

The International Submarine Races (ISR)

The First 19 Years plus The Next 19 Years and Beyond

By

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Abstract:

The International Submarine Race (ISR) presents opportunities to students to achieve excellence in areas of marine technology and ocean engineering. The quality of the technical expertise of our young students tends to be gradually decreasing. There exist too many distractions like peers pressure, expertise in athletic endeavors, an excess of time and money, or apathy. There also exists the need to strengthen and enhance the scientific and technical literacy of our students. If there is excitement in an activity, the student becomes motivated and will tend to exert his/her best efforts. Also, if there is a challenge to excel, the motivation factor increases. The ISR was conceived as a "hook" to interest talented and motivated students to become involved in marine technology and ocean engineering.

The ISR is an engineering design competition open to high schools, colleges, and university students, and individuals. The focus of the ISR is on the engineering principles and technologies involved in the design and operation of a human- powered submarine. The paper will address how the ISR provides the stimulus for engineering education that attracts favorable public and academic attention. Examples of some of the successes achieved to date will be presented.

The First 19 Years

Overview

The ISR exists as a means to interest and educate young people in specific marine-oriented technologies. Education yields the best results when you have a student willing to learn and an effective teaching program. A student becomes willing when his or her interest is stimulated and the desire to learn is motivated. The ISR facilitates the educational process by providing a challenge: to design, build and operate a one- or two-person, human-powered submersible on an underwater course. The ISR program provides an opportunity to excel in the validation of a technology, and also offers access to known technology, like software programs and analysis tools, and previous human-powered submarine designs. As the process of the past nine design competitions has evolved, the ISR education program appears to be working.

Rational

There is a continuing need to improve the efficiency of hydrodynamics, propulsion, and life support systems for small, subsea vehicles. Profound lessons may be learned through the process of designing, building and operating an “optimized design.” The rules of this competition restrict the vehicle’s power to human power, thus focusing attention on maximizing the vehicle’s design and its life support system.

In The Beginning

Human-powered submarines have been with us a long time. In 1776, during the Revolutionary War, the *Turtle*, powered by Staff Sergeant Ezra Lea, attempted to sink a British flagship, HMS *Eagle*, in New York City harbor with an explosive charge to be delivered through a hole drilled in the hull. The mission failed because of the copper cladding, but the submarine worked. During the Civil War, the CSA *H. L. Hunley*, crewed by nine men, sank the USS *Housatonic* during its blockade of Charleston harbor in 1864. The mission was successful, but all were lost, apparently as a result of the explosion. Both the *Turtle* and the *Hunley* were human-powered and considered to incorporate the latest advances in the technology.

The ISR submarines are “wet”: i.e., the occupants breathe via Self-Contained Underwater Breathing Apparatus (SCUBA), a capability not available at the time of the *Turtle* or *Hunley*. SCUBA reduces the complexity of the submarine design because the hull does not need to be a pressure vessel. However, since the submarines are free-flooding, the issues of buoyancy, and weight to be propelled forward are added challenges.

There have been isolated instances when creative individuals have designed and built human-powered submarines, but no opportunity was available for them to present the capability or interact with their peers in competition. This situation changed when Henry A. “Hap” Perry introduced the concept of the human-powered submarine races. He had always been interested in underwater vehicles, an interest he pursued with the Perry Oceanographic Company, building manned submersibles, some with lock-out capabilities. He was also the builder of many wet submarines for underwater sports enthusiasts and the movie industry such as the vehicle James Bond 007 used in *Thunderball*.

In the mid-80’s, Hap Perry approached the Department of Ocean Engineering at Florida Atlantic University (FAU) to form a joint venture to race human-powered submarines. The H. A. Perry Foundation would

provide management and financial support; FAU, technical guidance and logistical support for operations. Also required for the success of the race would be the dedicated support of volunteers. The object of the competition would be to foster technical advances in undersea vehicle hydrodynamic, propulsion, and life-support systems.

The original idea was simply to conduct some races among four or five submarines, with a few spectators; but coverage by media like a *National Geographic Explorer* program, and press coverage in *The Wall Street Journal*, and other media resulted in a new creation, the International Submarine Races. The ISR started to develop its own personality and required nurturing, control, and development. Now the challenge became to develop the event to promote education, create a design competition to validate the submarine designs and construction, and establish a structure to quantify the designs with awards.

