second time period. Companies should inform the mission station judge that they are attempting this task and ask the mission station judge to count off the five seconds.

Once the neutron backscatter device is calibrated, companies can return to the working area of the hull. Companies must maneuver their vehicle so that the neutron backscatter device is touching the working area of the hull of the shipwreck. The mission station judge must be able to see through an ROV camera that the neutron backscatter device is touching the hull for a continuous five seconds. If the sensor comes off of the hull during those five seconds, companies must reposition their vehicle and restart the five second time period. Companies should inform the mission station judge that they are attempting this task and ask the mission station judge to count off the five seconds.

EXPLORER class companies are also tasked with removing, replacing, and collecting the oil from the fuel tank. To prevent the degraded hull from collapsing, EXPLORER class companies must replace the fuel oil with seawater.

The fuel oil will be simulated by pool water colored green and will be located inside a clear tank. The MATE Center will provide simulated seawater to any EXPLORER class companies that wish to use it. The seawater will be simulated by clear saltwater. Companies may provide their own replacement liquid

provided that the liquid contains only water and salt. No other substances may be pumped into the fuel tank or pool.

Companies must access two locations, an inflow port and an outflow port, to effectively remove and replace the simulated fuel oil. Both the inflow port and outflow port are constructed from a 1-inch to ¾-inch PVC reducer bushing. These ports have an outer diameter of 4.2 cm and in inner diameter of 2.6 cm. A lip at the bottom of the bushing has an inner diameter of 2.1 cm. The top edge of both the inflow port and the outflow port will be covered with Velcro loops.

Companies must simulate drilling through the hull by penetrating a layer of petroleum jelly located inside the inflow port and outflow port. The petroleum jelly will be located at the end of each 1-inch to ¾-inch reducer bushing. The layer will be approximately 1 cm to 2 cm thick, will be 2.6 cm in diameter and located 1 cm to 3 cm deep into the reducer bushing. Companies must design a device to penetrate through the petroleum jelly seal on both reducer bushings.

No sharp objects are permitted on the vehicle to puncture through the petroleum jelly. Hypodermic needles, knives, razor blades, etc. are not allowed.

The top edge of both 1-inch to ¾-inch reducer bushings will be covered with Velcro loops.

Design note: Velcro loops are the soft, “wool” side of Velcro.

Any petroleum jelly removed by the vehicle may be left in the pool or returned to the surface with the ROV.

Seawater must be added to the tank through the inflow port. Fuel oil must not leak into the pool, but must be collected from the outflow port.

Companies will receive 20 points once the seawater enters the fuel tank through the inflow port. To receive these points, the mission station judge must be able to see, on a company video display, seawater moving into the fuel tank. Companies will receive an additional 40 points once all of the oil has been removed from the fuel tank. The mission station judge must be able to see, on a company video display, that the entire fuel tank is clear of oil. The judge will inform the pilot when all of the oil has been successfully removed from the fuel tank.

Companies must capture all of the oil that is removed from the fuel tank. Companies may contain the oil onboard their ROV or pump it to the surface. If any of the oil leaks into the pool, companies will not receive points for capturing the oil and will not be able to receive a time bonus.

Once your company is satisfied that you have removed the oil, you must use a magnetic patch to seal both drill holes. Magnetic patches will be simulated by Velcro. EXPLORER class companies must place a Velcro patch over each simulated drill hole.

The Velcro patch will have a diameter of 7.3 cm. The patch must completely cover the entire 4.2 cm diameter of the inflow port and the outflow port.

EXPLORER class companies will be provided with three patches at the mission control shack to patch both openings. If one patch is dropped, EXPLORER class companies may retrieve it from the bottom of the pool, or may return to the surface for another patch. If a second patch is dropped, companies will have to retrieve one of the patches from the bottom of the pool to complete this step of the mission.

EXPLORER companies that do not remove sufficient fuel oil may still receive points for patching the hull. However, once the Velcro patch is placed over the drill holes, companies may not attempt to remove them in order to attempt to remove additional fuel oil. Companies that do not remove all the oil from the fuel tank (and therefore do not receive full points for this task) cannot receive a time bonus.

Mission prop specifications

See the **EXPLORER Construction and Mission Prop Photos and SolidWorks Assemblies and Drawings** documents for visuals.

Mast:

The EXPLORER mast is constructed from 1 ½-inch PVC pipe. The mast is 99 cm tall and 71 cm wide. A 2 ½-inch U-bolt will be the attachment point for the lift bag. Six lengths of rope hang from the mast. Cement weights in the bottom of the mast will provide ballast.

To construct the mast:

3. Cut a 70 cm length, two 30 cm lengths, two 20 cm lengths, and a 15 cm length of 1 ½-inch PVC pipe.
4. Take the 15 cm length of 1 ½-inch PVC pipe and drill a pair of 7/16-inch holes. These holes must be spaced approximately 7.5 cm apart and be parallel along the pipe. The distance between these two holes should correspond exactly to the length between the two ends of a 2 ½-inch U-bolt. The EXPLORER class U-bolt is 8.1 cm wide (ACE Hardware part# **5230214**:3/8-inch x 2 ½-inch x 3 5/8-inch U-bolt). The U-bolt will stick out 7.5 cm from the mast. Use lock nuts to secure the U-bolt in place.

