2018 30.09.-07.10.

BREAKING THE SURFACE

BIOGRAD NA MORU, CROATIA

10th INTERNATIONAL INTERDISCIPLINARY FIELD WORKSHOP OF MARITIME ROBOTICS AND APPLICATIONS

BTS MAP

HOTEL ADRIATIC

1 / ACCOMMODATION

2 / LECTURE ROOM

3 / TUTORIAL ROOM

4 / REGISTRATION ROOM OFFICE

5 / COFFEE BREAK

6 / LAVENDER BAR
Social events

7 / DEMO SITE

8 / DEMO POOL

9 / HOTEL ILIRIJA RESTAURANT (in hotel)
Conference restaurant and accommodation for participants

10 / HOTEL KORNATI
Accommodation for participants

11 / PARKING

12 / BELVEDER BAR
Social events

ORGANIZED BY

University of Zagreb

Faculty of Electrical Engineering and Computing

Laboratory for Underwater Systems and Technologies

Center for Underwater Systems and Technologies

ABOUT BTS

The Breaking the Surface – BTS is an international interdisciplinary field workshop of maritime robotics and applications. Ever since 2009, it has served as a meeting place for international experts, university professors, scientists, industry representatives and students from various fields

BTS 2018 IN NUMBERS

7 DAYS

38 LECTURERS

5 TUTORIALS

10 VEHICLES

6 PROGRAMME TRACKS

>180 ATTENDEES

∞ OPPORTUNITIES TO NETWORK

COMMITTEES

COMMITTEES CHAIRS

Prof. Zoran Vukić, PhD
General Chair

Assoc. Prof. Nikola Mišković, PhD
Programme Committee Chair

Ivana Mikolić, mag. ing.
Organizing Committee Chair

Antonio Vasilijević, PhD
Technical Committee Chair

PROGRAMME COMMITTEE

Marco Bibuli, PhD; Prof. Bridget Buxton, PhD; Massimo Caccia, PhD; Marc Carreras, PhD; Edin Omerdić, PhD; Asst. Prof. Matko Orsag, PhD; Asst. Prof. Irena Radić-Rossi, PhD; Prof. Pere Ridao, PhD; Prof. Asgeir Sørensen, PhD; Prof. Daniel Toal, PhD

ORGANIZING COMMITTEE

Tonko Bogovac; Ivan Dominić; Petra Kovačević; Anamarija Miličević; Mladen Petr; Ivan Trubić; Valentino Žinić

TECHNICAL COMMITTEE

Anja Babić; Matej Celega; Nadir Kapetanović; Nikica Kokir; Ivan Lončar; Filip Mandić; Milan Marković; Đula Nađ, PhD; Kruno Zubčić

LEGEND

SESSION COLOURS

- Lectures
- Innovation Tuesday
- Social events and special programme
- Company programme
- Tutorials
- Demonstrations

CATEGORIES

- MAROB
- MARSEC
- MARBIO
- MARGEO
- MARCH
- INNOVA
- COMPANY PRESENTATION

LOCATIONS

LECTURE HALL – HOTEL ADRIATIC
ALL *lectures and presentations*

DEMO POOL AND OPEN WATERS NEARBY
Equipment demonstrations

TUTORIALS ROOM – HOTEL ADRIATIC
Tutorial

LAVENDER BAR – HOTEL ADRIATIC
Welcome Drink, Norwegian party

BELVEDER BAR
BTS karaoke, EXCELLABUST *party*

	MONDAY 01.10.	TUESDAY 02.10.
09:00	**Opening session** Zoran Vukić, Ivana Mikolić	**The ORCA Hub: Offshore robotics for certification of assets** *Yvan Petillot*
09:45	**Cyber security for marine technologies** *Niv David*	**The evolution of smart software within maritime robotics** *Scott Reed*
10:30	COFFEE BREAK	COFFEE BREAK
10:45	**"We're (not) going to need a bigger boat": the tech that will replace traditional coastal research vessels** *Bridget Buxton*	**Robots in politics and business** *Daniel M. Lofaro*
11:30	**Shearwater: The future of hybrid autonomous marine vehicles** *William Kirkwood*	**Consumer robotics in the age of acceleration** *Paul Oh*
12:15	**The role of technical devices in the frame of underwater archaeological researches** *Sebastiano Tusa*	**Protoatlantic – A European accelerator program of the marine sector** *Miriam Rueda*
13:00	LUNCH	LUNCH
14:30	*COMPANY PRESENTATION* **Blueye Robotics**	*WORKSHOP:* **Defining a ROS package to standardize underwater messages** *IQUA Robotics, University of Girona*
15:00	**T1 intro: Underwater optical image enhancement techniques** *University of Girona*	**IQUA robotics** *Marc Carreras* **14:30 - 15:00**
15:30	*DEMO 1* **Nido Robotics** *Group 1* *T1* **hands-on** *Group 2* *DEMO 2* **Blueye** *Group 3*	**ecoSUB** *Iain Vincent* **15:00 - 15:30** **Nido Robotics** *Enrique González Sancho* **15:30 - 16:00**
16:30	*DEMO 1* **Nido Robotics** *Group 2* *T1* **hands-on** *Group 3* *DEMO 2* **Blueye** *Group 1*	COFFEE BREAK **H2O Robotics** *Marin Bek* **16:15 - 16:55** **XOCEAN** *James Ives* **16:45 - 17:15**
17:30	*DEMO 1* **Nido Robotics** *Group 3* *T1* **hands-on** *Group 1* *DEMO 2* **Blueye** *Group 2*	**EUMR presentation** *António Sérgio Ferreira* **17:15 - 17:45**
18:00		
18:30	DINNER	DINNER
19:30		

WEDNESDAY 03.10.	THURSDAY 04.10.	FRIDAY 05.10.
Motion assessment of an unmanned planing craft in seaway *Morel Groper*	**Underwater acoustic communications: Fundamentals and new results** *Milica Stojanović*	**Key technologies towards the vision of complex autonomous underwater operations: From project SMIS to MUM** *Torsten Jeinsch and Martin Kurowski*
New survey visualization: merging photogrammetric 3D model with a multibeam bathymetry *Hironobu Kan*	**How to protect an outstanding shipwreck site?** *Irena Radić Rossi*	**Chasing ocean carbon – from sky to sea and below** *Ivona Cetinić*
COFFEE BREAK	COFFEE BREAK	COFFEE BREAK
Cyber-security solutions for unmanned systems, and their use in conjunction with new technologies to advance port security and maritime domain awareness *Philip McGillivary*	**Micro-scale wave energy generation for autonomous sensors and robotics** *Tim Mundon*	**Autonomy and remote control technology in sea aquaculture activities** *Walter Caharija*
Submarine technology for the study and conservation of deep coral gardens and cold-water coral reefs *Andrea Gori*	**Exploring the ocean and the seabed: oceanographic case studies where marine robotics can be applied** *Manuel Bensi*	**A fast fish-like human-powered racing submarine** *Iain A. Anderson*
Oceanids: Development of next generation marine autonomous systems for ocean science *Alexander Phillips*	**Cloud-based management and control of autonomous marine vehicles: Concept and demonstration** *Xianbo Xiang*	**ROV inspection** *Marko Bakašun, Matej Ćurić and Ivor Meštrović*
LUNCH	LUNCH	LUNCH
COMPANY PRESENTATION **Blueprint Subsea**	*COMPANY PRESENTATION* **Sonardyne**	*COMPANY PRESENTATION* **Evologics**
T2 intro: Sparus II *IQUA Robotics, University of Girona*	**T3 intro: Hands-on with software defined modems & underwater networks** *Subnero, National University of Singapore*	**T4 intro: subCULTron** *UNIZG FER*
DEMO 3 **BluePrint** *Group 1*	*T2* **hands-on** *Group 2*	*DEMO 4* **ecoSUB** *Group 3*	*T3* **hands-on** *Group 1*	*DEMO 5* **Torpex** *Group 2*	*DEMO 6* **Sonardyne** *Group 3*	*DEMO 7* **Evologics** *Group 1*	*T4* **hands-on** *Group 2*	*DEMO 8* **GeoMar** *Group 3*
DEMO 3 **BluePrint** *Group 2*	*T2* **hands-on** *Group 3*	*DEMO 4* **ecoSUB** *Group 1*	*T3* **hands-on** *Group 2*	*DEMO 5* **Torpex** *Group 3*	*DEMO 6* **Sonardyne** *Group 1*	*DEMO 7* **Evologics** *Group 2*	*T4* **hands-on** *Group 3*	*DEMO 8* **GeoMar** *Group 1*
DEMO 3 **BluePrint** *Group 3*	*T2* **hands-on** *Group 1*	*DEMO 4* **ecoSUB** *Group 2*	*T3* **hands-on** *Group 3*	*DEMO 5* **Torpex** *Group 1*	*DEMO 6* **Sonerdyne** *Group 2*	*DEMO 7* **Evologics** *Group 3*	*T4* **hands-on** *Group 1*	*DEMO 8* **GeoMar** *Group 2*
DINNER	DINNER	CLOSING CEREMONY

SOCIAL EVENTS

30.9.
SUNDAY
16:30 – 18:00
HOTEL ADRIATIC
REGISTRATION

30.9.
SUNDAY
18:00 – 19:30
LAVENDER BAR
WELCOME DRINKS

1.10.
MONDAY
FROM 21:00
LAVENDER BAR
NORWEGIAN PARTY

2.10.
TUESDAY
FROM 21:00
BELVEDER BAR
EXCELLABUST PARTY

4.10.
THURSDAY
FROM 21:00
BELVEDER BAR
BTS KARAOKE NIGHT

5.10.
FRIDAY
19:30 - 21:00
HOTEL ADRIATIC
CLOSING CEREMONY AND GALA DINNER

5.10.
FRIDAY
FROM 21:00
HOTEL ADRIATIC
GREAT GATSBY PARTY

6.10.
SATURDAY
09:00 - 16:00
FIELD TRIP

RESTAURANT HOURS

BREAKFAST
07:30 - 09:00

LUNCH
13:00 - 14:30

DINNER
19:30 - 20:30

LOCATION

Ilirija Resort
Tina Ujevića 7
23200 Biograd na Moru
Croatia

VENUE

BTS 2018 is taking place in Ilirija Resort hotels in Biograd na Moru, Croatia. The resort consists of three hotels that are within one minute of walk from each other.

REGISTRATION

The registration package includes:

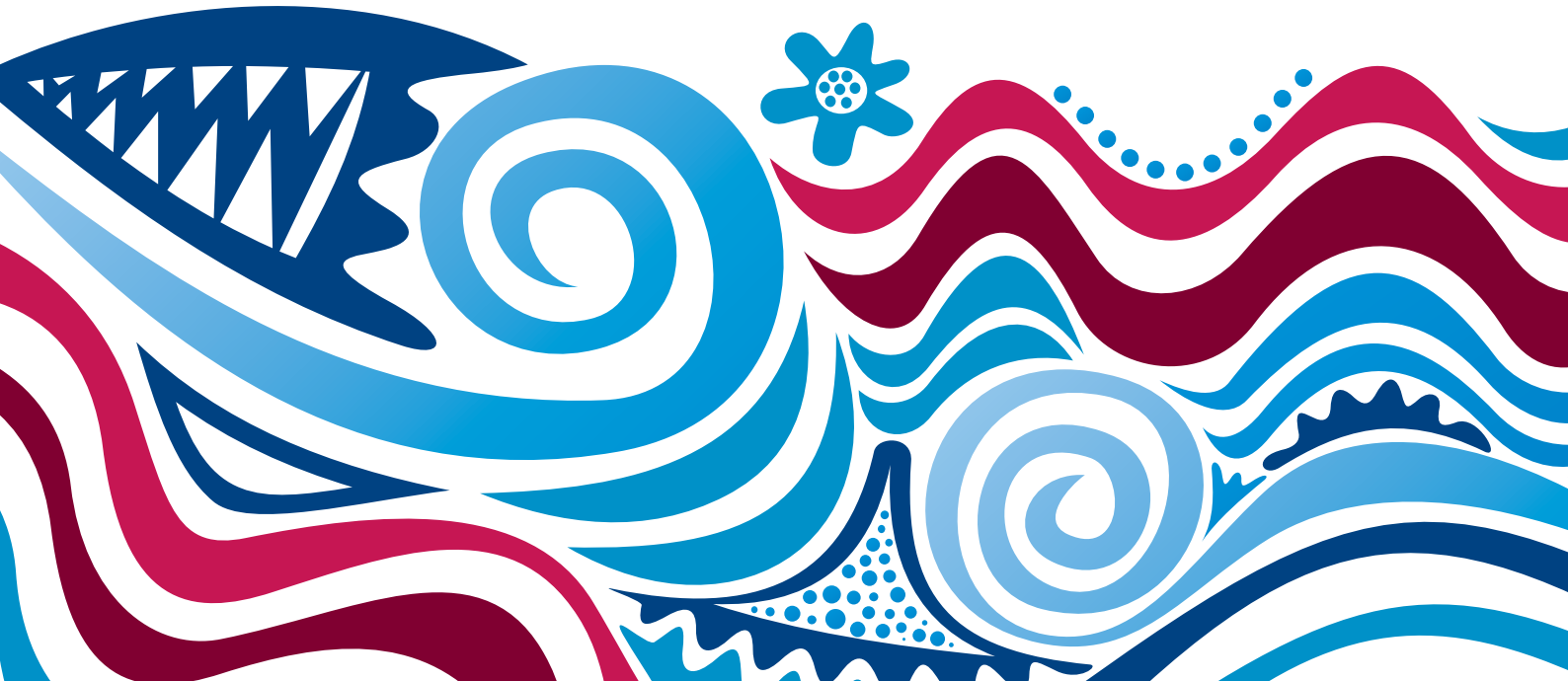
- accreditation which allows participation in all technical and social programmes
- accommodation with three meals per day in single rooms (Standard registrations) or shared double rooms (Student registrations) in a 4* hotel for 7 nights (from 30th September until 7th October)

