2007 MATE Center/MTS ROV Committee ROV Competition
For High School & College Students
www.marinetech.org/rov_competition/index.php

Celebrating the International Polar Year:
Challenging Students to Design & Build ROVs for Operation in Polar Environments

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 – the SCOUT class – is also available at the Monterey Bay Regional ROV Contest.)

EXPLORER class ROVs operate at a maximum of 51 volts DC, 40 amps.
RANGER class ROVs operate at a maximum of 13 volts DC, 25 amps.

Teams must choose to enter **one** competition class. Two teams per instructor 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 be considered on a case-by-case basis.

Design & Building Specifications:

The 2007 underwater missions will take place in 3 different environments: a flume tank, an ice tank, and a tow tank. Each environment will have a different scenario and tasks (see the **Competition Scenarios & Mission Tasks** document).

MULTIPLE VEHICLES ARE NOT PERMITTED. Teams are required to design and build ONE ROV that can operate in all 3 environments. Teams ARE **NOT** permitted to design, build, and operate a different vehicle for each different environment. "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.

EXPLORER

Power: Maximum surface supplied power – 51 volts, 40 amps.
Maximum onboard power – 13 volts, 25 amps.

Your ROV must operate on DC voltages. Only low-voltage AC control signals are allowed through the tether. The total electrical power allowed is 51 volts and 40 amps. This power may not be "stepped up" to a higher voltage/amperage once it reaches the vehicle. All power traveling down the tether must go through a single fuse that does NOT exceed 40 amps and is readily accessible to competition officials.

Onboard power is permitted but is limited to a maximum of 13 volts DC and 25 amps. Onboard power must be must be electrically isolated from surface-supplied power and use a power source that is safe for the event venue (e.g., gel cell batteries, non-liquid type batteries, generators, etc.). All onboard power systems must be connected in series to a single fuse that does not exceed 25 amps and is readily accessible to competition officials.

Onboard dive lights that contain their own DC batteries and use 9 volts or less are permitted and do not "count" towards onboard power limits. These lights must be self-contained; no other systems may be powered from onboard dive lights.

Other sources of "stored," non-electrical power (hydraulic or inert compressed gas) are permitted, provided that they meet the following safety guidelines:
- hydraulic, such as oil or other liquids up to 150psi
- pneumatic, such as compressed, inert gases up to 40psi

These non-electrical sources of power can be:
- run by hand or foot (e.g., manual bicycle tire pump)
- run by DC. Note that DC systems must be fused
- run by GFI-protected AC (e.g., AC-powered air compressor)
- generated from approved, tested, and inspected pre-pressurized containers. These containers must have a safety relief device. Please see safety rules on SCUBA and other compressed air containers in the **Safety & Power** section below.

EXPLORER class teams will be provided with a GFI-protected 110/120-volt, 15-amp AC power source. This AC power can be used to run topside computers, additional video devices, repair tools, etc. This AC power source cannot be used to power your vehicle or any onboard payload tools.

Monitors: Three.

Teams are limited to 3 monitors or display screens. MATE will provide one video monitor and one 6-outlet power strip at the control shack. This monitor will be powered by the GFI-protected 110/120-volt, 15-amp AC power source mentioned 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.

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.

See **ICE TANK – Other environmental parameters** below for further size considerations.

Tether Length:
The maximum depth that you will encounter in all 3 environments will be 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 each of the 3 environments. Tether length should be calculated accordingly.

RANGER

Power: Maximum surface power – 13 volts, 25 amps.

MATE will provide a 12-volt DC power source capable of 25+ amps to operate your ROV. This power may not be "stepped up" to a higher voltage/amperage once it reaches the vehicle. Your ROV must operate on DC voltages. Connections to this power supply will be via standard banana plugs. Your ROV must have male banana plugs in order to make this connection. (Note: Banana plugs are available at your local Radio Shack or through electronics supply companies such as Digikey and Newark.)

All ROV systems (cameras, motors, manipulators, control systems) must operate off of this 12-volt power source and are limited to a total current draw of 25 amps. ROV cameras **MUST** operate off the 12-volt power supply, not AC power.

Onboard power is **NOT** permitted for RANGER class vehicles, with one exception. Onboard dive lights that contain their own DC batteries and use 9 volts or less are permitted. These lights must be self-contained; no other systems may be powered from onboard dive lights.