The concept behind the ISR was that teams would form to develop human-powered submarines, compete with one another, stimulate interest, and increase public awareness of the challenges people face in working in and exploring the ocean depths. The fact that an event existed for controlled competitions assisted the teams in stimulating interest in their communities, whether universities, schools, corporations, or others. Universities and schools, even at the high school level, were supportive of the effort because it presented an engineering challenge for their students. The students could get involved in structural hull design, construction methods and materials, hydrodynamics, navigation, maneuvering and control issues, ergonomics, the safety aspects of SCUBA, and operation in a very small enclosure. The ISR provided the impetus for the various entities to create special educational programs for the development of human-powered submarines. Unfortunately, the occasional university with little vision would not allow a submarine to race under its auspices, even though a team from its own engineering department might have designed and built a viable human-powered submarine. It may be some time before submarine teams are supported the way football teams are.

Sponsorship

Hap Perry envisioned the creation of an opportunity to advance the development of subsea technology. For all of this to take place, financial support was essential. While the H. A. Perry Foundation was the original sponsor, defense contractors and the U.S. Navy recognize their need to help prepare future generations of ocean engineers, and have become major sponsors of the ISR. Electric Boat and Lockheed Martin are instrumental in the competition's continued growth and success.

Venue: ISR at Sea

The first and second ISR competitions were held at Riviera Beach, Singer Island, Florida, Hap Perry's "home town". It was a learning process acquiring the necessary support and organizational committee. Storm damage to the beach front at Singer Island required the ISR to locate a new site. A site selection package was developed, citing the necessary parameters.

In 1993, Fort Lauderdale bid for, won, and supported ISR 3. One-quarter mile off the beach in 20 feet of water, the submarines competed side by side around a 400 meter oval course. Unfortunately, high winds and seas forced cancellation of several days of practice and competition, causing problems for the 50 plus teams and ISR safety divers. Despite these setbacks, team morale and enthusiasm were high, and the races had demonstrated their technical and engineering merit.

After ISR 3, two significant developments occurred. The H. A. Perry Foundation decided that it was not in their best interest to continue sponsorship of the ISR. Also, the involvement of the Florida Atlantic University Department of Engineering came to an end because the funding source had with drawn. This loss, combined with spiraling logistics, high costs, and unpredictable weather and sea conditions, led to the conclusion that future ISR competitions could not be staged in open water.

Venue: the ISR at the US Navy NAVSEA Carderock Division David Taylor Model Basin.

The Perry Foundation transferred authority for the ISR to the Foundation for Underwater Research and Education (FURE), founded and headed by Nancy Hussey, who had been the Executive Director of the ISR since 1989. The ISR organization was restructured by a dedicated group of veteran sub- race volunteers.

Under FURE, ISR 4 was organized and conducted in December, 1995 in the controlled environment of the U.S. Navy’s Naval Surface Warfare Center’s Carderock Division, David Taylor Model Basin (DTMB) in Maryland. That test tank is 22 ft. deep, 51 ft. wide and 3,078 feet long. It holds 25 million gallons of water, and has proven to be an excellent venue for the human powered submarine design competition. The lift-platform at the mobilization end of the tank provides an excellent, safe space for launching submarines.

Race organizers were so pleased with the facilities and cooperation from the U. S. Navy that they elected to hold all subsequent competitions at Carderock. The 5th International Submarine Races were held June 23-27th, 1997, and human-powered records were shattered. A streamlined one-person sub, *OMER 3*, powered by a young Canadian ocean engineering student from the Ecole de Technologie Superieure, Montreal, streaked into the underwater spotlight, *OMER 3* achieved a speed of 6.97 knots (8 MPH) in a 10-meter measured timed section within a 100 meter course. Among other competitors were the first all-female crew in the nine-year history of the ISR.

ISR Organizers skipped 1999 but were back with the 6th sub-race in 2001. Subsequent events were extremely successful, expanding to more colleges, universities, technical high schools, and private entrants. As the Navy and Carderock officials became increasingly comfortable with the event and confident about its details, the Navy’s level of cooperation and support increased steadily. More than 150 volunteers provided resources required to conduct the races, including U.S. Navy Reserve divers and experts from the NSWC Carderock Division staff. Each commanding officer on whose watch the design competition has been held has extended a welcome hand of support, without which the ISR success could not have been possible.