A Corporate registration includes:

- 2 full Standard registrations (accreditations and accommodation)
- a 30-min time-slot for the presentation of the product gamut
- logistical/infrastructural local support and organization collaboration for an expo/hands-on demonstration activity at the prescribed site

TYPE	EARLY BIRD BY 1ST JULY	REGULAR BY 2ND SEPTEMBER
Student	500 €	600 €
Standard	660 €	800 €
Accompanying person	300 €	300 €
Corporate	3000 €	3500 €

ABSTRACTS & BIOGRAPHIES



1st OCTOBER
Mon

Opening session

Prof. Zoran Vukić and Ivana Mikolić, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

01.10.2018
09:00-09:45
Zoran Vukić
Ivana Mikolić

Opening words by the General Chair Prof. Zoran Vukić and Organisation Chair Ivana Mikolić.

Cyber security for marine technologies

Niv David, Tel-Aviv University, Israel

Marine robotics, automation and unmanned technology is quietly bursting throughout the seas, expanding to every field of operation. Though marine robotics were around long before their aerial drone cousins, new exciting technology is pushing the platforms towards more and more autonomy on one hand and full scale global connectivity on the other. There is also a clear trend towards joint air-sea (and land) operations. Marine technology relies more and more on COTS and open-source hardware and software components. Just like in other technology domains, this standardization has great business and operational advantages, however it is also subject to technological risks such as cyber attacks. Cyber attacks have evolved from anecdotal annoyances to global threats, considered a major risk to businesses, operations and even national security. A cyber attack can shut down marine operations, critical systems, cause significant business damage and even jeopardize missions and lives. The lecture will discuss the nature of cyber threats and risks to marine installations and marine robotic systems, the special technological and operational constraints, and possible applications of practical solutions under such limitations.

01.10.2018
09.45-10:30
Maritime Security
Niv David

Niv David *is a lecturer and research fellow with the Blavatnik Interdisciplinary Cyber Research Center (ICRC) at Tel-Aviv University and manages special cyber programmes with a leading Israeli technology firm. Niv holds a BA in interdisciplinary studies, MA in security and strategy and is pursuing a PhD in Marine Ecology at the University of Haifa. Niv has more than twenty years of experience with information technology and cyber hands-on and business practice, specializing in technical operations doctrines, security of mission critical systems and the synergy between technology, operational practice and geopolitics.*

"We're (not) going to need a bigger boat": the tech that will replace traditional coastal research vessels

Bridget Buxton, University of Rhode Island, USA

In 1968, the 85m RV Knorr was built for the Woods Hole Oceanographic Institute. In 1985, Knorr supported the first ROV operations on the RMS Titanic; it was sold in 2016 after an active research life of more than 45 years, and replaced with a 73m ship. In 1964, the US army T boat "Virazon" supported Professor George Bass's pioneering underwater excavations in Turkey; it was finally replaced with a newer 25m vessel in 2016. Over half a century when oceanographic technology for scientific and archaeological research has been characterized by spectacular innovation, the traditional research vessel has barely evolved at all. Research and dive vessel operational costs remain the greatest single obstacle to the democratization of the oceans through global participation in underwater research. The lack of alternatives to traditional RV platforms for marine science represents more than a failure of imagination: it is a collective abdication of environmental and social responsibility.

This paper explores the recent and potential application of new technology to reduce and replace the traditional RV in coastal scenarios, focusing on the excavation of the port of the Biblical King Herod at Caesarea Maritima in Israel. Recent discoveries at the coastal Caesarea site emphasize the need for technological agility, which the excavators are addressing with the new "Digski" class of RVs.

01.10.2018
10:45-11:30
Marine Archaeology
Bridget Buxton

Bridget Buxton, PhD, *is an associate professor of History at the University of Rhode Island and a member of URI's Archaeology Group. She obtained her PhD in Ancient History and Mediterranean Archaeology from the University of California, Berkeley on a Fulbright, and her MA in Classical Studies (with distinction) from Victoria University, Wellington, New Zealand. Her archaeological field experience includes both land and underwater projects in Greece, Israel, Turkey, the Black Sea, and in her homeland of New Zealand. Since 2006 she has been involved in deep water projects under the direction of Prof. Robert Ballard of the University of Rhode Island and Prof. Shelley Wachsmann of Texas A&M Nautical Archaeology Program, and a Croatian aviation archaeology project under the direction of Megan Lickliter-Mundon, Texas A&M. Since 2010 she has been collaborating with Jacob Sharvit, Director of the Israel Maritime Antiquities Unit at underwater sites along the Israeli Coast. She is a regular educational speaker on archaeological themes for the Archaeological Institute of America and the cruise ship industry, and publishes on topics in underwater archaeology and ancient history. Most recently, she became the science programme coordinator for Oceangate's planned Titan submersible expedition to the wreck of RMS Titanic.*

1st OCTOBER Mon

Shearwater: The future of hybrid autonomous marine vehicles

William Kirkwood, Monterey Bay Aquarium Research Institute, USA

The term Autonomous Marine Vehicle (AMV) is intended to encompass an entire class of systems operating in the marine environment. The concept is to view autonomy accomplishing work in the maritime environment as a system and not discrete elements. We are witnessing autonomous underwater vehicles (AUV) vertically integrating with an autonomous surface vehicle (ASVs) that are integrating with an autonomous aerial vehicle (AAVs), including satellites, as well as cellular networks. The same is true horizontally. Multiples of each vehicle type are currently working in unison with some developing swarms. The transition from manned to autonomous vehicles (AMVs) in ocean applications has advanced tremendously over the last few decades, with these systems making inroads into operating arenas that previously were only accessed by remotely operated vehicles (ROVs). Prior to AUVs, ROVs displaced operations that were previously accomplished by manned submarines. However, at each step of advancing these technologies there has been resistance. That resistance has slowed progress and cost money. Today, we still deploy and operate the majority of these ocean-going systems from the most costly of platforms, the manned ship. Shearwater has recently broken resistance and is in development to remove the ship and combine the aerial, surface and subsurface systems into a single platform. Shearwater is a new type of vehicle that will hopefully take its proper place in the AMV systems community.

01.10.2018
11:30-12:15
Maritime Robotics
William Kirkwood

William Kirkwood *has been involved in developing instruments and vehicles for military, industrial and science ocean applications for more than 30 years. Bill joined the Monterey Bay Aquarium Research Institute in 1991 and has been doing research and development of remotely operated and autonomous vehicles as well as in situ science instruments. He has operated many of those vehicles and instrument systems across the Pacific, Atlantic, Mediterranean, Arctic and Antarctic seas. He is also an adjunct professor at Santa Clara University, teaching robotics and ocean-going technologies since 1999, as well as the creator of the AUV Tutorial program for the IEEE – Oceanic Engineering Society. As Chair of the OES Technical Committee on Autonomous Marine Systems Bill, also sponsors the Bi-Annual AUV Symposiums and is also chairing the committee on Marine Autonomous Systems Competitions Coordination (MASC2) that is working globally to standardize student AUV Competitions.*

The role of technical devices in the frame of underwater archaeological researches

Sebastiano Tusa, Soprintendenza del Mare (Regione Siciliana), Italy

The presentation gives a wide panorama of the main innovative technologies used in the frame of a modern approach to the researches, protection, evaluation and management of underwater cultural heritage. After a brief part devoted to the beginning of scientific underwater archaeology, the presentation will deal with electronic devices such as side scan sonars, multi beam and magnetometers, as well as ROVs and AUVs. The presentation evaluates the advantage of the use of such technologies in the context of an up-to-date approach to underwater archaeology.

01.10.2018
12:15-13:00
Marine Archaeology
Sebastiano Tusa

***Sebastiano Tusa**, born in Palermo on August 2nd, 1952. Bachelor of Arts with a thesis in palaeontology at the University of Rome "La Sapienza" (110/110 cum laude) (1975). Specialized in Eastern archeology at the University of Rome "La Sapienza" (70/70 cum laude) (1985). Winner of a full professor chair of the Faculty of Arts, University of Cagliari – sett. L01Y – Prehistory and Early History (2000). Lecturer of Palaeontology at the Faculty of Conservation of Cultural Heritage – University Suor Orsola Benincasa of Naples (since 2000). Lecturer of Underwater Archeology at the Faculty of Cultural Heritage of the University of Bologna (branch of Trapani) (since 2001). Visiting Professor at Nautical Archeology Philipps-Universitaet Marburg. Director of the Archaeological Service at the Superintendence for Cultural Heritage Trapani (2000-2004). Superintendent of the Sea of the Sicilian Region (2004-2010 and since 2012). Superintendent of Cultural Heritage, Trapani since 2010 to 2012. Director of the journal "Sicilia Archeologica". Trident Gold prize by International Academy of Underwater Sciences and Techniques of Ustica (2004). Prize Book of the Sea in 2011 awarded by the Sanremo Casino. Since 1972 he has participated in and/or directed missions and archaeological researches and excavations in Italy, Malta, Tunisia, Iraq, Iran, Pakistan, Japan, Kenya and Turkey. Author of about 700 scientific and popular papers and monographs concerning archaeology, ancient history and cultural heritage.*

Company presentation and demonstration: Blueye Robotics

Martin Ludvigsen, Blueye Robotics, Norway

Blueye underwater drones for the consumer and low end professional market.

Website: www.blueyerobotics.com

01.10.2018
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Martin Ludvigsen

Tutorial: Underwater optical image enhancement techniques

Nuno Gracias and László Neumann, University of Girona, Spain

The underwater medium raises significant challenges for the processing of optical images. Two main processes dictate the behaviour of light in water: absorption and scattering. Absorption accounts for the conversion of light into heat and other forms of energy, whereas scattering refers to the changes in photon direction caused by variations in water density and interactions with suspended matter. These phenomena degrade the image-formation process in a much more significant way than the usual in-air imaging, leading to image blurriness, loss of color and loss of contrast. This session will overview a set of techniques for image enhancement, ranging from simple contrast enhancement to image dehazing and the removal of inconsistent illumination, with emphasis on practical applications.

***Nuno Gracias**, PhD, received the MSc and PhD degrees in Electrical Engineering (Control and Robotics) in 1998 and 2003 from the Technical University of Lisbon, Portugal. From 2004 to 2006 he was a postdoctoral fellow at the University of Miami. Since 2006 he has been a member of the Computer Vision and Robotics Group (ViCOROB) of the University of Girona. His research interests span the areas of underwater optical mapping, and navigation and guidance of autonomous underwater robots, image processing and classification. Dr. Gracias has authored 34 articles in peer-reviewed journals and more than 45 in scientific conferences, and co-supervised 2 PhD and 6 MSc theses. He is adjunct faculty*

01.10.2018
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Nuno Gracias,
László Neumann

at the department of Marine Geology and Geophysics of the University of Miami, and member of the editorial board of the Journal of Intelligent and Robotic Systems.

***László Neumann** holds an MSc in Engineering and Mathematics, (1978 from TU Budapest), and a PhD in Applied Mathematics: economical modeling (1982). Dr Neumann has led research and software development in architectural CAD, cartography, medical imaging, 3D face modelling, color harmony design, and numerical methods. He has authored 32 journal articles, 3 books, and 20 book chapters in and over 55 technical publications in conferences Between 1995 and 2007 he was a visiting lecturer at TU Vienna, and since 2002 he is an ICREA Research Professor at Universitat de Girona (UdG). He is member of over a dozen IPC and other committees.*

Demonstration: Sibiu Pro, cost-effective and easy-to-use Mini-ROV

Enrique González Sancho, Nido Robotics, Spain

Nido Robotics manufactures small-sized ROVs for professional applications, such as visual inspections, object recovery or water quality monitoring. During the demonstration, you will learn how to operate a mini-ROV: preparation, deployment, piloting, and maintenance.

01.10.2018
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
Enrique González
Sancho

***Enrique González Sancho,** CTO & Co-Founder at Nido Robotics. Since 2014 he has participated in the SIRENA project at the Polytechnic University of Cartagena (UPCT) as the Software Team Leader. Diving into this field, he met his current colleagues with whom he created Nido Robotics, a young but promising startup that develops Micro-ROV technologies, environmental sensors and more.*

Innovation Tuesday

Since 2016, BTS has been organizing an "Innovation day", a whole-day workshop where robotics experts, ranging from acclaimed researchers to the leaders of successful robotics start-ups, share their experience in commercializing robotics-related technologies with the rest of the scientific community and aspiring entrepreneurs.

The ORCA Hub: Offshore robotics for certification of assets

Yvan Petillot, Heriot-Watt University, UK

ORCA Hub is a £36M programme aimed at addressing the offshore energy industry vision for a completely autonomous offshore energy field. The Hub brings together leading experts from five UK universities with over thirty industry partners, led by the Edinburgh Centre of Robotics in collaboration with Imperial College, Oxford and Liverpool Universities. The Hub's primary goal is to use robotic systems and Artificial Intelligence to revolutionise Asset Integrity Management for the offshore energy sector, in order to enable cheaper, safer and more efficient production. The ORCA Hub will research, develop and deploy remote robotic solutions that will operate safely and efficiently within the complex cluttered marine, topside (on asset) and airborne environments of existing and future offshore energy assets. They will assist and co-operate with remote operational teams, in both autonomous and semi-autonomous modes, in order to assure and certify offshore assets and their own operations and maintenance. Driven by the needs of industry, the Hub will focus its research around four key work areas: (1) Mapping, Surveying and Inspection of complex dynamic structures; (2) Planning and Execution of efficient, localisable and coordinated motion of heterogeneous robotic teams; (3) Intelligent Human-Robot Interaction to provide intuitive communication of world view, system actions and re-planning, between robot teams and operators, to develop efficient operation and (4) Robot and Asset Self-Certification to guarantee safe operation particularly where self-learning AI technology is employed, to predict and diagnose faults, and optimise operational use over remaining lifetime. The talk will present the overall hub, its objectives and initial achievements in each research strand. It will also explain how academics and industry can be involved in current and future research.

02.10.2018
09:00-09:45
Innovation Day
Yvan Petillot

Yvan Petillot *is a Professor at Heriot-Watt University who specializes in robotics and sensing, and is an expert in autonomous systems, image analysis and control applied to the subsea domain. He has made major contributions in subsea robotics, from sensing to navigation and autonomy. He manages a portfolio of £1M grants covering all aspects of underwater signal processing from defense to perception for offshore asset management and underwater*

sensor networks. Prof. Petillot has a long history of collaborative research within the EU, having participated in 9 EU projects in various roles. In parallel, Professor Petillot has a strong track record in technology transfer and engagement with industry. He co-founded SeeByte Ltd in 2001 and led the transitioning of research, technology and personnel from the University to the company. Of note were the successful transfer of MOD funded collaborative framework for multi-vehicle collaboration, evaluated by the US Navy under their Foreign Competitive Technology framework and now a product sold to the US and UK Navies.

The evolution of smart software within maritime robotics

Scott Reed, SeeByte, UK

This presentation looks at the rapid evolution of maritime robotics during the last ten years, which has seen vehicles transition from being manually operated data collection devices to sophisticated assets capable of carrying out persistent, collaborative autonomy missions. This has resulted in a general shift in technology towards software focused solutions to meet new market requirements and expectations. Key development areas include a progressive move towards modular open architecture autonomy systems, the use of new generation machine learning algorithms to enable the conversion of raw sensor data into actionable information, and the use of intuitive Command and Control systems to enable the effective interaction between operators and unmanned systems. The first section of this talk will present SeeByte, a commercial company specialising in the delivery of maritime robotics software solutions, and some of the key applications that they have delivered to meet the needs of this evolving market. The second section of the presentation will provide some insight into SeeByte's view on future market trends and research requirements. These include a shift towards autonomous intervention tasks, improved methods for data storage and processing, adoption of next generation deep learning and transfer learning for data analysis and scene understanding and an increased uptake in Augmented Reality and Natural Language approaches for improved HMI.

02.10.2018
09:45-10:30
Innovation Day
Scott Reed

Scott Reed *leads SeeByte's engineering group, responsible for ensuring the successful delivery of the companies software products, projects and research in the field of maritime robotics. Having earned his Master's degree in Astrophysics, Scott attended the Ocean Systems Laboratory at Heriot-Watt University in Scotland, where he completed his PhD specialising in automated detection and classification techniques for side-scan sonar systems. Scott joined SeeByte in 2004 and in 2005 was an invited scientist at the NATO Undersea Research Centre in La Spezia, Italy. He has been the Head of Engineering at SeeByte since 2009.*

2nd OCTOBER
Tue

Robots in politics and business

Daniel M. Lofaro, George Mason University, USA

This presentation will discuss robots in the real-world with a focus on humanoid and legged robots. Specific points will include developing software infrastructures to create ubiquitous "skills" for the creation of a sustainable robot software ecosystem and how this affects the 4th Industrial Revolution. Additionally, key points will be made on how these "skills" are affecting and will affect our social and political climate. The presentation will also include an update on "robots in the wild", including autonomous cars, UAVs, and HitchBOT.

02.10.2018
10:45-11:30
Innovation Day
Daniel M. Lofaro

Daniel M. Lofaro *is an Assistant Professor in the Electrical and Computer Engineering Department at George Mason University (GMU) and holds a Faculty Appointment with the Navy Center for Applied Research in Artificial Intelligence (NCARAI) at the United State Naval Research Laboratory (NRL). He is the director of Lofaro Labs LLC and the DASL Autonomous Systems Lab at GMU (DASL@GMU). From 2012 to 2014 he was the Research Lead of the DARPA Robotic Challenge team DRC-Hubo. An NSF-EAPSI and ONR-SRFP Fellow, his research interests include Humanoid Robotics, Complex Control Systems, Robot Design, Secure Robotics, and Cloud Robotics all within the overarching field of "robots in the real-world".*

Consumer robotics in the age of acceleration

Paul Oh, University of Nevada, USA

The lines between consumer electronics and consumer robotics grow more blurry each year. For example, over 400 robotics companies exhibited at the 2016 Consumer Electronics Show (CES). Devices like drones, virtual reality headsets, 3D printers, driverless cars, and bionics – are essentially robots and/or were developed upon foundational knowledge in robotics. Projections like those by the Japanese Robotics Association see an annual $30B+ market for household robots by 2025 – and surpassing industrial robot sales. Beyond the Roomba, consumer robots like DJI quadcopters, Jibo and Pepper personal robots, Tesla driverless cars and related technologies like Oculus Rift headsets demonstrate this growing area. Observations suggest that the product adoption rate for a consumer robot hovers around seven years.

02.10.2018
11:30-12:15
Innovation Day
Paul Oh

Prof. Paul Oh *joined the University of Nevada, Las Vegas (UNLV) as the Lincy Professor of Unmanned Aerial Systems in 2014. Prior, he was in Drexel University's Mechanical Engineering Department from 2000-2014 where he founded and directed the Drexel Autonomous Systems Lab. He received mechanical engineering degrees from McGill (B. Eng 1989), Seoul National (M. Sc. 1992), and Columbia (PhD 1999) universities. He is a Fellow of NASA (2002), Naval Research Lab (2003), Boeing (2006) and ASME (2012). He received research (2004 NSF CAREER) and teaching (2005 SAE Ralph Teetor Award for Engineering Education Excellence) awards and authored over 100 publications. From 2008 to 2010, he served as an NSF Program Director managing the robotics research portfolio. From 2012 to 2015 he led Team DRC-Hubo and Team DRC-Hubo@UNLV for the DARPA Robotics Challenge.*

Protoatlantic – a European accelerator program of the marine sector

Miriam Rueda Noriega, Asociación EMERGE, Spain

Protoatlantic is an acceleration programme of start-ups related to the marine/maritime sector which will be developed in the Canary Islands (Spain) in the next three years. It is funded by the Interreg Atlantic Area European Regional Development Fund. This project will develop a whole model for the prototyping and exploitation of innovative ideas in the maritime sector. Taking into account the high costs of prototyping activities, the proposal will be narrowed down to three sectors: Renewable Energy, Marine Robotics and Blue biotechnologies. After the identification of ideas from the research community, start-ups and small and medium enterprises with product innovation capacity in the maritime sector, an acceleration programme with a normed and structured process will be implemented. The workshops of the acceleration programme followed by mentoring will use a methodology that will cover everything from business models to market validation. Agile methodologies for entrepreneurship will be tested, based in Lean start-up, teampreneurship, design thinking or learning by doing. Finally, eight start-ups will be chosen to be prototyped. In this way, a unique ecosystem in the Atlantic will be created, willing to address a co-creation paradigm with the local European start-up communities and all the stakeholders. The consortium is formed by 11 partners, Innovalia, EMERGE and the council of Las Palmas (Spain), The University and The Council of Cork (Ireland), The Institute of Engineering of Systems,Technology and Science (Portugal), Technopole Brest Iroise and Metropol of Brest (France), Marine South Limited and European Marine Energy (United Kingdom) and Happy Ventures (Morocco). EMERGE adds value with its expertise in the marine sector, its co-working space (Marine-Park) and its knowledge in prototyping.

02.10.2018
12:15-13:00
Innovation Day
Miriam Rueda Noriega

Miriam Rueda, *Project Manager of Protoatlantic, joined the Association EMERGE in March 2018. She obtained her PhD with International mention in Chemical Engineering at the University of Valladolid (Spain) in 2016, performing several stays in Hydrogen Lab in the University of Pavia (Italy). Her research experience started in 2010 when she was an ERASMUS student in Technique University of Denmark, where she developed her master thesis in Chemical Engineering. After this period, she joined the Department of Chemical Engineering and Environmental Technology in University of Valladolid (Spain) to study the Master 'Engineering Thermodynamic of Fluids' and after this, she started her PhD thesis. This thesis was focused on the development of innovative solid hydrogen storage material based on hydrides using pressurized fluids. The thesis was qualified with Cum Laude and recognized as the best thesis by International Society of Advanced Supercritical Fluids (ISASF). As a result, she has published 12 articles and she is also co-author of a National patent. Moreover, she has given 6 presentations; she has participated in another 10 and has been co-author of 8 posters presented in international congresses. Also, due to the outstanding results obtained during this PhD thesis, she received an award from the Foundation Iberdrola to continue the research until March 2018. Her entrepreneur spirit has given her the opportunity to transfer her knowledge from the lab to the market as a promoter of LightEnergy Engineers, a project which has been awarded in several programs: 1st Yuzz Valladolid and 2nd Yuzz Spain 'Young with Ideas', one of 5 awarded projects in Model 2 Market (Spin 2016) and also she has been recognized in the list Forbes 30 under 30 in the category Industry 2017 and Forbes Spain.*

Democratising the AUV: ecoSUB Robotics – from concept to commercial reality

Iain Vincent, Planet Ocean Limited / ecoSUB Robotics Limited, UK

ecoSUB Autonomous Underwater Vehicles (AUVs) were conceived to be a disruptive technology, intended to substantially increase end-user access to autonomous systems in the marine environment. Designed to be smart, low cost, small vehicles that can be easily launched and recovered by a variety of methods and potentially used in shoals to rapidly complete tasks, ecoSUB Robotics set out to democratise the AUV. ecoSUB Robotics has been established to spin out a technology developed by Planet Ocean Limited in collaboration with its academic partner, the National Oceanography Centre (NOC). Contrary to the traditional approach of technology development being spun out of academia, ecoSUB AUV development has been customer-led from the outset, with Planet Ocean using extensive stakeholder engagement to inform concept design, specifications, and performance requirements, and then supported by the technical expertise of the NOC, leveraging over 20 years of AutoSUB experience. A truly collaborative R&D/engineering team with members from both Planet Ocean and the NOC have worked

together throughout the development process. Both parties own IP within the products, with the NOC licencing its IPR to Planet Ocean for commercial exploitation. This presentation will provide an overview of the development journey, funding, stakeholder engagement, projects and commercialisation of ecoSUB AUVs, and the aspiration behind the technology, to markedly grow AUV use in marine science applications.

02.10.2018
15:00-15:30
Innovation Day
Iain Vincent

Iain Vincent *is a graduate in Marine Environmental Science from the University of Portsmouth, UK. In his current role with the marine science technology supplier Planet Ocean, he has the privilege of working with key marine science institutions across the UK, as well as international manufacturers of sensor technology, and benefits from many productive relationships with members of the science community. Iain has led programs to secure funding for the development of ecoSUB AUVs and has been involved in the concept design, stakeholder engagement, project overview and direction of the ecoSUB program. In 2016, Iain was appointed Director of ecoSUB Robotics Limited, the company formed to spin out the low cost AUV technology developed in collaboration between Planet Ocean and the National Oceanography Centre (NOC).*

Entrepreneurship in marine robotics

Enrique González Sancho, Nido Robotics, Spain

02.10.2018
15:30-16:00
Innovation Day
Enrique González Sancho

We live in a changing world. The new technologies are producing changes in our society in the most general sense: medicine, agriculture, industrial production, etc. It is our responsibility to promote responsible and innovative changes in this new scene, not only as viewers, but as proactive change agents. We can choose how to face this situation: passively or actively. Entrepreneurship allows us to contribute with relevant progresses, analyzing the society's needs, and creating a viable and innovative solution. At Nido Robotics, robotic solutions for real challenges are created, such as high risk in underwater works.

Experiences in building an international business

Marin Bek, H2O Robotics, Croatia

This presentation will show the path H2O robotics took following BTS in 2017, when it was conceived, until today. The company took part in various international fairs, expos and events, made contact with many businesses worldwide and gained significant insight into the industry. In this presentation, they will share their experiences, thoughts and knowledge gained in the hope that many more university projects will find their place under the sun of successful commercialization.

02.10.2018
16:15-16:45
Innovation Day
Marin Bek

Marin Bek *is a Master of Science in Electrical engineering in the field of control systems and automation, graduated in 2012 at the University of Zagreb Faculty of Electrical Engineering and Computing. His focus of studies were autonomous underwater vehicles, mainly exploiting latest hardware and software technologies in new products. He is currently working as CEO of H2O Robotics, a university spin-off company manufacturing autonomous surface vehicles and other advanced maritime technologies developed at the University. His goal is to expand the company to foreign markets, grow sales and turn H2O Robotics into a recognized expert company in advanced maritime technologies.He is also founder of Ascalia Ltd., an IT company working in the field of data science, machine learning and industrial monitoring and control for smart cities and industry. Prior to joining H2O Robotics as CEO in charge of growing the business and strategy, he worked as CTO at the startup NextUser in San Francisco USA (2013-2016), helping raise $2.5M in funding, and grow the engineering team from 3 to 20 employees. NextUser is now a successful and profitable business and Mr. Bek has since stayed on in an advisory capacity as VP of Technology. Before NextUser, he founded and served as CEO of Marine Tech Factory Inc. in Palo Alto USA (2012-2014), a startup which was commercialising an autonomous underwater vehicle he developed as part of his MSc thesis. Even though the venture eventually failed, he gained invaluable experience in organising a business, fundraising and both good and bad parts of running a startup. Insight into the startup culture of USA, as well as offshore maritime industry, gave him a significant edge in his later endeavours, especially in growing H2O Robotics into a respectable business.*

Unmanned ocean data collection

James Ives, XOCEAN, Ireland

The size of the ocean economy is set to double by 2030. Ocean data is a key enabler of this growth.
XOCEAN has developed an unmanned surface vessel (USV) specifically for performing tasks such as hydrographic survey, fish stock assessment and data harvesting. The USV is 4.5m long x 2.2m wide, has over three weeks endurance and operates over the horizon via a satellite link. The benefits of using the USV for ocean data collection are that it is safe with no crew required to go offshore, can tolerate extreme weather conditions, has minimal environmental impact and collects data at 1/3rd cost of conventional means.

02.10.2018
16:45-17:15
Innovation Day
James Ives

James Ives *is the founder and CEO of XOCEAN, he is a Charted Engineer and Fellow of Engineers Ireland. James was previously the CEO of a marine energy business and a senior manager at Accenture.*

EUMarineRobots: The "Oprah" of Marine Robotics

António Sérgio Ferreira, Laboratório de Sistemas e Tecnologia Subaquática (UPorto), Portugal

The marine-robotics industry is growing rapidly and is a crucial high-value/high-cost sector with considerable entry barriers to R&D. Currently, Europe leads in many aspects of maritime, but lacks well integrated and coordinated oceanic robotic infrastructure or presence. It is in this challenging environment that EUMarineRobots (EUMR) emerges.
The main objective of the EUMR project is to open up key national and regional marine robotics research infrastructures (RIs) to all European researchers, from both academia and industry, ensuring their optimal use and joint development to establish a world-class marine robotics integrated infrastructure. The EUMR consortium consists of 15 partners from 10 countries who can collectively deploy a comprehensive portfolio of marine robotic assets with required associated support assets and expertise.
The proposal is to build a network of marine robotics to help ensure that the EU remains a world-leader in ocean science and engineering, with a thriving maritime industry. In order to do so, there will be a series of Trans-national access activities (TNA) with the focus of providing a coherent framework for stakeholders to gain access to both the "standard" and the "developing" capacities of the RI; providing access to appropriate levels of training and best-practices, to build sustainability by educating the next generation of practitioners; providing access to experimental activities proposed by external partners or use-cases that are chosen to provide a broad cross-section of experimental opportunities for end-users.

02.10.2018
17:15-17:45
Innovation Day
António Sérgio Ferreira

António Sérgio Ferreira *is a PhD student and holds a Masters degree in Informatics and Computing Engineering from the University of Porto. Since 2011, he has been part of the Underwater Systems and Technology Laboratory (LSTS) where his work focused on further developing the Neptus Command and Control Infrastructure for UAS, as well as being a UAS field operator. He's currently a senior research assistant charged with project management, logistical coordination and outreach for the laboratory. His main academic focus now resides on expanding software defined networks (SDNs), in conjunction with delayed-tolerant networks (DTNs), to teams of autonomous systems for remote maritime operations. His research interests include unmanned vehicle systems, communications and coordination of multiple dynamic systems, systems engineering, and management architectures for multi-vehicle systems.*

Workshop: Defining a ROS package to standardize underwater messages

Narcís Palomeras, University of Girona, Spain and **Natàlia Hurtós**, IQUA Robotics, Spain

The Robot Operative System (ROS) has become a de facto standard for robot programming. The underwater community is also following this trend and adopting it as its main middleware. However, while commonly used sensor messages are well described for aerial and terrestrial robots (by means of standard packages like sensor_msgs), descriptions for most underwater sensors are not available. This has brought each center to implement their own messages, wasting efforts and making the cooperation among them difficult. This workshop is intended to set the basis for a package containing the definition of a set of marine-related sensors commonly used by the underwater community.
This is a 4 hour standalone workshop starting on Tuesday, 2nd of October at 14:30 and ending at 18:30.

Narcís Palomeras *(MSc 2004, PhD 2011) is a Postdoctoral Fellow at the University of Girona (UdG), he is a member of the Underwater Robotics Laboratory in the Computer Vision and Robotics Group (VICOROB). He has participated in several research projects (both national and European) related with underwater robotics and has taken part in several European AUV competitions. His research activity is mainly focused on underwater robotics in research topics such as intelligent control architectures and mission control.*

Natàlia Hurtós *(MSc 2007, PhD 2014) is currently working as a software product manager in IQUA Robotics. Since 2006 she has participated in multiple research projects (both national and European) related to underwater robotics and has been involved in several technology developments. She has extensive experience in developing and integrating software for autonomous underwater vehicles, as well as in applications involving the use of sonar devices for mapping underwater environments.*

02.10.2018
14:30-18:30
Workshop
Narcís Palomeras,
Natàlia Hurtós

Motion assessment of an unmanned planing craft in seaway

Morel Groper, The Hatter Department of Marine Technologies, University of Haifa, Israel

To promote the development and operation of an unmanned/autonomous small planing craft, the capability to predict the accelerations and motions the craft is expected to develop based on the knowledge of the incoming waves in real time is much required. In this study, an improved nonlinear mathematical model for the simulation of motions and accelerations of planning monohulls in seaway having a constant or variable deadrise angle, in head or following waves, has been formulated. The developed model, based on the 2-dimensional strip theory, improves previously developed models and provides accurate results for the acceleration, velocities and expected motions of a planing craft in the longitudinal plane and in the time domain. The sectional hydromechanic forces are determined by the theory of wedge penetrating the water surface. The sectional wetted breadth and immersion are directly integrated into the expressions for the hydromechanic forces. A near transom pressure correction affecting both the hydrostatic and the hydrodynamic terms of the force is introduced. The dynamic drag force is calculated based on a semi-empirical model. To validate and calibrate the developed computation model, a Jet-Ski platform is fitted for unmanned operation and is instrumented with an Inertial Measurement unit (IMU) to log the linear accelerations and angular velocities and the attitude of the craft. The incoming waves are measured by a separately deployed buoy. The wave induced heave, pitch and vertical accelerations, as computed by the model, have been validated with these experimental data and the differences are addressed.

03.10.2018
09:00-09:45
Maritime Robotics
Morel Groper

Prof. Morel Groper *served from 1987 to 2011 in the Israel Navy as a design engineer, Navy Shipyard Chief Marine Engineer and finally as the Navy Head of Naval Architecture and Marine Engineering. Through his career in the Israel Navy, he was directly involved in many of the naval architecture and marine engineering research and development efforts, including the development of advanced naval platforms and unique marine systems. Prof. Groper received his PhD degree in 1999 from the Faculty of Mechanical Engineering at the Technion, Israel Institute of Technology in Haifa, Israel. His research under the supervision of Professor Izhak Etsion focused on the cavitation phenomena in hydrodynamic bearings. In 2010 Prof. Groper retired from the Navy and launched his own R&D company to provide comprehensive mechanical engineering and naval architecture services to naval, marine, offshore and industrial sectors. In 2014 he joined the University of Haifa to promote his own research, as well as assist with establishing and developing the new Hatter Department of Marine Technologies. Currently, Prof. Groper serves as the Head of this department at the Charney School of Marine Sciences at the University of Haifa. His research focuses on maneuvering and propulsion of underwater marine vehicles and on the engineering design of components for underwater applications.*

New survey visualization: merging photogrammetric 3D model with a multibeam bathymetry

Hironobu Kan, Kyushu University, Japan

Precise mapping enables us to accurately survey and describe seafloor geomorphology and improve our understanding of environments in coastal areas. The multibeam survey method provides accurate bathymetric information about seafloors. The author and his research colleagues have been conducting multibeam bathymetric surveys and mapping coastal seafloors with a horizontal grid with the size of 1–2 m in the Ryukyu Islands, southern Japan. Moreover, photogrammetry has frequently been used to map underwater terrains in the past several years. Photogrammetry provides high-resolution textures of targeted areas underwater. However, the obstacle of this application is its limitation of survey areas. It is not practical to use photogrammetry to capture areas larger than a hundred square meters. They therefore experimented with a new method to map and visualize seafloors; this new methodology provides '3D bathymetric data' from multibeam surveys and 'high resolution textures' from photogrammetry. Consequently, this methodology provides a new type of visualization of the seafloor, as the generated data of the methodology has general colored bathymetric data, meaning that, along with targeted small areas, it can display diagnostic high-resolution textures on the surface. They also tried to generate a precise seafloor map from photogrammetry by incorporating control points obtained from multibeam bathymetry. The experimental project was carried out with a ship-rigged multibeam apparatus and diver-based photogrammetry and the results are outstanding. Yet the author believes that photogrammetric data can be gathered by ROVs and AUVs, not human divers. Henceforward, the methodology can be applied for deep-water mapping. In his lecture, the author shall share the results of his experimental projects and the methodology.

03.10.2018
09:45-10:30
Marine Geology
Hironobu Kan

Hironobu Kan *is the Director of the Research Center for Coastal Seafloor, Kyushu University, Japan. He is also a Professor in the Graduate School of Integrated Sciences for Global Society, Kyushu University. The primary focus of his current research is Coral Reef Geomorphology using Multibeam Bathymetric Echo Sounder and SCUBA Diving Surveys. Because scientific knowledge of the coastal seafloor is limited, he is conducting geomorphology and related interdisciplinary research on the coastal zones by observing high-resolution seafloor bathymetric maps using a multibeam echosounder that he introduced to his laboratory. He discovered large submerged karst features and coral assemblages in the Ryukyu Islands, Japan. He also explained historical harbor formation in Yarabuzaki, Ishigaki Island, Japan through his bathymetric research. He is challenging novel scientific discovery in his ongoing research. He is also studying the development of coral reefs during glacial and post-glacial ages using cores obtained from a marine platform, drilling vessel and also using a diver-operated submersible hydraulic drill or through observation and sampling from harbor excavation in reefs.*

Cyber-security solutions for unmanned systems, and their use in conjunction with new technologies to advance port security and maritime domain awareness

Philip A. McGillivary, *US Coast Guard Pacific Area, USA*

As the use of unmanned systems, including unmanned aircraft systems (UAS), autonomous surface vessels (ASVs) and autonomous underwater vessels (AUVs) increases in the maritime realm, particularly for shipping and port and harbor security, there is an immediate need to improve the cyber-security of these systems. The presentation will discuss international and national efforts to improve maritime cyber-security for ships, and how these approaches can be adapted to unmanned systems. A migration to optical communications with Delay and Disruption Tolerant (DTN) networking protocols can provide increased communications bandwidth, resilience, and security for autonomous systems. This step in cyber-security represents an interim phase prior to a future transition to quantum communications. With secure high-bandwidth communications from and between networked unmanned systems, new technologies to assist in maritime domain awareness can be used. For port and harbor security, acoustic communications and detection systems for AUVs have proven problematic, so the use of optical communications methods is preferred, and the use of optical scintillation to detect AUV threats is discussed. Quantum methods for unmanned systems also offer a variety of options. The presentation will discuss issues relating to the use of quantum magnetometers and quantum gravimeters for the detection of AUVs and benthic devices from airborne systems, and the use of quantum optical methods such as 'ghost imaging' to image materials in turbid or turbulent waters. Finally, the presentation will discuss how the use of Fluid Lensing and MiDAR optical methods permit concurrent optical imaging and communication from submarine to surface or airborne assets, and how quantum computing has been used to process data from such systems.

03.10.2018
10:45-11:30
Marine Security
Philip A. McGillivary

***Dr. Phil McGillivary**, as Science Liaison for Coast Guard PACAREA for the past two decades, coordinates science conducted using Coast Guard aircraft, buoy tenders, and icebreakers from the Arctic to the Antarctic, and provides scientific support for Coast Guard missions throughout the Pacific. He previously worked on advanced Internet technologies, computer security and quantum encryption technology in the Office of Secretary of Defence. Earlier work included a NOAA postdoctoral position coordinated jointly with the Naval Postgraduate School that focused on advanced radar, acoustic and laser technologies. A prior Office of Naval Research post-doctoral position at the University of California, Santa Barbara studied ocean processes related to submarine defence and detection. His 1988 doctorate in Ecology from the University of Georgia researched processes at Gulf Stream fronts, and followed three years prior work as an oceanographer at the NOAA Atlantic Oceanographic & Meteorological Laboratory (AOML) in Miami. His experience includes more than two years at sea on submersibles, research vessels and icebreakers. He has been active in the development and integration of autonomous underwater and surface vessels with unmanned aircraft systems for ocean research*

and monitoring, has served as a member of the Navy/NSF UNOLS Scientific Committee on Oceanographic Aircraft Research (SCOAR), and currently serves on the State Department Arctic Council Unmanned Aircraft Expert Working Group. Recent publications have addressed the incorporation of supercomputers on ships, use of unmanned systems for persistent maritime surveillance and monitoring, and the development of technology for advanced optical communications at sea.

Submarine technology for the study and conservation of deep coral gardens and cold-water coral reefs

Andrea Gori, Institut de Ciències del Mar - Consejo Superios de Investigaciones Científicas, Spain

Difficult access has historically limited the study of deep-marine ecosystems. Only in the last decades, advanced submarine technology has made the exploration of deep marine bottoms increasingly affordable, allowing for the identification and characterization of highly-diverse coral-dominated communities. Remotely Operated Vehicles, manned submarines, and Autonomous Underwater Vehicles have been used in the past to characterize the ecology and conservation status of coral gardens and cold-water coral populations in the Cap de Creus canyon and in the Menorca Channel (Western Mediterranean Sea). This presentation focuses on the use of these underwater technologies for the ecological research, management and conservation in the deep-sea. Moreover, future developments and possibilities will be proposed and discussed.

03.10.2018
11:30-12:15
Marine Biology
Andrea Gori

Andrea Gori's *research experience began at the Institute of Marine Science (Barcelona, Spain), with his degree project and PhD thesis. After finishing his PhD, he spent two years as postdoctoral research associate at the Centre Scientifique de Monaco (Principality of Monaco) and one year at the Heriot-Watt University (Edinburgh, Scotland). After this, he joined the University of Barcelona (Spain) for two years, and currently he is a postdoctoral research associate at the Institute of Marine Science (Barcelona, Spain). The main line of his research has centred on the study of the ecology and eco-physiology of marine ecosystem engineering species (primarily corals and gorgonians) to provide understanding for the sustainable management and conservation of coastal and deep marine ecosystems. This research is developed following a multidisciplinary approach combining fieldwork, experimental studies, and laboratory analyses. More specifically, his research is developed into 4 specific lines: (1) Distribution pattern of marine ecosystem engineering species (primarily corals and gorgonians) in coastal areas, continental shelf and upper slope (0-400 m depth). (2) Spatial and depth variability of ecological processes in corals and gorgonians, and their response to anthropogenic impacts. (3) Eco-physiological processes in shallow and deep corals and gorgonians depending on environmental conditions and anthropogenic impacts. (4) Ecological restoration of deep coral and gorgonian populations.*

Development of next generation marine autonomous systems for ocean science

Alexander B. Phillips, National Oceanography Centre, UK

The UK's National Marine Equipment Pool (NMEP) is the largest centralised marine scientific equipment pool in Europe, providing scientific instruments and equipment capable of sampling from the sea surface to the deep ocean. The Marine Autonomous and Robotic Systems (MARS) fleet of robotic platforms (AUVs, ROVs, USVs and Underwater gliders) forms a key component of the NMEP. To maintain the UK's position at the forefront of global marine science and technology innovation, NERC/ISCF have made a £19m investment in the developments of Marine Autonomous Systems (MAS) including platforms, sensors and supporting infrastructure. This presentation will describe the progress to date on the: Autosub2000 Under Ice (Autosub2KUI), Autosub Long Range 1500 (ALR1500) and Command & Control (C2) developments being led by the MARS Development group.

03.10.2018
12:15-13:00
Maritime Robotics
Alexander B. Phillips

Dr Alex Phillips *is a qualified Naval Architect with 10 years' experience in the unmanned marine industry. Upon graduating from the University of Southampton, Alex spent two years in the offshore industry before returning to Southampton to complete a PhD in hydrodynamics of underwater vehicles. On completion of his PhD he continued to research in the field of underwater robotics. In 2015 he joined the National Oceanography Centre as Head of Marine Autonomous Systems Development within the Marine Autonomous and Robotic Systems group. In 2018 he became Head of the Marine Autonomous and Robotic Systems Development Group, where he is responsible for the development of a range of new Autosub Autonomous Underwater Vehicles.*

Company programme: Blueprint Subsea

Robin Sharphouse and Kevin Webster, Blueprint Subsea, UK

03.10.2018
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Robin Sharphouse,
Kevin Webster

Blueprint Subsea manufacture a range of sonar, navigation and positioning systems including: Oculus dual frequency multibeam imaging sonars suitable for a wide range of platforms, StarFish sidescan sonars offering fully featured professional capabilities in a compact package, Artemis diver handheld navigation systems, and SeaTrac USBL positioning modems providing robust acoustic tracking and data communications.

Website: www.blueprintsubsea.com

Tutorial: Sparus II

Narcís Palomeras, University of Girona, Spain and **Natàlia Hurtós,** IQUA Robotics, Spain

03.10.2018
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Narcís Palomeras,
Natàlia Hurtós

IQUA Robotics in collaboration with the Robotics and Underwater Vision group of the University of Girona will demonstrate the capabilities of the Sparus II AUV. This is a lightweight vehicle with hovering capability and a mission-specific payload area. The vehicle is designed to work in shallow water (up to 200 meters) and its torpedo shape with the ability to hover allows an easy deployment, as well as being able to be operated in environments where maneuverability is paramount. The Sparus II AUV uses an open software architecture based on ROS. The tutorial will consist of a demonstration divided in three parts: first, inspect an area using an acoustic sonar; then, make a preliminary analysis of the gathered data; and finally, make a second survey, based on vision, in the areas of interest identified in the previous one. An interface designed by IQUA Robotics will be used to define the missions, monitor their execution and perform preliminary analysis of the mission data.

Demonstration: ecoSUB - smart network localisation

Iain Vincent and Jérémy Sitbon, Planet Ocean Limited / ecoSUB Robotics Limited, UK

Inherent to ecoSUB AUV's small, low cost design is the limited ability to understand its position in the water column and navigate accurately, currently relying on dead reckoning. Planet Ocean, along with project partners the National Oceanography Centre (NOC) and University of Newcastle (UoN) are currently engaged in an 18-month project to develop a Smart Network Positioning capability with artificial intelligence imbedded in the vehicles to enable them to react to their environment and adjust navigation accordingly. The conclusion of this project will demonstrate 10 ecoSUB AUVs operating together with low cost nanomodems, localising themselves with high levels of accuracy from a single unit surfacing and acquiring a GPS fix. This demonstration will show progress towards the final project objective and will show shore launch and recovery of an ecoSUBm (2500m rated small AUV with target market price of <GBP20k) and ecoSUBμ (500m rated micro AUV with target market price of <GBP10k) localising within an LBL and completing lawnmower surveys. ecoSUB AUVs will be deployed together and will return to shore to transmit data for presentation and review by delegates. The advancement of this approach towards localisation and enhanced navigation will greatly expand the functional use of affordable AUV technology and offer significant benefits to the science community.

03.10.2018
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
Iain Vincent,
Jérémy Sitbon

Jérémy Sitbon *graduated from the engineering school Polytech Paris-UPMC, part of Pierre et Marie Curie University (Paris, France), with a major in robotics engineering, where he undertook an internship with the French Defence Procurement working on micro-UAV's vision systems. Jérémy joined the ecoSUB team in 2015 and is the technical lead with special responsibility for software on the ecoSUB range of AUVs. Jérémy is based at the ecoSUB R&D facility at the Marine Robotics Innovation Centre located within the National Oceanography Centre, Southampton.*

4th OCTOBER
Thu

Underwater acoustic communications: Fundamentals and new results

Milica Stojanović, Northeastern University, USA

Underwater wireless communications rely on transmission of acoustic waves, since electromagnetic waves propagate only over very short distances. Acoustic waves, however, are confined to low frequencies (usually up to a few tens of kHz), and the communication bandwidth is limited. Sound travels underwater at a very low speed (1500 m/s) and propagation occurs over multiple paths. Delay spreading over tens of milliseconds results in a frequency-selective signal distortion, while motion creates an extreme Doppler effect. The worst properties of radio channels—poor link quality of a mobile terrestrial channel, and long delay of a satellite channel—are thus combined in an underwater acoustic channel, which is often said to be the most difficult communication medium in use today. The quest for bandwidth-efficient acoustic communications has progressed over the past few decades from an initial feasibility proof of phase-coherent detection, to the development of the first high-speed acoustic modem, and finally to a plethora of innovative solutions on both the signal processing and the networking fronts. In this presentation, there will first be an overview of channel characteristics, focusing on the major differences between acoustic and radio channels. This will be followed by a discussion of signal processing methods, over viewing single-carrier broadband equalization used in an existing acoustic modem, and focusing on recent research results in multi-carrier signal detection on Doppler-distorted channels. The performance of various techniques is illustrated through experimental results, which include transmissions over few kilometers in shallow water to hundreds of kilometers in deep water, at highest bit-rates demonstrated to date. The presentation will be concluded by outlining the open research problems.

04.10.2018
09:00-09:45
Maritime Robotics
Milica Stojanović

Milica Stojanović *graduated from the University of Belgrade, Serbia, in 1988, and received the MSc and PhD degrees in electrical engineering from Northeastern University in Boston, in 1991 and 1993. She was a Principal Scientist at the Massachusetts Institute of Technology, and in 2008 joined Northeastern University, where she is currently a Professor of electrical and computer engineering. She is also a Guest Investigator at the Woods Hole Oceanographic Institution. Her research interests include digital communications theory, statistical signal processing and wireless networks, and their applications to underwater acoustic systems. Milica is a Fellow of the IEEE, and serves as an Associate Editor for its Journal of Oceanic Engineering (and in the past for Transactions on Signal Processing and Transactions on Vehicular Technology). She also serves on the Advisory Board of the IEEE Communication Letters, and chairs the IEEE Ocean Engineering Society's Technical Committee for Underwater Communication, Navigation and Positioning. Milica is the recipient of the 2015 IEEE/OES Distinguished Technical Achievement Award and is the 2018 IEEE/OES Distinguished Lecturer.*

How to protect an outstanding shipwreck site?

Irena Radić Rossi, University of Zadar, Croatia, **Vedran Dorušić,** Diving Centre FOKA, Croatia and **Matko Čvrljak**, Strandingsmuseum St. George, Denmark

In summer 2018, an outstanding shipwreck site was discovered in the waters of the island of Pag. It consists in several hundreds of amphorae of Lamboglia 2 type from the 1st c. BC, which lie in the original position as in the ship hold, reflecting the outline of the sunken ship. The site also contains come pottery items from the ship's galley, and the lead anchor stock bearing the inscription STRATON, indicating the probable owner of the misfortunate vessel. The first well-preserved sites were discovered in the waters of Lastovo Island at the end of the 1980s, and since then their number grew to eight. Seven sites, located at the islands of Rab, Pag, Žirje, Lastovo (2), Mljet and Supetar in front of Cavtat, are protected with the iron cages, which through time demonstrated their advantages and limitations. The recent negative experiences on the argument led to the conclusion that some other solutions should be experimented for the needs of the in situ protection of non looted shipwreck sites. The newly discovered site at the island of Pag served as a hint for attempting to find the alternative solution. Up to now a system composed of a 360 degrees fieldview camera for surface survey, and two PTZ cameras for underwater survey was suggested, and should be implemented next year. The paper aims at discussing the problem and challenging the professional audience to propose alternative solutions.

Vedran Dorušić *is a professional diver and director of Dive Centre FOKA Ltd. As an ex-navy diver he opened his own dive center on Pag providing commercial diving services for the oil & gas industry. Vedran is a NAUR representative for Croatia and his dive center a NAUI branch office. He was the president of the Croatian Tourist Diving Association, co-founder and president of the association NAVALIS, and active member of Institute for Maritime Heritage ARS NAUTICA. He actively participates in underwater archaeological research with the University of Zadar and other institutions.*

Irena Radić Rossi *graduated in archeology at the University of Zagreb in 1988. while being assigned a position of the underwater archaeologist-conservator in the Republic Institute for the Protection of Cultural Monuments obtaining the title of a senior conservator. Later she moved to the University of Zadar as an assistant professor and became a world-renowned researcher at multiple institutions across the globe with her involvement in numerous archaeology excavations in Croatia and abroad. She currently directs several international research projects as well as being the principal investigator of the Archaeology of Adriatic Shipbuilding and Seafaring (AdriaS) Project, supported by Croatian Science Foundation.*

04.10.2018
09:45-10:30
Maritime Robotics
Irena Radić Rossi,
Vedran Dorušić,
Matko Čvrljak

Matko Čvrljak *holds an MA degree in archaeology from the University of Zadar. He was involved in many archaeological projects around the world, improved his skills at Nautical Archaeology Program of Texas A&M University. He had professional practice at the Viking Ship Museum in Roskilde, Denmark as well as worked for their Department of Maritime Archaeology from where he moved to Strandingsmuseum St. George in Thorsminde, Denmark leading their underwater archaeological research. He is also a commercial diver, an associated researcher of the Archaeology of Adriatic Shipbuilding and Seafaring Project, and an active member of the Institute for Maritime Heritage ARS NAUTICA.*

Micro-scale wave energy generation for autonomous sensors and robotics

Tim Mundon, University of Washington, USA

While research in wave energy converter (WEC) design and technology has continued to advance toward grid-scale implementation, there is a new interest in simultaneously exploring the development of much smaller-scale 'MicroWEC' wave energy systems. This interest is borne of multiple potential benefits, but perhaps of the most interest is the provision of small quantities of power in locations where other sources are intractable; in particular remote ocean sensing applications and offshore charging for autonomous robots, but also many others. The applications that could benefit the most are those that are defined by power availability and currently rely upon battery storage, transported fuels, or small-scale photovoltaics, but do not currently capitalize on the local wave resource. Provision of long-term power in this way opens up new possibilities for mission profiles and sensor deployments. A general definition of the MicroWEC category can be taken loosely as <200W with a physical footprint and mass that allow them to be handled by an individual. This definition is such that they can rapidly be designed, deployed, and have a wide range of potential implementation scenarios, making them attractive to researchers and offshore applications. However, the assumption that existing grid-scale WEC design and optimization efforts can simply be scaled down to meet the reduced power need of these potential applications is invalid. As the scale of power demand and the physical envelope of the WEC reduces, the design drivers and the technical challenges change significantly. This presentation presents the concept, challenges and benefits of developing MicroWECs that are able to provide power for remote applications, enabling extended persistence and potentially rapid deployability.

04.10.2018
10:45-11:30
Maritime Robotics
Tim Mundon

Tim Mundon, *PhD, has more than 15 years experience working on the development of wave energy. His primary role is as the Chief Engineer with Oscilla Power, where he is responsible for the design and development of the Triton wave energy converter. He has a faculty position with the Mechanical Engineering department at the University of Washington. Dr Mundon received his PhD in wave energy from the University of Edinburgh in 2005 and has since gained experience working on the design and development across a number of different renewable and conventional offshore energy projects. He is currently involved with a number of academic research projects related to the development and optimization of wave energy converters.*

Exploring the ocean and the seabed: Oceanographic case studies where marine robotics can be applied

Manuel Bensi, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Italy

The ocean is a natural resource mostly still unexplored, especially in its deepest parts. Deep ocean and seas, as well as coastal areas, are complex environments, where atmospheric pressure and internal processes drive ocean currents and mixing, leading to the ventilation of the deep layers and re-distribution of nutrients throughout the water column. In addition, the ocean plays a critical role in removing carbon from the atmosphere and regulating the global climate. Seafloor topography influences ocean circulation by steering ocean flows and providing barriers that prevent deep water from mixing. Smaller scale seafloor features such as provinces of mud volcanoes and/or pockmarks are expressions of the venting of gas-rich fluids through sediments into the ocean. Their extrusive behavior and their physical and chemical interactions with ocean waters remain poorly understood due to their inaccessibility. Marine robotics now represent the technological frontiers to reach these geological features and study their functioning. Moreover, the possibilities offered today by the new tools to map the seafloor at high resolution (i.e. combining bathymetry with photo-mosaics of the seabed) allow to expand the marine survey fields, such as habitat mapping for biological applications, underwater archaeology, geotechnical studies on coastal and port infrastructures, coastal evolution surveys, etc. This presentation will focus on some oceanographic case studies where marine robotics (e.g. Glider, AUV, ROV, TV-Multicorer, Ocean Floor Observation System) was or can be successfully applied in support of conventional measurements (vessel surveys, moorings, etc.) to make ocean observations more efficient, cost effective, and low-risk.

04.10.2018
11:30-12:15
Maritime Geology
Manuel Bensi

Manuel Bensi, *PhD, is a marine scientist with more than 14 years' experience in the physical oceanography field. He graduated in 2003 from the University of Genoa, in 2006 obtained an MSc degree in Tropical Marine Science from the University of Fortaleza, Brazil, and in 2012 his PhD degree in Marine Science from the University of Trieste, Italy. His research focuses on thermohaline circulation, dense water formation and cascading processes in areas of the Mediterranean Sea and Polar regions. Author of more than 30 publications among peer-reviewed journals (e.g., Scientific Report, Nature Communication, JGR-Oceans, PLoS ONE, Deep Sea Res., Ocean Science, etc.), book's chapters, technical reports, and more than 40 communications in national and international conferences. He took part in more than 25 oceanographic cruises in the Mediterranean Sea, in the Atlantic and in the Arctic Oceans. He holds a large expertise in ocean data acquisition and processing (thermohaline data, ocean-velocity data, time-series, etc.) and instruments set-up. He is the coordinator and task leader in several national and international projects.*

Cloud-based management and control of autonomous marine vehicles: Concept and demonstration

Xianbo Xiang, Huazhong University of Science and Technology, China

In recent decades, emerging applications of robotic marine vehicles, including autonomous surface vehicles (ASV) and autonomous underwater vehicles (AUV), rise up to replace human beings on board to explore and exploit abundant ocean resources. Beyond achieving practical oceanic applications, smart management and control of single/multiple marine vehicles is one of the essential problems in attaining surface or underwater operational objectives. In this lecture, the latest research activities in this field at the Lab of Advanced Robotic Marine Systems (ARMs) will be presented. First, scenarios and concerns on management and control of marine vehicles will be introduced, in which some concepts and ideas are introduced to achieve flexible access to robotic marine vehicles. Second, cloud-based management framework will be illustrated, and hardware/software architecture embedded with intelligent control methods is proposed for diverse robotic marine platforms. Finally, practical demonstrations of tele-management via mobile terminal platforms and smart control of single/multiple robotic marine vehicles will be delivered, and some remarks on running projects at Lab of ARMs will conclude this presentation.

04.10.2018
12:15-13:00
Maritime Robotics
Xianbo Xiang

Xianbo Xiang, *PhD, Professor, Head of Laboratory of Advanced Robotic Marine Systems (ARMs), School of Naval Architecture and Ocean Engineering, Huazhong University of Science and Technology (HUST), P.R.China. He received the BE and ME degrees in automatic control and marine engineering from HUST, Wuhan, China, in 2000 and 2003, respectively, and his PhD degree in System Automation and Micro-electronics from the University of Montpellier 2, Montpellier, France, in 2011. His research interests include robotics and marine surface/underwater vehicles. From September to December 2006, he was an EU Erasmus Mundus Visiting Scholar in the SpaceMaster Project. From February 2008 to March 2011, he was in the European Project FreeSubNet as an EC Marie Curie ESR Fellow at LIRMM, CNRS UMR 5506. Currently, he leads the research Lab of ARMs and builds international collaborative connections with researchers in Croatia, France, UK, USA, etc. He is a member of the IFAC Technical Committee 7.2 on Marine Systems, IEEE Oceanic Engineering Society and IEEE Robotics and Automation Society. He serves as the Chair of 2018 IEEE 8th International Conference on Underwater System, Computing and Engineering, and serves as the guest editor for the International Journal of Intelligent Robotics and Applications, International Journal of Fuzzy Systems and Indian Journal of Geo-marine Science.*

Company programme: Sonardyne International Ltd

Tom Bennetts and Colin Sutherland, Sonardyne International Ltd, UK

John Partridge founded Sonardyne in 1971 and his vision was to improve the safety and efficiency of underwater navigation for divers through innovation in acoustic signal processing, hardware design and custom engineering. From their origins in the North Sea in the early 1970s, innovation and performance has maintained our reputation for technical leadership, and today they have an unrivalled portfolio of acoustic and non-acoustic technologies for use in the most challenging marine environments. Today, the vision is to facilitate safe, secure, economical and environmentally sound operations upon and within the world's oceans and seas; continuing to expand on John's original vision. Now with 230 employees worldwide, underwater acoustics remains at the very core of what they do, the business now reaches far beyond this and has been driven by both the possibilities of new technologies and the needs of our clients. In just a few short years, sonar imaging, optical communications and inertial navigation technologies have emerged from our research programmes. But if experience has taught them one thing, it is that the more you understand about your client's business, the more responsive you can be as an organisation and the better prepared you are to deliver and support the right solution. These investments have provided great value to Sonardyne's customers. Survey operations become ever faster and more efficient, deep water vessels are able to operate safely in all conditions, seabed to surface data transfer is reliable and quick and waterside installations are better protected against the threat of an attack.

04.10.2018
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Tom Bennetts,
Colin Sutherland

Tom Bennetts *graduated from Liverpool University in 1998 with a BSc honours in Geophysics. He spent 6 years conducting inshore geotechnical survey work for renewable market and coastal infrastructure developments. One such project involved working with Hrvatski hidrografski institute in Croatia shortly before joining Sonardyne. He has been located at Sonardyne headquarters in Hampshire England since 2004 as a Navigation Systems Engineer, managing the integration of navigation solutions on numerous offshore and nearshore projects. Experienced in USBL and LBL acoustic navigation systems and recent enhancements offered by INS and Doppler systems on autonomous vehicles. Currently he is working as an Applications Group manager ensuring technically pioneering Sonardyne products are embedded on customer vehicles correctly and the data interface exchange functioning optimally. Project delivery includes Acoustic modem control and positioning of swarms of AUV's for wide area survey. The ability to control multiple AUV's from ASV's is a rapidly emerging market which demands novel concepts and a reliable platform which Sonardyne deliver. He frequently works with the National Oceanography Centre's Marine Autonomous and Robotic Systems, embedding acoustic positioning, optical comms, Sonar, INS and control of Gliders over Iridium. Vehicle management from desk to seabed gateway solutions is a passion and he hopes to gain additional knowledge during Breaking the Surface 2018. Tom is a keen outdoors enthusiast willing to give most activities a go. He enjoys summer weekends sailing with the family and winters snowboarding and mountain-biking with colleagues.*

Colin Sutherland *has been working on subsea positioning technology since he graduated from the Shell Mechatronics scheme in 2008. Since joining Sonardyne, a leading company in underwater acoustics, he has been working on a variety of niche subsea projects involving subsea positioning, bespoke wireless communications and acoustic monitoring applications. Based in Aberdeen, he has participated in a wide range of operations across Europe. This includes Seabed Subsidence monitoring, where large arrays of Sonardyne equipment are used to monitor deformation of the seabed, large structure tow out and installation projects, using a mix of acoustic repeater node networks, high accuracy sensors, USBL and LBL technology along the way. In his current Sales Engineer role, he is mainly focused on wireless command, control and monitoring solutions with some crossover into many of Sonardyne's other positioning system range and bespoke projects.*

Tutorial: Hands-on with software defined modems & underwater networks

Mandar Chitre, Chinmay Pendharkar, Prasad Anjangi and Manu Ignatius, *Subnero, National University of Singapore, Singapore*

Software-defined underwater modems and networks are rapidly gaining popularity due to the flexibility they offer in communicating underwater in challenging environments. With advances in low-power computing technology and flexible software architectures, some modems are able to support not only customizable network stacks, but also reprogrammable signaling at the physical layer. This enables researchers & engineers to customize the behaviors of the modems to robustly communicate in many challenging environments, and to take advantage of special features of the channel, such as propagation delay and channel sparsity. It also allows modems to interact closely with the command & control systems of autonomous underwater vehicles (AUVs), providing critical information for adaptive path planning in light of communication & navigation constraints. In this workshop, the team will explore how software-defined modems and network stacks work, and provide attendees with hands-on experience developing applications that utilize the software-defined features of modems. They will see how the modems can be used for not only communication tasks, but also as transmitters and receivers for acoustic localization & navigation applications. The workshop will use UnetStack as the software platform for the hands-on part of the workshop.

Mandar Chitre *is currently the Head of the Acoustic Research Laboratory at Tropical Marine Science Institute, and an Associate Professor at the Department of Electrical & Computer Engineering of the National University of Singapore. He has more than 15 years of research experience with underwater communication networks and marine robotics, and currently serves as the Editor in Chief for the IEEE Journal of Oceanic Engineering.*

Chinmay Pendharkar *is the Chief Technology Officer of Subnero, a company specializing in underwater communication & sensing networks. He has over 15 years of experience in acoustics, software and embedded systems.*

Prasad Anjangi *is a Senior Engineer with Subnero. He earned his PhD through research on underwater networks, and currently focuses on developing algorithms for high performance underwater communication.*

04.10.2018
TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30
Tutorial
Mandar Chitre, Chinmay Pendharkar, Prasad Anjangi, Manu Ignatius

Manu Ignatius *is the CEO of Subnero, a Singapore based company that specializes in providing underwater communications and sensing solutions. He has experience working with a diverse set of customer bases such as defense, subsea engineering, water utilities and academia. He has over 13 years of experience in embedded systems, computer communication networks, and underwater acoustic systems. He is also an active member of IEEE OES Singapore chapter.*

Demonstration: Underwater scooter Torpex with a newly developed hollow shaft motor

Thomas A. Glotzbach, Sabir Ouchen and Joaquim Pinol Bel, Aalen University of Applied Sciences, Germany

Conventional diver propulsion vehicles (DPV) have an electric motor with a shaft and a mounted propeller on it. The underwater scooter Torpex has a new ring motor topology with three propeller blades inside the rotor. Because there is no shaft needed anymore, the scooter is less error-prone due to entanglement, for example with old fishing-nets. Furthermore, the propeller blades ensure an optimal power transmission from the engine to the water. The motor itself is a permanent magnet synchronous motor with a rated power of 4.5 kW. The winding and the bearings of the motor are cooled by water in the air gap. This allows high current densities up to 18 A/mm2, which is important due to restrictions of space. The scooter has a thrust of 75 kg and a maximal diving depth of 200 m at speeds up to 4 km/h. The current inverter that drives the motor consists of a three-phase power module with up to 100 A peak current and rated DC-Link Voltages between 30 V and 60 V. The current inverter is controlled by a STM-Microcontroller with an implemented sensorless motor control that guarantees high efficiencies and therefore an extended use time. The motors have been developed at the Power Electronics and Electrical Drives Laboratory at Aalen University. This demonstration will show a motor as a stand-alone unit in a small aquarium. The team will also bring one of the scooters, which will be shown on display or possibly in water, if the situation allows. The scooter is a market-ready product, which is distributed by the company Submatix.

4th OCTOBER
Thu

04.10.2018.
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Demonstration
Thomas A. Glotzbach,
Sabir Ouchen,
Joaquim Pinol Bel

Thomas A. Glotzbach *studied electrical engineering with focus on automation engineering at the University of Applied Sciences in Fulda and received his degree in 2001. From 2001 until 2010, he was with the Technische Universitaet Ilmenau, and from 2004 on, he was also a member of the Fraunhofer Application Center System Technology (AST). He received his doctoral degree in 2009 in the area of mission and manoeuvre management for autonomous mobile systems with different levels of autonomy. He participated in the GREX Project in the topics mission planning, control algorithms and control design for cooperative marine robots. In 2010 and 2011, he was with the Instituto Superior Técnico in Lisbon, Portugal in the framework of a Marie Curie Intra-European Fellowship, doing research in the areas of cognitive robotics, cooperative control and navigation of multiple marine robots. From 2011 until 2017, he was back at Technische Universitaet Ilmenau, participating in the MORPH project with a focus on absolute and relative navigation for multiple unmanned marine vehicles with employment in real unstructured, 3D environments by use of acoustic/laser distance measurement and sensor data fusion, as well as team mission planning for scenarios without a priori known vehicle paths and event driven planning paradigms. His habilitation thesis is currently under review. Since 2017, he holds the temporary professorship 'Autonomous Systems and Control Engineering' at the Aalen University of Applied Sciences, Faculty of Electrical Engineering & Computer Science.*

Sabir Ouchen, PhD *is a researcher in the Laboratory for Power Electronics and Electrical Drives at Aalen University of Applied Sciences, Germany under supervision of Prof. Heinrich Steinhart, and a member of Institute of Electrical and Electronics Engineers. He obtained his PhD in control of energy systems from the University of Biskra, Algeria. His power electronics field experience includes both renewable energies and electrical energy quality projects in Algeria, France, and Germany. Since 2013, he has been involved in projects in active power filtering and integration of renewable energies under the direction of Prof. Achour Betka of the University of Biskra, Algeria and in cooperation with Prof. Jean Paul Gaubert from the University of Poitiers, France. Since 2018, he has been collaborating with Prof. Frede Blaabjerg and Prof. Mouhamed Benbouzid, from Aalborg University, Denmark and Brest University, France respectively.*

Joaquim Pinol Bel *received the BEng Degree in Industrial Electronics and Automatics from Universitat Politècnica de Catalunya in Barcelona, Spain, in 2015. He wrote the bachelor thesis at the Aalen University of Applied Sciences. Since 2015, he has been working as a research assistant on the Power Electronics and Electrical Drives department at the Aalen University of Applied Sciences. During this time, he has participated in several projects involving wireless power and data transmission, instrumentation devices development and control of electrical machines. Recently, he is working towards the MSc in Advanced Systems Design. The topic of his master thesis is the thermal modelling of induction machines. His main interests include robotics, control and modelling of electrical drives and artificial intelligence.*

Key technologies towards the vision of complex autonomous underwater operations: From project SMIS to MUM

Torsten Jeinsch and Martin Kurowski, University of Rostock, Germany

Efficient monitoring of large-scale deep-sea areas are gaining importance, especially with regard to marine resources, habitat mapping and environmental changes. In general, there are competing approaches with the use of survey vessels or autonomous vehicles. In this context, the presentation will examine the key technologies towards the vision of complex autonomous underwater operations using multi-vehicle setups. To ensure a robust mission management in disturbed environments the autonomous or better highly automated systems demand for innovative solutions for communication and localization, guidance, navigation and control, vehicle interaction as well as fault tolerance. The focus of project SMIS (Subsea Monitoring via Intelligent Swarms) was to develop autonomous teams consisting of an unmanned surface vehicle (USV), autonomous underwater vehicles (AUVs) and a seabed station (SBS), enabling deep-sea operations up to 6.000m and a mission endurance of one week. Base functions for vehicle "networking", cooperative path planning and mission execution, as well as vehicle interaction have been developed and tested in extensive open water trials. Project MUM moves one step further and brings the supply vessel under water. Weather conditions of the world's oceans are often rough and difficult to forecast. To ensure that work on open seas is safe and efficient, a new class of unmanned underwater vehicle is necessary, the Large Modifiable Underwater Mothership, or MUM. MUM is breaking with old conventions: Its unique modular design allows its rearrangement for each deployment and the long-range operations are performed largely autonomously. Possible activities range from heavy-duty payload operations to stationary deep-sea tasks, always associated with AUVs and ROVs.

05.10.2018
09:00- 09:45
Maritime Robotics
Torsten Jeinsch,
Martin Kurowski

Torsten Jeinsch *is a Professor of Control Engineering. He was an R&D Engineer at IAV GmbH and Gifhorn from 2002. Since 2007 he has been a research consultant for Powertrain Mechatronics Gasoline Engine Systems at IAV GmbH. Between 2007 and 2012 he worked as a Professor of Control Engineering at the Department of Electrical Engineering at the Lausitz University of Applied Sciences. He has led a number of research projects, and authored numerous papers in journals and international conferences, and holds various patents. He is a member of the following institutions: VDE Verband der Elektrotechnik, Elektronik und Informationstechnik e.V., Working Group Methods for Diagnosis, IFAC TC 6.4 IFAC Technical Committee on Fault Detection, Supervision & Safety of Technical Processes-SAFEPROCESS Working Group on Industrial Application of Advanced FDI/FTC Technology and IFAC TC 7.2 IFAC Marine Systems.*

Martin Kurowski, *MSc Ing, is a scientist at Institute of Automation and is responsible for the R&D activities of the maritime research group. His main focus lies on automation and control of operational unmanned marine vehicles. Besides that, he is chairman of the registered association MATNAV e.V. that generates a transfer of knowledge and technology. His research interests are modeling and simulation of marine vessels, the development of integrated guidance, navigation and control systems and the application of control theory, e.g. adaptive and hybrid control systems, multivariable and robust control.*

Chasing ocean carbon – from sky to sea and below

Ivona Cetinić, NASA Goddard Space Flight Center/USRA, USA

The transport of organic carbon from the surface of the ocean to its depths plays a central role in regulating atmospheric carbon, and thus the world's climate. In many ways, the pathway that carbon will take is dictated by type of microscopic algae, phytoplankton, present in the sunlit portion of the ocean. Hence, if we were able to continuously see the diversity of the oceanic phytoplankton and have a better understanding of the complexity of biologically driven carbon flux, we would be able to monitor and predict changes to the ocean carbon cycle on human-kind relevant timescales. For this talk, Ivona will explain how exactly this is done: chase the oceanic carbon from sky to sea (NASA PACE mission), and below (EXPORTS, Sea2Sky), all thanks to the amazing, and sometimes quirky, technology.

05.10.2018
09:45-10:30
Marine Biology
Ivona Cetinić

Ivona Cetinić, PhD, *graduated from the University of Zagreb with a degree in Biology. After working for two years at the Department of Biology, University of Zagreb, as a research and teaching assistant, she transferred to University of Southern California, where she gained her PhD in biological oceanography in 2009. In the same year, she started her postdoctoral appointment at University of Maine, where she worked until 2015: first as a research scientist, then as a research professor. Currently, she is an USRA scientist working at NASA GSFC Ocean Ecology Laboratory. Her research focuses on developing new ways to resolve ocean diversity and biogeochemistry from space. She is a science lead for ocean biogeochemistry under PACE mission, and a NASA Project Scientist for the EXPORTS campaign. She likes submesoscale processes, ocean observing technology (in-situ and remote), pretty silicoflagellates and good olive oil.*

5th OCTOBER
Fri

Autonomy and remote control technology in sea aquaculture activities

Walter Caharija, SINTEF Ocean AS, Norway

Current state-of-the-art technologies and operations for sea-based aquaculture farms are highly dependent on manual labor and close human interaction with the process and cage structures, where the need for personnel to operate on fish farms, including highly specialized divers, is a risk factor, as well as a significant economic cost. Hence, new reliable technological solutions with more autonomy and remote control features by means of unmanned vessels can minimize personnel exposure time, reduce cost and improve regularity and planning of operations such as net inspection and dead fish removal. Moreover, motivated by good water quality and lack of available sheltered locations, the industry is moving to more exposed areas and this renders manual work difficult and highlights the need for autonomous vessels, teleoperations and remote control. Autonomy and remote control technology can hence deliver the key to open areas that are exposed to harsh weather conditions to sea aquaculture activities. This talk will present the ongoing research within SINTEF Ocean in the fields of autonomy, remote control and robotics for sea aquaculture, since SINTEF Ocean has been investigating unmanned vessels and remote technology for application in aquaculture sites for the last 10 years where the most relevant concluded project is MerdROV. The MerdROV project developed navigation and station-keeping control systems for ROVs, for aquaculture specific operations such as net cleaning, inspection and repair, and showed that holes in the net can be detected via computer vision algorithms. Given the promising results, a new generation of ongoing projects within autonomy and remote control followed: ARTIFEX, CageReporter, RACE, EXPOSED, INDISAL and CrowdGuard.

05.10.2018
10:45-11:30
Maritime Robotics
Walter Caharija

Walter Caharija *received an MSc in electrical engineering from the University of Trieste, Italy, in 2009 and obtained a PhD in engineering cybernetics from the Norwegian University of Science and Technology, Norway, in 2014. During his PhD, he worked in the field of marine control, focusing on guidance systems, as well as control techniques capable of handling and compensating sea loads such as wind, waves and currents. From 2014 until 2017, he was employed at the Lloyd's Register in Norway as a consultant, where he was involved in software assurance, analysis of dynamic positioning systems, RAMS, collision avoidance systems and autonomous vehicles. Since 2017 he has been employed by SINTEF Ocean as a research scientist, where he is involved in the following activities: underwater robotics, automation and instrumentation for aquaculture, product development, as well as modeling of physical and biological systems. Walter is one of the recipients of the 2017 IEEE Transactions on Control Systems Technology Outstanding Paper Award and he is the recipient of the 2017 SINTEF's Award for Excellence in Research.*

A fast fish-like human-powered racing submarine

Iain A. Anderson, University of Auckland, New Zealand

In July 2016, the Auckland Biomimetics Lab's human-powered fish-like submarine 'Taniwha 2' won the 3rd European International Submarine Races (EISR) at the QinetiQ Ocean Basin Gosport, England. Like its 10 competitors, Taniwha was pedal powered, driven by a pilot breathing on scuba inside a non-pressurized wet hull. But unlike the majority of its propeller-driven rivals, Taniwha was powered by fins; a modified double Hobie mirage drive with one set on top and another set underneath, mimicking the dorsal and anal fins of a triggerfish. This propulsion design was very reliable; with no aborts in all race starts. The submarine had no rudder for steering, instead, its rear body could flex in a smooth curve, like a fish, under the control of a single hydraulic line. The top speed for this submarine was 4.7 knots, only 0.2 knots short of the world record for a non-propeller driven human-powered submarine. Iain will describe the development work for the company's successful Taniwha 2 design and the lessons they learned from their first submarine: Taniwha 1. In 2014 Taniwha 1 competed at the 2nd EISR, but couldn't finish the course. They had tried to mimic fish too closely, placing pectoral-like dive planes at the front rather than the rear of the vehicle. Their pilot, lacking the sensory/control system fish have inherited, could not counteract a nose-up or down orientation in time to stop the sub from continuing to rotate beyond the point of no return. In his talk, Iain will also speculate on the future of human-powered biomimetic submarining.

05.10.2018
11:30-12:15
Maritime Robotics
Iain A. Anderson

Iain A. Anderson *is an Associate Professor with the Auckland Bioengineering Institute (ABI) and the Department of Engineering Science at the University of Auckland. He has worked as a product designer (Fisher and Paykel Ltd) and a research engineer (Industrial Research Ltd, New Zealand). In 2006 he founded the Biomimetics Laboratory at the ABI. His research interests include control and self-sensing aspects of artificial muscle technology for energy harvesting and soft robotics applications. He is a founder (together with two of his PhD students), director and Chief Scientist for StretchSense Ltd, a Biomimetics Lab spin-out company, launched in 2012 that produces soft elastomer sensors for monitoring human motion.*

ROV inspection

Marko Bakašun, Matej Ćurić and Ivor Meštrović, GEOmar d.o.o., Croatia

ROV (Remote Operated Vehicle) inspection is a rather challenging task to perform correctly and efficiently. You need to have a good understanding of the equipment, its capabilities and of course the environment in which the task is done. The procedure is as follows: first the team conducts a multibeam survey of the targeted object and its surroundings. This gives them a base map of the area, seabed features, potentially dangerous objects that could jeopardize the entire operation (you don't want your umbilical stuck in an shipwreck or something...). After that, they are not "blind" when they operate the ROV itself, because it is much easier to navigate on the seabed with such a map. For navigation the team uses GNSS RTK satellite positioning combined with a USBL (Ultra Short Base Line) system which monitors the ROV's position in real time. For better results the USBL is augmented with external roll/pitch sensors of great accuracy. Also the average sound velocity in the seawater column is measured to assure the best possible position. The ROV inspection after these steps is a much more relaxed operation because the pilot always knows where it is in relation to the target object and it's aware of hazardous areas (which it should avoid). The aim of this presentation and demonstration is to show how it's done and what needs to be done so that the inspection runs smoothly.

Marko Bakašun, *Masters of Engineering in Geodesy (1965) Graduated in 1991 from the Faculty of Geodesy (University of Zagreb). He was employed at the Croatian Hydrographic Institute (1992-1997) as hydrographic surveyor, and in 1997 he founded a geodetic-hydrographic enterprise GEOmar, that he has successfully lead to the present. Marko is a member of the Croatian Chamber of Chartered Geodetic Engineers.*

Matej Ćurić, *Masters of Engineering in Geodesy and Geoinformatics (1991). In 2010 he enrolled at Faculty of Geodesy and graduated in June 2015 with his thesis subject titled "Hydrographic survey and analysis of spatial data for the construction of Split port ". Since August 2015, he is employed as a hydrographic surveyor in GEOmar d.o.o, working on numerous projects in the field of marine geodesy, such as hydrographic and geological survey of harbours, subsea installation, ROV inspection etc. Matej is a member of the Croatian Chamber of Chartered Geodetic Engineers.*

05.10.2018
PRESENTATION
12:15-13:00
DEMONSTRATION
(divided in 3 groups)
15:30-18:30
Marine Geology
Demonstration
Marko Bakašun,
Matej Ćurić,
Ivor Meštrović

Ivor Meštrović, *mag. ing. geod. et geoinf. (1988) – graduated from the University of Zagreb, Faculty of Geodesy, in 2014. He has been employed at Tripodij d.o.o. ever since. Ivor has done numerous multibeam surveys, SBP surveys, ROV inspections. He is a member of the Croatian chamber of chartered geodetic engineers.*

Company programme: Evologics GmbH – scalable hybrid acoustic localization approach for AUV formation control

Konstantin Kebkal and Oleksiy Kebkal, Evologics GmbH, Germany

05.10.2018
COMPANY PRESENTATION
14:30-15:00
COMPANY DEMO
(divided in 3 groups)
15:30-18:30
Company programme
Konstantin Kebkal,
Oleksiy Kebkal

Evologics is a high-tech enterprise founded in 2000 to develop innovative key technologies for maritime and offshore industries. It developed many underwater communication and navigation systems which are currently the most advanced products on the maritime market. Evologics' commercial underwater products have networking capabilities and can successfully operate under different communication protocols. Moreover, Evologics' experts collaborated with its industrial partners on a series of modular systems and have experience in adapting its products to multiple protocol requirements. Further developments include bionic sonar systems for positioning, navigation and monitoring applications, and non-destructive material control and underwater inspection. Flexible-bodied bionic robots, such as the award-winning "Bionic Manta ray" and "Aqua-Penguin", and innovative underwater manipulators have also been developed. A combination of these technologies led to most advanced robot systems designed for special inspection purposes in aircraft security and aquatic environments (SONOBOT). Supported by the German Ministry of economy and industry, Evologics recently conducted R&D of a deep water acoustic network with mobile nodes. Evologics currently participates in following EU and national German projects: EU Projects: SUNRISE (FP7-ICT-2013-611449): sensing, monitoring and actuating the underwater world through a federated research infrastructure extending the future Internet, WiMUST (H2020-ICT-2014-645141): widely scalable mobile underwater sonar technology, SWARMS (H2020-ECSEL-RIA-2014-662107): smart and networking underwater robots in cooperation meshes, German Projects: DNS Teifsee (German project: BMWi 03SX276C), BOSS-Manta (German project: BMWi, 03SX361A).

Konstantin Kebkal *has a PhD in electrical engineering, and his expertise ranges from underwater acoustics to applied mathematics and signal processing. Dr Kebkal's studies of the physics of dolphin communication laid the groundwork for EvoLogics Sweep Spread Carrier (S2C) technology for underwater data transmissions. Co-founder of the company Evologics GmbH.*

Oleksiy Kebkal *has an MSc in computer science and applied mathematics, and he is an expert in underwater acoustic signal processing, embedded programming, algorithms/protocols design for underwater acoustic communications. He is the leading developer of Evologics proprietary D-MAC software (proprietary protocol stack), and of media access and networking software of the EviNS Framework (Evologics intelligent Networking Software Framework).*

Tutorial: subCULTron – underwater measurements using aMussel

Barbara Arbanas, Anja Babić, Ivan Lončar, Milan Marković, Filip Mandić and Goran Vasiljević, University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

subCULTron aims for achieving long-term autonomy in a learning, self-regulating, self-sustaining underwater society/culture of robots in a high-impact application area: Venice, Italy. Our heterogeneous system consists of 3 different robot types: artificial mussels (aMussels) on the sea-ground, artificial lily pads (aPads) on the water surface, and artificial fish (aFish) that move/monitor/explore the environment and exchange info with the mussels and lily pads. aMussels monitor the natural habitat, while each aPad serves as a charging and transportation station for aMussels and a connection to the outer world. The project aims to construct 120 aMussels, 5 aPads, and 25 aFish. During this tutorial we will show how to program an aMussel platform to sink to the bottom, make an underwater measurement, transmit it acoustically to an aPad, return to the surface after a predefined time and SMS measurements to a cell phone.

Barbara Arbanas *is a research assistant in the Laboratory for Robotics and Intelligent Control Systems (LARICS) at the Department of Control and Computer Engineering at the Faculty of Electrical Engineering and Computing, Zagreb. She joined the group after graduating from Faculty of Electrical Engineering and Computing (FER) in 2015. Coming from a Computer Science background, her interests include multi-robot coordination and planning, distributed artificial intelligence, scheduling and optimization. She is currently involved in two EU-funded projects: subCULTron and EuRoC (European Robotics Challenges).*

Anja Babić *is a researcher and PhD student at the University of Zagreb Faculty of Electrical Engineering and Computing and a member of the Laboratory for Underwater Systems and Technologies – LABUST. She works primarily on the H2020 project subCULTron. She was previously involved in implementing tasks for a robot-assisted autism spectrum disorder diagnostic protocol using the humanoid robot NAO for the HRZZ funded ADORE project, as well as in developing diver-focused sensing, data processing, and underwater communication as part of the FP7 project CADDY – