



**11<sup>th</sup>**

**International Submarine Races  
Year 2011  
Contestants' Manual**

**Produced by the  
International Submarine Races (ISR™)  
Judging and Directors Committee  
and the  
Foundation for Underwater Research and Education  
(FURE)**

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# The 11th ISR Rules and Contestant's Manual

## 1.0 INTRODUCTION

### 1.1 BACKGROUND INFORMATION

This manual has been prepared for those who are interested in participating in the 11<sup>th</sup> running of the International Submarine Races, to be held at the Carderock Division of the U.S. Naval Surface Warfare Center at Bethesda, Maryland. Originally called the David Taylor Model Basin, this indoor heated facility is one of the largest fresh water hydrodynamic facilities in the world. The races are scheduled for 27 June – 1 July 2011.

The manual is intended to be a guideline for submarine design and to provide information on registration, schedules, rules, operations, and related subjects. It has been written and edited by the ISR Judging and Directors committee. As a working document, this manual is subject to change and any updated information will be circulated to all participants. Please refer to the calendar in Section 3.11 for pertinent dates.

### 1.2 HISTORY

Human-powered submarine racing has come a long way since its inception in 1988. In that year, the concept was brought forth and developed by the H. A. Perry Foundation and Florida Atlantic University's Department of Ocean Engineering. The original and current objectives are

*to inspire students of the various engineering disciplines to delve into broad areas of underwater technology advancement and to provide them an educational experience that translates their theoretical knowledge into reality;*

*to foster advances in subsea vehicle hydrodynamic, propulsion, and life support systems;*

*to increase public awareness of the challenges faced by people who work in and explore the ocean depths.*

The first ISR was held in June of 1989 at Riviera Beach, Florida. Nineteen entrants from academic institutions, corporations, and independent groups gathered together to race their submarines and test their designs. The week-long event was extremely educational for all parties involved, who learned just how complicated submarine racing can be. Many different factors had to be taken into consideration for the project to meet with any degree of success, not the least of which was weather, which forced premature cancellation of these races. The U.S. Naval Academy's submarine *Squid* garnered the overall performance prize for this first race

In 1991 the second ISR was held at the same location. It had been decided to make the event biennial, to allow time for new submarine development and construction. Because the first event had received much media attention, there were many more entrants, attendees and spectators. The ISR organization of the event had improved and grown considerably to meet the requirements. The entry list consisted of thirty- six racing teams and was truly an international event, with one team coming from as far away as Germany. Again, many excellent lessons were learned, good weather prevailed, and the competition was fast-paced and fierce. The *Subasaurus*, an entry from Benthos, an oceanographic corporation, won the prize for best overall performance.

The ISR was back in 1993 with the third design competition. This time the races were staged off Ft. Lauderdale, Florida. Fifty teams participated in the competition. For two weeks these teams dealt with mechanical difficulties and unpredictable weather in the form of high winds and seas, which compressed the already full schedule. The final race was terminated early by the failure of mechanical course components. Tennessee Tech University's *Tech Torpedo II* was selected as overall performance winner.

The escalation of growth in the ISR led to increasing demands for funding and personnel. The H. A. Perry Foundation and Florida Atlantic University determined that it was no longer in their best interests to commit the considerable resources required to continue running the event and dropped out. A restructured ISR emerged, led by several individuals whose main motivation is to encourage creativity and innovation among engineering students interested in becoming submariners, while at the same time offering a unique educational experience in a real-world environment to apply what they are learning in classrooms and lecture hall.

The 4<sup>th</sup> ISR event was held in late December, 1995 during winter break. The NSW-Carderock Division David Taylor Model Basin facility in Bethesda, Maryland, was the new location, and from all aspects the race was a complete success. The facility turned out to be ideal for this event. Eleven submarines from three countries competed. All design categories were covered: one- and two-person, propeller- and non-propeller-driven submarines, submitted by corporate, academic and private entities. Though the world speed record for a two-person submarine set at WSI'94 was not beaten, the record for single-person was, by the *Substandard* independent entry at 5.0 knots. This was also the first ISR event in which women propelled submarines. In four days over 260 dives were made, with a total of 544 hours underwater, and dozens of subrace runs. New lessons were learned, and everyone enjoyed the experience in a controlled environment.

In 1997, ISR 5 was again held at Carderock, with nineteen teams. There were many more single-person subs this time, and leading the pack was team *OMER 3*, from the University of Quebec Ecole de Technologie Superieure. On their last run the Canadians turned in a speed of 6.97 knots, breaking all records. Many innovative ideas appeared at this interesting competition. The first sub with its propeller mounted on the bow of the vehicle caught attention, as did an entry that utilized a water-jet propulsion system. It was a great pleasure to see how expert these students were getting to be at building human-powered submarines. Their excellent workmanship and pride were as readily apparent as their enthusiasm!

ISR 6, held June 11 – 15, 2001, had sixteen teams. *Omer 4*, a one-person submarine from the University of Quebec Ecole de Technologie Superieure, established a new world speed record of 7.192 knots, over 8.2 miles per hour, besting the previous record that *Omer 3* set in 1997. Six categories of awards were given out. The competition was filmed by Scientific American Frontiers television, for public broadcasting in May, 2002.

From June 23– 27, 2003, ISR 7 took place with twenty-one teams. *Omer 5*, a two-person submarine from the University of Quebec Ecole de Technologie Superieure continued that team's record of outstanding effort, winning the overall performance award as well as best speed and innovation. Seven categories of awards were presented.

The 8<sup>th</sup> ISR design competition, held in June 2005, continued at NSW Carderock, again the promoting the spirit of the ISR, namely to encourage innovation in the design, fabrication, testing, and racing of human powered submarines. Two new features were incorporated: a slalom course and a two submarine runoff. *Omer 5* continued to win, holding the top speed with 7.061 knots.

ISR # 9, held in 2007, saw world speed records tumble when OMER 5 completed the course at a speed of 8.035 knots. That year, 24 subs competed from the U.S, Canada, Mexico and the United Kingdom. Speeds set in the human-powered event have moved steadily upward since the competition began in 1989.

Eighteen teams competed in ISR #10, held in June of 2009, and featured a first-time-ever sweep of overall prize categories by a high school team. The Overall Performance Award went to team “Sublime” from Hernando County Schools, Florida. The high school team from Spring Hill also beat out arch-rival Florida Atlantic University’s “FAU Boat” in a special head-to-head Florida teams race. New international speed records were also set in a nonpropeller-powered vehicle built by the Ecole de Technologie Superieure, Montreal, Canada. A submarine team from Universidad Simon Bolivar, Caracas, Venezuela joined the International contestants from Canada and England.