Other sources of "stored," non-electrical power (hydraulic or inert compressed gas) are permitted, provided that they meet the following safety guidelines:
- hydraulic, such as oil or other liquids up to 150psi
- pneumatic, such as compressed, inert gases up to 40psi

These non-electrical sources of power can be:
- run by hand or foot (e.g., manual bicycle tire pump)
- run by DC. Note that DC systems must be fused
- run by GFI-protected AC (e.g., AC-powered air compressor)
- generated from approved, tested, and inspected pre-pressurized containers. These containers must have a safety relief device. Please see safety rules on SCUBA and other compressed air containers in the **Safety & Power** section below.

RANGER class teams will be provided with a GFI-protected 110/120-volt, 15-amp AC power source. This AC power can be used to run topside computers, additional video devices, repair tools, etc. This AC power source cannot be used to power your vehicle or any onboard payload tools.

Monitors: Three.

Teams are limited to 3 monitors or display screens. MATE will provide one video monitor at each control shack. This monitor will be powered by a separate GFI-protected 110/120-volt, 15-amp AC power source. 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 AC. MATE will provide a single 6-outlet power strip at each control shack. Only video monitors, video recording devices, and repair tools can use this AC power. All other systems must run of the 12-volt DC power supply.

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.

See **ICE TANK – Other environmental parameters** below for further size considerations.

Tether Length:
The maximum depth that you will encounter in all 3 environments will be 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 each of the 3 environments. Tether length should be calculated accordingly.

OPERATING ENVIRONMENTS:

(See the "**Helpful Hints for Working in Extreme Environments**" document for design and building assistance.)

Note: All electrical components must be waterproofed against the elements. **ROVs that cannot demonstrate basic waterproofing will not pass the safety check.**

FLUME

(see www.mi.mun.ca/csar/flume_tank.htm)
Mission performance period = 15 minutes.

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

Depth
Your vehicle must be able to operate at a water depth of 4 meters.

Temperature
Your vehicle must be able to operate in water temperatures between 15 and 18° Celsius.

Visibility
Visibility in the flume tank is unlimited. Although the tank itself is not illuminated, ambient light levels should provide sufficient illumination.

Current
EXPLORER class teams should be prepared to operate their vehicles in a maximum current velocity of 0.5 m/s.

RANGER class teams should be prepared to operate their vehicles in a maximum current velocity of 0.1 m/s.

The current will be consistent throughout the flume tank; screens, vanes, a deflector, and a wave damper produce a uniform water velocity.

Other environmental parameters
The bottom of the flume tank is flat (no sloping sides) with no obstructions. The mission will be situated so that the current is moving from left to right.

ICE TANK

(see http://iot-ito.nrc-cnrc.gc.ca/facilities/it_e.html)
Mission performance period = 20 minutes.

Salinity/water chemistry
The water in the ice tank contains a solution of ethylene glycol (0.3% EG), aliphatic detergent (0.03% AD), and sugar (>0.04% S). The specific gravity of this EG/AD/S solution is very close to that of fresh water; at 0°C it is 1.0025 and assumed to change, as fresh water does, with increasing temperature. The viscosity of the solution is the same as fresh water. For design and building purposes, the solution should be considered conductive of electrical currents.

Why use this solution? Will it harm your vehicle?
The ice formed when the EG/AD/S solution in the ice tank freezes is a crystalline structure that closely models the flexural, shear, and crushing strength of sea ice found in Polar Regions. To learn more about this solution and how it is used in ice modeling, see the following:

Timco, G.W. 1986. EG/AD/S: A New Type of Model Ice for Refrigerated Towing Tanks. *Cold Regions Science and Technology*, Vol. 12, pp 175-195.

This mixture should not damage your ROV or reduce the integrity of its seals. Ships and ocean-going equipment have been tested in the ice tank without harm for the past 20 years. Fresh water hoses and/or basins will be provided for you to rinse your vehicle once you have completed your mission performance period.

Note: Because the water in the two other mission environments has a specific gravity closer to that of fresh water, it is recommended that you design an easily adjustable buoyancy system so that quick adjustments can be made between mission environments.

Will this solution harm you?
The liquid in the ice tank may be toxic if consumed. (Do not drink the solution in the ice tank!) Washrooms are in the vicinity for rinsing hands to prevent any irritation. If you have a concern about allergies (or the temperature of the water), you may consider wearing insulated, waterproof gloves when launching/recovering your vehicle or retrieving a sample recovered during the mission performance period.

Also, the ice tank uses ammonia as a refrigeration agent. Therefore, the slight smell of ammonia within the tank area is normal.

Depth
Your vehicle must be able to operate at a water depth of up to 3 meters.

Temperature
Your vehicle must be able to operate in water temperatures maintained at – 1° Celsius.

