2011 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 20 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 the offshore oil and gas industry and focuses on the challenges that they faced during the Gulf of Mexico oil spill. The mission tasks include removing a damaged riser pipe, capping a wellhead, collecting a water sample, measuring depth, and sampling organisms.

2011 marks the 10th year of international competition. The event is being hosted by the Neutral Buoyancy Lab (NBL) at the NASA Johnson Space Center in Houston, Texas June 16 – 18, 2011.

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 the offshore oil and gas industry and the challenges they faced during the Gulf of Mexico oil spill.

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.

NEW IN 2011 – PARTICIPATION FEE FOR EXPLORER AND RANGER TEAMS

Teams registering for the 2011 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 PayPal, checks made out to MPC, and money orders.

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. 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 spokesperson or captain.
- 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. 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; 2) remove the Velcro strip to simulate cutting the damaged riser pipe (see mission task #1); and 3) measure depth at a specified point (see mission task #3) prior to the international competition.

The demonstration can be accomplished in one of two ways:

1. EXPLORER class teams within a reasonable driving distance* to a regional contest must attend that regional contest on the date of the event to demonstrate to the regional coordinator (or other designated competition official) that their vehicle can accomplish the tasks listed above.

   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.

2. EXPLORER class teams that feel that they are beyond a reasonable driving distance* to a regional contest must contact the MATE competition coordinator so that an alternative verification plan can be arranged. For example, the MATE competition coordinator will

seek out an impartial individual, such as a member of the Marine Technology Society or the Institute for Electrical and Electronics Engineers Oceanic Engineering Society, and make arrangements with him or her to visit the team at their school or practice location for the demonstration. The demonstration must be completed by the date of the final regional contest of the 2011 competition season. This exact date is TBD but will be confirmed in February 2011.

Regardless of where the demonstration takes place, the water depth for the demonstration must be between 1 and 4 meters.

*This will be determined on a case-by-case basis through discussions with the MATE competition coordinator.

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.

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.

IMPORTANT CHANGE FOR 2011!!!

ALL RANGER TEAMS MUST PARTICIPATE IN A REGIONAL

Starting this year, 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. (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.marinetech.org/rov_competition/index.php.

INTERNATIONAL COMPETITION VENUE

The 2011 international competition is being hosted by the Neutral Buoyancy Lab (NBL), which is located at the Sonny Carter Training Facility at the NASA Johnson Space Center in Houston, Texas.

The Sonny Carter Training Facility provides controlled neutral buoyancy operations to simulate the zero-g or weightless condition that is experienced by spacecraft and crew during space flight. It is an essential tool for the design, testing, and development of the International Space Station and future NASA programs. For the astronaut, the facility provides important pre-flight training for extravehicular activities (EVA) and with the dynamics of body motion under weightless conditions. See http://dx12.jsc.nasa.gov/site/index.shtml for more information.

Note: The depth of the pool at the NBL is 12.2m (40ft). EXPLORER teams should prepare their vehicles to operate at this depth. RANGER teams should prepare their vehicles to operate at 4.6m (15ft) (a platform will be placed at this depth). The depth of regional venues may differ; contact the regional coordinator in your area for more information.

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.marinetech.org/rov_competition/2011/participant.php as it becomes available.

REGIONAL CONTESTS

In 2011, the MATE Center is supporting and helping to organize 20 regional contests in the U.S., Canada, Hong Kong, Scotland, and Japan. 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.

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)

For more information about the regional contest nearest you, visit www.marinetech.org/rov_competition/2011/regional_contests.php.

KEY MILESTONES AND SCHEDULE OF EVENTS FOR THE INTERNATIONAL COMPETITION*

Key milestones:

- December 3rd – design specs, competition rules, and mission tasks posted

- December 6th – on-line registration form posted
- **February 1st – on-line registration deadline**
- April 1st – application for travel assistance posted
- May 19th – deadline for submitting application for travel assistance
- May 19th – technical reports due to MATE competition coordinator
- June 16th – 18th – international competition held at the NBL in Houston, Texas
    - 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.marinetech.org/rov_competition/2011/regional_contests.php 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
    - Facility tours for those interested
- 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:

- **Financial assistance (up to $500) with travel and lodging expenses.**
  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.marinetech.org/rov_competition/resources.php contains information on where to purchase building materials, lists of helpful web site and books, and a teams' only password protected area, 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 a letter from MATE's competition coordinator that teams can use to approach local businesses (e.g., Home Depot) for donations of funds, materials, equipment, etc.

  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.
SCOUT class ROVs operate at a nominal 12 volts DC, 15 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.

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 operate on a separate power scheme and/or are not physically connected to the main vehicle are also NOT permitted. Cameras designed to provide a "birds-eye view" are permitted provided that these cameras operate on the same power scheme as and are physically connected to the main vehicle.

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.

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 allowed 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.

ELECTRICAL POWER – GENERAL

All power provided to your system through an external connection for any purpose during the competition must be obtained from the provided MATE competition power supply for your class of vehicle. This includes dedicated lines for cameras, manipulators, or any other devices. This is a singular point of connection and all power to a competition ROV must pass through the MATE competition-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 of 12.7 Volts. In the EXPLORER class, four fully charged lead acid batteries in series would show a voltage of 50.8V. Any power supplies used will be set at 12.7±0.1Volts and 50.8±0.1Volts.

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.
- Bipolar control signals are allowed, for example ±12V RS-232 control signals. Other signals used in twisted pair communication are acceptable. These may be provided by an external device, such as a laptop computer.
- 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 end of the ROV tether.

Note: The voltage limits set 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.

Suggesting 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.

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

On-board electrical power is only allowed for the following two exceptions:

1) Lighting
2) Instrumentation (instrumentation does not include cameras)

In addition, the following constraints must be followed:

- The batteries must be enclosed in a watertight container.
- The batteries must not be used for control systems or propulsion.
- A maximum of four batteries per device is allowed.
- A maximum of 9.6V is allowed.
- The following types of batteries are the only ones acceptable:
    - PP3 (9V), AA, AAA, any button cell battery
    - PP3: http://en.wikipedia.org/wiki/PP3_battery
    - AA: http://en.wikipedia.org/wiki/AA_battery
    - AAA: http://en.wikipedia.org/wiki/AAA_battery
    - Button Cell Battery: http://en.wikipedia.org/wiki/Button_cell

FLUID POWER – GENERAL (applies to both EXPLORER and RANGER)
Power shutdown requirement: For safety purposes, any ROV that is disconnected from the surface supply must stop functioning in less than 5 seconds. Any filters, capacitors or accumulators must be sized accordingly to meet this specification.

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: 150 psia
- Hydraulic system: All lines, fittings and hydraulic devices must be rated for a minimum pressure of two times the maximum supply pressure.

***** IMPORTANT NOTICE FOR TEAMS COMPETING IN THE INTERNATIONAL EVENT!!!**
At the time of the publication of the specifications and rules, MATE did not have confirmation from NASA of the approved hydraulic fluids. The following fluids have been submitted for approval:

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

If your team plans on using hydraulics, please be on notice that any combination of these three fluids may (or may not) be approved. Depending on what fluid(s) is approved, your team will

need to adapt your system accordingly. A notice will be sent to all teams as soon as MATE receives word from NASA.

Pneumatic: Compressed air or inert gas.

- Maximum pressure allowed: 40 psia
- 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 a 1200 psia tank is regulated to 30 psia, then all system components must have a minimum rating of 75 psia**.**

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 thruster motors. 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. Systems that use pumps on the ROV are allowed.

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).
- 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 40 psia.
- 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.

IMPORTANT CHANGE FOR 2011!!!

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 early 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.marinetech.org/rov_competition/2011/regional_contests.php for a listing of regional contests and their respective dates.) Teams failing to do so 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)

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. 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: Your ROV must be capable of operating in a maximum pool depth of 12.2 meters. 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.