In summary, the ISR committee intends to continue to pursue the original objectives set forth in 1988. The committee is dedicated to making all future human-powered submarine design competition as simple, safe, and effective as possible, and to promoting and enhancing creative advancements in the field of marine technology.

### **1.3 SANCTIONS AND AFFILIATIONS**

The west coast volunteer human-powered submarine racing organization, HPS, is no longer holding HPS Submarine Races. That committee and the ISR are melding history and technical information.

### **1.4 FURE - RACE ORGANIZER**

The Foundation for Underwater Research and Education (FURE) is a not-for-profit, educational, charitable, operating foundation established in 1987. FURE’s purpose is to increase awareness of and encourage educational programs about marine science, technology and engineering among students,

the general public, government leaders, educators, other scientists, and journalists throughout the world. FURE has organized educational and outreach activities in marine science and has managed the International Submarine Races since 1994. FURE is the race organizer for the 11th ISR

## 1.5 JUDGING AND DIRECTORS COMMITTEE

### ISR Directors

Jerry Rovner	--	Operations Director
Dave McGee	--	Executive Director
Peter Hanway	--	Assistant Race Director
Dave McGee	--	Assistant Race Director
Dave Peterson	--	Surface Operations Director
Claude Brancart	--	Senior Judge and Contestant Liaison
Vin Malkoski	--	Diving Supervisor

## 1.6 LIABILITY

Every effort is being made to conduct this event as safely as possible. There will be a medical team on hand, and many highly qualified safety divers prepared to intervene in the case of mishap. Because of the potentially dangerous nature of submarine racing, every participating contestant must fill out and sign a Release of Liability agreement, a Medical Release, and a Contestant Medical Briefing form. A copy of these documents may be found in the forms identified in sections 5.2 , 5.3 and 5.4 and can be retrieved from the ISR web site. They are specifically colored for ease of identification. Each team shall also assume full responsibility for the loss or damage of their equipment and any damage to the submarine or injury to personnel.

## 1.7 DIVER CERTIFICATION

All subteam members and in-water support crew must have valid and current open water certification by a nationally recognized diver certification organization such as NAUI, PADI, YMCA, etc. A copy of the certification must be submitted to the ISR committee prior to the event. Anyone not having this certification will not be allowed into the water. All divers should have their certification cards with them during the event.

## 1.8 SECURITY CLEARANCE AND FACILITY RULES

Because the Bethesda, Maryland, facility of the Carderock Division of the U.S. Naval Surface Warfare Center is used for research of a classified and sensitive nature, all persons allowed access to the facility must be properly cleared. A Privacy Act Statement ( see Section 5.5) must be filled out by each participating individual prior to the event. Every participant will be issued a special badge

that must be worn at all times while in the facility (except when actually in the water). While there is plenty of parking space available, contestants should attempt to limit the number of vehicles coming into the facility. This should help with the traffic control workload of the security guards.

Cameras are allowed into the facility, but can only be used in the model basin itself, and only for the purpose of filming the race proceedings. Do not attempt to use a concealed camera. Carderock will require everyone to fill out a Camera Form, available from our website. After the camera form has been reviewed by government security personnel, a Camera Pass will be issued and must be carried with the camera at all times in plain sight. **Cell phone with camera are not allowed.**

Contestants are strongly encouraged to stay within the race area. Anyone found wandering around or going into restricted areas could be escorted out of the facility and asked to surrender his/her badge. Unless you are taking a tour with Carderock personnel, visiting the cafeteria, or are with authorized personnel, please remain in the event area.

The possession or use of alcohol or illegal drugs is **absolutely prohibited** by Carderock and ISR anywhere on the facility grounds. Each team, as well as all ISR personnel are solely responsible for the loss, damage or theft of their equipment. When it is unattended, make every attempt to lock or secure it. The help and support of one another through the loan of tools and equipment is strongly encouraged; but mark loaned gear so that it will return to its owner, and make sure that anything you offer, particularly dive gear, is intact and safe.

## **1.9 ENTRY FORM, FEES AND DATES**

A \$1,000.00 entry fee will be assessed from each submarine racing team, \$100.00 of which is to be submitted along with the completed entry form by 3 November 2010, with the balance of \$900 due on 1 February 2011. All other important dates are listed in the calendar, section 3.9. Checks must be made payable to Foundation for Underwater Research and Education. Send them to

International Submarine Races  
c/o Claude Brancart  
18 Juniper Road  
Brunswick, ME 04011-3418

The ISR reserves the right to cut off registration for the event if the number of boats exceeds the capacity of the race facility. Suggestion is to register on-time.

## **2.0 SUBMARINE DESIGN GUIDELINES**

## 2.1 DEFINITION

For the purpose of this event, a submarine shall be defined as a free flooding (liquid-filled) vehicle that fully encapsulates the occupant(s), and operates entirely beneath the surface of the water. The vehicle may carry one or two persons.

## 2.2 PROPULSION SYSTEM

### 2.2.1. Propeller system

A propeller system is defined as a water-coupled device with radiating blades that create thrust when spinning.

### 2.2.2 Non-Propeller system

A non-propeller system is defined as any other water-coupled device that creates a thrust when operated.

A bottom crawling vehicle is not a water-coupled device.

### 2.2.3.

Submarine propulsion systems shall be directly coupled to a human being and shall not employ any stored-power devices. All power trains shall be direct-drive without the use of any de-coupling devices.

### 2.2.4.

Exhausted crew-air may be eliminated by any method at the discretion of the team, but may not be used to produce a propulsive force. You are encouraged to give this considerable thought; any exhaust air trapped in the hull will cause major changes in trim and buoyancy.

### 2.2.5.

In the case of a two-person submarine, BOTH of the crew may elect to provide propulsion. In this case, however, both crew members must be directly coupled to the drive train; i.e. pilots may not have a system where they could stop providing power by de-coupling (see 2.2.3). The pilot must retain the capability to provide navigational, safety, and steering functions.