Note: You will enter the tank area from a corridor where the ambient air temperature is near 20° Celsius; the air temperature in the ice tank will be kept at 5° Celsius. The formation of condensation inside and outside your vehicle will be a factor that your team should consider as you design and build your ROV.

Visibility
Visibility beneath the ice sheet is unlimited; however, because of the ice sheet, light levels are reduced.

Current
None.

Other environmental parameters
There will be a hole in the ice sheet through which to launch your ROV. The hole will be no less than 80cm x 80cm square. The bottom of the ice tank is flat (no sloping sides) with no obstructions.

Note: Slush may form at the surface of the hole in the ice. You should consider taking steps to protect your motors/propellers against small ice particles.

TOW TANK

(see http://iot-ito.nrc-cnrc.gc.ca/facilities/tt_e.html)
Mission performance period = 20 minutes.

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

Depth
Your vehicle must be able to operate at a water depth of up to 2.8 meters.

Note: The actual depth of the tow tank is 7 meters. To achieve the competition's specified operating depth, platforms will be placed at 2.8 meters depth. The mission tasks will be staged on these platforms. (For those teams that participated in the competition at the NASA NBL, this will be very similar to the platforms set up for the RANGER class.)

Temperature
Your vehicle must be able to operate in water temperatures between 8 and 15° Celsius.

Visibility
Waves will impair visibility at the surface and may result in reduced visibility and light levels at depth.

Current
Surface waves (see **Other environmental parameters** below) may cause your vehicle to heave up and down just under the water surface. The deeper your ROV dives, the less these waves will affect it. At depth, there will be little to no current. Your team should consider these factors in the design and operation of your vehicle.

Other environmental parameters
EXPLORER class teams should be prepared to operate their vehicles in uni-directional surface waves with a maximum height of 15cm. The average wave period will be on the order of 1.2 – 1.3. **EXPLORER** class teams should also be prepared for obstacles near the mission props. These obstacles will be secured to the bottom of the platform but may extend into the water column. No obstacle will be within 1 meter of the mission props.

RANGER class teams should be prepared to operate their vehicles in uni-directional surface waves with a maximum height of 10cm. The average wave period will be on the order of 1.2 – 1.3.

Launch & recovery
Teams will launch their vehicles from a 5-foot x 10-foot platform located at the edge of the tow tank. Teams will access the launch station using a small stairway that leads from the deck of the tow tank, up and over the wall of the tow tank, and down to the platform. From the deck of the tow tank to the top of the wall is 54 inches. Teams must be able to carry and maneuver their vehicles up the stairway, over the wall of the tank, and down the stairway to the launch station. Pilots will control the vehicle from the deck of the tow tank, facing the wall. The tether handlers will be located on the launch station. The launch station will be secured approximately 1 foot above water level to avoid waves. (See photos inserted at the end of this document.)

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 involved in the competition (e.g. teachers, mentors, parents) 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 student 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.

  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 than they have been in past competitions.

  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
- Thrusters, motor controllers, cabling, and control box designed and sold as a "system"

Procedural:

- Teams must compete during their assigned time slots. You are **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 various events.

- 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. One or two mentors will also be allowed on the pool deck to video their team during the competition. Video is 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 designated 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 3 different missions staged in 3 different environments. Both EXPLORER and RANGER teams will get only ONE attempt to complete each of these 3 missions.

- Each mission consists of a 5-minute set-up period, a mission performance period, and a 5-minute demobilization period. The FLUME mission performance period is 15 minutes; the ICE TANK mission performance period is 20 minutes; and the TOW TANK mission performance period is 20 minutes. 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: Due to the environmental constraints of working under the ice, **divers will NOT be able to assist a disabled vehicle during the mission in the ice tank.** Only after the mission performance period is completed will a diver be dispatched to "salvage" the vehicle – NO EXCEPTIONS. In the real world, missions under the ice are difficult; the risk of losing a vehicle is very real. Design your vehicle to be robust and practice piloting to get the best performance from your pilot, team, and ROV.

- 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:

- All ROVs must be operated using DC voltages. Only low-voltage AC control signals are allowed through the tether. This power may not be "stepped up" to a higher voltage/amperage once it reaches the vehicle.

  Note: Like the U.S., Canada uses a 110-VAC electrical system and an NTSC video format.

- Maximum DC voltage for RANGER class teams is 13 volts.
  Maximum DC voltage for EXPLORER class teams is 51 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 within their vehicle's electrical circuitry to competition officials in order to pass the safety inspection.** EXPLORER class teams using onboard power must also demonstrate the presence of a fuse within their vehicle's onboard electrical circuitry. Other power control devices similar to a fuse, such as a breaker switch, will be considered on a case by case basis.