Design note: The 15 cm length of PVC pipe with the U-bolt is recycled from the 2011 EXPLORER class missions. It was used in 2011 as the connection point for lifting the riser pipe off the oil well.

5. Insert the two 20 cm lengths of 1 ½-inch PVC pipe into opposite openings on a 1 ½-inch PVC cross. Insert the 70 cm length of pipe into a third opening of the PVC cross. Insert the 15 cm

length of pipe with U-bolt into the fourth opening of the PVC cross. Adjust the angle of the U-bolt so it is set at a 90° angle from the mast.

6. Attach a 1 ½-inch end cap to the other end of the 15 cm length pipe with the U-bolt. Drill holes into the end cap to allow air to escape from the mast.
7. Attach the middle opening of a 1 ½-inch PVC tee to the other end of the 70 cm length of 1 ½-inch PVC pipe.
8. Attach a 1 ½-inch end cap to one end of each 30 cm length of 1 ½-inch PVC pipe.
9. Fill both 30 cm lengths of PVC pipe with cement. When the cement is dry, insert these 30 cm lengths into the side openings of the 1 ½-inch PVC tee.
10. Add additional cement into the 70 cm length of pipe (companies will have to remove the 70 cm length of pipe from the cross) to achieve the desired weight in water.

The EXPLORER class mast will weigh between 50 and 75 Newtons (between 11 and 16.5 pounds) in water.

11. Drill three 3/16-inch holes in each of the 20 cm lengths of 1 ½-inch PVC pipe (six holes total).
12. Cut six lengths of 1/8-inch braided nylon and polypropylene rope (Home Depot part #**140-287**, ACE Hardware part #**75851**). The lengths of rope should vary from 25 cm to 75 cm long. Insert one end of each length of rope into the holes drilled through the pipe and tie and overhand knot to secure them in place.

See EXPLORER construction photo #18.

Coral:

The coral is simulated using chenille stems (pipe cleaners) set into a ½-inch PVC end cap base.

To construct a coral:

9. Cut three 30 cm long, pink pipe cleaners into six 15 cm lengths. Cut four 30 cm long, white pipe cleaners into eight 15 cm lengths.
10. Drill an 1/8-inch hole 0.5 cm off center in the bottom of a ½-inch PVC end cap. Insert 4 cm of a white pipe cleaner through this hole. Twist the end of the pipe cleaner into an overhand knot so that it is secured in the end cap.
11. Drill a pair of 3/16-inch holes on opposite sides of the wall of the ½-inch PVC end cap. Insert a small cable tie through both holes on the side of the end cap, over the top of the end cap and over the white pipe cleaner coming out the top of the end cap. Pull the cable tie to secure the pipe cleaner tightly against the surface of the end cap.
12. Take a 15 cm length of pink pipe cleaner and twist the middle of it twice around the white pipe cleaner, about 1 cm up from the end cap. 7 cm should extend from each end of the twist.
13. Take two 15 cm lengths of white pipe cleaner and twist the middle of each around either length of the pink pipe cleaner, about 1 cm up from the base.
14. Repeat until all 15 cm lengths of pipe cleaner are used.

15. Bend the ends of all pipe cleaners upwards, away from the end cap.
16. Cut a 3 mm by 4 cm length of Velcro loops. Attach the Velcro strip to the base of the end cap, placing one end approximately 1.5 cm inside the end cap, and the other end outside the end cap.

See EXPLORER construction photo #19.

Coral will be placed onto the working surface (black ABS sheeting) of the shipwreck.

1. Cut two 5 cm x 5 cm lengths of Velcro hooks. Attach the two squares of Velcro to the center of the black ABS sheeting using the adhesive on the back of the Velcro hooks. The two squares should be located approximately 15 cm to 20 cm apart, halfway down the ABS sheet.

Ultrasonic thickness gauge sensor and neutron backscatter devices:
EXPLORER class companies are tasked with building their own simulated ultrasonic thickness gauge sensor and neutron backscatter device. Both simulated sensors may be combined into one unit; in other words, once device can serve as both sensors. The sensor must be able to touch a flat, vertical surface. The sensor must be at least 12 cm long. The sensor must be at least 2 cm in diameter or at least 2 cm x 2 cm square.

EXPLORER class companies may attach the sensors to their vehicle by any method they choose.

Calibration tank:
The calibration tank will be simulated by a milk crate.

3. Use cable ties to attach a 34 cm x 34 cm length of colored corrugated plastic to the top of a milk crate.
4. Turn the milk crate on its side and add sufficient weight to secure it to the bottom of the pool.

The neutron backscatter device must be held to the 34 cm x 34 cm sheet of corrugated plastic surface for five seconds.

Design note: Check sign-making/printing stores for colored corrugated plastic sheeting. Alternatively, use 1/8-inch black ABS sheeting, Plexiglas or Lexan.

Fuel Tank:
The fuel tank is simulated by two clear Lexan sheets around a rectangle of ½-inch PVC.

To construct the tank:

1. Cut two Lexan sheets 20 cm x 12.5 cm. Smooth or snip the corners off for safety.
2. Cut two 15 cm lengths and two 7 cm lengths of ½-inch PVC pipe.