## 2.3 DESIGN CATEGORIES

All submarines participating in this event shall fall into one of the following categories:

one-person submarine, propeller driven --  
academic sponsorship, corporate sponsorship, independent  
sponsorship;

one-person submarine, non-propeller driven --  
academic sponsorship, corporate sponsorship, independent sponsorship;

two-person submarine, propeller driven --  
academic sponsorship, corporate sponsorship, independent sponsorship;

two-person submarine, non-propeller driven --  
academic sponsorship, corporate sponsorship, independent sponsorship.

## **2.4 LIFE-SUPPORT SYSTEMS**

### **2.4.1. AIR SUPPLY**

#### **2.4.1.1. Primary air supply**

The primary air supply shall be carried onboard the submarine, and have the calculated capacity to contain the air supply for a minimum of one speed run, plus 150% in reserve capacity for each crew member. No crew member shall allow his/her air supply to fall below 500 P.S.I. All air pressure gauges should be readily accessible, if not continuously visible, for ease of checking by both crew and support divers.

#### **2.4.1.2. Secondary (Reserve) air supply**

The secondary air supply for each crew member shall be self contained and worn securely on the body, and have sufficient capacity to enable the crew member to exit the submarine and surface. This air supply can be utilized for such duties as getting into the submarine and preparing for a run, but crew members shall not allow their secondary air supply to fall below 500 P.S.I. Bear in mind that your secondary air source is critical and air volume should be checked often.

#### **2.4.1.3. Support Diver air supply**

It is very strongly recommended that all support divers be equipped with octopus regulators so as to support submarine crew activities, like getting in and out of the submarine at depth. All support divers are required to monitor their own air supply, and shall not allow their air supply to fall below 500 P.S.I.

Note regarding air supply: the diving supervisor will have complete discretionary authority with regard to allowing divers to enter the water, especially with less than a full cylinder of air. Divers must have sufficient air to complete their task (sub race, support assignment, etc.) safely and return to the dive station.

#### 2.4.1.4. Pressure regulators

All breathing air must be delivered via a SCUBA regulator. Re-breathing units are not allowed. The brand of regulators used for both primary and secondary air supplies, as well as those used by support divers, is left to the discretion of the submarine team, but it is strongly advised that the brand selected be well-known and have a good track record. The regulator should be easy to disassemble and service, and replacement parts should be on hand. Have all regulators checked by a qualified service prior to the event. You are responsible for the condition of your regulators, and the judges will reserve the right to check the condition of each unit and possibly forbid its use.

#### 2.4.1.5. Air tanks

All tanks used by submarine crews and support divers shall have current hydro and visual inspection dates on them. The air-charging personnel will check each unit to confirm that the inspections are up to date. **Cylinders made of 6351-T6 Aluminum alloy will not be permitted to be used in ISR #11.**

#### 2.4.1.6. Air

All breathing air used by contestants shall be compressed normal atmospheric air. Special air mixes such as Nitrox or oxygen-enriched air are prohibited. The use of non-SCUBA air systems, such as rebreathers or closed-circuit systems are prohibited.

## 2.5 SAFETY REQUIREMENTS

### 2.5.1 Submarine coloration.

It is advised for the purpose of easy location that each submarine be painted with high-visibility coloration, using lighter colors like white, yellow, or orange. Fluorescent or contrasting schemes are advisable to make your submarine distinct. Hull numbers will not be assigned to each submarine. For the purpose of precise identification it is recommended that the contestants feature the team or submarine name prominently on the hull. The listing of sponsors, affiliates, or team members is acceptable. Propeller tips shall be painted or marked in bright orange for easy visibility for divers.

### **2.5.2. Rescue egress**

Any and all exits that are to be used by a submarine crew for emergency egress shall be clearly marked at the location of the handle or release mechanism by a 4" square orange patch bearing the word "Rescue." If this is not possible, the handle or release mechanism must be clearly marked with at least fluorescent tape. The handle or release mechanism shall be easily accessible from both inside and outside the submarine.

### **2.5.3. Crew restraint**

Any method of attachment of a crew member to the submarine, such as restraining harnesses or toe-clips, must have the release system clearly marked with orange paint or florescent tape. During both the dry and wet safety inspections, the judges will ensure that this requirement is met, and will point out to the rescue divers the specific release points for each submarine.

### **2.5.4. Crew visibility**

Viewports, windows, canopies, etc., shall be located on the submarine so that the crew has as unrestricted a view as possible, especially forward in the case of the navigator. The crew face and head areas shall also be visible to the safety divers at all times.

### **2.5.5. Strobe marking light**

Each submarine shall carry a flashing white strobe light that is visible for 360 degrees in the horizontal plane and visible when viewed from above the submarine.. The light should flash at an approximate rate of once per second, be visible for at least thirty feet under normal visibility conditions, have sufficient power to flash for a minimum of one hour, and be operating whenever the submarine is submerged. If you prefer, your design may incorporate more than one strobe light, so long as a flash is visible for all 360 degrees in the horizontal plane. It is recommended that batteries be changed frequently, depending on usage.

### **2.5.6. Emergency Pop-Up Buoy**

All submarines shall carry a high visibility buoy that will release from the hull and float to the surface when an emergency occurs. The float shall be attached to the submarine by thirty feet of strong, highly visible line, at least 1/16" thick. Each crew member shall have a dead-man type of switch that will automatically release the float in the event of disablement. Switch safety mechanisms may be employed during staging to prevent inadvertent release, but the switches MUST be activated whenever the submarine is operating. The release of this buoy will initiate an emergency rescue by the safety divers, whose primary interest will be getting the crew member(s) out of the submarine and to the surface as quickly as possible. If a buoy is accidentally released, the safety divers will react and the run will be considered aborted.

## **2.6 SAFETY INSPECTION**

Prior to entering the water, each submarine shall receive an inspection to ensure maximum crew safety. The inspection shall be performed by one or more judges, who may be accompanied by members of the safety diver crew so that they can familiarize themselves with construction of the submarine and the location of hatch handles, crew restraint releases, etc. A second safety wet inspection shall occur when the submarine has been placed in the underwater staging area on the bottom of the basin. The crew shall be asked to perform an emergency egress and demonstrate the operation of the emergency pop-up buoy (from both positions in the case of two-person subs).

.Once each submarine has passed both inspections, an adhesive sticker will be placed on the hull to signify compliance, so that inspections don't have to be repeated every time the submarine is deployed.

## **2.7 SAFETY PRECAUTIONS**

Every precaution is being taken to ensure that this event will be run as safely as possible. There will be qualified rescue divers stationed around the course so that one is always near the racing submarine.