  The MATE battery provided at each RANGER class 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 above and beyond the fuse provided on the MATE battery for the RANGER class, YOU WILL NOT PASS THE SAFETY INSPECTION**.

  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.

- If a RANGER class team blows MATE's in-line 25-amp fuse during a mission, the team is allowed one replacement 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 an EXPLORER class team blows its 40-amp fuse, the team has 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 waters or atmosphere. This includes adding or depositing chemicals of any kind. All materials entering the competition waters 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 environment must demonstrate the reliability of their seals to competition officials prior to entry into any of the competition environments.

- 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 should 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:

- **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, the 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 any 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.

- EXPLORER class teams using AC to DC power supplies (transformers) must be locate them at least 3 meters from the pool's edge. They must be elevated off the pool deck to prevent standing water from creating an electrical hazard.

- RANGER teams may use their own 12-volt DC power source. This is permitted as long as the competition officials are ensured that the supply is safe, fused, and gives no advantages over other teams using the power source supplied by MATE. **If you do plan to use your own power source, you must submit your intention in advance of the competition; include it as a separate note when you submit your technical report.** You are encouraged to use standard banana plugs to connect to your own power source. That way, if there is a problem with your power source, the 12-volt power source that MATE provides can be used as a backup.

- 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.

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

- 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.

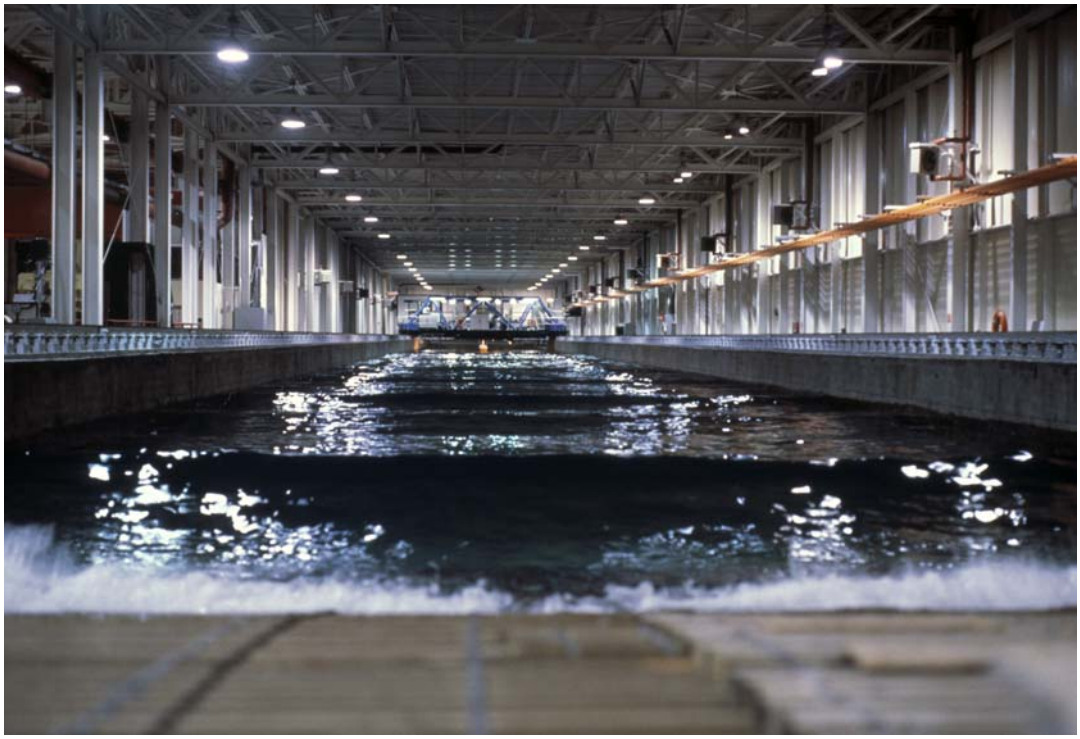
- Light levels may be reduced and the surface of the water may be rippled to make it difficult to clearly see your vehicle or the pool bottom.

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

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

TOW TANK – Launch & recovery photos

Tow tank wall (top) and "beach" (bottom)



The mission control shack (and pilot) will be located on the "deck," which is to the right in the top photo. The stairway will proceed up and over the outer wall then down the inner wall of the tow tank. The launch station will be located against the inner wall of the tow tank (well above the water line).