RANGER class: At the international competition, your ROV must be capable of operating in a maximum pool depth of 4.6 meters. 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

At the international competition, EXPLORER class teams will operate their ROVs on the bottom of the NBL's pool, which may or may not have mock-ups of the International Space Station and/or Space Shuttle. The mission tasks will not be intentionally placed in range of these mock-ups, but

it is possible that the mock-ups may be near the missions and/or in range of the ROVs' tether. RANGER class teams will operate their ROVs on platforms with no obvious obstructions.

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) should 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 servos 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.**

- 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 four distinct mission tasks. 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, they 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: At the international competition, the NASA's safety regulations prevent SCUBA divers from entering the water while the ROVs are under power. 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.

  In addition, some regional events may not provide SCUBA diver support.

- 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. Teams are permitted to correct any issues, although they will not be given additional time to do so. A final safety check will take place during the 5-minute set-up period. If the safety issue has not been corrected, or the mission control officials express a safety concern, your team will not be allowed to compete.

- Keep an eye out for tripping hazards in the mission station and at your team's work station. Make sure power cords are not lying 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.

- At the international competition, all teams must wear personal flotation devices (PFDs) when launching and recovering their vehicles OR when otherwise working at the edge of the pool (e.g. retrieving a sample recovered during the mission performance period). PFDs will be provided.

COMPETITION MISSIONS

ROVs and the Offshore Oil & Gas Industry

Highlighting the Challenges that ROVs Faced During the Gulf of Mexico Oil Spill

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)

COMPETITION MISSIONS

The Deepwater Horizon drilling rig explosion and the oil spilled and vented from the wellhead into the Gulf of Mexico represents a very tragic and challenging time in our history. The largest ecological disaster in the U.S. resulted in the loss of eleven lives and the livelihoods of thousands of workers; the devastation of miles of ocean, beaches, and shoreline; the destruction of thousands of birds, sea turtles, fish, mammals, and invertebrates (not to mention the long-term effects on these and hundreds of other species that have yet to be determined); ongoing health issues for residents as well as clean-up workers and volunteers; and severe economic impacts on local tourism and seafood industries. From the reports, it is evident that the spill was the result of both technology and human failures.

In spite of a strong push toward renewable energy sources, we will probably continue to rely on oil for at least the next 50 years. In the meantime then, we must continue to pursue oil reserves in deeper and deeper waters of the Gulf of Mexico and elsewhere on our ocean planet. To do this successfully, not only will we need to continue to advance technology, we will need qualified individuals to design, build, operate, and maintain those technologies. And should such a tragedy ever occur again, we will need qualified people to develop and implement effective technological solutions and response practices that mitigate and minimize its impact.

COSEE's "OIL SPILL IN THE GULF" EDUCATIONAL RESOURCES

Before embarking on your mission, take some time to educate yourself on the offshore oil and gas industry and Deepwater Horizon oil spill. One excellent resource is the Center for Ocean Science Education Excellence Networked Ocean World (COSEE NOW) blog located at

http://coseenow.net/blog/oil-spill-resources/. The "Trouble in the Gulf" PowerPoint presentation is particularly helpful in explaining what led to the spill and how it was eventually contained.

THINK OF YOURSELVES AS ENTREPRENEURS

From deepwater oil drilling to space 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), work as an integral part of a team, and apply technical 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?
- 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 has defined the rules, as well as the products and services you need to provide to solve the "problem."

The MATE competition is challenging your company to develop specialized tools (including ROVs) for oil spill mitigation and to demonstrate the utility of these tools in an oil spill response training mission.

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 training mission – that is, the tasks that you must accomplish – are described below.

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TRAINING MISSION OVERVIEW

The scope of the Deepwater Horizon spill was beyond anything that we could have imagined. It was the realization of a worst case scenario, and one that our existing technologies and practices were, unfortunately, not able to address in timely manner. We learned the hard way that it is important to be

prepared for the worst, even while hoping for the best.

However, we *are* making progress. For example, a Massachusetts-based company has developed a robotic control system that is now being tested on an automated drilling and exploration platform[1]. The new rig is designed to operate on the ocean floor, enabling unmanned, and therefore safer, exploration of deepwater regions. And ROV training and operations manuals are being modified to incorporate "worst-case" scenarios that anticipate the challenges of deepwater technology and find solutions that minimize the impact in the event of a problem.

And this is exactly what the MATE ROV competition is asking your company to do.

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

Task #1: Remove the damaged riser pipe (70 points)
Task #2: Cap the oil well (120 points)
Task #3: Collect water samples and measure depth (80 points)
Task #4: Collect biological samples (30 points)

You must complete mission task #1 before attempting mission task #2. See the mission task descriptions below for more details.

Your company will get up to **TWO** attempts to complete this single training 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 ROVs 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.

[1] www.masshightech.com/stories/2009/05/25/daily29-Energid-digs-up-deal-with-Seabed-Rig.html and www.prnewswire.com/news-releases/seabed-rig-and-energid-technologies-developing-a-safer-oil-drilling-system-93678419.html

Otherwise, the clock will only stop after all four 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 all four 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 ALL FOUR OF THE 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!

****

Task #1: Remove the damaged riser pipe

One attempt to stop the flow of oil at the Deepwater Horizon wellhead involved placing a device called a Lower Marine Riser Package (LMRP) cap onto it. Before the LMRP cap could be installed, a portion of the damaged riser pipe had to be cut and removed. The procedure is described here:

www.youtube.com/watch?v=fosYeR9__4A&feature=related
www.youtube.com/watch?v=e_qfLypiENE&playnext=1&list=PLD0FA525A32A632E8&index=11
www.youtube.com/watch?v=a5pc7um4Io8&list=PLD0FA525A32A632E8&index=13&playnext=2

Your company's task is to make a cut close to the wellhead, then remove the damaged riser pipe.

This mission task involves:

- **Transporting and attaching a line to a U-bolt on the damaged riser pipe.**
- **Simulating cutting the riser pipe by removing a Velcro strip.**
- **Lifting and moving the cut-off portion of the pipe from the work area.**

Scoring – up to 70 points:

- Transporting and attaching a line to a U-bolt on the damaged riser pipe – 30 points
- Simulating cutting the riser pipe by removing a Velcro strip – 20 points
- Lifting and moving the cut-off portion of the pipe from the work area – 20 points

Mission notes

Your company must complete task #1 in order. You must first connect to the U-bolt on the riser pipe before you simulate cutting the pipe. After completing both of these tasks, you must lift the pipe and move it from the work area. "Moving it from the work area" is defined as moving the pipe so that it does not physically touch any part of the wellhead or cement base. You can touch the wellhead or cement base while moving the pipe, but, if you choose to leave the pipe on the bottom, once you release it, it should not be touching any part of the wellhead or cement base.

Oil, simulated by water, will be flowing through the wellhead and riser pipe as you attempt to complete this task. Details on the flow rate are included within the mission prop specifications under task #2.

The wellhead rises vertically from a cement base that simulates the ocean floor. The riser pipe is simulated by PVC. It attaches to the top of the wellhead, extending vertically approximately 40cm before it turns horizontally. The riser pipe extends horizontally for 24cm, before turning again and descending at a 45^{o} angle back to the seafloor. Once it reaches the seafloor, the riser pipe turns again and extends horizontally along the seafloor for more than 1 meter.

The "working" portion of the wellhead is constructed from 1 ½-inch PVC pipe and ¾-inch PVC pipe. The EXPLORER riser pipe is constructed of 1 ½-inch PVC pipe. The RANGER riser pipe is constructed of ¾-inch PVC pipe. A large U-bolt is secured on the top of the upper horizontal section of the riser pipe.