A qualified dive supervisor will be on hand at all times to monitor and coordinate underwater activities. The sub crew and support divers are required to inform the dive supervisor when entering and leaving the water so that he can be aware of their activities. The dive supervisor is responsible for your safety and the smooth operation of the races. Please pay close attention to any instructions given by this individual. A qualified emergency response team shall be on hand at all times to react to any accidents. They will be completely equipped to handle injuries and will have an emergency vehicle for transportation. Arrangements have also been made for medical evacuation if required.

Each sub team shall be responsible for training crew and support divers for emergency egress. They should practice the exercise under water until all involved are thoroughly familiar with the procedure. Teams are also encouraged to act responsibly and safely with regard to other sub crews and underwater personnel. As there are several objects that protrude from the side of the basin at the surface, like the wave attenuators, and several objects that float upon the basin surface, like boats, all divers are advised to take the usual precautions when surfacing. In general, stay alert and be aware of your surroundings when underwater. Carrying a light is advisable for your own use and also to mark your presence for others. The traffic areas around the ends and sides of the basin

are concrete and when wet they may become slippery. Non-skid footwear like dive boots, reef walkers, or boat shoes are recommended.

**DANGER: Access to the center right narrow aisle (between the wide basin and narrow basin) is limited to ISR Operations Staff and volunteers. The timing and video control station is located in this aisle. There is a major hazard in the ceiling of this area: unshielded high voltage power cables that power the carriages the test basin uses.. Contact with these cables can kill you. Do not handle long poles, pipes, etc. in this area.**

There are numerous underwater objects (sharp metal fragments, debris, etc.) in the area between the dry-dock and the concrete "beach" structure. Divers should not descend in this area and should swim only on the surface from the dry-dock to the beach. All in-water checkouts will be held on or beyond the beach area.

The beach structure is not solid; there is water under it. **Do not enter or swim under the beach structure.** Be careful not to catch toes or equipment between the slats of the beach structure.

There are slatted steel walkways along both sides of the basin. To avoid injury, always look up prior to ascent, especially near the walls.

There is a carriage-arresting gear structure that hangs over the water at about the 200-foot mark. Again, always look up prior to ascent, particularly near the walls.

There may be debris on the bottom, especially within 3-4 feet of both walls. Be careful of any cabling, string, rope, etc.

Be advised that water in the basin is untreated.

Disruption of the debris on the bottom may cause some local clouding of the water. Visibility can go to zero in seconds. **DO NOT PANIC IF THIS HAPPENS!** Simply ascend a few feet and swim away.

Lighting may be limited depending upon an individual's location in the tank. Also, summer electrical storms can cause power failures. The basin can get very dark, very quickly. Dive lights are recommended. Dive lights also work well as signaling devices and enhance the ability of others to see you.

**Personal Flotation Device (PFD) Requirements:** All contestants inside the tow tank carriage rails (on longitudinal side of the tank) **MUST** wear a United

States Coast Guard Approved Type I, II, III, and Type V Personal Flotation Device (PFD) that is in good serviceable condition and appropriately sized for the intended user.

**The crane may be operated only by a trained NSW Carderock Division crane operator.**

**The dry-dock may be operated only by an NSW Carderock Division employee.**

## **2.8 SUBMARINE BRAKING**

Submarine braking at the end of the marked course will not be a major problem at the Carderock facility because of its great length, but crews are encouraged to stop their submarines in as short a distance as practical. Speed brakes, flaps and propeller reversals are acceptable methods, but drogue chutes or sea anchors are discouraged because of their tendency to snag on other objects. "Catcher" divers are not permitted because of the possibility of injury. Braking by rapid ascent or breaching is strongly discouraged as there is a potential for embolism in even a few feet of water. Once the submarine has stopped, the support crew must assist in disembarking the crew and returning the sub to the staging area. Suggestions will be made by the OPS people for the return process.

## **2.9 DRAG REDUCTION**

The use of drag-reduction material is acceptable provided that the material is non-hazardous, non-soluble and will not slough off into the model basin. Crews are required to provide to the Senior Judge, Claude Brancart, documentation to support the qualities of this material; the ISR judges and Carderock representatives will review this information for conformance. The technical aspects of this material will remain in strictest confidence if used.

## **2.10 SUBMISSION OF BASIC DESIGN REPORT**

Each submarine team will be required to submit a basic design report to the ISR judging panel. This report shall completely document the team's efforts in the conception, design, construction, and testing of its submarine. Entry to the races will not be allowed if this document is not presented by the assigned date. There are three reasons for this requirement. The judges will use the design report to determine if the submarine conforms to the design guidelines and rules set forth in this contestant's manual. In addition, they reserve the right to reject from

competition any contestant or team whose design or intentions are not in keeping with the honor and tradition of the races. Deficiency in design from the standpoint of crew safety is also cause for rejection.

The report for each submarine will be compiled and a journal produced to provide educational benefit to those interested in human-powered submarine engineering. An award shall be given to the submarine crew that develops the most complete and informative report for their project.

A presentation to the judging panel is required. These presentations will last 20 minutes. The format of the presentation will be conveyed to the contestants participating in the 11th ISR. Because of the importance of this document, it should be as detailed and complete as possible, and it must be easily read and understood.

ISR organizers firmly believe that one of the most important aspects of the races is the educational benefit that these reports will offer. ISR Judge can provide a generic format of the report and 20 minutes presentation if requested by a team.. Section 3.11 identifies dates of all deliverables. Note that there is also a date listed for final submission of the basic design report. This allows an opportunity to modify the original design. All modifications should be detailed and submitted to the judging panel for review.

All reports are to be copyrighted to the 11th ISR™ and will become the property of the ISR. It is the intention of the ISR to compile the reports into one volume at a later date. Copyright forms will be supplied after the 1 February 2011 date.

## **3.0 OPERATIONS.**

### **3.1 FACILITY DESCRIPTION**

The Carderock hydrodynamic facility consists of a large, in-ground, freshwater basin approximately 3000 feet long, 51 feet wide, and 22 feet deep. **It is fully enclosed in a heated building, but the temperature of the water is a chilly 60-65 degrees F. A full wetsuit is required.** The water is filtered and kept very clear, but because of the extremely large volume of water in the tank, the filtration cycle is very long, and suspended sediment will cloud the water all day if stirred up. To maximize visibility, all divers are requested to minimize disruption of the water near the bottom of the tank. ISR will provide compressed air for filling bottles at the facility. There are separate bathroom and showering facilities for women and men. There is a cafeteria on the premises open to all event participants.

Much classified and sensitive research is conducted at this facility and in the surrounding buildings, so access to the area and building is limited and guarded. **Security clearance for all participants will have to be applied for (see Section 1.8).**

The facility will be open from 7:00 AM to 7:00 PM during racing days. It is important to arrive early to allow everyone time to pass through security. Vehicles and their occupants may be searched while entering or leaving the facility, at the discretion of base security personnel. At the end of the day, everyone must be prepared to leave by 7:00 PM, so start wrapping things up and cleaning beforehand.

If you are competing within a time constraint, you may elect to come to the ISR for just long enough to run your submarine and get a good performance time. However, we encourage all teams to attend the races for as long as possible, especially in light of the fact that submarines and their teams will be judged in categories other than speed.

Each team will be asked to provide a primary and a secondary four-hour time slot in which they would prefer to race. When all of the time slot requests have been received, a schedule will be drawn up and circulated. Additional slots will be assigned, if available, to those wishing more runs. See Section 3.3 for more details.

See Section 5.9 for a diagram of the basin. The race operations will be staged at the east end of the tank, as in the 11<sup>th</sup> ISR. Some of the model basin's main equipment consists of large platforms mounted on wheeled carriages which move up and down the tank on rails placed upon the tank walls. These rails are extremely sensitive, even when covered over. Care must be taken not to walk near or place anything on them.

**AT NO TIME SHALL ANY DIVER CROSS OVER A TOW CARRIAGE RAIL. NO WET ITEMS SHALL BE HANDED OVER THE RAIL. IF SOMETHING WET NEEDS TO BE PLACED OVER THE RAIL, PROTECTION MUST BE PLACED UNDER IT. IF WATER GETS ON THE RAIL, IT MUST IMMEDIATELY BE DRIED AND WIPED CLEAN.**

**Bear in mind that without the Carderock personnel and their generous support, this event could not take place. Give them your highest respect, obey their directions, and honor their workplace.**

### **3.2 COURSE LAYOUT AND MARKING**

The course will run up the approximate center of the basin. The center of the course shall be marked along its entire length by rope lights that will be weighted to stay on the bottom. There will be a 100 foot acceleration zone leading to the start gate at 0 meters. Timing gates will be at 45 meters and 55 meters and the finish gate at 100 meters. These gates will be constructed of white PVC tubing approximately 25 feet apart and will be precisely measured and located. They will be rigid enough to support their equipment, but flexible enough to sustain a major collision; and the measuring system used will allow them to be precisely and quickly re-located.

The first gate will be clearly marked with lights of a particular color so as to differentiate it from the center gates and finish gate. (Please refer to the course diagram in Section 5.7.) The second gate will be equipped like the first and will mark the beginning of the ten-meter run. From the starting gate to this gate is 45 meters. The third gate marks the end of the ten-meter run. The end of the course is 45 meters farther, with a fourth gate positioned at the end, again with lights and a camera mounted on it. The entire course length from the first to the last gate is 100 meters. The speed will be recorded for both 100-meter and 10-meter distances

Underwater video cameras will be running continuously to record the submarine as it passes through each timing gate. They will be placed at about mid-depth on the timing gates and will have a wide-angle view so that they will see the submarine pass by at most depths. Contestants should be aware that there will be continuous white incandescent lights illuminating each gate area so that the timing cameras can view the submarines clearly. Every effort will be made to clean all accumulated silt from the bottom of the pool. The water itself is filtered and is completely clear. Because turbidity produced from bottom sediments being stirred up can cause a problem with the visibility of the submarine crews and the timing cameras, all divers are strongly discouraged from swimming close to the bottom anywhere within the racecourse bounds, and the areas just before and after it, unless in an emergency situation. Submarine support personnel should never go beyond the START line.

In addition to red lights marking the last gate and the presence of safety and recovery divers, the area after the end of the course will be vividly marked. Submarines passing this point will find the tow basin quite dark and there will be little surface support in this area. PVC tubes may be suspended vertically to form a non-damaging barrier, and lighting might also be used to mark the absolute end of the subsea operations area.

Teams are strongly discouraged from hitting the timing gates. Damaging them

can close the race course for repairs. Also avoid hitting the manned and unmanned mobile and fixed cameras located at various places on the course to feed non-timing-related video to the surface.

### **3.3 SUBMARINE PREPARATION**

Upon arrival, each team will be assigned an area outdoors in the parking lots adjacent to the working end of the basin. The exact size of the area for each sub and crew will be determined by the number of submarines that will have to be positioned there. The space should be large enough to contain a storage vehicle, the submarine, dive gear, tools, and sufficient working space. There will be limited power available both in and outside of the building. In the outside area, where all the submarine teams will be located, power is very limited. ***It is strongly suggested that contestants supply their own power generators.***

**It gets very hot during June and July in Washington, DC. Shade cover is strongly recommended.**

It may be helpful if teams come with a van or large truck in which to store nonessential gear and work on their submarine. The use of power tools, epoxies, paint, etc. is permitted, but please be aware that teams are responsible for completely cleaning up any debris or stains resulting from the process.

Any chemical which is considered to be hazardous to health or environment should be accompanied by a Material Safety Data Sheet (MSDS). Be as considerate as possible of the other teams and the people who work at the basin. The disposal of any epoxy, paint, solvent, or petroleum-based product is expressly forbidden unless supervised by Carderock personnel. There are areas inside the building around the working ends of the basin for crews to work on their submarines and prepare to enter the water. However, this space is somewhat limited and will probably be most available for those in their final stages of preparation or already in the queue.

When the work on a submarine is complete and the crew is ready to deploy, a crew representative will notify the ISR. The ISR committee will send Judges and safety divers to your area to perform the safety inspection. Once passed, you will join the queue awaiting entrance into the basin. Since there may be many submarines ready at the same time, and because some teams will not be able to stay for the duration of the event, the ISR committee has elected to give each team a loose time slot (See section 3.1). It is likely that additional racing time will be available for those who are prepared when others are not. There will be a big advantage in coming to the races as early and staying as long as possible. If

your submarine is ready and you are in your selected time slot, your team will have priority.

