



MATE
MARINE
ADVANCED
TECHNOLOGY
EDUCATION
CENTER

2009 MATE International ROV Competition

www.marinetech.org/rov_competition/index.php

ROVs: The Next Generation of Submarine Rescue Vehicles

June 24 – 26, 2009
Massachusetts Maritime Academy
Buzzards Bay, Massachusetts



Design & Building Specifications and Competition Rules

Competition Classes:

The MATE Center's ROV competition is divided into two classes – **EXPLORER** and **RANGER**. (A third class – SCOUT – is also available at the MATE Monterey Bay, Pacific Northwest, and Big Island Regional ROV Contests.)

EXPLORER class ROVs operate at a nominal 48 volts DC, 40 amps.

RANGER class ROVs operate at a nominal 12 volts DC, 25 amps.

There are two classes in which teams can compete – **EXPLORER** and **RANGER**. Teams can register to compete in one (but not both) competition class. Instructors interested in entering two teams in one competition class will be considered as long as one team represents a high school or home school and the other a college or university. Institutions/instructors interested in entering one team per competition class will also be considered provided that they meet the eligibility requirements for both classes listed with the [General Information](#) document.

Note: This applies to the international competition. Regional contests may differ. Regional teams should contact the regional contest coordinator in their area for more information.

Design & Building Specifications:

Note: The design and building specs for EXPLORER and RANGER teams are the same **EXCEPT** for power. Please review the power 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.

ELECTRICAL

The rule

All power provided to your system through an external connection for any purpose during competition must be obtained through the provided MATE competition power connector 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. Self-contained laptops (two laptops 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.

MATE will provide electrical power for your ROV of the amounts and types indicated below. Electrical power may **NOT** be transformed ("stepped up") to a voltage above the specified maximum for your particular ROV class. Neither the voltage nor the total current may exceed the particular class limits in the tether or ROV. Voltages are measured at the MATE-provided connection with all equipment on the ROV powered up in the ready mode. Currents are measured continuously at the MATE-provided connection during operations and are noted by judges. Fusing is based on a "slow blow" in-line fuse, which provides a tolerance for momentary current variance. (**Note:** While MATE provides an in-line fuse, each team needs to protect their system with an additional fuse. See below for further information.)

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.

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.

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

- 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 $\pm 12V$ 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 powered by an internal original equipment commercial battery provided with the laptop.
- DC main-supply as per class specifications.
- **Note:** 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.

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.

EXPLORER class electrical

Power: Maximum allowed power entering the tether will be a nominal 48 Volts DC at a maximum current of 40 amps.

Voltage: *Explorer Class power supply connections will be 48 Volts DC ONLY.* Teams are free to use any voltage necessary up to 48 Volts, but the conversion must be done after the connection to MATE provided power. The conversion may be done on the surface at any point after the team-provided circuit protection or on the ROV itself. *However, never at any point in the system can the amperage exceed 40 amps.*

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/connectors for these posts to obtain power.

RANGER class electrical

Power: Maximum supplied power at pool-side will be nominal 12 Volts DC at a maximum current of 25 amps.

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

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 does include 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 location, 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

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

NON-ELECTRICAL

Other sources of non-electrical power, such as hydraulic or inert compressed gas, are permitted and are only permitted to be supplied from the surface, provided that they meet the following guidelines:

EXPLORER and RANGER class non-electrical power sources

Hydraulic: Oil, water or other liquids

Maximum PSI: 150

Fluid: Any fluid used must be Biodegradable Food Grade or water.

A Material Data Safety Sheet must be provided at the safety inspection showing the type of oil used and it's compatibility with the Biodegradable Food Grade specification. Teams using water do not need to provide a MDS for water.

Hydraulic lines: All lines and fittings must be rated for a minimum pressure of 300 PSI.

Pneumatic: Compressed air or inert gas

Maximum PSI: 40

Pneumatic lines: All lines and fittings must be rated for a minimum of 100 PSI.

Exception to the surface supply rule

Hydraulic systems utilizing water and an on-board ROV pump are allowed, with the maximum rating of 150psi. These systems must show a minimum pressure rating of twice the maximum pressure generated by the on-board pump.