Your company must attach a line to the U-bolt on the riser pipe. You must provide this line, and design and construct a mechanism to attach it to the U-bolt. During the competition, a member of your company will hold onto the other end of this line as your ROV transports it to the bottom. Once your ROV has attached the line to the U-bolt, AND your ROV has simulated cutting the riser pipe by removing the Velcro strip, then one or more members of your company can pull on the line by hand to move the cut-off portion of the riser pipe from the work area.

You should determine the pool depth at their regional competition and at the international competition to determine the length of line your company will need. There are no restrictions on the design of this mechanism or the type of line to use, provided that you adhere to the general design and building specifications for your ROV and the rules on safety.

Cutting the pipe is simulated by removing a length of Velcro from the pipe. For the RANGER class, both the wellhead and the riser pipe will have a 0.3cm wide, 10.5cm long piece of Velcro hooks attached around the PVC on each side of the "cut." For the EXPLORER class, only the riser pipe will have a length of Velcro hooks. A 1cm-wide, 21.5cm long piece of Velcro hooks will attach around the bottom of the PVC just above the "cut."

For both RANGER and EXPLORER, a 10cm long, 5cm wide piece of Velcro loops will cover the Velcro hooks. A 1cm-wide ring of 1 ½-inch PVC coupling will be attached to the Velcro loops, centered in the middle of the strip. The strip does not completely surround the PVC pipe (see the mission prop photos). You can use this ring to grab onto the Velcro strip and remove it. The Velcro strip will be attached to the riser pipe by a 0.5meter length of 1/8-inch nylon and polypropylene rope. Once the Velcro strip is removed from the pipe, it may be released by your vehicle.

Once the line is connected to the pipe and the riser pipe is "cut," a member of your company can pull on the line to move the riser pipe away from the work area by hand. Your vehicle is NOT required to lift the fallen riser pipe from the wellhead, but it can if you wish. Once the riser pipe is removed from the wellhead, you may pull it to the surface or deposit it on the bottom away from the work area. If the riser pipe is discarded on the bottom, it must not be touching any part of the remaining wellhead or the cement base to the wellhead.

EXPLORER and RANGER mission prop specifications

The mission props specifications for task #1 are detailed in task #2 below.

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Task #2: Cap the oil well

Companies competing in the EXPLORER class must successfully complete mission task #1 before attempting and receiving full points for mission task #2. The cut-off riser pipe must be moved away from the wellhead, exposing it, before you can attempt to cap it. This is also true for companies competing in the RANGER class; however, those companies can still receive partial points for mission task #2. See the RANGER class task description below for details.

EXPLORER and RANGER tasks differ. The EXPLORER task is presented first.

EXPLORER

With the damaged riser pipe cut and moved from the wellhead, the Lower Marine Riser Package (LMRP) cap could be installed. The cap is shaped like an upside-down funnel and is designed so that its sheer weight holds it in place. Pipes that extend from the top of the cap to the surface 1) transport methanol[2] to the cap to prevent methane hydrates from forming and clogging the cap and 2) transport oil to the surface where it is collected by a drillship. The procedure is described here:

www.youtube.com/watch?v=SVgM1BwFK6o
www.youtube.com/watch?v=BRR-9pjKb7o (Bill Nye the Science Guy explains just how difficult this is!)

Your company's task is to design a cap to cover the wellhead that, once you install it onto the wellhead, will stop the flow of oil.

[2] Methanol lowers the temperature and increases the pressure at which hydrates will form. Those in snowy climates can relate it to putting salt on ice in the wintertime!

Note: In this scenario, your cap DOES NOT have to include pipes that extend to the surface. Your success will NOT be measured by how much oil is funneled to the surface, but rather by HOW LONG your cap STOPS the flow.

This mission task involves:

EXPLORER class:

- **Pre-competition, designing a cap to cover the wellhead and stop the flow of oil.**
- **At the competition,**
  - **Transporting that cap to the oil well and installing it onto the wellhead.**
  - **Stopping the flow of oil for at least some period of time.**

EXPLORER class scoring – up to 120 points:

- Designing a cap to cover the wellhead and stop the flow of oil – 10 points
- Transporting the cap to the oil well and installing it onto the wellhead – 30 points
- Stopping the oil from flowing – up to 80 points
  - Oil flow is stopped for the remainder of the mission – 80 points
  - Oil flow remains stopped once the ROV releases the cap, but starts flowing again before the end of the mission performance period – 40 points
  - Oil flow is stopped while the ROV is in contact with the cap, but starts again once the ROV releases the cap – 20 points

EXPLORER class mission notes

Your company must design and build a cap that fits onto the wellhead and stops the flow of oil (which is being simulated by water) emerging from the top of the wellhead. There are no restrictions on the design of this cap, provided that you adhere to the general design and building specifications for your ROV and rules on safety. Note that these specifications, and this event's rules, specifically DISALLOW the use of chemicals or other agents that might damage the pool or its filtration system or alter the water in any way, shape, or form. Such chemicals include adhesives, grease, oils, gels, resins, and other coatings. The cap must be able to be removed from the wellhead at the end of your mission performance period.

The EXPLORER wellhead is constructed from 1 ½-inch PVC pipe and 1 ½-inch PVC couplings set into a cement base. At the top of the wellhead, the water emerges from a hole approximately 4.1cm in diameter.

Your company will receive 30 points for installing the cap on the wellhead provided that the cap remains in place once your ROV releases it. Once you install and release the cap, you will need to demonstrate to the mission judges that the cap is still in place by showing it to the judges on your ROV's video monitor. "Still in place" means that the cap sits on the wellhead and is concentric with the wellhead. It

is not necessary to stop the flow of oil (water) from the wellhead to receive points for installing the cap, but it is necessary to stop the flow of oil to receive full mission points. Caps dangling or hanging on the wellhead will not be considered "installed."

EXPLORER class demobilization instructions:
Your company must provide a set of clear, step-by-step instructions for the competition support divers on how to remove your cap from the wellhead. These instructions must be in a minimum of 18 point Ariel Bold Font. Diagrams may be included if they increase the clarity. This instruction sheet must be laminated so that if necessary, the divers can take it into the water. You should hand the instructions to the mission judge during the 5-minute set-up time. The instructions will be returned to you when your cap is returned.

Companies not providing a demobilization instruction sheet will receive a 10 point deduction.

EXPLORER class mission prop specifications – tasks #1 and 2

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

Oil pressure and flow rate:
Oil is simulated by water. At the surface, the water pressure outlet will be regulated between 1.73 to 2.42 bars. The regulator output will connect to the wellhead with a 1.6cm (internal diameter) hose. The "oil" flow rate is estimated to be between 132 – 192 barrels per day (5.5 – 8.0 barrels per hour).

Cement base:
The seafloor is simulated by a cement base constructed from a 40cm-diameter by 10cm-tall oil pan filled with cement. A 2-inch PVC coupling simulates the base of the wellhead emerging from the seafloor. To construct the base:

1. Fill the oil pan with wet cement.
2. Insert a 2-inch PVC coupling into the center of the oil pan, half submerged (3.6cm) in the cement.

Check auto supply stores or hardware stores for oil pans.

Design note: The cement base with the 2-inch coupling is the cement base used in the 2007, 2008, and 2010 competition missions.

Design note: Attaching the 2-inch coupling to a 2-inch PVC tee will help to stabilize the coupling in wet cement. The 2-inch PVC tee is not necessary, but will facilitate construction.

Wellhead:
The EXPLORER wellhead is constructed from 1 ½-inch PVC pipe. To construct the EXPLORER wellhead:

1. Push a 2-inch to 1 ½-inch PVC reducer bushing (Home Depot part #**232-769**, ACE Hardware part #**46188**) into the 2-inch coupling in the cement base.

2. Insert a 5cm length of 1 ½-inch PVC pipe into the top of the bushing. Attach a 1 ½-inch x 1 ½-inch x ½-inch tee, slip/slip/FIPT (Home Depot Part #**796-726**) onto this pipe.