### **3.4 SUBMARINE LAUNCHING**

For ease of transportation around the facility and for launching, it is recommended that your submarine have a cradle with wheels or some sort of cart to move it around on. If you launch your submarine using this device, make it negatively buoyant, or equip it with tie-down cleats or eye bolts so that it can be restrained from floating during the launch. The working end of the basin has a platform with an elevator built in. Submarines will be moved into position on the elevator one at a time. If you don't have a device like the one described above, you may wish to build a simple cradle, or perhaps a couple of padded mounts on which to rest the hull. The elevator will then be lowered, and the sub eased off by the crew and support divers. Recovery will be by the same process.

### **3.5 SUBMARINE STAGING**

In the working end of the basin beyond the lowering elevator there will be staging areas. After the dive supervisor has cleared your team to launch, you will be directed to one of these spots. The purpose of this is to give your crew time to ballast and balance the submarine, check out all of the systems, practice egress, and generally get familiar with the submarine underwater. The goal is to get everything worked out and be completely prepared when your turn comes to get on the course. Sometime during this period, an in-water judge will request that your crew perform an emergency egress from the submarine and demonstrate the pop-up release mechanism from all crew positions while the submarine is on the bottom. If you pass this inspection, you are clear to proceed. A sticker will be applied to your submarine signifying compliance so that the inspection will not have to be done every time you wish to launch. When you are prepared to race, one of your support divers will surface and notify the dive master that you are in hot standby and ready. It might be prudent to bring an anchor or some lead weights so that the submarine can be moored or weighted down at your staging area in the event that the course waiting line is long. In that case it is wise to get out of the water and stay warm; but be ready to go as soon as you are called.

### **3.6 COURSE OPERATIONS**

When your submarine is called, prepare to move it into the course starting area. Try to keep your support diving crew small so as to avoid excessive traffic in the starting area. If there is a submarine already poised to launch in that position, avoid it and allow it to

launch unhindered, and then move into the start position. From this time on you will have up to five minutes for final preparation for launching your submarine. If you exceed this time without launching, you may have to move out of position and be placed at the back of the queue if other submarines are ready. There are 100 feet between the line marking the start of the course and the first timing gate. All submarines have the option of starting anywhere along this acceleration area. You can use the whole 100 feet, or start right at the gate or anywhere in-between. Since every submarine will be allowed as many runs as possible, you may wish to experiment with this factor. Similarly, the crew can elect to start the run at any depth from the surface to the bottom. Bear in mind that by definition, a submarine travels completely submerged, so a run down the course where the submarine never quite submerges cannot be declared official. The same also applies if the submarine fails to pass between the vertical markers marking each gate. The submarine is allowed to wander off course a little during the run, but must pass through all four gates properly. Striking the gate uprights and disturbing the cameras or targets may cause the run to be declared unofficial.

When your submarine is straight and level, is pointing down the course properly, and is far enough off the bottom so that nothing will hit, the support diver shall check to see that everyone else is out of the way, both fore and aft of the submarine. The support diver will then surface and notify the Dive Supervisor, who, through an underwater loudspeaker, will give permission to race. The safety diver will sign to the crew to commence propelling in case they could not hear the race command. This sign will be to rotate one arm as though cranking, and shall be universal so that any diver in the area will be aware of what is going on and can avoid the submarine. The Dive Supervisor will notify all subsea personnel by underwater loudspeaker that the submarine is under way and on course. The support crew will then traverse the course on the concrete aisle to assist divers at the other end in retrieving your submarine. Subsurface support crew shall not follow the submarine onto the course, nor can your support personnel follow on the surface by boat or swimming. This is to minimize traffic on the active race course.

Once the submarine has traversed the course, it should be slowed and steered to the left side of the basin. The crew should not exit until the submarine is well away from the finish line and nearly stopped. Then the crew should exit the submarine and climb out of the basin or into the support boat. The submarine is then towed to the working end of the basin by the support divers. Care should be taken to hug the basin wall to avoid obstructing the race course. When the submarine gets back to the beginning of the start line, you may be vectored right back onto the start line, or be put in the queue, or waved back to the underwater staging area, depending on the traffic at that moment.

Check all crew and support diver air supplies; if any are low, request positioning into the staging area immediately. The goal will be to have each submarine run

several times during each immersion. If for any reason your crew cannot repeat runs, you should request positioning back to the staging area for removal of your submarine from the water. The submarines will be allowed to make as many runs as time will allow. Thus every team needs to be as fully prepared as possible before entering the race queue. Be considerate of other teams: if you come up with a problem that takes a little time to fix, allow other teams to pass by to keep everything moving.

### **3.6.1 SAFETY CONCERNS DURING SUBMARINE OPERATIONS**

**1. There are three primary hazards to the crew during human-powered submarine operation:**

- a. DON'T PANIC! If you remain calm, keep breathing from the regulator, and stay in/with the sub until help arrives, almost any situation can be controlled.**
- b. Ascent is controlled by the vehicle and may be more rapid than free diver ascent. This means that crewmembers must continue breathing during the entire human powered submarine operation. NEVER HOLD YOUR BREATH!! The vehicle should always operate near the bottom, unless there is a control problem or emergency.**
- c. Air supply can be lost by simply dropping your regulator from your mouth, or by running out of SCUBA air, or other equipment malfunction. KEEP YOUR REGULATOR IN YOUR MOUTH AT ALL TIMES!! If there is an air supply problem, reach for your alternative air source first, and then pop the hatch.**

2. The support divers have control of the vehicle prior to the start and must make sure the crew is o.k. at all times.

3. Some submarines may have buoyant hatches. If the hatch is opened, the submarine will descend and the hatch will lift up. Do not be under the submarine when the hatch is opened.

4. Be careful of hand placement when closing the hatch, especially in the water. Always hold the sub with your hands away from the hatch opening and say "CLEAR" before closing the hatch. Also, be careful not to let SCUBA equipment get in the way of closing.

5. Never position yourself under the submarine during any operations, either in or out of the water.

6. The support divers control the descent of the vehicle to the bottom and must make sure the crew is not experiencing ear clearing problems or any other distress during descent. Visual contact is needed with all crew members during the entire descent.

### **7. BEWARE OF THE PROPELLOR/PROPULSION UNIT DURING OPERATION AND STAY CLEAR WHEN IT IS ROTATING.**

8. The submarines may have sharp edges, bolt heads, and hatches that can cut or pinch hands and snag SCUBA equipment. BE CAREFUL.

9. A moving submarine has a lot of inertia. Never be between a moving sub and the basin walls.

10. Never attempt to keep up with the submarine when it is underway. It has the potential to be 2-4 times as fast as a swimming diver.