3. Attach two ½-inch 90° elbows to both sides of a 7 cm length of pipe. Adjust the angle of the elbows so both opening face the same direction.
4. Drill five ¼-inch holes into the inside edge pipe and 90° elbows.
5. Insert both 15 cm lengths of ½-inch PVC pipe into the openings of the two 90° elbows. Attach the side opening of a PVC tee to the other end of each 15 cm length of pipe. Face the two middle openings of the PVC tee towards each other.
6. Take the remaining 7 cm length of PVC pipe and tape over one end. Use 5-minute or other epoxy to form a 1 cm long plug in the taped end of this 7 cm length of pipe. Once the epoxy has dried, remove the tape.
7. Drill three ¼-inch holes into the 7 cm length of pipe. Insert the pipe between the two PVC tees in the tank framework. Rotate pipe so that the drill holes are along the inside edge of the framework.

See EXPLORER construction photo #20.

The dimensions of the PVC framework rectangle should be approximately 21.5 cm x 13.5 cm. The Lexan sheets fit over both sides of this framework and are waterproofed with caulking or silicone.

1. Cover one edge of the framework completely with a thick ring of caulking or silicone. Press one 20 cm x 12.5 cm sheet of Lexan into the caulking or silicone.
2. Secure the Lexan to the PVC framework with four sheet metal screws.
3. Cover the other edge of the framework completely with a thick ring of caulking or silicone. Press the other 20 cm x 12.5 cm sheet of Lexan into the caulking or silicone.
4. Secure the Lexan to the PVC framework with four sheet metal screws.

Design note: Properly placing the 8 screws (4 per side) will allow you to secure the four lengths of PVC pipe into the elbows and tees.

Allow the caulking or silicone to dry overnight. Test to insure the tank is watertight. Add additional caulking or silicone as necessary to make the tank watertight.

To construct the inflow port and outflow port:

1. Cut a 10 cm length of ½-inch PVC pipe.
2. Attach a 1-inch to ½-inch reducer bushing (Home Depot part# 438-130HC, DuraPlastics Online #C437-130) to one end of the 10cm length of pipe.
3. Attach a 1-inch coupling to the reducer bushing. Insert a 1-inch to ¾-inch reducer bushing (Home Depot part #437-131HC, Home Depot Online part# C437-101, Home Depot SKU# 188042, DuraPlastics Online #C437-131) into the other side of the 1-inch PVC coupling.
4. Spray paint the 1-inch coupling of the inflow port green. Spray paint the 1-inch coupling of the outflow port silver.

5. Cut Velcro strips and cover the entire top surface of the 1-inch to ¾-inch reducer bushing with Velcro wool.
6. Use PVC glue to secure the reducer bushings and couplings together.

See EXPLORER construction photo #21.
See EXPLORER construction photo #22.

7. Add a layer of petroleum jelly (Vaseline) to the 1-inch to ¾-inch reducer bushing. The petroleum jelly should completely fill the entire diameter of the bushing and should be 1.5 cm to 2 cm thick.

The fuel tanks will hold less than 1.5 liters of green colored water.

Design note: Check pharmacies/drug stores for petroleum jelly.

Fuel oil and seawater:
For the fuel oil, add 8 drops of green food coloring per 1.0 liters of water. The simulated seawater provided by the MATE Center will have 125ml (1/2 cup) of salt per liter of water.

Patch:
The contact surface of the patch is constructed from a 3-inch knockout cap (Home Depot part# 39102, SKU#508260, Home Depot online# 39102) covered with Velcro hooks.

To construct the patch:

8. Use heavy wire cutters or dykes to cut the pull tab from the 3-inch knockout cap.
9. Place the top of a ½-inch PVC end cap onto the center of the bottom side (non pull tab side) of a 3-inch knockout cap.
10. Use two #6 ½-inch sheet metal screws to secure the end cap onto the 3-inch knockout cap. The heads of the screws should be on the top side flat, 7.3 cm side of the knockout cap (the side the pull tab was removed from).
11. Cut an 8 cm length of ½-inch PVC and insert it into the end cap.
12. Drill a pair of 3/16-inch holes in the 8 cm length of pipe approximately 0.5 cm from the end.
13. Cut a 20 cm length of 1/8-inch braided nylon and polypropylene rope. Insert one end of the rope through a drill hole from the outside to the inside of the pipe. Tie an overhand knot to secure the rope inside the pipe. Insert the other end of the rope through the other drill hole, from the outside to the inside of the pipe. Tie an overhand knot to secure the rope inside the pipe.
14. Cover the entire top of the 3-inch knockout cap, including the heads of the sheet metal screws, with Velcro hooks.

See EXPLORER construction photo #23.

ENGINEERING & COMMUNICATION

Spec sheets, technical reports, engineering presentations, and poster displays

The ability to effectively communicate information about your vehicle and the design and building process is equally as important as how well your vehicle performs. To emphasize this point – in addition to the ROV– the competition requires spec sheets, technical reports, engineering presentations, and poster displays.

This document, **Engineering & Communication**, contains information about the EXPLORER and RANGER class spec sheet, technical report, engineering evaluation, and poster display requirements. The **SCOUT Class Competition** document contains engineering and communication information relevant to the **SCOUT** class.

COMPETITION SCORING OVERVIEW

The competition consists of underwater missions, technical reports, engineering presentations, and poster displays with the following scoring breakdown:

- Mission
  - **EXPLORER** – 300 points (max), plus a time bonus
  - **RANGER** – 300 points (max), plus a time bonus
- Engineering & communication – 200 points (max)
  - Technical reports – 80 points (max)
  - Engineering evaluations – 80 points (max)
  - Poster displays – 40 points (max)
    - INTERNATIONAL COMPETITION TEAM ONLY – 5 bonus points (max) for media outreach (see **Poster Display** section below)

REGISTER WITH ALUMNIWEB (www.marinetech.org/alumni)

Each student and instructor/mentor participating in the MATE competition is **required** to register (or to update his or her information) with MATE's AlumniWeb, a web site designed to help MATE follow the progress of students, instructors, mentors, and others who have participated in MATE's programs. AlumniWeb also helps the MATE Center to demonstrate the impact of the competition program to its funding agencies, which in turn helps the MATE Center to continue to offset expenses associated with the competition events.

Students and instructors/mentors are required to complete the entire AlumniWeb form. Note that personal contact information provided to MATE's AlumniWeb is confidential and is only viewed by MATE Center staff and MATE's independent evaluator. It will not be shared with anyone outside of the MATE staff or evaluator. Visit www.marinetech.org/alumni for details and to register.

THINK OF YOURSELVES AS ENTREPRENEURS

Once again this year the MATE competition is asking you to think of yourself as an entrepreneur. What is an entrepreneur and what skills does he or she possess? An entrepreneur organizes and manages a project or company – especially one that is challenging, involves some risk, and requires energy and creativity. The skills that are needed for such an undertaking include an understanding of the breadth of business operations (from finances to research and development to marketing), the ability to work as an integral part of a team, and the ability to apply technical

skills in new and creative ways. Entrepreneurs are innovative thinkers (and tinkerers!) who can use their resourcefulness to quickly adapt to changing work environments.

As entrepreneurs participating in the MATE competition, your first task is to create a company or organization that specializes in solutions to real-world marine technology problems. Questions to help guide you in this process are included in the **Competition Missions** document. This document builds upon those questions and challenges your company to prepare documentation, displays, and presentations that help to "sell" your products and services to your client, the MATE Center.

AWARD CATEGORIES AT INTERNATIONAL COMPETITION

In addition to the awards based on point scoring (e.g. missions, technical report, engineering presentations, and poster), the MATE Center presents awards in the following categories:

- Sharkpedo award
- Biggest Bang for the Buck
- Design Elegance
- Safety Conscious
- Aloha Team Spirit
- Guts & Glory
- Engineering MVP awards
- Flying Fish award
- gROVer award
- Martin Bowen Memorial Inspiration for Future Engineers award

For a description of each of these award categories and the 2011 award winners, visit www.materover.org or www.marinetech.org/rov_competition/archive.php.

COMPANY SPEC SHEET (ONE PAGE ONLY)

Your company is required to submit a one-page "company spec sheet" along with your technical report (see below for information about the report). The goal of the spec sheet is to provide the judges with a "snapshot" of your company. It includes basic information about your company and vehicle.

Companies must submit their spec sheets to the MATE competition coordinator 4 weeks prior to the competition date. (Note that regional contests' deadlines may vary. See www.materover.org under the COMPETE tab > Regional Contests for more information.) **The spec sheet should be sent to jzande@marinetech.org as a pdf attached to an e-mail or as a pdf saved on a CD-ROM or DVD and snail-mailed to the MATE Center. The spec sheet should NOT exceed one page in length and should follow the font style requirements of the technical report.**

The only exception to this one-page limit is EXPLORER class teams that are documenting the modifications made to their vehicles between their demonstration and the international competition. See the **General Information** document for details about the EXPLORER class demonstration and the requirement to submit a list of modifications along with the spec sheet.

Spec sheets must include the following information:

COMPANY SPECS

- **Company and school, club, or community organization name**
- **Home state**
- **Distance required to travel to the international competition**
- **History of MATE ROV competition participation.** Be sure to specify if your company and/or the members of your company are "new" or "returning." If your company has participated in a regional contest before but this is your first trip to the international competition, please indicate that, too.
- **Company photo and caption indicating members' names and roles (e.g. CEO, CFO, Design Engineer, Pilot, etc.).** This photo should include all of the members of your company, especially those planning to travel to the international event.
- **Range of grade/college levels represented by the members of your company**

ROV SPECS

- **ROV name** if applicable
- **Total cost.** Be sure to include the approximate cost of any donated items.
- **Primary material(s) used in construction** (e.g. PVC, aluminum, acrylic)
- **Approximate dimensions in metric units**
- **Total weight in air in kilograms**
- **Safety features**
- **Special features**
- **Photo of the vehicle**

TECHNICAL REPORT

Prior to the competition, your company is required to submit a technical report that will be reviewed and evaluated by a panel of working professionals – individuals who represent science, exploration, government, and industry. (These individuals may not be the same judges who evaluate your company's engineering presentation.) Keeping a project notebook is a good business practice that will help your company with this report. Documenting your company's progress, including your research, designs (regardless of whether or not they work), experiments, vehicle specifications, testing, expenditures, and donations, will provide you with both content and reference information to help you organize your report.