3. Screw a ¾-inch FHT x ½-inch MNPT fitting (Home Depot part #**685-903** – Orbit brand name) into the side opening of this tee. Attach a hose to this fitting to provide water pressure for the wellhead.

4. Insert a 10cm length of 1 ½-inch PVC pipe into the top of this tee. Attach a 1 ½-inch PVC coupling to the end of this pipe. Insert a 7cm length of 1 ½-inch pipe into the coupling. Attach another 1 ½-inch PVC coupling to the top of this pipe.

5. Insert a 1 ½-inch to 1-inch reducer bushing (Home Depot part #**294-284**) into the top of the 1 ½-inch PVC coupling.

Design note: The five pieces of PVC at the top of the wellhead (two 1 ½-inch PVC couplings, two lengths of 1 ½-inch PVC, and one reducer bushing) will be glued together using PVC glue. This will provide companies competing in the EXPLORER class with a clean, unmarred surface to work with. Glue the 1 ½-inch to 1-inch reducer bushing into the topmost 1 ½-inch coupling. Glue the 7cm length of PVC into the topmost coupling, and glue a coupling onto the other end of the 7cm length of pipe. Be sure that the gap between these two couplings is exactly 1cm. Glue the 10cm length of 1 ½-inch PVC pipe into the bottom of the second PVC coupling. All other portions of the wellhead must be screwed together to resist the water pressure inside the pipe.

Design note: The 1 ½-inch x 1 ½-inch x ½-inch tee, slip/slip/FIPT (Home Depot Part #**796-726**) is a 1 ½-inch tee with the side opening a 1/2-inch female adapter fitting. The ¾-inch FHT x ½-inch MNPT (Home Depot part #**685-903** – Orbit brand name) screws into the female adapter opening and allows a hose to be attached to the fitting.

Riser pipe:

To construct the riser pipe:

1. Insert a 24cm length of 1 ½-inch PVC pipe into one end of a coupling. Attach a 1 ½-inch 90^{o} elbow to the other end of this length of pipe.

2. Take a 13cm length of 1 ½-inch PVC pipe and drill a pair of 7/16-inch holes. These holes must be spaced approximately 7cm 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 2.5-inch U-bolt. The EXPLORER class U-bolt is 8.1cm wide (ACE Hardware part# **5230214**, 3/8-inch x 2 ½-inch x 3 5/8-inch U-bolt). The U-bolt will rise 8cm above the fallen riser pipe. Use lock nuts to secure the U-bolt in place.

3. Take the pipe with the U-bolt and insert one end into the 1 ½-inch 90^{o} elbow. Rotate the pipe so that the U-bolt stands straight up over the pipe. Attach a 1 ½-inch 45^{o} PVC elbow to the other end of this pipe.

4. Insert a 110cm length of 1 ½-inch PVC pipe into this 45^{o} elbow and rotate it so the far end of this pipe aims towards the ground/pool bottom. Attach a 45^{o} elbow to the end of this pipe.

5. Insert a 100cm length of 1 ½-inch pipe into this elbow so that the pipe lays flat along the bottom.

A 2-inch PVC coupling holds the riser pipe onto the wellhead. To add this coupling to the riser pipe:

1. Insert the 2-inch PVC coupling 1cm over the 1 ½-inch PVC coupling at the bottom end of the riser pipe. Use small ¾-inch self tapping screws to hold the 2-inch coupling in place. This 2-inch coupling will fit over the PVC coupling and 1 ½-inch to ¾-inch reducer bushing that comprises the top end of the wellhead, holding the riser pipe in place.

2. Cut a 21.5 x 1cm length of Velcro hooks. Attach this Velcro around the bottom end of the riser pipe, 2cm above the bottom edge of the 2-inch PVC coupling. Make sure the Velcro is placed on the riser pipe above the point where the pipes connect and not on the wellhead itself.

Velcro strip:

To construct the Velcro strip that attaches to the riser pipe at the cut area:

1. Cut a 21cm x 5cm length of Velcro loops. Cut a 1cm deep notch out of the Velcro on both sides between the 10cm and 11cm mark.

2. Cut a 1cm length from a 1 ½-inch PVC coupling. Slide this thin ring around the Velcro strip until it rests in the two cut notches.

3. Cut a 1 meter length of 1/8-inch braided nylon and polypropylene rope (Home Depot part #**140-287**, ACE Hardware part #**75851**). Tie one end of this rope to the thin PVC ring.

4. Remove the back of the Velcro to expose the sticky surface. Fold the Velcro over on itself, connecting the two sticky surfaces, securing the ring and the knot in the rope at one end of the Velcro strip. Attach the strip of Velcro loops, now 10cm in length, to the 21.5cm length of Velcro hooks on the riser pipe just above point where the wellhead and the pipe connect.

5. Drill a ¼-inch hole in the riser pipe, 8cm above the 1 ½-inch PVC coupling. Insert the other end of the 1 meter rope into this hole. Tie an overhand knot in this rope to secure it inside the riser pipe.

It will take less than 2 Newtons of force to remove the Velcro strip.

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RANGER

Another attempt to stop the flow of oil from the Deepwater Horizon wellhead involved a procedure known as a "top kill." During a successful top kill, heavy drilling mud is pumped from a surface vessel into the wellhead and drill pipe, slowing the flow of oil to a stop. Once the flow has stopped, concrete is pumped into the wellhead, effectively sealing the well. The procedure is described here:

www.youtube.com/watch?v=v4YG7J-Ws6k&feature=related
www.youtube.com/watch?v=n7tles0IoL4&feature=related

www.youtube.com/watch?v=PLhOb5yuiEk&feature=related
www.theoildrum.com/node/6505

Your company's task is to connect the hoses that carry the heavy drilling mud to the wellhead, turn a valve to start the mud flowing, and, once the flow of oil has stopped, place a cap on the wellhead to seal the well.

Note: In this scenario, you will not actually start mud flowing but rather turn a valve that will stop the flow of oil coming from the wellhead, allowing you to then cap it. So, the remainder of this task describes stopping the flow of oil, not starting the flow of mud.

This mission task involves:

RANGER class:

- **Removing the hose line from the top kill manifold that rests on the seafloor.**
- **Inserting the hose line into the port on the wellhead.**
- **Turning the valve wheel to stop the flow of oil.**
- **Installing the cap onto the wellhead.**

RANGER class scoring – up to 120 points:

- Removing the hose line from the top kill manifold – 20 points
- Inserting the hose line into the port on the wellhead – 20 points
- Turning the valve wheel clockwise from completely open to completely closed (approximately 1080^{o}), stopping the flow of water coming from the wellhead – 60 points
- Installing the cap onto the wellhead – 20 points

The last two parts of this task must be done in the order listed.

RANGER class mission notes

If your company is unable to cut and remove the riser pipe in task #1, you will be unable to install the cap on the wellhead (the last part of this task). However, you can still proceed with (and receive points for) removing the hose line from the top kill manifold, inserting the hose line connector into the connection port, and turning the valve. The RANGER class wellhead is constructed from 1 ½-inch PVC pipe and ¾-inch PVC pipe set into a cement base. The port is constructed from 2-inch PVC. The diameter of the port opening is approximately 5cm and it is set at a 45^{o} angle.

Your ROV must turn the valve wheel approximately three times around (~1080^{o}) to close the valve. The valve wheel is constructed from ½-inch PVC pipe in the shape of an octagon. One of the PVC tees of the octagon is painted bright red to help you and the judges determine when one full turn (360^{o}) is completed. The wheel is attached to a ¾-inch gate valve.

The top kill manifold is constructed from 1 ½-inch PVC surrounded by a ½-inch PVC framework. The holder for the hose line connector sits at a 45° angle in the top kill manifold. The hose is simulated by a 5m, 1/8-inch braided nylon and polypropylene rope attached from the top of the hose line connector to the center of the top kill manifold.