11. The water is cold and can cause cramps. Be sure to stretch prior to diving and eat appropriate foods to help reduce the risk of cramps. The crewmembers are more susceptible to cold because they are moving only during the run.

12. Be an asset, not a liability. If you have a diving or equipment problem, stop diving. You will become a liability at that point and will not help anyone, including yourself. Make sure the Diving Supervisor is aware that you are getting out of the water.

13. It is recommended that support divers be "heavy" to submerge the submarine. The wet suits on two submarine crewmembers are 10 pounds buoyant at the surface. The BC's have enough lifting capacity to overcome this. In the event of an emergency or BC failure, the diver must remove his/her weight belt prior to ascent.

### **3.7 TIMING GUIDELINES**

Every submarine run will be observed through four underwater television cameras whose signals will be combined in a video processor and recorded on

video tape. The elapsed time on the course of each submarine will be based on analysis using frame-grabbing of the recorded timing camera video. The timing will start and stop when an easily identifiable part of the submarine passes between each timing target and camera. A time will be determined for both the 10 and 100 meter sections of the course and the speeds will be calculated from these times. A contestant speed form will be generated for every run of each sub, and will be authenticated by the timing officials.

### **3.8 TIMING STATUS**

Submarine speeds will be displayed on television monitors and posted on a status board as soon as they are available. A section of the status board will show the highest speed in each category. As each speed is bettered, a new higher speed will replace the previous maximum. When races are in rapid succession, speed determination may be delayed, but the speed will be posted as soon as it is available. Please do not ask the timing officials for speed data during active racing. REMEMBER you are not allowed up the center aisle.

### **3.9 CREW COMFORT**

The tow basin water is not heated and is completely enclosed. It is strongly recommended that the crew and support divers wear dry or wet suits, gloves, hoods, and booties to protect against possible hypothermia. The contestants are also advised to leave the water, when they are not actively preparing or operating their submarine, in order to limit exposure time. Contestants are advised to bring hand-held, battery-operated, underwater lights to facilitate work on their submarines when submerged.

### **3.10 CREW COMMUNICATIONS**

The use of walkie-talkies by the submarine crews is allowed, but they must provide the frequency of operation for approval by the ISR, who will ensure that there is no frequency conflict between the model basin's own radio frequencies and those of the ISR. Crew intercommunications or crew-to-team intercommunication systems are allowed but must be fully described in your basic design outline so that they can be reviewed by the Judges' panel. Diver signaling systems (or "Gertrudes") will be in use by the ISR operations personnel, so sub teams are not permitted to use this method of communication.

### **3.11 CALENDAR**

#### **1 November, 2010**

Deadline for submission of Entry Form ([see section 5.1](#)) with the \$100.00

non-refundable portion of the entry fee.

Mail to

C. Brancart  
18 Juniper Road  
Brunswick, ME 04011-3418

**1 February, 2011**

Deadline for remainder of application fee of \$900.00. This portion of the application fee is refundable at the discretion of the ISR Directors Committee. Basic design report outline and 20 minutes presentation suggested format are available upon request from the Contestant Liaison.

Mail to

C. Brancart  
18 Juniper Road  
Brunswick, ME 04011-3418

**A second submarine may be entered by a team for 50% of the original application fee (\$50 1 November 2010 and \$450 1 February 2011).**

**Applications submitted after 1 November 2010 will require a FULL PAYMENT of \$1250.00 at the time of application, but no later than 1 February 2011. 1 (50% for a second submarine). Contestants who submitted the \$100 entry fee on time, but failed to meet the 1 February 2011 deadline with the \$900 fee, will be require to pay the fee \$1150.00 (50% for a second submarine).**

**NO APPLICATIONS WILL BE ACCEPTED AFTER 1 MARCH 2011.**

**1 March, 2011**

A *DRAFT* of the basic design report outline and specifications are to be mailed to

C. Brancart  
18 Juniper Road  
Brunswick, ME 04011-3418

Comments on the reports will be issued by 1 April 2011.

The following documentation is to be sent to Jack Nicewinter,  
Registration/Administration

***On all forms, indicate your involvement with the ISR: Volunteer, Contestant (Diver or non-diver), Visitor (such as family member) and Judge.***

Waivers (see section 5.2),  
Crew roster (complete list of team members and their function.  
Documentation to be submitted for every person as appropriate.),  
Diving certifications (copy of dive certificate, see section 1.7),  
Medical Release (see section 5.3)  
Medical History (see section 5.4)  
Visit Approval Request and Camera Permit (see section 5.5)  
:

Jack Nicewinter  
312 North Scott Ave  
Glenolden, PA 19036

**NOTE: If shipping via UPS or FedEx, send it as “no signature required”.**

E-mail Jack Nicewinter ([jacknice2000@yahoo.com](mailto:jacknice2000@yahoo.com)) advising him what you are sending him and he will confirm receipt of documentation.

### **2 May, 2011**

Final design report and specifications due.

#### Mail to

C. Brancart  
18 Juniper Road  
Brunswick, ME 04011-3418

### **25-26 June, 2011**

11<sup>th</sup> ISR course setup.

### **26 June, 2011 (Sunday)**

We will expedite the subrace schedule and offer dry safety checks starting at noon Sunday, 26 June, for those submarine teams that are on site and prepared for the safety check. Wet inspections may or may not be available on Sunday. Because it is anticipated that the number of entries will increase, it is very important that all participants make maximum use of the time available to be in the water.  
Welcoming reception and Briefing and Dinner.

**27 June, 2011 (Monday)**

Races begin!.

**28-30 June, 2011 (Tuesday – Thursday)**

Races continue.

**1 July, 2011 (Friday)**

Races conclude with slalom event. This event may be replaced with tandem races as teams desire.

Awards ceremony and dinner..

**2 July, 2011 (Saturday)**

Break-down and departure.

**3.11 THE SLALOM COURSE**

The 11th ISR may continue the slalom course and an associated award for maneuverability. As in ISR #9, the slalom course will consist of six vertical poles (or ropes with buoys) located along or near the centerline of the course at 10 meters, 20 m, 30 m, 70 m, 80 m and 90 m. This will allow the subs' times to be captured by the timing cameras. This course will be added to the existing racecourse sometime towards the end of the race week, and only those subs that have demonstrated a reasonable amount of maneuvering capability will be permitted to run the course, if they so desire. The award will be given to the sub that successfully navigates the 100-meter course with the fastest time.