To-date, the ISR events that have taken place are:

ISR 1	1989	Riviera Beach, Florida	16 submarines
ISR 2	1991	Riviera Beach, Florida	38 submarines
ISR 3	1993	Ft. Lauderdale, Florida	44 submarines
ISR 4	1995	DTMB, Carderock, Maryland	11 submarines
ISR 5	1997	DTMB, Carderock, Maryland	16 submarines
ISR 6	2001	DTMB, Carderock, Maryland	24 submarines
ISR 7	2003	DTMB, Carderock, Maryland	19 submarines
ISR 8	2005	DTMB, Carderock, Maryland	19 submarines
ISR 9	2007	DTMB, Carderock, Maryland	26 submarines

The ISR statistics:

Number of races conducted	9
Number of teams that have participated	212
Number of submarines that have entered the races	87

The summary statistics of the number of people that have attended the ISR are not readily available. For ISR 9, the statistics are:

Number of teams	22
Number of Submarine	26
Number of members in the teams	198

How the Races are Conducted

Committee

The ISR Executive Committee comprises a Chairman and two Directors, an Advisory Committee, and a Steering Committee. Assisting them are the DTMB Liaison, an Advisory Committee, and the Funding and Budget members. Operationally, there are five groups: Education, Volunteer Coordinator, Administration, Operations, and Judging. Many people hold two or more functional positions. At last count, there are 53 functional positions, and many additional volunteers assisting those functions. The ISR and non-profit FURE sponsoring organization are all volunteer. No volunteer receives compensation for services and time rendered except during race week, when FURE covers the cost of the hotel accommodations for the out of town, indispensable volunteers.

Sponsorship

Sponsorship is critical. The major sponsor is the US Navy NAVSEA, with the contribution of the Carderock test tank and assisting personnel as well as The US Navy Marine Diving and Salvage Unit (USN MDSU) who supply safety divers and high pressure air charging capabilities. IEEE-OES has continued to be a major sponsor, both with funds and qualified volunteers. Electric Boat Co. is the 3rd major sponsor. There are numerous other sponsors and in kind contributors. It is the intent of the ISR to seek major funding from various government agencies interested in the technologies being promoted by the ISR.

Venue

The races are conducted at NAVSEA, Carderock. The ISR is gratified that the US Navy continues to offer their hospitality with the Carderock test tank and personnel support.

Schedule

The ISR design competitions are scheduled for the end of June in odd numbered years. Students are out of school and are more readily available to attend the races. Recently, in even-numbered years, a two-day educational workshop has been conducted for interested contestants. There are no plans to change this two-year cycle schedule.

Interaction with Contestants

All contestants are directed to interact with the Contestant Liaison for registration, submitting technical reports, and requesting answers to both logistical and technical questions. This single-point-of-contact format has minimized confusion and has established a tight cohesive communications network.

The Competition

During race week, everybody on the ISR committee knows her or his area of responsibility and limitations of authority. There is only one person in charge of safety in the water, and that is the Dive Supervisor. All activities in the test tank during the competition are under the leadership of the Operations Director. The authority of these two is absolute and final. All functional responsibilities, whether Timing, Registration, Judging, Staff Support, or others, are well defined and executed. The majority of the 70-80 volunteers have been involved with the races for several years.

Documentation

There are many categories of documentation, and each category has a specific purpose. The Contestant Manual is the handbook for all contestants interested in registering for the ISR. Design-critical limitations are identified; all safety issues are addressed; required medical and release forms are included. The required conduct of operations is specified. The Carderock/DTMB Visit Request forms are included. The people who are points of contact for all functional positions are listed. Also, the milestone chart identifies the due dates of all required deliverables. The Contestant Manual, updated before every new race, is available on the ISR web site to all interested individuals in November prior to the race year.

Photographic documentation is varied. There is underwater video of the submarines on the race course, along with still shots. Topside, video and stills are being taken all the time. After the race, all the photographic documentation is put together in an ISR video. DTMB assisted greatly by generating a DVD of ISR 8. The complete process is in its infancy, but it will get better with every event. The major technical

documentation items are the team project reports and the executive presentations. The following excerpt from the Contestant Manual defines these reports.

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 is compiled and a compendium produced to provide educational benefit to those interested in human-powered submarine engineering. An award is given to the submarine crew that develops the most complete and informative report for their project, sponsored by Sea Technology magazine. A 20 minute presentation to the judging panel is required. The format of the presentation is conveyed to the contestants participating in the ISR.

ISR organizers firmly believe that one of the most important aspects of the races is the educational benefit that these reports offer. The ISR Judge can provide a generic outline of the report and 20-minute presentation if requested by a team. Section 3.11 in the Contestant Manual identifies dates of all deliverables, including the date listed for final submission of the basic design report. This allows an opportunity to modify the original design. All modifications are detailed and submitted to the judging panel for review. All reports are copyrighted to the ISR and become the property of the ISR.