The hose line connector is constructed from ½-inch PVC.

Unlike the companies competing in the EXPLORER class, MATE will provide your company with the cap for the wellhead. The cap is constructed to easily fit over the ¾-inch coupling of the RANGER wellhead. The cap has an 8.5cm opening (3-inch PVC joint) that tapers to 3.8cm (1 ½-inch PVC pipe). The wellhead cap is topped off with an end cap. You can only install the cap on the wellhead when you have turned the valve wheel to completely stop the flow of oil.

RANGER mission prop specifications – tasks #1 and 2

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

Oil flow rate:

Oil is simulated by water. The flow rate of oil (water) could be as high as 120 barrels per day (5 barrels per hour) and as low as 34 barrels/day (1.4 barrels per hour). This flow may be created by using a hose from a poolside faucet or by connecting a bilge pump to the wellhead and supplying it at depth from the pool itself.

Cement base:

The seafloor is simulated by a cement base constructed from a 40cm-diameter by 10cm-tall oil pan filled with cement. A 2-inch PVC coupling simulates the base of the wellhead emerging from the seafloor. To construct the base:

1. Fill the oil pan with wet cement.
2. Insert a 2-inch PVC coupling into the center of the oil pan, half submerged (3.6cm) in the cement.

Check auto supply stores or hardware stores for oil pans.

Design note: The cement base with the 2-inch coupling is the cement base used in the 2007, 2008 and 2010 competition missions.

Design note: Attaching the 2-inch coupling to a 2-inch PVC tee will help to stabilize the coupling in wet cement. The 2-inch PVC tee is not necessary, but will facilitate construction.

Wellhead and connection port:

The RANGER wellhead is constructed from 1 ½-inch PVC pipe and ¾-inch PVC pipe. To construct the RANGER wellhead:

1. Push a 2-inch to 1 ½-inch PVC reducer bushing (Home Depot part #**232-769**, ACE Hardware part #**46188**) into the 2-inch coupling in the cement base.

2. Insert a 5cm length of 1 ½-inch PVC pipe into the top of the bushing. Attach a 1 ½-inch x 1 ½-inch x ½-inch tee, slip/slip/FIPT (Home Depot Part #**796-726**) onto this pipe.

3. Screw a ¾-inch FHT x ½-inch MNPT fitting (Home Depot part #**685-903** – Orbit brand name) into the side opening of this tee. Attach a hose to this fitting to provide water pressure for the wellhead.

4. Insert a 5cm length of 1 ½-inch PVC pipe into the top of this tee. Attach a 1 ½-inch PVC coupling to the end of this pipe. Insert a 1 ½-inch to ¾-inch reducer bushing (Home Depot part #**896-981**, Ace Hardware part #**44305**) into the top of the 1 ½-inch PVC coupling.

Design note: The 1 ½-inch x 1 ½-inch x ½-inch tee, slip/slip/FIPT (Home Depot Part #**796-726**) is a 1 ½-inch tee with the side opening a 1/2-inch female adapter fitting. The ¾-inch FHT x ½-inch MNPT (Home Depot part #**685-903** – Orbit brand name) screws into the is female adapter opening and allows a hose to be attached to the fitting.

5. Place a 2-inch PVC tee over the top of the wellhead pipe. The 2-inch PVC tee should just fit over the 1 ½-inch couplings and rest on the side opening of the 1 ½-inch x 1 ½-inch x ½-inch tee.

6. Insert a 5.5cm length of 2-inch PVC pipe into the side opening of the 2-inch tee. Attach a 2-inch 45^{o} elbow to the end of this pipe, with the end of the elbow angled up. Insert a 16cm length of 2-inch PVC pipe into the other side of the 45^{o} elbow.

This opening will serve as the port for the hose line.

7. Insert a 6cm length of ¾-inch schedule 40 PVC pipe into the 1 ½-inch to ¾-inch reduce bushing at the top of the wellhead.

8. Attach a ¾-inch male adapter to the top end of this pipe. Screw a ¾-inch threaded gate valve (Home Depot part# **868-020**) onto the male adapter. Screw another ¾-inch male adapter into the top of the gate valve.

9. Insert a 3.8cm length of ¾-inch schedule 40 PVC pipe into the male adapter. Attach a ¾-inch PVC coupling to the length of pipe. Insert a 3.8cm length of ¾-inch class 200 PVC pipe. Attach a ¾-inch PVC coupling to the length of pipe.

Design note: Schedule 40 PVC pipe is the standard, thicker walled PVC. Class 200 PVC pipe is thinner walled PVC rated for less pressure. ¾-inch class 200 PVC should be available at most hardware stores. It is important to use class 200 PVC pipe when it is called for in the specifications.

10. Cut a 10.5cm x 0.3cm length of Velcro hooks (0.3cm is 2 rows of hooks). Attach the 10.5cm length of Velcro hooks around the PVC pipe of the wellhead, 1cm below the top.

Hose line:

The hose line will connect the top fill manifold to the wellhead. To construct the hose line:

1. Cut a length of 15cm PVC pipe and two 5.5cm lengths of PVC pipe.

2. Insert one end of the 15cm pipe into the center opening of a ½-inch PVC tee. Attach a ½-inch PVC end cap to the other end of this pipe. Insert a 5.5cm length of PVC pipe into each side opening of the PVC tee.

3. Drill a ¼-inch hole into the top, center of the PVC tee. Insert a 5 meter length of 1/8-inch braided nylon and polypropylene rope (Home Depot part #**140-287**, ACE Hardware part #**75851**) into this hole. Tie an overhand knot to secure the rope inside the PVC tee.

The hose line will be located on the bottom of the pool, resting in the top kill manifold. It will sit at an angle of 45°.

The hose line will weigh less than 0.5 Newtons in water. Flotation or weights can be inserted into the PVC pipe to achieve the desired weight and to provide stability.

Top kill manifold:

The top kill manifold is constructed out of ½-inch PVC. To construct the top kill manifold:

1. Start with four PVC side outs, male adapters inserted.

2. Cut two 18.5cm sections of ½-inch PVC pipe. Take one 18.5cm section of pipe and insert it into the long, male adapter end of the side out. Take another side out and attach the long, male adapter opening to the other end of the 18.5cm PVC pipe. Repeat this process with the other length of 18.5cm pipe and the other two side outs with male adapters.

3. Cut two 10cm lengths of ½-inch PVC pipe. Connect the PVC from above, 18.5cm lengths of PVC with side outs attached, with these two lengths of 10cm PVC to form a rectangle. This will form the base of the top kill manifold. All four openings remaining on the side outs should be facing upwards.

4. Insert a 3cm length of ½-inch PVC pipe into each opening. Attach a ½-inch 90° PVC elbow to each 3cm length of PVC pipe. Align these elbows so the opening faces the long way along the manifold, lining up with the male adapter end of the side out.

5. Insert a 3cm length of ½-inch PVC pipe into each opening on the 90° elbows. Attach the side opening of a PVC tee to each length of pipe.

6. Cut two 10cm lengths of ½-inch PVC pipe. Insert these 10cm lengths of pipe into the middle openings of the PVC tees, connecting them together.

7. Cut two 12cm lengths of ½-inch PVC pipe. Use these 12cm lengths to connect the side openings of the PVC tees, completing the manifold framework.

8. Cut two lengths of 15cm long 1 ½-inch PVC pipe. Connect these two lengths of PVC pipe with a 1 1/2-inch 45° elbow. This 1 ½-inch PVC pipe will hold the RANGER hose line at a 45° angle within a PVC framework.

9. Insert this 1 ½-inch 45° pipe into the center of the ½-inch PVC framework. One open end should stick up at a 45° angle; the other should be horizontal with the framework. Use 2-inch long screws to secure the horizontal section into the PVC framework.