Hydraulic and/or pneumatic pressure generation

In order to create pressure in such hydraulic and/or pneumatic systems from an electrically-driven pump, MATE will provide one GFI protected outlet with a nominal 115V AC (60 Hertz) and 15 amps maximum. This outlet is intended to provide power for pumps and 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 thrusters, the power for the pump must come from the MATE supplied power supply for that class or from a pressurized cylinder.

In addition to electric pumps, hydraulic and pneumatic systems can be powered by hand or foot pumps (e.g. bicycle tire pump) or supplied from an approved, tested, and inspected pre-pressurized cylinder with a safety relief device.

Pressurized cylinders

Pressurized cylinders must meet the following specifications:

- Approved by US DOT (Department of Transportation) or TC (Transport Canada).
- Have a current inspection/test sticker and/or stamp.
- Stamped with the maximum allowable pressure.
- Contain a safety relief device.
- They may be filled up to the maximum allowable pressure of the cylinder, but must be regulated at its output to a maximum of 40 psi for pneumatics and 150 psi for hydraulics.
- Cylinders 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 allowed to be used. They must meet all the above specifications, i.e., they may be filled up to the maximum allowable pressure of the cylinder, but must be regulated at its output to a maximum of 40 psi.

Pressure storage devices (pressure accumulators)

Pressure storage devices are allowed on the ROV if they meet the following requirements:

- Maximum volume stored is 1L.
- Designed or rated to handle a maximum pressure of 100 psi if pneumatic and 300 psi if hydraulic.

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.

Power shutdown requirement

It is possible that, through the use of capacitors and/or pressure accumulators, an ROV could continue to function long after it was disconnected from the surface supply. For safety purposes, any ROV that is disconnected from the surface supply must stop functioning in less than 5 seconds. Any filter capacitors or accumulators must be sized accordingly to meet this specification.

Monitors

Three.

Teams are limited to 3 monitors or display screens, such as computers that display video. MATE will provide **ONE** video monitor at each control shack. This monitor will be powered by the GFI-protected 115-volt AC (60-cycle) and 15 amps AC power source described in the **Power** section above. This monitor will have both RCA and RF inputs. Your team must supply any additional monitors (including monitors for practice sessions), video recorders, etc. These additional video devices and/or any repair tools (repair tools **NOT** payload tools) can be powered by the GFI-protected power strip described in the **Power** section above. Only video monitors, video recording devices, and repair tools can use this AC power.

Size Restrictions

The mission team must be able to personally transport the vehicle and associated equipment to the control shack. 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.

Note: At the international competition venue, the team work station area and the pool venue are on different levels. **Teams participating in the international competition must be able to hand-carry the vehicle and associated equipment up and down a flight of stairs.**

Please let the competition coordinator know AS SOON AS POSSIBLE if your instructor or any member of your team is physically unable to manage a flight of stairs. Accommodations will be made.

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

The maximum depth that your team will encounter at the international competition is 4 meters. All underwater missions will take place within 10 meters from the side of the pool. The control shack will be no more than 2 meters from the side of the pool. Tether length should be calculated accordingly.

The pool venues of regional competitions may be held in pool venues with a 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. Although the pool itself is not illuminated, ambient light levels should provide sufficient illumination. The pool will not be covered or purposefully darkened in any way.

Current

None.

Other environmental parameters

At the international competition, the bottom of the pool is sloping from the shallow to the deep end. Mission tasks will not take place on this slope. There are no other obstructions on the bottom of the pool.

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 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.

Upon arriving at the ROV competition, **ALL** work done on the vehicle must be conducted by team members. Teachers, mentors, parents, and non-competing students will not be allowed 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: much of 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 competition coordinator 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 will contain sections devoted to control systems, as they have in previous competitions. 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 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 control shack 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.

- While there is no limit to the number of students who can compete as part of a team, **the 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 a 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 trials.**

- Only the mission team members and judges are allowed in the control shack 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 control shack 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.
- Control shacks will be marked, roped off, and marked as the either RANGER or EXPLORER. Control shacks 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. Control shacks will be set up to prevent the pilot and team members from looking at the ROV in or under the water except through the ROV 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 **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.
- 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 control shack at the end of the 5-minute demobilization period, they will be **penalized 1 point per each additional minute**.
- Manipulating the tether to free it from underwater obstacles is permitted. Pulling on the tether to speed up the recovery of items or to return your vehicle more quickly to the surface is not permitted and will result in penalty points. Judges will issue one warning if tether pulling occurs. Each future infraction will result in **5** points deducted from the final mission score.
- If your vehicle is completely disabled and/or its tether tangled and unable to free itself from the underwater environment, SCUBA divers can be called in to assist. However, the mission performance period time will NOT stop and **5** points will be deducted from the final mission score. **Note:** Some regionals may not provide SCUBA diver support.
- Communication between mission team members poolside and those in the control shack 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 poolside 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.
- Pilots can only leave the control shack 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.