Technical reports must be submitted to the MATE competition coordinator 4 weeks prior to the competition date. (Note that regional contests' deadlines may vary. See www.materover.org under the COMPETE tab > Regional Contests for more information.) **The report should be sent to jzande@marinetech.org as a pdf attached to an e-mail or as a pdf saved on a CD-ROM or DVD and snail-mailed to the MATE Center. The report should not exceed a file size of 2MB.**

Any changes or additions that you make to your ROV that differ from the information in the technical report that you submit should be presented to the judges as part of your poster display and during your company's engineering presentation. **Note that the judges will not review and rescore revised versions of your technical report during the competition.**

Each judge on the panel will award a technical report score (80 points max). Judges' report scores and comments will be returned to you shortly after the event.

Examples of technical reports from previous competition years are posted on the competition web site at www.marinetech.org/rov_competition/report_examples.php.

The guidelines and required components for the report are:
Note: Make sure to label any and all figures, graphs, diagrams, and photographs.

- **Length is less than 20 pages***
- **Font size of at least 12 points (font type can vary)**
- **All measurements are in SI units (metric)**
  Exceptions include ½-inch PVC pipe and other items described or sold in imperial units.
- **Title page** that includes:
  - Your company's name
  - School, club, or community organization's name, city, and state. If you are an international company, include the city and country.
  - **COMPLETE** list of the members of your company and their role (CEO, CFO, Design Engineer, Pilot, etc.). 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.
- **Table of contents**
- **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 photos 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, travel stipends, etc.) that were donated, the organization or individual who made the donation, and an estimate of the item's value. A sample expense/budget sheet is provided on the competition web site at www.materover.org under the COMPETE tab > Missions & Specs showing 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).
- **Block-diagram or flow-chart of software in the ROV (if applicable)**
  This flow diagram should detail the software code written for your control system or other elements of your ROV. If you are using a purchased control system that utilizes software, you are encouraged to learn about its operation and describe it in a diagram.
- **Design rationale** presented in a clear and logical manner. This section should comprise the bulk of your report. It should focus specifically on the technical aspects of your vehicle and include a discussion of how your ROV was built/adapted to perform to the specific mission tasks.

- **Description of at least one challenge** that your company faced and what methods were used to overcome it. These can include both technical challenges and those related to working as a team.
- **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**
  In this case, the MATE Center is your "client" and has defined both the problem and the products and services you need to provide. However, future clients could include research institutions, oil companies, and government agencies. A synopsis of ideas for future improvements is essential to any entrepreneurial organization.
- **Reflections on the experience**
  This can be written from the point of view of your company as a whole or each individual member of the company can contribute a reflection. It can include personal or professional accomplishments achieved as a result of participating in the competition.
- **References**
  List any books, journal articles, magazines, trade publications, web sites, and professional advice that you used as sources of information for your work.
- **Acknowledgements**
  Please recognize the companies, organizations (including the MATE Center), professionals from industry, and/or mentors who helped to support your company by donating funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise. You can include organizations and/or individuals that provided logistical and/or moral support (e.g. your parents, siblings, or pets). Companies competing in regional events should also acknowledge regional contest supporters.

*You are permitted to include appendices that exceed the 20-page limit if the appendices are critical to explaining a particular aspect of your vehicle. However, judges reserve the right to deduct points for excessive use of appendices.

ENGINEERING EVALUATION

During the competition, your company is required to give a 15-minute presentation to a panel of working professionals – individuals who represent science, exploration, government, and industry. (These individuals may not be the same judges who evaluate your company's technical report.) Your presentation should describe the engineering behind your vehicle's design and operation and address any possible safety issues. It should also highlight any design innovations or creative solutions to solving the mission tasks. After the presentation, the judges will take 10-15 minutes to ask the members of your company questions about your ROV. The judges will evaluate both your presentation and responses to their questions.

Instructors, mentors, family members, friends, and members of other companies are permitted to attend this evaluation. However, we ask that those in attendance be respectful and courteous throughout the presentation and follow-up question and answer period. Be mindful that this evaluation may be a stressful time for the students who are presenting. If the room becomes crowded or the spectators become distracting, it is up to the judges' discretion to request that some or all spectators leave the presentation. **While they are permitted to attend, instructors and mentors are not allowed to participate in the interview process.**

Who presents?
All student members of your company must participate in this presentation and question and answer period. You can choose to designate one member to give the complete, 15-minute talk or divide topics up among one, two, or all of the members of your company. You are required to have your ROV with you. **You are also required to bring an electronic copy of your software code, if applicable, and a print-out of your electrical schematic.**

MATE will not provide audio visual aids, such as slide projectors, computer projection screens, white boards, etc.; however, you are welcome to bring your own. You are also welcome to distribute handouts to help judges better understand the information that you are presenting. During the question and answer period, all members of the company must be present and prepared to answer.

Each judge on the panel will award an engineering score (80 points max). Judges' engineering scores and comments will be returned to you shortly after the event.

The judges' panel will focus on the features of your ROV's design and the process that went into building the vehicle. The judges will pay particular attention to whether or not the vehicle was built by the students from "scratch" or excessively uses complete, off-the-shelf systems. The use of complete, commercially-available systems is highly discouraged (see **Design & Building Specifications and Competition Rules** for more information on this topic). Design originality and innovation as well as safeguards to prevent injury or damage to the underwater environment will be noted.