10. Drill a ¼-inch hole in the 1 ½-inch 45° elbow. Insert the other end of the 5 meter length of 1/8-inch braided nylon and polypropylene rope (secured to the hose line) into this hole. Tie an overhand knot to secure the rope inside the 1 ½-inch 45° elbow.

The hose connection will sit in the 45° angled length of 1 ½-inch PVC.

Valve wheel:

The valve wheel is constructed from ½-inch PVC and is shaped like an octagon. The outer portion of the wheel is constructed from a series of PVC tees and 45° elbows. To construct the valve wheel:

1. Cut twelve 3cm lengths of ½-inch PVC pipe.
2. Connect two ½-inch 45° PVC elbows together using a 3cm length of ½-inch pipe. Rotate the 45° elbows so when connected, they make a 90° bend. Insert a 3cm length of ½-inch PVC pipe into each end of the 45° elbows.
3. Connect all the 45° elbows together with ½-inch PVC tees to form an octagon.

   There must be no gaps between PVC tees and PVC elbows. All open ends of the PVC tees must be facing inward.
4. Cut four 7cm lengths of ½-inch PVC pipe. Insert each length of pipe into an opening of a ½-inch PVC cross. Insert the other ends of the 7cm lengths of pipe into the four PVC tee openings in the octagonal wheel.
5. Paint one PVC tee and its corresponding 7cm length of pipe bright red. This will help to identify when one full turn (360°) is completed.

   Two #10-24 x 2-inch bolts are used to connect the PVC cross to the handle of the ¾-inch threaded gate valve (Home Depot Part #**868-020**).
6. Insert two #10-24 x 2-inch bolts up through two of the six inner holes located on the valve handle, making sure that the holes selected are directly across from each other.
7. Drill two holes completely through the ½-inch PVC cross to correspond to the placement of the bolts coming up from the valve handle. The distance between these holes needs to precisely match the distance between the two bolts. Push these bolts through the hole, and tighten the PVC cross onto the valve handle with #10-24 nuts. Use lock nuts to secure the handle in place.

Design note: It may be easier to secure the cross onto the valve handle without the wheel attached to it. Remove the wheel, attach the ½-inch PVC cross to the valve handle then replace the wheel.

8. Just below the wheel is a large brass nut that controls the force needed to turn the valve handle. Loosen this nut so the valve wheel is easy to turn. The valve wheel will take less than 0.5 Newton of force to rotate.

Riser pipe:

The RANGER riser pipe is constructed from ¾-inch class 200 PVC pipe. To construct the RANGER riser pipe:

1. Attach a ¾-inch coupling to a 28cm length of class 200 ¾-inch PVC pipe. Attach a ¾-inch 90° PVC elbow to the other end of this length of pipe.

2. Take a 20cm 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 10cm 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 10.6cm 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 rise 8.5cm above the fallen riser pipe. Use 3/8-inch lock nuts to secure the U-bolt in place.

3. Take the pipe with the U-bolt and insert one end into the ¾-inch 90° elbow. Rotate the pipe so that the U-bolt stands straight up over the pipe. Attach a ¾-inch 45° PVC elbow to the other end of this pipe.

4. Insert a 122cm length of ¾-inch PVC pipe into this 45° elbow and rotate it so the far end of this pipe aims towards the ground/pool bottom. Attach a 45° elbow to the end of this pipe.

5. Insert a 100cm length of ¾-inch pipe into this elbow so that the pipe lays flat along the bottom.

A length of ½-inch PVC pipe holds the RANGER riser pipe onto the RANGER wellhead.

6. Cut a 12.5cm length of ½-inch PVC pipe. Insert 4cm of this ½-inch pipe into the center of the ¾-inch coupling on the riser pipe side, not the wellhead side. Approximately 8.5cm of pipe should stick down beyond the coupling. Use two or more screws to secure this ½-inch PVC pipe in place.

7. Insert the 8.5cm of ½-inch PVC pipe into the coupling at the top of the wellhead.

This length of ½-inch PVC pipe will hold the riser pipe in place until the simulated cutting takes place and the fallen riser pipe is removed.

8. Cut a 10.5cm x 0.3cm length of Velcro hooks (0.3cm is 2 rows of hooks). Attach the 10.5cm length of Velcro hooks around the ¾-inch PVC coupling at the bottom of the riser pipe, approximately 1cm above the bottom edge. This should match the first strip placed near the top of the PVC pipe of the wellhead.

Velcro strip:

To construct the Velcro strip that attaches to the riser pipe at the cut area:

1. Cut a 21cm x 5cm length of Velcro loops. Cut a 1cm deep notch out of the Velcro on both sides between the 10cm and 11cm mark.

2. Cut a 1cm length from a 1 ½-inch PVC coupling. Slide this thin ring around the Velcro strip until it rests in the two cut notches.

3. Cut a 1 meter length of 1/8-inch braided nylon and polypropylene rope (Home Depot part #**140-287**, ACE Hardware part #**75851**). Tie one end of this rope to the thin PVC ring.

4. Remove the back of the Velcro to expose the sticky surface. Fold the Velcro over on itself, connecting the two sticky surfaces, securing the ring and the knot in the rope at one end of the Velcro strip. Attach the strip of Velcro loops, now 10cm in length, to the 21.5cm length of Velcro hooks on the riser pipe just above point where the wellhead and the pipe connect.

5. Drill a ¼-inch hole in the riser pipe, 8cm above the ¾-inch PVC coupling. Insert the other end of the 1 meter rope into this hole. Tie an overhand knot in this rope to secure it inside the riser pipe.

It will take less than 1 Newton of force to remove the Velcro strip.

Wellhead cap:

The wellhead cap is constructed from a 3-inch to1 ½-inch flexible drain coupling (Home Depot part **#687-979**). To construct the wellhead cap:

1. Remove the larger hose clamp from the end of the drain coupling; it is not needed. Insert an 8cm length of 1 ½-inch PVC pipe into the 1 ½-inch end of the drain coupling.

2. Attach a 1 ½-inch end cap to the end of the pipe.

3. Cut a 30cm long length of 1/8-inch braided nylon and polypropylene rope.

4. Drill two 3/16-inch holes into opposite side walls of the 1 ½-inch end cap, near the top. Insert one end of the 1/8-inch rope into one of the holes. Tie an overhand knot to secure the rope inside. Insert the other end of the rope into the opposite hole, and secure that with an overhand knot as well.

A small bit of foam, 0.5cm x 0.5cm x1cm, taped to the top center of the rope will provide flotation for the rope if the well head cap is dropped.

The wellhead cap will weigh less than 1 Newton when submerged in water.

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Task #3: Collect water samples and measure depth

During the spill, a number of technologies were used to collect information about the plume of oil on and below the water. Satellites and aircraft revealed the extent of the spill at the surface, while ship samples and autonomous underwater vehicles (AUVs), such as gliders, investigated the nature and extent of the oil plumes beneath the surface. Examples of these vehicles and what they discovered can be found here:

www.mbari.org/news/news_releases/2010/auv-gulf/auv-gulf-release.html
www.irobot.com/gi/more_information/gulf_oil_spill_response
http://rucool.marine.rutgers.edu/deepwater/
http://news.sciencemag.org/sciencenow/2010/08/report-paints-new-picture-of-gul.html
http://asascience.com/news/bulletins/clean-gulf-2010.shtml

Your company's task is to collect a water sample from a specific depth to test it for presence or absence of actual oil. You must verify the depth at which your ROV actually collected the sample.

This mission task involves:

- **Interpreting a graph to determine the correct depth at which to sample.**
- **Measuring the depth at the sample site.**
- **Collecting water sample.**
- **Returning the water sample to the surface.**

EXPLORER class scoring – up to 80 points:

- Interpreting a graph to determine the correct depth at which to sample – 10 points
- Measuring the depth at the sample site – up to 20 points
    - Within 0.10 meters – 20 points
    - Within 0.30 meters – 10 points
    - Within 0.50 meter – 5 points
- Collecting a water sample so that it is in possession of your ROV and no longer in the container – 20 points
- Returning the water sample to the surface side of the pool so that a member of your company can retrieve the sample – 10 points
- Returning the following volume of water sample to the surface – up to 20 points
    - >100mL – 20 points
    - 26mL to 99mL – 10 points
    - < 25mL – 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).

