13th Annual

# MANNED UNDERWATER VEHICLES SYMPOSIUM

# 2016

Underwater Intervention, February 23-25 New Orleans, LA USA

# 2016 MTS MUV Schedule

| ROOM 343 | DAY 1 - TUES 2/23/2016 | DAY 2 - WED 2/24/2016 | DAY 3 - THURS 2/25/2016 |
|---|---|---|---|
| 8:30 to 9:00 | | **The Evolution of Thicker & more Complex Acrylic Windows for Manned Submersibles**<br>By: Andy Turner<br>Blanson Ltd, UK | |
| 9:00 to 9:30 | **World Overview of Manned Submersible Activity in 2015**<br>by: William Kohnen<br>MTS MUVC, USA | **Review of Modern Glass: Transparency Stronger than Steel**<br>By: Bill Raggio<br>Rayotek Scientific Inc, USA | **The Perfect Mothership? Sea State 4/5 Launch & Recovery of Manned Vehicles**<br>By: Chris Welsh<br>Deep Sub LLC, USA |
| 9:30 to 10:00 | **MUV Operations Consensus Standard**<br>By: Capt. Kip Peterson (USMM)<br>Thorsborg Institute, USA | **Use of Finite Element Analysis in Designing AcrylicStructures for Fatigue and Stress**<br>By: Bart Kemper, Krista Kemper<br>Kemper Engineering Services, USA | **ICTINEU 3 - 1000 meter Test Dive and Final DNVGL Certification**<br>By: Carme Parareda, Pere Fores<br>Ictineu Submarins SL, SPAIN |
| 10:00 to 10:30 | **BREAK** | **BREAK** | **BREAK** |
| 10:30 to 11:00 | **Chinese Journey to the Challenger Deep: A new strategy and current progress**<br>By: Dr. Weicheng Cui<br>Shanghai Ocean Univ, P.R. CHINA | **Overview of the ABS Underwater Rule Change Proposals for 2016 (Annual ABS – Industry Meeting)**<br>By: Roy Thomas<br>American Bureau Shipping, USA | **MTS Manned Underwater Vehicle Committee**<br><br>**10:30 to 11:30PM**<br><br>**ANNUAL MUVC MEETING** |
| 11:00 to 11:30 | **Design and Implementation of a New Control System for HOV ALVIN**<br>By: Jonathan Howland<br>WHOI, USA | **Design of Submersible Pressure Hulls – Comparison of Analytical Calculations versus FEA**<br>By: Jonathan Struwe<br>DNVGL, Germany | |
| 11:30 to 12:00 | **DSV Alvin CO2 Scrubber Qualification Test Report**<br>By: Lane Abrams<br>WHOI, USA | **An Experiment to Adapt the Commercial Classification Process for Military Submersibles**<br>By: Stephen Armstrong<br>Submergence Group LLC, USA | |
| 12:00 to 1:30 | **LUNCH** | **LUNCH**<br>**ADVANCED UW ENGINEERING** | **LUNCH** |
| 1:30 to 2:00 | **The Shell Ocean Discovery X-Prize**<br>By: Jyotika I. Virmani<br>XPRIZE, USA | **Intersecting Spherical Hull Form for MannedSubmersible Vehicles**<br>By: Fred Jensen<br>Patriot Engineering Co., USA | |
| 2:00 to 2:30 | **Cyclops Launch and Recovery System (LARS)**<br>By: Stockton Rush<br>OceanGate Inc., USA | **Characterization of Dive Helmet Noise and Development of Practical Means for its Reduction**<br>By: Steven Africk<br>Acentech, USA | |
| 2:30 to 3:00 | **A Collaborative Effort to Expand Underwater HumanExploration**<br>By: Todd Kincaid, R. Carmichael<br>Global Sub Dive, USA | **Innovative Acrylic Chamber Design: From Space Simulator to Undersea Habitats**<br>By: William Kohnen<br>HYDROSPACE Group, USA | |
| 3:00 to 3:30 | **BREAK** | **BREAK** | **BREAK** |
| 3:30 to 4:00 | **Overview of ALUCIA Submersible Operations in 2015**<br>By: Mark Taylor<br>MV ALUCIA, USA | **MTS MUV Consensus Standard WORK GROUP SESSION**<br>Open work meeting<br>MTS MUV Members | |
| 4:00 to 4:30 | **Undersea Manned Quad Copter - DeepFlight Dragon**<br>By: Graham Hawkes<br>DeepFlight, USA | | |
| 4:30 to 5:00 | **Status of Underwater Flight**<br>By: Graham Hawkes<br>DeepFlight, USA | | |
| 5:30 PM<br>7:30PM | **MTS Manned Submersible Reception Cocktail Party MARRIOTT Hotel** | | |

# Welcome to the 2016 MTS MUV SYMPOSIUM

Dear Colleagues,

On behalf of the Manned Underwater Vehicle Committee of the Marine Technology Society, welcome to UI 2016. Each year, we take this opportunity to conduct our annual meeting and explore new developments and innovation from within our industry. We are always pleased that professionals from around the world come together for an exciting few days of networking, business development and technology exchange.

Once again, we offer a full technical program and a speaker schedule which demonstrates how the MUV industry can stay lean while being productive and staying innovative. As a community, we focus on leveraging strategic partnerships/relationships to advance engineering, designs and materials sciences to go further, deeper and more efficiently into the world's oceans.

Our session begins on Tuesday, February 23rd at 9:00am and will include presentations and panel discussions, culminating with a reception and cocktail party at the Marriott Hotel at 5:30pm. Of note this year, Dr. Weicheng Cui from Shanghai University, will present progress on their endeavor to build a full ocean depth submersible. China is currently the only country working on an 11km vehicle development. Woods Hole is presenting some new technology updates on the ALVIN upgrade. Ms Jyotika Virmani from the XPRIZE organization will talk about the Shell Ocean Discovery XPRIZE. As we continue to look for ways to champion our industry to new stakeholders, Ms. Virmani's discussion presents a great opportunity to bridge those connections between manned, unmanned and robotics technology.

On the regulatory side, both ABS and DNVGL continue to support the conference with their latest updates and directions. With regards to viewports, Andy Turner from Blanson Ltd. will present information about new capabilities for large spherical acrylic windows. Also, after many years Bill Raggio of Rayotek has agreed to come and tell us the basics and his perspective on glass technology for windows. Finally, the committee's big push is to initiate discussions on writing an Operations Consensus Standard for MUVs. There is enough collective experience and expertise in our community to create a legacy that future generations can build on.

The MUV annual committee meeting is on the last day. I realize everyone is in a hurry to leave but I encourage you to participate, share your opinions and help set the direction for future meetings.

Finally, whether your business interactions are international or local, business-to-business or business-to- government, MUV is the intersection between engineering, technology advancements and the spirit of human subsea exploration. Thank you to our speakers for their time and presentations. Thank you for attending and for your participation. Thank you to our generous sponsors and thank you to Underwater Intervention for making this all possible.

I look forward to meeting up with everyone, don't forget to visit the show floor. Enjoy the conference, New Orleans is a great place to mingle.

William Kohnen
Chair, Manned Underwater Vehicles
Marine Technology Society

# CONTENTS



# MANNED UNDERWATER VEHICLES PROGRAM

## Day 1 - Room 343 - Tuesday, February 23

9:00-9:30 **World Overview of Manned Sub Activity in 2015**
by: William Kohnen, Hydrospace Group, USA

A yearly review of the state of the Manned Submersible industry in 2015. The overview will look at developments in all branches, including international research, tourism activity, leisure and security developments. This will include a summary of submersibles under Classification, operating and in construction, review of the industry trends and regulatory highlights for the year.

9:30-10:00 **"Consensus Operating Standards" For Manned Underwater Vehicles**
By: Kip Peterson, Thorsborg Institute LLC, USA

This is the time to be proactive for the MUV community to come together to create the "Consensus Operating Standards" on the commercial operations of manned undersea vehicles to be able to put forward an industry recommended resource to the government to consider and accept as they have in other aspects of the marine operations which could become the 'de-facto" basis for the government to allow the MUV industry to self-regulate in the same manner as the ADCI has been granted by the Federal Government to be the source of operational standards within the commercial diving industry. This discussion is an evolving document that will be developed through input from all members of the Marine Technology Society's MUV Committee. These Consensus Operating Standards will augment the technical expertise and inspection that currently occurs with the classification agencies/societies that are active in the manned undersea vehicle community and is not designed or expected to impinge on the technical standards derived by the classification societies, but to have an industry standard operating consensus on the commercial operations of manned undersea vehicles. In due time, these industry standards will assist in the negotiations with the marine insurance industry as it will be the MUV industry's guidelines for operations of manned undersea vehicles that will have a positive impact on rates and coverages for manned underwater vehicle operators who comply with the Consensus Operating Standards.

10:00-10:30 Coffee Break

10:30-11:00 **Chinese Journey to the Challenger Deep: A new strategy and current progress**
By: Dr. Weicheng Cui, Shanghai Ocean Univ, P.R. CHINA

The hadal trenches and the biology and ecology of the organisms that inhabit them remain one of the least understood marine environments. The study of hadal trenches which is often referred to as hadal science, needs special technical equipment support such as landers, unmanned submersibles and manned submersibles. Sending sampling devices or exploratory vehicles to hadal depths is technically challenging and expensive, consequently, our current understanding of hadal ecological structure is still very much in its infancy. In recognition of the significance that hadal science holds and the unique and challenging requirements that work in the deep ocean presents, Shanghai Ocean University has made a significant commitment to develop an operational support for the promotion of hadal science in China. The first three authors from the JIAOLONG development team were invited by Shanghai Ocean University to establish a hadal science and technology research center (HAST). The first focus of HAST is to construct a movable laboratory for hadal trenches which includes a mothership, an Human Occupied Vehicle

(HOV), an Autonomous and Remotely-operated Vehicle (ARV) and three landers. In additional to the technology challenge in the development of full ocean depth (FOD) landers and submersibles, the funding challenge is also significant. In this project, a new mode called "private investment + governmental support" is introduced and through three years practice the results are very good. In this paper, the basic philosophy how to overcome the technology challenge and funding challenge is explained and the current progress is reported. It includes the results of 4000m sea trials just completed in South China Sea in October 2015 of the first FOD lander and FOD ARV developed in this project.

11:00-11:30 **Design and Implementation of a New Control System for HOV ALVIN**

By: Jonathan Howland, WHOI, USA

In 2010 the Woods Hole Oceanographic Institution embarked upon a major upgrade to the Alvin HOV. The upgrade included a complete replacement of the submarines computing and data systems. The system architecture relied heavily upon lessons learned in successful development and operation of the control systems for the Institution's Jason ROV and other deep submergence vehicles. The presence of human operators subsea forced modifications to parts of the system, but in essence, the new Alvin is a computer controlled fly by wire submarine. Automation allows a reduction in pilot workload, enhancing the ability of the pilot to focus on the scientific mission of the submarine. Closed loop control allows automated independent axis control of submarine position, depth, and heading, with data provided by a new navigation system. Enhanced logging allows the integration of the submarine into previously developed data processing pipelines and provides fodder for engineering analyses. All of the vehicles in the National Deep Submergence Facility now rely upon a common code base and similar architectures.

11:30-12:00 **DSV Alvin CO2 Scrubber Qualification Test Report**

By: Lane Abrams, WHOI, USA

The DSV Alvin submersible life support system employs an Oxygen source to bleed gas into the personnel sphere at a controlled rate, and a CO2 Scrubber employing Sofnolime® absorbent material. Both of these systems are of extremely simple design to promote ease of use and extremely high reliability. As part of the 2013/2014 refit, the CO2 Scrubber system was upgraded to simplify the design and procurement of component parts, and to address certification deficiencies of the previous design. Because the importance of this system's safe operation cannot be overstressed, these changes needed to be qualified for use with an appropriate test program. Qualification testing was performed through the Fall and Winter of 2014/2015. A test chamber was assembled to simulate the submarine's personnel sphere, and instrumented for atmospheric parameters. This was provided with controls to allow adjustment of the pressure, temperature, Oxygen input flow rate, Scrubber operational speed and absorbent material selection. Collected data also included CO2 level and power consumption by the Scrubber. The test program checked a variety of scenarios against performance requirements. The overall results were that the new Scrubber design to performed as well as or better than the previous design, that the Sofnolime® and LiOH materials are acceptable and appropriate for use in the submarine, and that the absorbent materials perform as the manufacturers describe. Of keen interest to the submarine's operators, this work determined the quantities necessary to support the standard and emergency mission requirements. These notes serve to document the work done leading up to qualification testing, as well as a summary of the testing results. Submarine operators may find this information useful to help define their own CO2 Scrubber design and testing efforts.

12:00-1:30 Lunch

1:30-2:00

### The Shell Ocean Discovery X-Prize

By: Jyotika I. Virmani, XPRIZE, USA

Ocean exploration has been inextricably linked with technology. Marching on from a bucket, Secchi disk and a spyglass to ROVs, satellites and sensors, we keep moving forward developing methods to look deeper and with more detail to improve our understanding of the ocean. This presentation will cover the current uses of technologies such as instruments and sensors, sonar and acoustics, manned submersibles commercial diving, ROVs, AUVs and UUVs and where future applications and developments can further the advancement of ocean exploration. The presentation will provide a history and overview of the X-Prize and offer details of the Ocean Discovery prize.

2:00-2:30

### Cyclops Launch and Retrieval System (LARS)

By: Stockton Rush, OceanGate Inc., USA

In the summer of 2015 OceanGate completed construction of its third LARS and conducted dive operations in the Gulf of Mexico on the Flower Garden Banks National Marine Sanctuary. The Cyclops LARS carried the 9.5 ton Cyclops 1 submersible over 220nm while being towed from the RV Pelican. While 110nm out at sea OceanGate conducted deployment and recovery of the submersible without assistance from the tow ship. This presentation will cover the construction and operation of OceanGate's LARS as well as future variants and its use with the Cyclops 1 submersible.

2:30-3:00

### A Collaborative Effort to Expand Underwater Human Exploration and Promote Marine Conservation

By: Todd Kincaid, R. Carmichael, Global Sub Dive, USA

Brownies Global Logistics operates the 44-meter DP1 OSV "Baseline Explorer" equipped with two 300-meter observation submersibles and a technical diving support system to advance the underwater conservation effort entitled Project Baseline (www.projectbaseline.org). Project Baseline's mission is to leverage volunteer and collaborative endeavors to document the underwater world and promote policies and actions aimed at effective conservation and protection. With Baseline Explorer and the submersibles, BGL has successfully conducted more than 10 expeditions involving more than 250 human occupied submersible dives to depths between 30 and 300 meters putting researchers, media professionals, or policy makers underwater on the target sites with almost every dive. In many cases, the human presence onsite for extended periods both inside and outside of the submersibles facilitated rapid expansion of knowledge and understanding that had not been possible with previous work using only remote technologies. Beyond the benefits gained in terms of knowledge of the environments surveyed, pairing researchers with volunteers and media personnel through the Project Baseline portal resulted in public awareness levels not likely achievable from results obtained from remotely performed work where the humans are removed from the setting and the action. The feedback and interest derived from our work and results to date clearly demonstrate the critical importance of human occupied submersibles in the pallet of tools being brought to bear in undersea research. Our experience with collaboration between private, government, academic, philanthropic, and volunteer entities in support of marine conservation has embodied the adage "the whole is greater than the sum of its parts."

3:00-3:30 Coffee Break

3:30-4:00

### Overview of ALUCIA Submersible Operations in 2015

By: Mark Taylor, MV ALUCIA, USA

The Alucia is a 56 meter research and exploration vessel built to broaden our scientific understanding of the ocean and illuminate its myriad natural wonders. Her launch and recovery platform facilitate a wide range of diving and submersible operations. She boasts the latest in technical diving, filming and scientific research equipment. She contains two subs - the Triton 3300/3 and the Deep Rover 2 – both of which are rated for a maximum depth of 1000 meters. The Alucia also the latest in nautical expedition media technology. The presenter is Mr. Mark Taylor, submersible operations team leader and he will provide an overview of the diving activities for 2015.

4:00-4:30 **Undersea Manned Quad Copter - DeepFlight Dragon**
By: Graham Hawkes, DeepFlight, USA

The Presentation outlines the design research and first sea trials, challenges and results of this new type of manned submersible craft, together with issues and need for rapid response to development of "new type" best safety practice fro use by early adopters.

4:30-5:00 **Status of Underwater Flight: Part 2 - The Development and Testing of DeepFlight Dragon**
By: Graham Hawkes, DeepFlight, USA

DeepFlight has recently launched its 6th generation DeepFlight submersible, Deepflight Dragon. I will be presenting material regarding the development and testing of this new type of submersible that is: fixed positively buoyant; the lightest and smallest two-person submersible; dives solely on the power of thrust; has advanced proprietary software to set depth limits and manage other aspects of the dives; and is so easy and intuitive to use that a professional pilot is not needed.

**Please Join us for the MTS MUV Cocktail Reception**
*Tuesday, February 23*
*Marriott Hotel, 5:30-7:30pm*

## Day 2 - Room 343 - Wednesday, February 24

8:30-9:00 **The Evolution of Thicker & more Complex Acrylic Windows for Manned Submersibles**
By: Andy Turner, Blanson Ltd, UK

The manufacture of large, custom acrylic windows is a classic niche market, requiring a significant depth of understanding of polymer chemistry, acrylic properties, Standards, casting, machining, polishing, bonding, QA and annealing; all of which are required to produce a window of quality that meets the needs and expectations of customers and classification societies. This paper discusses the challenges of making thicker & thicker windows and in complex shapes whilst ensuring that they are fit for purpose.

9:00-9:30 **Review of Modern Glass: Transparency Stronger than Steel**
By: Bill Raggio, Rayotek Scientific Inc, USA

Glass is ubiquitous in our lives, both past and present. Because of the transparent nature of glass it is often "out of sight, out of mind", except when it breaks. For many of us our first memories of glass are of it breaking, followed by an upset parent cleaning up the spilled milk. So its no wonder that most peoples gut feelings about glass is its delicate and should be avoided in mechanically challenging environments. The purpose of this paper is to educate, "re-condition" the reader as to the true nature of glass as a excellent material for many mechanical applications; in some cases much stronger than steel. We will do a "101" review of the physical properties of glass, how it is made, how it is formed into useable, durable products, and how it is ideally suited for underwater applications. The key concept we will focus on is compression; the more compressive forces, the stronger the glass gets. And what better place to indulge in glasses biggest ally than underwater; the deeper the better. Finally, we will discuss applications where glass can improve upon existing underwater technologies, and in many cases introduce exciting new technologies that will support faster, safer, more reliable equipment and methods for underwater intervention.

9:30-10:00 **Use of Finite Element Analysis in Designing Acrylic Structures for Fatigue and Stress**
By: Bart Kemper, Krista Kemper, Kemper Engineering Services, USA

Acrylics are a proven, reliable material for submersible viewports. The current codes and standards reflect a first-generation development of defining a nonmetallic for pressure vessel application. This presentation builds upon engineering techniques regarding designing acrylic structures for fatigue and stress presented at the 2013 Joint ASME/USCG Conference.

10:00-10:30 Coffee Break

10:30-11:00 **Overview of the ABS Underwater Rule Change Proposals for 2016 (Annual ABS – Industry Meeting)**
By: Roy Thomas, ABS, USA

Open meeting of the American Bureau of Shipping (ABS) with the subsea industry to review proposed Rule changes to the ABS Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities. This meeting facilitates an open dialogue with the industry on current issues that work well or do not work. All active designers, fabricators, owners and operators are invited to attend and provide feedback.

11:00-11:30 **Design of Submersible Pressure Hulls – Comparison of Analytical Calculations versus FEA**
By: Jonathan Struwe, DNV GL, Germany

Designers of Pressure Hulls and Pressure Vessels intended for Manned Submersibles are faced with the question which design standard and which design methodology provides the most reliable and efficient way for safe pressure hull design.

While the use of recognized pressure vessel codes is mandatory, the geometries are more and more complex in nature and require more detailed analysis capabilities than most of the recognized standards can provide.
This presentation will answer the questions

- Which design methodology is the most efficient and which is the most reliable one?
- Is a comparison of Analytical Calculations versus FEA meaningful?
- Is the combination of Analytical Calculations based on recognized standards and FEA practicable?

The author will provide insight in the pressure hull design approval methodology developed during the recent years of approval activities.

11:30-12:00 **An Experiment to Adapt the Commercial Classification Process for Military Submersibles**
By: Stephen Armstrong, Submergence Group LLC, USA

Submergence Group LLC, Lockheed Martin Inc., and the U.S. DoD recently concluded a multi-year effort that applied the commercial classification process and combined it with the military system safety process to safety certify a commercial submersible for military use. The commercial submersible is the MSubs S301i "Marie", a 2 pilot, 6 diver lock-out submersible. After classification and certification, the S301i was used to train military pilots and divers and to test equipment and components. However, the project's most important contribution was in pioneering a new safety process that opens the door to using commercial marine processes to design and build military submersibles.

12:00-1:30 Lunch

## Advanced Underwater Engineering Session

1:30-2:00 **Intersecting Spherical Hull Form for Manned Submersible Vehicles**

By: Fred Jensen, Patriot Engineering Co., USA, William M. Simpson, Jr., Ph.D., PE, U.S. Coast Guard Academy, Capt Jack Ringelberg, MS, PE, JMS Naval Architects and Salvage Engineers, USA

The most used hull form for the design of underwater vehicles is the single sphere or for larger vehicles a cylinder with spherical caps at each end. The objective of this paper is to show the structural advantages of hull geometry in the form of intersecting spheres for multipurpose submersibles. A theoretical discussion is presented of how a physical arrangement of intersecting structural spheres, reinforcing rings and compression bulkheads results in a structure that is very competitive with the above mentioned conventional hull forms. The goal of this work has been to develop a general purpose manned underwater vehicle adaptable to a variety of deep water tasks. Some observations from this design work conclude that an intersecting spherical hull form results in a more efficient use of usable interior volume especially for smaller submersible vessels. The current standard cylindrical hull form requires a central passageway for crew movement fore and aft of the vessel. Thereby, the entire central volume is unavailable for payload and is not usable space. The intersecting spherical hull form allows multiple passageways and multiple equipment areas for payload within the interior. This allows the work platform to be easily altered for tasks such as underwater transport, commercial diving, sub-sea survey work, and ocean research. Another observation is the intersecting spherical hull form lends itself to a saucer like disk hull form which has hydrodynamic advantages in underwater handling and maneuverability similar to a Manta fish. These practical advantages of the proposed hull form are the incentives to proceed with the structural analysis and discussion presented in the paper.

2:00-2:30 **Characterization of Dive Helmet Noise and Development of Practical Means for its Reduction**

By: Steven Africk, Acentech, USA

Dive helmets are notoriously noisy, posing a potential hazard to Diver hearing and limiting bottom times. Under NAVSEA 00C sponsorship, Acentech performed a study to characterize dive helmet noise and develop reduction techniques that could be applied to existing helmets or incorporated into future designs. A theoretical model of the respiration-generated noise was assembled based on laboratory measurements of KM-37 helmets and KM 350 Superflow regulators at our facility and at the ANSTI pressurized breathing simulator at Dive Lab. Inhalation noise is generated by turbulent airflow within the regulator and propagates through the breathing tube and oral/nasal mask to the diver's ear and exhalation noise is generated within the "whiskers" at the air/water surface where the bubbles are formed and propagates through the regulator and then along the same path to the diver's ear. Bubble noise does not appear to cross through the helmet from the water. While the exhalation bubble noise dominates the total noise at shallow depths, inhalation noise increases with the increase in air density with depth and exceeds the bubble noise below about 70 fsw, making its reduction essential for overall helmet quieting. Two promising methods to reduce both exhalation and inhalation noise by weakening the paths from these sources to the ear that could be incorporated into existing helmets, the use of expansion chambers and screens within the regulator airflow paths were demonstrated, yielding about 8 and 10 dBA respectively. These reductions would each permit a fourfold increase in bottom time allowed by the Navy's NOEL standards. Means to reduce regulator-generated inhalation noise by reducing the radius of curvature of the major airflow turning channel and eliminating roughness of the surfaces over which the air flows were investigated. Reduction of this noise by 6 dBA was demonstrated. Realization of these modifications will require a significant regulator redesign. If all these methods were to be implemented a reduction on the order of 24 dB is possible. In addition, the ability of an external elastomeric treatment to reduce the intrusion of external noise due to tools or sonar into the helmet was demonstrated.

2:30-3:00

### Innovative Acrylic Chamber Design: From Space Simulator to Undersea Habitats

By: William Kohnen, HYDROSPACE Group, USA

Hydrospace Group is a specialist in the design and construction of certified pressure vessels for human occupancy. The company experience with PVHO certified acrylic offers a range of innovative options for the conceptualization of large displacement pressure vessels. Recent advancements in the commercial space industry have required new space simulation chambers for the testing and training of space tourists to familiarize with new commercial space suits. Hydrospace delivered a ten person chamber to simulate the pressure hull of a modern commercial space craft. The chamber was based on a 96 inch diameter acrylic cylindrical hull and the facilities to accommodate eight passengers and two crew in space suits. The primary function of the chamber is to perform a rapid cabin depressurization test to simulate an emergency hull failure while in orbit. The pressure chamber was design and tested to the ASME PVHO-1 safety standards for the full vacuum of space, to an altitude of 100km. The design also provides the basis for a PVHO certified underwater habitat module rated for a depth of 30 fsw. The presentation will review the design, fabrication and testing of this chamber.

3:00-3:30 Coffee Break

3:30-4:30

### MTS Manned Submersible WORKING GROUP SESSION
### MUV Operations Consensus Standards

Chaired by William Kohnen, MTS MUV Chair

This is the first Work Group session to outline the plan for the MUV Consensus Operating Standards. This discussion is the first start of an evolving document that will be developed through input from all members of the Marine Technology Society's MUV Committee. These Consensus Operating Standards are not meant to replace existing classification rules. They will augment the technical expertise and inspection that currently occurs with the classification agencies/societies that are active in the manned undersea vehicle community and is not designed or expected to impinge on the technical standards derived by the classification societies. They are meant as an industry standard OPERATING consensus on the operations of manned underwater vehicles, whether classed or unclassed, commercial or non-commercial, civilian or military. In due time, these industry standards will assist in the negotiations with the marine insurance industry as it will be the MUV industry's guidelines for operations of manned undersea vehicles that will have a positive impact on rates and coverages for manned underwater vehicle operators who comply with the Consensus Operating Standards.

# Day 3 - Room 343 - Thursday, February 25

9:00-9:30

## The Perfect Mothership? Sea State 4/5 Launch & Recovery of Manned Vehicles

By: Chris Welsh, Owner/Operator Deep Sub LLC USA

Light catamaran design allows easy launch and recovery in 8'-10' seas with 20 knot winds windwaves. Key aspects to the suitability include the crane being located at the center of buoyancy and gravity of the mothership and the light weight of the mothership. The combination results in little to no heave, regardless of conditions. Catamaran design should be incorporated into all future motherships for efficiency and high launch utility. The presentation will also review submersible operations performed at the Farralon islands in late 2015 in heavy sea conditions.

9:30-10:00

## ICTINEU III - 1000m Test Dive and Final DNVGL Certification

By: Carme Parareda, Pere Fores, Ictineu Submarins SL, SPAIN

The ICTINEU 3 is a scientific manned submersible with a depth rating of 1200 meters and a crew of three: one pilot and two observers (passengers). Certified and classed by DNV-GL it successfully performed sea trials and a deep certification dive to 1.000 meters depth in November 2015, in France. The sea trials and the deep dive were done under the surveillance of DNV-GL inspector and French Maritime Affairs commission, where the ICTINEU 3 obtained the French flag and registry as well as navigation permits. The tests area was in Villefranche bay and Cap Ferrat, in the clear waters of the Cote d'Azur which offers excellent conditions for dives.

Previous harbor tests had been done in the same area in April where operational procedures, communications and functional tests were performed. Stability tests were done for different situations, and safety systems were tested such as emergency surfacing by blowing the diving tanks and also by releasing the ballast system. The vehicle is designed to be versatile with an architecture that allows easy implementation of client equipment. In addition, it can be either operated from an oceanographic vessel or towed by a small vessel for near-shore dives. It's a unique vehicle which can dive to 1.200m depth being extremely lightweight (5.500 kg) and compact, and thus can be easily transported on private yachts. In addition to the certification dives, the ICTINEU performed more than 50 dives including a scientific campaign in the Cote d'Azur area and an archaeological campaign in the Cap de Creus area on north Catalonia on a roman shipwreck. The scientific dives were done in cooperation with researchers at the Oceanographic Observatory of Villefranche (UPMC, CNRS) with an unexpected discovery that will be presented at UI.

10:00-10:30 Coffee Break

**10:30-11:30**

## *MTS Manned Underwater Vehicles 2016 Yearly Committee Meeting*

By: William Kohnen, Chair, Manned Underwater Vehicles, MTS, USA

ALL MTS MUV Members and Industry delegates are invited to attend, participate and join in the planning for the committee work for 2015.

# 2016 SPEAKER BIOS

Lane Abrams
Senior Engineer
Woods Hole Oceanographic Institution

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Lane Abrams has been a member Alvin Group, part of the Woods Hole Oceanographic Institution, since 1991. Currently a Senior Engineer, he has been the primary Electrical Engineer for the DSV Alvin submersible's systems. This includes battery and power systems, control, data and video systems, propulsion and cabling. More recently, he is the Lead Electrical Engineer for the Alvin Upgrade project.

In addition to these efforts, he has also provided Electrical Engineering design and support for a variety of projects, including several high-definition underwater camera projects, the Remus and OOI programs, the Shipboard Scientific Services Group, the National Marine Fisheries Service's Scallop Research Set Aside Program, the Ocean Cubes project, and numerous instrumentation development programs.

His expertise includes analog and digital circuit design and schematic capture, computer and microcontroller programming, circuit board layout, enclosure design, assembly, integration and testing. He is also familiar with the specific concerns of interest to underwater systems such as power and volume limitations, leaks and grounds, and pressure tolerance.

Steven Africk
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Steven Africk has a Ph.D. in physics from Brown University and 40 years experience in underwater acoustics at Bolt Beranek and Newman (BBN), Atlantic Applied Research Corp., Physical Sciences Inc, and Acentech Inc. He has also been a research associate in the Chemical Engineering Department at MIT where he is developing a ultrasonic backscatter system (e.g. active sonar) for characterization of nanoparticles.

Stephen Armstrong
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Mr. Steve Armstrong grew up just up the road from John Holland's submarine workshop in New Jersey, USA. He is the Chief Technology Officer for Submergence Group LLC and it's UK affiliate MSubs Ltd. Together Submergence Group and MSubs design, build and operate manned and unmanned submersibles and deep ocean systems for government and commercial clients. Prior to joining Submergence Group, Mr. Armstrong was a senior civilian with the U.S. Department of Defense, specializing in the research and development of advanced special operations maritime systems. In this capacity his teams developed and fielded numerous manned submersibles and high performance surface craft. Mr. Armstrong is also a retired Captain, U.S. Navy Reserve with 30 years of active and reserve service in submarines and shore commands. Mr. Armstrong is a member of the Marine Techniology Society and a senior member of the Institute of Electrical and Electronics Engineers.

Robert Carmichael
Director of Global Logistics
Brownies Global Logistics/
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Robert Carmichael: Director of Global Logistics Robert Carmichael a constant passion for underwater exploration and a knack for improving the functionality of mechanical devices. e learned how to build a recreational hookah system in 1980 as the first full-time employee of Brownie's Third Lung, a job that inaugurated his love for diving. In the late 1980's he began experimenting with technical mixed gas diving and was the enterprising force behind the development of what would become the Halcyon "PVR-BASC" rebreather. This rebreather helped revolutionize deep, technical diving and would lead to numerous world record cave dives. Over more than 15 yrs these and many other innovations were developed with Robert's business partner and friend, Jarrod Jablonski, with whom he founded Halcyon Manufacturing in 1995. Robert continues to bring innovative solutions into a wide range of marine applications, building a team at Brownie's Global Logistics which supports mixed gas supply and submersible support systems for yachts and expedition ships around the world. Robert is proud to donate some of BGL's time and resources to the exploration and conservation efforts of Project Baseline worldwide.

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Dr. Weicheng Cui, born in 1963. Currently, he is a research professor and dean of Hadal Science and Technology Research Center (HAST), Shanghai Ocean University. He received his B.Sc. from Department of Engineering Mechanics of Tsinghua University in 1986 and his Ph.D. from University of Bristol, England, in 1990. From 1990 to 1993, he did his post-doctorate research in the Department of Aerospace Engineering of University of Bristol. He made contributions in the aspects of measurement of inter-laminar shear strength, nonlinear effect and size effect of the delamination strength and the delamination mechanism for composite materials. From February 1993 to May 1999, he worked at the China Ship Scientific Research Center (CSSRC) and from June 1999 to September 2002 he was appointed as the Changjiang Professor of Shanghai Jiao Tong University and from October 2002 to March 2013 he was working in CSSRC again. Since March 2013 he is working at Shanghai Ocean University. He was the project leader and first deputy chief designer of Jiaolong deep manned submersible. He made contributions in the application of multidisciplinary design optimization method and the establishment of a rational design standard for the manned cabin. Before the Jiaolong project, he mainly engaged in the research in ship structural mechanics. He is an associate editor of «Ocean Engineering» and a member of the editorial board of another four international journals «Marine Structures», «Journal of Marine Science and Technology», «Journal of Engineering for the Maritime Environment», «Ships and Offshore Structures» and several national journals. He has published more than 400 technical papers in various technical journals and conferences. His current interest is to develop a full ocean depth manned submersible in order to promote the development of hadal science in the world.

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Pere Forès. Industrial Designer. Co-founder, administrator and director of ICTINEU Submarins SL and co-founder of the Ictineu Institute, Catalan Submarine Research Centre in 2004. He has conceived and designed the ICTINEU 3 manned submersible for 1.200m. He has worked as an industrial designer, model maker, modeller, and after studying naval design has worked in the construction of recreational sailing and racing vessels for 15 years. He specialized in construction materials and processes involving composites and new materials. He built his first submarine at the age of 11, and later has designed and built his own sailing boats, being the last one an open racing ship with which he has crossed the Atlantic ocean twice. He co-wrote the book l'Atlàntic a quatre mans (The Atlantic four hands).


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Graham Hawkes, an internationally renowned ocean engineer/inventor, has been responsible for the design of a significant percentage of all manned (and more than 350 remote) underwater vehicles built for research or industry worldwide, including the Wasp and Mantis Atmospheric Diving Suits, the Deep Rover research submersibles – which were featured in the James Cameron 3-D Imax film, "Aliens of the Deep," and the Deep Flight series of personal submersibles. DeepFlight are a new type of manned underwater craft that are fixed positively buoyant and operate on the principles of flight.

Mr. Hawkes has successfully founded and managed six high technology companies, including, Precision Remotes, Inc., which manufactures remote (land-based) systems for the military. Precision Remotes' products were hailed by Time Magazine as one of the best inventions of 2004; Hawkes Remotes (HRI), a Company that was acquired by Bluefin to introduce a new generation of Remotely Operated Vehicles (ROVs) based on a range of proprietary, patented technologies which solve the inherent problems of operating conventional ROVS; and Hawkes Ocean Technologies (HOT), now doing business as DeepFlight, which designs and builds the Deep Flight series of personal submarines for exploration and recreation. DeepFlight has recently launched its 6th generation DeepFiight craft, the Dragon at the Monaco Yacht Show.

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Jonathan Howland is a Senior Engineer in the Woods Hole Oceanographic Institution's Deep Submergence Laboratory, where his career has focussed on software development, imaging systems, and navigation. He has been a principal developer of the software used in the Jason ROV system, the Alvin submersible, and many other robotic vehicles. He led camera development efforts for the Nereus Hybrid ROV and for several generations of cameras used on Habcam, the Sentry and Abe AUVs, and in observatory efforts. He is a lead developer of the navigation software used in all of the National Deep Submergence Facility's vehicle systems.

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Fred C. Jensen, co-founder of Patriot Engineering Company with Barbara Jensen; located in Chagrin Falls, Ohio 44023. He is a graduate of Florida State University with a BS in Engineering Science and a Master's in Mechanical Engineering from Cleveland State University. At Patriot he completed mechanical engineering, design and structural Finite Element Analysis (FEA) of the housing / packaging for the Gamma Ray Spectrometer and Neutron Spectrometer for the Messenger Spacecraft to Mercury. He was the lead mechanical engineer for the (SAX) Satellite Astronomy X-ray telescope that identified numerous gamma-ray bursts with extra-galactic objects. Patriot Engineering has completed over 1200 projects in aerospace, marine, medical, mining and special machinery for industry. He is a lifelong sailor having commercial fished off the East coast, was paid crew on various vessels, ICYRA championship sailing including the Kennedy Cup at the US Naval Academy and the nationals while attending FSU. He was past commodore of the FSU sailing team. Fred and Barbara sailed their current vessel for the past twenty-five years on the Great Lakes.

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Bart Kemper, P.E. is the principal engineer for Kemper Engineering Services, LLC. Based in Baton Rouge, LA, Bart has over 20 years of experience in engineering ranging from pressure vessels to mechanisms to FEA & CFD to shock, blast and ballistics. His work includes saturation diving systems, downhole tools and marine applications. Past recognitions include being one of the Top 10 Federal Engineers in 2007. He is a member of the ASME Pressure Vessels for Human Occupancy (PVHO) codes and standards committee, has written numerous professional articles, and has several patents and patents pending.Bart is also a military Reservist with multiple overseas and combat deployments as an engineer.

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Krista Kemper is the President of Kemper Engineering Services, LLC. Based in Franklin, LA, Krista's experience as combat veteran, mechanical designer and project manager provides the foundation for her leadership to the firm. She is a member of the ASME Pressure Vessels for Human Occupancy (PVHO) codes and standards committee with professional expertise in the design, analysis, and regulatory review of medical hyperbaric and saturation diving systems. She is on the Industry Review Panel for the LSU Engineering Capstone Design course, a 2 semester multi-discipline program where she mentors young engineers.

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Dr. Todd Kincaid has been diving since 1979 and cave diving since 1987. He has explored and mapped underwater caves in Florida, Turkey, Mexico, and China and studied the role of caves in controlling groundwater flow patterns for M.S. and Ph.D. university degrees. He is currently working with a team of researchers and explorers with the Florida Geological Survey and GUE's Woodville Karst Plain Project to understand karstic groundwater flow to Wakulla Spring in North Florida. That work has included detailed underwater cave mapping, quantitative groundwater tracing, hydraulic metering of discrete cave passages, and the numerical simulation of conduit/matrix groundwater flow. He is one of the original founders of GUE, currently serves as GUE's Vice President, and also leads a small consulting company, GeoHydros, that specializes in geological and groundwater modeling. He also serves on the Advisory Board for the Hydrogeology Consortium and the Florida Springs Institute, both non-profit organizations dedicated to the protection of Florida's springs.

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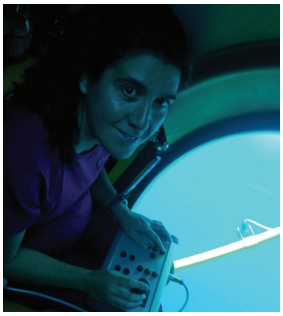
Mr. William Kohnen is President of Hydrospace Group Inc. a company that specializes in integrated solutions for manned submersible intervention, all sectors of pressure vessels for human occupancy. Mr. Kohnen has 25 years of engineering experience in aerospace and submersible vehicle design. He directs development for underwater vehicle design, power plant & propulsion systems and PVHO pressure hull technology where high reliability and safety are paramount. He is co-founder of SEAmagine Hydrospace Corp. manufacturer of manned submersibles which delivered nine ABS classed submersibles to date. Mr. Kohnen has a background in aerospace with a M.Sc. Elec. Engr. from McGill University, Canada. He was named MTS Fellow in 2014 and has been chair of the Marine Technology Society Manned Underwater Vehicles Committee since 2003 leading the MUV program at Underwater Intervention conference to represent the manned submersible industry. Mr. Kohnen is an active member of the ASME Pressure Vessel for Human Occupancy (PVHO) Committee, and chair of the Submersible sub-committee. He was an industry representative on the ALVIN Replacement HOV Oversight Committee (RHOC) for NSF. He has worked for over 25 years with the US Coast Guard and ABS rules and regulations for building submersibles, and is a member of the ABS Special Committee on Underwater Systems and Vehicles and member of the Deep Submersible Pilots Assoc.



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Carme Parareda. Co-founder, administrator and COO of ICTINEU Submarins SL. As a Surveying Engineer she worked in the service of the Cartographic Institute of Catalonia for 15 years, since 1992, in the field of geodesy, high accuracy positioning and GPS navigation techniques. In 2004 she re-oriented her carreer to ocean observation and underwater technology, co-founding in 2004 the Ictineu Institute, Catalan Submarine Research Centre where she is the Secretary, and in 2007 ICTINEU Submarins SL. At the same time she coordinated the Argo Maris Foundation activities (sea exploration and outreach). She is a board member of the Catalan Maritime Cluster. A traveller who loves adventure sports and mountaineering, after crossing Mongolia by bike, she sailed across the Atlantic twice. She co-wrote a book l'Atlàntic a quatre mans (The Atlantic four hands).

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Bill Raggio is the CTO and President of Rayotek Scientific, Inc. Founding Rayotek in 1992, after 14 years as a successful corporate engineer and scientist, he created Rayotek as a glass and materials engineering company to support his passion for creative thinking, inventing novel new products, and avoiding corporate middle management. Over the last 23 years, with Bill at the helm, Rayotek has become an internationally respected organization in glass and optical engineering and manufacturing. Rayotek is now considered the go-to company for engineered viewing and structural product solutions in extreme pressure, temperature and hostile environments. Current projects are spacecraft windows for NASA Orion and Boeing CCtCAP spacecraft, safer extreme temperature firemen goggles, seven foot diameter spherical glass hulls for FOD manned submersibles, massive optics for the worlds largest digital camera for the LSST telescope, and for chocolate lovers several huge, glass chocolate fountains for a 5 star hotel.

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Jonathan Struwe, an Inspection Engineer for Underwater Technology, is part of the Underwater Technology Section of DNV GL and was mainly involved in the recent manned submersible classification activities of DNV GL. The technical experts at DNV GL's Underwater Technology Section are dealing with approval and analysis of a wide range of underwater systems and provide, besides approval according to the GL Rules for Underwater Technology, technical expertise based on an engineering approach.

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Buck was born on the South coast of the UK. After studying mechanical engineering he signed up with the British Royal Navy where he served 14 years as a clearance diver. In his last 3 years of service he was attached to the UK submarine rescue team where he trained as an LR5 rescue crewmember. In 2000 Buck was part of the team sent to assist the stricken Russian submarine Kursk. Shortly after this he left the Royal Navy and took up a position with Rumic Ltd as a rescue pilot. Over a ten-year period with Rumic and James Fisher he conducted test and acceptance on the NATO, South Korean, Singaporean and Chinese rescue submersibles. From here he became a senior rescue pilot and trained rescue crews from China, Singapore, NATO, South Korea and Australia. On and off Buck has been running the submersible operations onboard the MV Alucia since 2007 and has run many media and science submersible operations during this period.

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Roy Thomas has worked with the American Bureau of Shipping (ABS) for the past 13 years and serves as the Engineering Manager of the Corporate Chief Engineer's Office.

Mr. Thomas has extensive experience with the Classification of underwater vehicles, systems and hyperbaric facilities for commercial and military applications. He has served as the lead design review engineer on numerous projects involving underwater vehicles, systems and hyperbaric facilities of every possible form and design. Over the years, he has played an active role in updating the ABS Rules for Underwater Vehicles, Systems and Hyperbaric Facilities and has authored new sections on Diving Systems, Lock-Out Submersibles, Ambient-Pressure Submersibles, Atmospheric Diving Suits, AUVs, ROVs, Lithium Batteries, etc.

Mr. Thomas has previously worked as a seagoing marine engineer on board tankers and has hands-on experience in the running, maintenance and overhaul of marine machinery. Mr. Thomas holds a master's degree in Naval Architecture from Memorial University of Newfoundland, Canada with a specialization in underwater vehicles. He also holds a bachelor's degree in Marine Engineering from Marine Engineering and Research Institute, India.

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Andy Turner is the Managing Director of Blanson Limited. His experience is in owning and managing manufacturing businesses for more than 20 years. Qualified as a Chartered Accountant with Ernst & Young 1995, he joined Blanson in 2010 as Finance Director and promoted to Managing Director in 2012. Interests include: Football (soccer), Tennis, Fishing & Cars.

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Dr. Jyotika Virmani joined XPRIZE in 2014 with more than 10 years of experience in the oceanic and atmospheric sciences, including both research and leadership positions. As Senior Director in Prize Operations, she is the Prize Lead for the Shell Ocean Discovery XPRIZE. Prior to this, she was the Director of Technical Operations for the Wendy Schmidt Ocean Health XPRIZE. To these positions, Dr. Virmani brings her scientific and technical expertise and knowledge of ocean and atmospheric observing systems to help address the challenging problems we face in understanding the Earth's climate system.

Before joining XPRIZE, Dr. Virmani served as the Associate Director of the Florida Institute of Oceanography, as a Senior Scientist at the UK Met Office (the UK's national weather service), and as the Executive Director of the Florida Coastal Ocean Observing System Consortium. Dr. Virmani has also served on the Scientific Planning Committee for the joint AGU/ASLO/TOS Ocean Sciences 2014 Meeting, on the Board of Directors for the Southeast Atlantic Coastal Ocean Observing System Regional Association, and on the Board of Directors for the Pier Aquarium/Secrets of the Sea.

Dr. Virmani has a Ph.D. in Physical Oceanography from the University of South Florida, where she worked on air-sea interactions and both blue water and coastal oceanography. She won a Rotary Foundation Ambassadorial Scholarship which allowed her to earn a M.S. in Marine Environmental Science (Atmospheric Science) from SUNY at Stony Brook. She also has a B.Sc. in Physics from Imperial College London and is an Associate of the Royal College of Science and a Fellow of the Royal Meteorological Society.

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Chris Welsh is a life long mariner, licensed captain and submersible operator. Deep Sub LLC owns the 11KM Challenger submersible and the mothership Cheyenne with a goal of deep diving worldwide. Chris is also a pilot with Single Engine, Multi-Engine, IFR, Glider, Seaplane and Helicopter ratings and has flown extensively in the Western United States, Alaska and Baja. He has flown his twin engine plane and his helicopter across the continental U.S.

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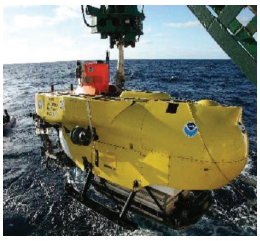

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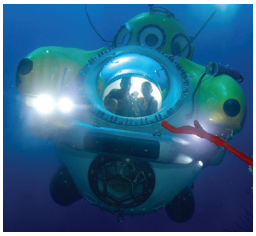

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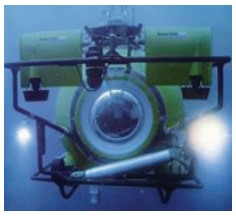

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