Here are some examples of questions that the judges may ask. **NOTE: These are only examples and may not be the actual questions asked.** Your team must be prepared to answer questions other than those examples listed below.

Structure
- How did you decide on the shape of the vehicle and the materials used to build it?
- What is the design depth rating of your ROV? Did you test this? How?
- Did you use any pressure housings 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 in air? In water?

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?
- 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.
- 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 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 type of payload tool(s) did you design to accomplish the mission tasks and why?
- Explain how the 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 systems exhibit unique concepts?
- Does the vehicle make excess use of commercially-available systems?
- Are there any innovations or modifications that resulted in higher functionality and reduced costs?
- If you are using the same vehicle as last year, why? What are the advantages? What, if any, modifications or additions did you make?

Workmanship

- What is the overall quality of the workmanship?
- Are the electrical systems neatly contained and wired?
- Is it easy to access components for maintenance?
- Is the tether neatly bundled and protected?
- Can the tether withstand the strain from the vehicle weight, handling, and operation?
- Does the vehicle look aesthetically pleasing yet have practical functionality?

Safety

- What potential safety hazards did you identify then address?
- Are warning labels and safeguards posted on potentially hazardous components?
- Did your team develop a safety checklist or protocol?

Theme

- What role do ROVs play in the competition theme?
- What organizations or individuals work closely on the competition theme?
- What is one recent technological advance that could benefit the competition theme?

Preparing for your engineering presentation and evaluation

- Make sure that every member of your company has a good, general working knowledge of your vehicle, even though they may have specialized in one specific aspect of its design and construction.
- Your company should keep a project notebook. Project notebooks are good practice and 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 technical report (see **Technical Report** above). Write down relevant technical and procedural issues 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 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 among the members of your company.
- Produce clear, simplified diagrams that you may choose to use in your presentation.
- Make sure that your vehicle is complete and in working condition.
- Write a concise technical report (see **Technical Report** above) and make sure all the members of your company have contributed to it. Ask every member to read it over to catch any errors or omissions. This exercise will help to familiarize everyone with all aspects of the project.
- Practice your presentation. Generally, you will have more to say about your ROV than can be presented in 15 minutes. That is why it is critical to organize your material and practice communicating it. Ask 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 company is prepared and knows the material well, you will all be more comfortable and confident. This will come across favorably to the judges.

Note: The engineering presentation is designed to be a face-to-face interaction where students and representatives from industry become engaged in conversation. To that end, PowerPoint presentations are discouraged, but not disallowed. However, if your company chooses to create a PowerPoint presentation, you are responsible for supplying a laptop, LCD projector, screen, and/or other devices and materials needed to present your PowerPoint.

Other important items

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

- Your company is discouraged from using off-the-shelf, plug-and-play systems. You are encouraged to demonstrate innovation and creativity in the construction of your vehicle and its systems. This will also be reflected in your engineering evaluation score.

POSTER DISPLAY

Your company is required to create a poster that will be on display during the competition event. Your poster display should be an informative, clear, and concise marketing presentation about your company and how you designed and built the specialized tools to effectively complete the mission tasks. During the competition, your company's display will be evaluated and scored by a completely different group of working professionals – individuals who will represent science, business, government, industry, and education/outreach.

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

Each judge will award a poster score (40 points max). Judges' poster scores and comments will be returned to you shortly after the event.

INTERNATIONAL COMPETITION ONLY! MATE will provide each company with one 3-panel, free-standing 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

Note: You are welcome to bring your own poster display board, but the space that the text and photographs/graphics occupy CANNOT exceed 36" tall by 48" wide. For example, company names CANNOT be mounted above the poster board. NO EXCEPTIONS!

For more details about the display board, visit www.staples.com and search for project display board item #922528. MATE will also provide scissors, tape, glue sticks, adhesives, and other means of attaching display items to the presentation board, although you are also welcome to bring your own.

The guidelines and required components for the poster display are:

Note: Keep in mind that, with 60+ posters to score, the judges will have approximately 10 minutes to evaluate your poster. Make key points. Be concise. Keep the general public (a.k.a. potential future clients) in mind. **Also, make sure to label any and all figures, graphs, diagrams, and photographs.**

GENERAL GUIDELINES

- **Font size that is clearly legible from a distance of 1.5 m**
- **Choose a font style and use it throughout**
- **All measurements are in SI units (metric).** Exceptions include ½-inch PVC pipe and other items described or sold in imperial units.
- **Include headers (see REQUIRED COMPONENTS below)**
- **Photos should be clear and high-quality for the print sizes that you choose**
- **EVERY PHOTO MUST HAVE A CAPTION!** No caption = no credit for that photo. Also include photo credits if the photo was not taken by someone in your company.
- **Items that you MAY include in your poster or have on display include:**
    - Diagrams or sketches (CAD drawings, for example). Make sure they are understandable to a general, non-technical audience; if they are not, do not include them.
    - Photo journals
    - Copies of your company's technical report
    - Resumes of the members of your company
- **Items that you MAY NOT include in your poster:**
    - Flip charts on the poster board
    - Video screens on or in the actual poster board

REQUIRED COMPONENTS

Note: The following are REQUIRED headers. These headers not only assist the judges in evaluating your display, they also make your poster easy to read.