RANGER class scoring – up to 80 points:

- Interpreting a graph to determine the correct depth at which to sample – 10 points
- Measuring the depth at the sample site – up to 20 points
    - Within 0.25 meters – 20 points
    - Within 0.50 meters – 10 points
- Collecting a water sample so that it is in possession of your ROV and no longer in the container – 20 points
- Returning the water sample to the surface side of the pool so that a member of your company can retrieve the sample – 10 points
- Returning the following volume of water sample to the surface – up to 20 points
    - >100mL – 20 points
    - 26mL to 99mL – 10 points
    - < 25mL – 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

During the 5-minute set-up period, the mission judge will give your CEO a plot that shows Colored Dissolved Organic Matter (CDOM) concentration versus depth and ask your company to collect a water sample at a certain CDOM concentration. You will have to interpret the plot and determine the depth at which to sample. You must report to the mission station judge the depth at which you plan to sample BEFORE you descend to complete this task. If the depth that you report corresponds with the correct CDOM value, you will receive full points. If it does not, you may still continue with this mission task and collect a water sample; however, you will not receive full mission points or be eligible to receive a time bonus.

The water to collect at the sampling sites will be simulated by super-saline, colored water in a container with a PVC pipe extending from the top of it. You must collect your sample through this ¾-inch PVC pipe. A red stripe on the pipe will mark the location at which to measure the depth of the sample. There will be three sample containers at different depths.

You must report depth data to the mission station judge in metric units. If your depth readout is in non-metric units, or the depth readout determines pressure, you are responsible for converting to a metric measurement of depth and reporting the metric value to the mission station judge. Your depth reading should be visible to the mission station judge on your ROV's video monitor or integrated into your ROV's control system or other device. You must inform the judges when you are preparing to take a depth reading and when you are ready to have your measurement scored. The judge must see the reading taken by your vehicle.

You must retrieve a "pure" water sample from the container. Each mission station will have standard color samples to determine the purity of your sample and a graduated cylinder to determine volume. When you return your water sample to the mission station judge, the judge will pour it into the graduated cylinder to determine volume. Then the judge will compare your sample against the standard. Points will be deducted for returning a diluted sample (i.e., a sample that is lighter in color when compared to the standard).

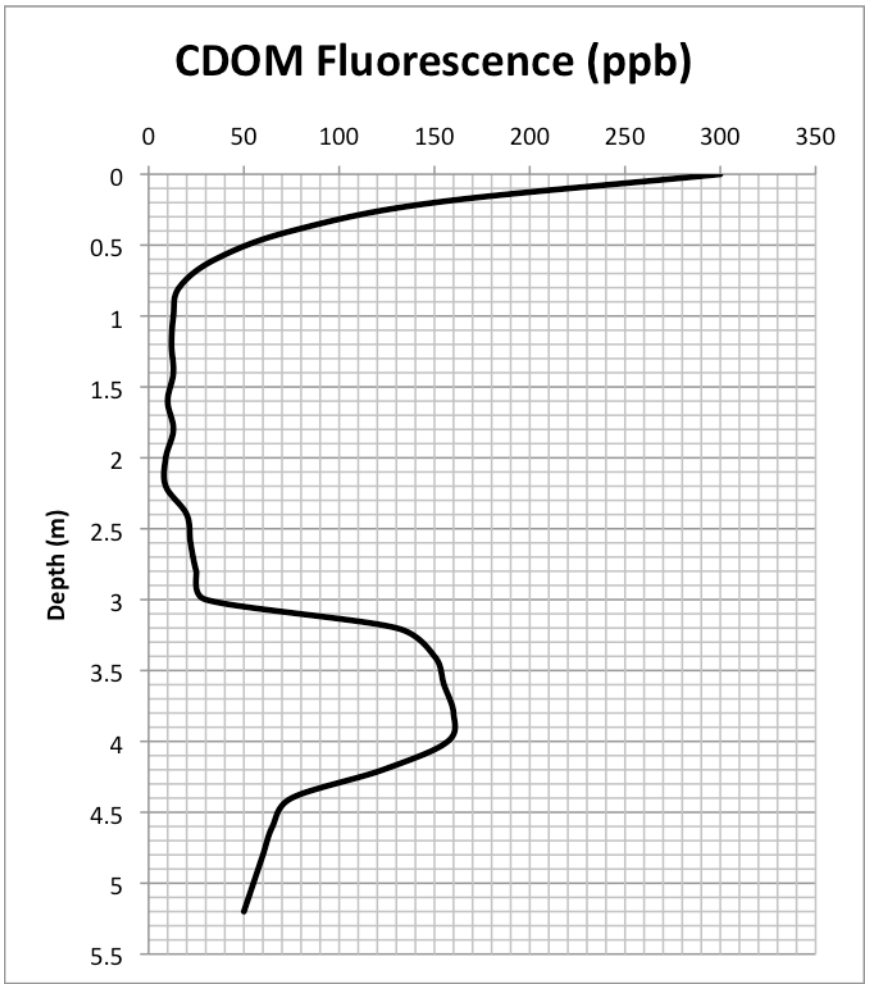
Companies that are unsure if they sampled the container at the correct depth may elect to move to a different container and try to collect another water sample. If you sample multiple containers, it is your responsibility to present the sample that you would like scored to the mission judge. Once you return a sample and present it to the mission judge for scoring, you are not permitted to collect another sample.

Mission prop specifications

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

Plot:
On the plot the X-axis will define CDOM concentration and the Y-axis will define depth, from 0 at the surface to the depth of the event pool.

An example plot can be seen here.



For example, a mission station judge could ask for a water sample from a depth where the CDOM concentration is 160 ppb. A proper reading of the plot shows that 160 ppb concentration occurs at two places – one very close to the surface (less than 0.2m deep – where a ship might sample) and another within a larger region of elevated values at a depth of 3.9 meters. You would report to the mission station judge that your target sampling depth is 3.9 meters.

Water sample container:
The water sample container is a 1-liter soft water bottle within a 2-gallon bucket. The soft water bottle design allows the container to collapse under pressure when a sample is removed from it with minimal mixing of the pool water. It is placed within a 2-gallon bucket for protection and to allow for proper

weight. The nozzle of the water bottle sticks through, and is secured to, the lid of the 2-gallon bucket. A ¾-inch PVC connector and 7.5cm length of ¾-inch pipe allow access to the water sample.

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, 34fl ozs, Item **#797977**). Any 2-gallon bucket with lid can be used as the outer container. Check your local hardware store or paint store for 2-gallon buckets.

To construct the water sample container:

1. Use a 1-inch hole saw to drill a hole in the center of the 2-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 the mouth of the soft water bottle to fit through it, but not large enough so a ¾-inch PVC connector will fit through it.

2. Push the mouth of the soft water bottle completely through the hole in the bucket lid.

3. Fit a ¾-inch PVC coupling over the mouth of the soft water bottle. This should sandwich the bucket lid between the soft water bottle and the ¾-inch PVC coupling. Use super glue or 5-minute epoxy to secure the water bottle, the bucket lid, and the ¾-inch PVC coupling together.

4. Insert a 7.5cm length of ¾-inch PVC pipe into the coupling. Use red plastic tape to create the depth mark on the ¾-inch PVC pipe.

Drill 10 ¼-inch holes in the 2-gallon bucket to allow flooding. Weights can be added inside the 2-gallon bucket to hold it on the bottom. Make sure the lid is tightly secured on the 2-gallon bucket. Use straps to hold the lid on if necessary.

Water sample:
Add 125ml (1/2 cup) of salt and 4 drops of red food coloring to 1.0 liters of water. Mix well. Note that the food coloring used will be different for different depths.

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Task #4: Collect biological samples

The impact of the oil spill on organisms that live above, on, or below the water is being investigated. The effect of the spill on some of these organisms was obvious; photos of oil-soaked birds and sea turtles filled our TV and computer screens. However, the effect of the spill on organisms below the surface was less obvious. Scientists used (and are still using) submersibles and ROVs to collect samples of these organisms and bring them back to their laboratories for analysis. Examples of these efforts are described here:
www.fau.edu/hboi/oilspill.php
www.fau.edu/hboi/oilspill_sealifeinventory.php

Your company's task is to collect samples of each of three specific benthic organisms and return the samples to the surface.

This mission task involves:

- **Collecting one sample of each of the following organisms: sea cucumber, glass sponge, and Chaceon crab.**
- **Returning these samples to the surface.**

Scoring – up to 30 points:

- Collecting one sample of each of the following organisms: sea cucumber, glass sponge, and Chaceon crab so that the samples is in control of your ROV and no longer in contact with the seafloor – 5 points for each sample (up to 15 points total)
- Returning one sample of each of the following: sea cucumber, glass sponge, and Chaceon crab to the surface side of the pool under the control of your ROV so that a member of your company can retrieve the samples – 5 points for each sample (up to 15 points total)

Mission notes

There will be three sea cucumbers, three glass sponges, and three Chaceon crabs within the mission area. Your company must collect one of each organism and return the organisms to the surface. You may collect more than one of each type of organism, but will not receive points for doing so.

A company member may reach into the water to retrieve the samples from your ROV ONLY AFTER the ROV has reached the surface and physically touched the side of the pool.

Mission prop specifications

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

Sea cucumber:

EXPLORER class sea cucumbers are simulated by toy ”water snakes,” also called ”water wigglies.” The EXPLORER sea cucumbers are between 10 and 22 cm long and filled with water. Weights need to be inserted into the center of the “water snake” to make it negatively buoyant. The EXPLORER class sea cucumbers weigh less than 1.0 Newtons in water.

They can be punctured during the collection process if you are not careful. Points will not be awarded for any sea cucumber that returns to the surface with leaks in its body.

Design note: Check Target, the Dollar Tree, or Party City (as well as online) for these toys.

RANGER class sea cucumbers are constructed out of ½-inch PVC pipe. To construct the sea cucumber:

1. Cut a 12cm length of ½-inch PVC pipe.
2. Drill eight 3/32-inch holes in the pipe, four at each end. The four holes at each end should be located 90° from each other, spread evenly around the pipe.
3. Insert a ¾-inch screw into each hole, leaving 1cm to 1.5cm of the screw outside the pipe (not screwed in).

Insert foam inside the PVC pipe, between the screws, to provide buoyancy.

The RANGER class sea cucumbers weigh less than 0.5 Newtons in water.

Glass sponge:

The glass sponge is simulated using chenille stems (pipe cleaners) and basic felt. The base of the glass sponge is a ½-inch PVC end cap. To construct a glass sponge:

1. Cut a circle of felt approximately 7.5cm in diameter. Felt commonly comes in 12-inch by 9-inch sheets. These sheets will provide felt for 12 glass sponges.

2. Use a small screwdriver or drill bit to punch two small holes in the center of this circle of felt. The two holes should be between 0.5cm and 1cm apart. Push 3cm of a pipe cleaner up through one of these holes, bend the pipe cleaner back onto itself, and push it back down through the other hole. Twist the ends together to secure the felt circle onto the top of the pipe cleaner.

3. Drill a 3/32-inch hole in the bottom of a ½-inch PVC end cap. Insert 4cm of the pipe cleaner through this hole. Twist this end of the pipe cleaner into an overhand knot so that it is secured in the pipe cleaner.

A glass sponge will weigh less than 0.5 Newtons in water.

Design note: Check local craft stores for basic felt.

Chaceon crab:

The Chaceon crabs are simulated using 1 ½-inch ABS end caps for the bodies and chenille stems (pipe cleaners) for the legs and claws. If ABS end caps are unavailable, 1 ½-inch PVC end caps may be used. To construct a Chaceon crab:

1. Drill ten holes in each 1 ½-inch ABS end cap, five on each side. These holes are attachment points for 8 legs and 2 claws.

2. Twist a 30cm long pipe cleaner in half to shorten and strengthen it. Leave 2.5cm of one end of pipe cleaner untwisted and insert this end through one of the holes in the ABS end cap. Repeat until you have completed eight legs, four per side. Twist the loose ends of the legs together inside the end cap to hold them in place.

3. Twist the middle of two pipe cleaners together. At one end, leave 2.5cm untwisted. At the other end, leave 8cm untwisted.

4. Insert the end with 2.5cm of untwisted pipe cleaners through one of the holes in the ABS end cap. Repeat for the second claw, inserting the pipe cleaner through the other unused hole in the end cap. Twist the loose ends together inside the end cap to hold the claws in place.

5. Fold 4cm of the other untwisted end of the pipe cleaners back upon themselves. Shape these 4cm lengths into claws.

6. Add two small self-tapping #6 - ½-inch, round top screws to the ABS end caps to simulate the crab's eyes.

A Chaceon crab will weigh less than 1 Newton in water.

Design note: The crab design is the exact same as the crab design for the 2008 RANGER contest. Check local craft stores for pipe cleaners.

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)

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. It will not be shared with anyone outside of the MATE staff. Visit www.marinetech.org/alumni for details and to register.

THINK OF YOURSELVES AS ENTREPRENEURS

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), 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.

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 and 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.marinetech.org/rov_competition/2011/regional_contests.php 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 disc 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.**

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.marinetech.org/rov_competition/2010/regional_contests.php 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 disc 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)**
- **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.marinetech.org/rov_competition/nonvehicle_requirements.php 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 oil companies, contractors, 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 will be required to have your ROV with you. **You are also required to bring a print-out of your electrical schematic as well as software code, if applicable.** 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. Design originality and innovation as well as safeguards to prevent injury or damage to the underwater environment will be noted. The use of complete, commercially-available systems is highly discouraged (see **Design & Building Specifications and Competition Rules** for more information on this topic).

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.) **You should create posters to accomplish this.**

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

At the international competition, 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
      Note: Again this year we plan to circulate the resumes of students nearing graduation and/or interested in applying for a MATE Center Technical Internship to competition sponsors (i.e., employers – think JOBS!) participating in the **Ocean Career Expo**. If you are interested in participating in this process, contact the competition coordinator ASAP. There is no obligation to participate.
- **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 oil spill response. Don't assume that your audience knows what an ROV is or the details about the Deepwater Horizon oil spill.
- **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, 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 tasks, safety, general operations, etc.
- **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**
  This section should present information about some aspect of the Deepwater Horizon oil spill (e.g. what were the technical failures? What are some of the potential ecological, social, or economic consequences? What technologies or people were involved in the spill or are working on improving oil spill response technologies and practices?). Include a photograph or other graphic, making sure to credit the source. Do not copy information directly from a book or web site. Synthesize the information and draw parallels between it and your work. Credit all sources.
- **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 2011!!! CREATIVE MEDIA OPPORTUNITY

This year the competition is offering companies the opportunity to submit creative media (videos, games, children's books, stories, etc.) about the competition or some aspect of the competition theme. This is entirely voluntary and will have no effect on your competition score. A prize will be awarded at the international competition. A special announcement about the creative media opportunity, along with an intent to submit form, will be circulated and posted to the competition web site in the near future.

OTHER 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
- Creative Media award

For a description of each of these award categories and the 2010 award winners, visit www.marinetech.org/rov_competition/2010/2010_award_winners.pdf