Awards

There are seven award categories. All but one are selected by the Operations and Judging committees. The award for Best Spirit of the Race is selected by the submarine teams themselves. Every competing team is given an ISR participation plaque with a team photo, and a video of their underwater performance.

Absolute speed award – first, second and third place

Fastest speed by category – first, second and third place

Innovation – first, second and third place

Best use of composites – first, second and third place

Best design outline

Overall Performance, which is decided by comparing the points of the winners in the above awards to determine the best overall submarine team performance

Best Spirit of the Race

The Education Process

From the outset, the International Submarine Races are meant to facilitate the education process. The contestants gain invaluable experience in real-world problem situations, and learn how to “fix” things that break or malfunction. They have the opportunity to take theoretical knowledge gained in the classroom and apply it, in multidisciplinary approaches, in the design, construction and operation of a human-powered submersible built from scratch. Programs using such a multidisciplinary, “real-world” approach are not usually found in most of our ocean engineering education programs.

The ISR organization has offered engineering workshops in some even years to provide lectures from marine technology experts, written materials such as samples of drag analysis and propeller design, and details of all the safety issues. Project management is also discussed. Team project funding is presented. Some teams fund their operation with out-of-pocket monies. Others have a dedicated group who pursue funding from many sources. One team was able to obtain \$70,000. In-kind support is quite common. The second day of the workshop features a walk-through of the Carderock tank facility. The ISR and FURE expect to have the workshops available online

Contestants are required to prepare a design report, which is a complete project report defining concept development, feasibility studies, analysis, design, construction, and ergonomics, among other things. In addition to the design report, each team is required to present a 20-minute executive presentation of their project for review by the judges' panel. The object is to convey a top-level overview of their project. The design report and the 20-minute overview are two of the educational products of the ISR. Through them each team is exposed to a valuable professional experience. All team reports and presentations are compiled on one CD that is given to all current and potential future contestants. This practice has helped to improve the technology level exemplified in each race.

The benefits of the competition include the synergy and experience enjoyed by the more than 1,500 ocean engineering, marine technology students who have participated from a diverse group of schools and universities. These young people will benefit from the opportunity to apply what they are learning in a real world environment conducive to problem-solving, while operating a human-powered submarine.

The Next 19 Years, and Beyond

The twentieth anniversary of the ISR will be celebrated at ISR 10, June 21-27, 2009. The competition continues to expand, with more sophisticated technology and innovation producing more efficient human-powered subs. Winning speeds have gone from 3 + knots, to over 8. What will we see in the future?

We encourage universities to give students credit for their ISR projects, the major portion of which are conducted outside the classroom. The sub races strengthen leadership and management skills necessary for students joining the professional workforce. Hundreds of ISR alumni have entered careers with the U. S. Navy, or become defense contractors, or educators in ocean engineering and naval architecture.

High school teams benefit tremendously as well. The instructor and team leader at Sussex County (N.J.) Technical High School is proud that all five of his graduating seniors this year, who were on their 9th ISR submarine team, have been accepted at university engineering programs, some with scholarships. He attributes this change of direction towards additional higher education to the sub-team program. His engineering design class enrollment is now "maxed out." "If you make it fun and interesting, the kids will come and excel."

The FURE and the ISR goal to increase the pool of trained ocean engineers and marine technology experts will help fill the pipeline of America's future needs. We hope to encourage schools and industry to increase participation; industry benefits from this larger pool of talented, motivated graduates to recruit into rewarding careers. The U.S. Navy understands this and materially supports our continued commitment to help make a difference in the level of scientific and technological competence of the next generation.

FURE is developing plans to hold the engineering workshops online, which will eliminate travel expense and allow for more interactive participation by many more students. We will also increase the dissemination of knowledge attained through the competitions. Focusing upon educational outreach, FURE is planning a program where retired human-powered subs are placed in museum and science center exhibits, with story boards and video documentary intended to increase understanding of technology by the general public, with special emphasis on early adolescents. Interesting students as early as middle school can help them decide to pursue math and science curricula in high school, thus preparing them to continue in higher education.

FURE officers and ISR contestant submarine team members participate in marine technology symposia, such as Oceans '08. Power point presentations and exhibits help promote our future growth plans, where the thrust is on science principles and the technology underlying the submarines.

For more information:

If more information is desired, view the ISR web site, www.isrsubrace.org, or contact the ISR Chairman, Claude Brancart at c.Brancart@ieee.org