- **Company name and school, club, or community organization name**
  Make sure that your company name is in large, bold font (larger than any other font on your poster). Include your school, club, or community organization name as well as your company name. Include your geographic location (i.e. city and state). If you are an international company, include the city and country.
- **Abstract (concise – 250 word limit)**
  Include a written introduction to your company and how your company designed and built specialized tools to effectively complete the mission tasks. Make sure to relate the mission to how ROVs can be used in real shipwreck exploration and management. Don't assume that your audience knows what an ROV is or the details about potentially polluting shipwrecks from World War II.
- **Company information**
  Include photo(s) (group or individual) of all of the members of your company. Provide a brief description of each member. This description should include the person's name, role in the company (e.g. CEO, CFO, design engineer, pilot, marketing and communications specialist, etc.) and their qualifications, such as grade level, major or area of expertise, career goals, etc.
- **Design rationale**
  This section should be the bulk of your poster display. It will be worth the most points.
    - Why did your company build your ROV the way that you did?
    - Include photos of your ROV. Make sure to highlight the various systems of your vehicle.

- Include photos or drawings (by CAD or by hand) of any special features of your vehicle and how these features relate to the mission tasks, safety, general operations, etc. This is the most important part of your design rationale.

- **Company evaluation**
  Answer the following questions:
  - What was the most rewarding part of this experience?
  - If you were to do this again, what would you do differently?

- **Theme**
  The management of World War II shipwrecks is a hot topic, capturing the attention of government agencies, scientists, engineers, technicians, and the general public. After years on the seafloor, the hulls of these wrecks have suffered the corrosive effects of seawater and are further deteriorating with every passing year. With the possibility of fuel oil and other hazardous materials still on board, the clock is ticking on how to prevent a potentially catastrophic environmental disaster.

  Assessing the condition of these shipwrecks and determining what, if any, hazardous materials remain on board is the "easy" part. Deciding what to do about these materials (and how to do it) is the much more difficult – and potentially controversial – task. Where there was loss of life, these wrecks are considered war graveyards that many feel should remain undisturbed. However, if they are left alone and oil should release from the deteriorated hulls, who's responsible for the ensuing environmental damage? What country, countries, or other organizations are responsible for the cost of clean-up and mitigation? In addition, the current United Nations Educational, Scientific and Cultural Organization (UNESCO) treaty on submerged cultural resources will apply to WWII shipwrecks once they turn 100 years old. At that time they will become designated "underwater cultural heritage" sites, which have their own set of restrictive rules and regulations for exploration.

  Dealing with these shipwrecks is more than an engineering issue – it's an issue of responsible exploration that must take into consideration environmental as well as philosophical, political, and socioeconomic concerns.

  This section challenges you to research, consider, debate, and form an opinion on these "tough" issues. Rather than regurgitating information that you find on the Internet, take the time to think through the challenges that decision-makers are confronted with in managing these shipwrecks. You can focus on one aspect (the UNESCO treaty, for example) or cover several. In addition to the Internet, you are encouraged to contact individuals (maritime heritage personnel at your local National Marine Sanctuary, for example) who can offer their views.

- **Acknowledgements**
  Please recognize any companies, organizations (including the MATE Center), professionals from industry, and/or mentors who helped to support your company by donating funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise. You can include organizations and/or individuals that provided logistical and/or moral support (e.g. your parents, siblings, or pets). Regional competition teams should also acknowledge regional contest supporters.

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

NEW IN 2012!!! BONUS POINTS FOR MEDIA OUTREACH FOR INTERNATIONAL COMPETITION PARTICIPANTS ONLY

Companies that participate in the international competition can earn bonus points by writing a press release and working with their local media to publicize their company's participation in the competition. This can help your company gain community support, media exposure, and local sponsorship.

Include your press release and the results of your media campaign as part of your poster display. **The media outreach component is worth 5 bonus points, in addition to the 40 total points awarded for the poster display.**

Media outreach consists of:

- Developing a list local media contacts
- Writing a press release about your participation in the MATE ROV competition
- Distributing it to your media contacts
- Following up with your media contacts to see if they're interested in your company and its ROV
- Compiling a summary of results
- Submitting your results via your team registration form.

Please submit a copy of your press release, a copy of your media contacts list, and a summary of news articles, TV or radio coverage, etc. that your team received. Include copies of articles and URLs, and list any television or radio coverage. Be sure to include name of outlet, date, and a summary of the coverage.

Media Relations Guidelines (for International ROV Competition Participants ONLY)

Here are some general guidelines for working with the media.

1. You should begin your media effort about 4-5 weeks before the competition (which is from June 21 – 23, 2012).

2. Write a press release highlighting your team's involvement in the upcoming MATE competition. If you participated in a regional, feel free to talk about it and how you performed. It doesn't have to be more than 1-1 ½ pages, double-spaced. Be creative. For example, you could find out if there are any World War II shipwrecks, or other potentially hazardous shipwrecks in your local ocean or lake and weave that information into your press release. A sample release follows these guidelines below.

3. Develop a list of community news media contacts, including newspapers, magazines, radio stations with public service announcements and local news, television news programs, and

local online news reports or blogs. If your town is small and doesn't have any media outlets, reach out to those in the city or large town that's closest to you.

4. Try to find the name and email address of a reporter who covers education or technology—they're the ones that will be most interested in your story. You can often find this information online, or you may have to call the media outlet and speak with a receptionist to find out who the most appropriate contact is and how to reach them. Usually, email is the best way to contact a reporter.

5. Become familiar with the news outlets and the reporter that you're going to "pitch" your story to. For example, learn if they've written about your school before, or what kinds of news stories they tend to develop.

6. Compose an email introducing yourself, your team, and your school. Tell them that you're participating in the Marine Advanced Technology Education (MATE) Center's international ROV competition, which will be held in June 2012 in Orlando, Florida. Explain what ROV stands for, and tell them how ROVs are used in the real world. Give examples of the skills that you and your teammates have learned by designing, building, and piloting ROVs. You may have already written some of this information for your poster display or engineering report.

7. Reporters are interested when a local team is participating in an international event. So make sure to let them know that the MATE competition is an international competition, funded by the National Science Foundation, the Marine Technology Society ROV Committee, and other international organizations and businesses, and that teams from all over the world participate.

8. Copy and paste the release below your email. (Reporters in general prefer cut and pasted releases to opening up an attachment.) If you have any photos of your team and/or ROV, especially a photo of your vehicle in action, feel free to attach the photo to the email. Explain to the reporter what's going on in each photo you attach.

9. Make sure you include your name and a phone number where the reporter can reach you. Also include MATE's media contact information and let them know they can contact her if they want more specific information about MATE or the competition. MATE's media contact is Caroline Brown at caroline@carolinebrown.com, or (401) 338-8980.

10. After you've emailed your media contacts, wait for a week and email them a reminder if you don't hear back from them. You can simply forward the original message to them.

11. If a reporter calls and wants more information, be creative about how you provide it. Offer to give interviews with a few of the team members, your mentor, or even a key sponsor. Invite them to meet you at the pool to see your ROV in action. Ask them if they want to try piloting the ROV on their own. If they want to speak with someone from MATE, give them the MATE media contact information from above.

12. If your team receives media coverage, save a paper copy of print or Internet coverage. For radio or TV stories, include the URL to the video or audio if available. If not list the station, name of reporter, date and time of broadcast and summary of the broadcast.

13. To earn the five extra points, you must include as part of your poster display:
    - a copy of your press release
    - a sample of your "pitch" email
    - your list of media contacts
    - copies or lists/summaries of media coverage

IN ADDITION, you must also enter the following media citation information into the appropriate fields within your team registration form:

- Media name:
- Location:
- Type of media (TV, radio, etc.)
- Date:
- Headline or Title:
- Reporter name:
- URL (If available):

NOTE: These fields will be added to your team registration form later this spring.

Below is the sample press release to help you get started.

East Lake Charter School Team to Participate in International Underwater Robotics Competition

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Local students develop underwater technologies to assess World War II shipwrecks at MATE International ROV Competition in Orlando

May 15—Saginaw, Mich.—A team from the East Lake Charter School has been selected to compete the Marine Advanced Technology Education (MATE) Center's 11th Annual International Student ROV Competition. Remotely operated vehicles, or ROVs, are tethered underwater robots used to complete tasks in underwater environments. The East Lake team will compete against more than fifty teams from around the world, using an ROV that they designed and built during the past 6 months.

At the International ROV Competition, which will be held June 21-23 in Orlando, Florida, East Lake Charter will compete against the top teams from MATE's network of 21 regional competitions. East Lake Charter was one of the winners in the MATE Great Lakes Regional ROV Contest, which was held in April.

Each year, MATE's ROV competition encourages students to learn and apply science, technology, engineering, and math skills to complete tasks that simulate real-world problems from the ocean workplace. This year, the contest focuses on the role that ROVs play in assessing World War II shipwrecks and the potentially hazardous fuel oil that they may still contain.

World War II was the first war in which oil was indispensable. Ships transporting oil were prime targets for attack. Seventy years later, many of these vessels have decayed to the point that their cargo is a potential environmental disaster. Over 8,500 oil-bearing ships, more than 6,300 of them from the World War II era, lie at the bottom of the world's oceans and even in bodies of water like the Great Lakes.

Teams will participate in mission tasks, piloting their ROV to assess the condition of a simulated shipwreck and determine a course of action if oil is still on board. In addition, they must prepare an engineering report, make a presentation to a panel of judges, and create a poster display.

This is the fifth year that East Lake Charter has participated in the Great Lakes Regional ROV Contest, and the third year it has attended the MATE International ROV Competition. The team members are:

- Jill Zande
- Deidre Sullivan
- Erica Moulton
- Matt Gardner
- Candiya Mann
- Scott Fraser
- Jeremy Hertzberg

East Lake Charter's ROV team is supported by local sponsors, including Tom's Hobby Shop, East Bay Marina, and Schaumberg Electronics.

For more information about the East Lake Charter School ROV team, please contact Matt Gardner at (831) 555-1234 or matt@gardner.com.

For more information about the MATE ROV competition, visit www.materover.org or contact Caroline Brown at (401) 338-8980 or caroline@carolinebrown.com.

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