Safety & Power

- **The only voltages and currents allowed through your ROV's tether are the following: low voltage AC or DC control signals and DC supply per competition regulations.**

Maximum DC voltage for RANGER class teams is a nominal 12 volts.
Maximum DC voltage for EXPLORER class teams is a nominal 48 volts.

Maximum DC amperage for RANGER class teams is 25 amps.
Maximum DC amperage for EXPLORER class teams is 40 amps.

All teams – RANGER and EXPLORER – must demonstrate the presence of a fuse on the positive side of their vehicle's electrical circuitry to competition officials in order to pass the safety inspection. The MATE power supply provided at each pool station does include 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, YOU WILL NOT PASS THE SAFETY INSPECTION.**

DC circuit breakers may be used in place of or in addition to fuses. However, inform the MATE competition coordinator competition **as soon as possible** if you plan on using a circuit breaker.

See the Power section within the Design & Building Specifications above for further details about power specifications and safety.

- If a team blows MATE's in-line fuse during a mission, the team is allowed one replacement fuse. The mission performance period time will **NOT** stop during the replacement of the MATE fuse. If the vehicle blows the second MATE fuse, their mission performance period is over. The team will receive points for the mission tasks they have completed up to that point, but will not receive a time bonus score.
- If a class team blows its own fuse, the team will have the opportunity to replace the fuse (or reset the circuit breaker) and continue with the mission. However, the mission performance period time will **NOT** stop.
- Hazardous and/or non-biodegradable materials may not be intentionally released into the competition pool waters or atmosphere. This includes adding or depositing chemicals of any kind. All materials entering the pool must not alter the waters in any discernable way and must be removed from the waters at the end of the mission performance period. Teams with ROV designs incorporating the use of substances such as mineral oils or other elements that might leak into the ambient water must demonstrate the reliability of their seals to competition officials prior to entering the pool.
- SCUBA tanks and other pressure vessels are permitted as a source of non-electrical power. However, the line pressure delivered from the SCUBA tank or other pressure vessel to your vehicle can be no more than 40 psi. This means that the pressure from the tank or vessel must be reduced and there must be a pressure gauge in the line to measure it. In addition, please be aware of the following safety requirements:
 - Tanks are required to be visually inspected at least once a year. Make sure that the tanks that you are using have been inspected. Competition officials will look for a valid inspection sticker during the safety check.
 - Tanks must be restrained and must have a protective guard around the regulator. Competition officials will inspect the restraint and guard to ensure that the tank cannot be upset or damaged during transportation and use.

- **Teams with questions about their planned power scheme should contact the MATE competition coordinator AS SOON AS POSSIBLE. (It is better to clear up any concerns now rather than the day of the competition.)**

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 as they evaluate the teams.

- **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 control shack and at your team's work station. Make sure power cords are not laying in pools of water on the deck.
- During your mission period, be sure to secure any equipment so that it does not fall off the control shack table, damage the deck, or cause injury.
- RANGER class teams must have two individual male banana plugs (not a dual banana plug) on the end of your 12-volt DC power connections in order to connect to the 12-volt DC power source provided by MATE (see **Power** section within the **Design & Building Specifications** above).
- EXPLORER class teams must have two individual ring connectors on the end of the power connection in order to connect to the power supply provided by MATE. These ring connectors should fit 3/16" bolts (see **Power** section within the **Design & Building Specifications** above).
- 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.
- The surface of the water may be rippled to make it difficult to clearly see your vehicle or the pool bottom.
- All teams must wear close-toed shoes and safety glasses or goggles. **No one will be allowed into the work station area without closed toed shoes and safety glasses or goggles. No one will be allowed on the pool decks without closed toed shoes.**

This includes team members, parents, mentors, and guests. Safety glasses/goggles are also recommended on deck.

- 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.
-