The exact details of how and if the slalom course will be operated is being developed and finalized. There is a possibility that Friday will be allocated for slalom races. Further updates concerning the slalom races will be presented on the ISR web site and issued to each registered contestant by the Contestant Liaison. As mentioned, the slalom race may be replaced with a tandem (two submarines) race.

**4.0 MISCELLANEOUS**

**4.1 DIRECTIONS TO THE CARDEROCK FACILITY**

In section 5.6 under Forms and Diagrams you will find where to obtain an overall map of the Washington area, a map to the Carderock area in Bethesda, and a

diagram of the facility. Building Number 4 will house the races, and parking will not be allowed at the east end of the building. be along the side of the building.

#### **4.2 SHIPPING INSTRUCTIONS**

If you wish to send your submarine by air or overland, the address for the Carderock Facility is

Carderock Division Headquarters  
David Taylor Model Basin  
9500 MacArthur Blvd.  
West Bethesda, MD 20084-5000  
Attn: Dan Dozier  
Code 2700

Mark containers **INTERNATIONAL SUBMARINE RACES** in very large letters. The facility will unload the containers from the transport trucks and store them outside near the model basin. Allow sufficient transport time so that your gear will get there before you do. **Do not ship before mid-May.**

#### **4.3 HOST HOTEL**

Contract with a host hotel has not been finalized. Contestants will be advised as soon as the information is available.

#### **4.4 PARKING**

Parking will be available at the Carderock facility, including space for large vehicles. People will not be allowed to stay there during the night in motor homes or otherwise. Teams are encouraged to bring as few vehicles as reasonable, since the facility likes to keep the traffic flow to a minimum. Extra vehicles can be left at the hotel, and car-pooling or a shuttle service will be arranged.

#### **4.5 SPECTATOR CLEARANCE**

Spectator access to the facility will be very limited. Forms to be filled out can be found on the web site.

#### **4.6 PUBLICITY AND REPORTER CLEARANCE**

Any media personnel interested in attending the ISR should contact Paula McGee for more information. See Section 4.7.

#### **4.7 ISR CONTESTANT CONTACT INFORMATION**

At this time your points of contact regarding the 11<sup>th</sup> ISR are listed below. If they cannot answer your questions, they will direct you to someone who can.

## ISR Contact List

### Race Director

Jerry Rovner                      jrovner@rapidresponsecs.com                      843-235-0163

### ISR Executive Director

Dave McGee                      [edavemcgee@cox.net](mailto:edavemcgee@cox.net)                      703-399-7619

### Assistant Race Directors

Peter Hanway                      [pjhanway@cs.com](mailto:pjhanway@cs.com)                      856-446-9150

Dave McGee                      [edavemcgee@cox.net](mailto:edavemcgee@cox.net)                      703-399-7619

### Surface Operations Director/Local Site Contact

Dave Peterson                      [speterson@chesapeake.com](mailto:speterson@chesapeake.com)                      410-257-2331

### Head Judge/Contestant Liaison

Claude Brancart                      [c.brancart@ieee.org](mailto:c.brancart@ieee.org)                      207-729-7873

### Volunteer Coordinator

Sue Peterson                      [speterson@chesapeake.com](mailto:speterson@chesapeake.com)                      410-257-2331

### Diving Supervisor

Vin Malkoski                      [Vincent.Malkoski@state.ma.us](mailto:Vincent.Malkoski@state.ma.us)                      508-910-6318

### Registration/Admin.

Jack Nicewinter                      [jacknice2000@yahoo.com](mailto:jacknice2000@yahoo.com)

### Media Relations

Paula McGee                      [pmcgeee80@yahoo.com](mailto:pmcgeee80@yahoo.com)                      757-299-8585

### Timing Operations

Frank Lang                      [flang@ieee.org](mailto:flang@ieee.org)                      410-641-4857

### Foundation for Underwater Research and Education (FURE)

Nancy Hussey                      [seacure@earthlink.net](mailto:seacure@earthlink.net)                      843-278-1474

### ISR Mailing Address:

International Submarine Races  
c/o C. Brancart  
18 Juniper Road  
Brunswick, ME 04011-3418

**All relevant information can be found on the internet. Our web site address:**

<http://www.isrsubrace.org>

#### **4.8 AWARDS**

The following awards will be given to the contestants at the 11th ISR .

##### **Absolute speed award:**

Given to the submarine team of the boat from any of the design categories listed in Section 2.3 which sets the highest speed of the race.

##### **Fastest speed by category:**

First, second and third place awards to be given to submarine teams in each design category listed in Section 2.3.

##### **Innovation:**

First, second and third place awards to be given to submarine teams in any design category who display the most successful design and construction innovations.

##### **Best use of composites:**

One award given to the submarine team from any design category who exhibit the best and most successful use of composite materials in the construction of their vessel.

##### **Best design outline:**

One award given to the team that submits the best basic design outline of their submarine project. See Section 2.10 for more details.

##### **Overall Performance:**

One award given to the submarine team from any design category that displays the best overall performance. This performance will include not only aspects of the above awards, but also team attitude, persistence, and resourcefulness.

Prize of \$1,000, sponsored by the Institute of Electrical and Electronic Engineers, Oceanic Engineering Society.

**Best Spirit of the Races:**

This award is given to the submarine team that displays the best gusto, fortitude, support for the other teams, and overall best spirit. The winner will be selected by the submarine teams themselves, and is awarded in memory of the late ISR contestant, Steve Barton of team *Sublime*.

**Slalom Maneuverability Award:**

This award is given to the team submarine that demonstrates the greatest skill in maneuvering through the slalom gates.

**Every competing team will be given an 11th ISR participation plaque with a team photo.**

## **5.0 Addenda - FORMS AND DIAGRAMS**

**These forms and diagrams are available from the ISR web site, under “Contestant” category.**

**5.1 TEAM ENTRY FORM**

**5.2 LIABILITY RELEASE FORM**

**5.3 MEDICAL RELEASE FORM**

**5.4 CONTESTANT MEDICAL BRIEFING FORM**

**5.5 NAVSEA VISIT APPROVAL REQUEST and CAMERA PERMIT FORM**

**5.6 COURSE DIAGRAM (See ISR Web site.)**

**5.7 FACILITY MAP (See DTMB web site.)**

**5.8 FACILITY DIAGRAM (See DTMB web site.)**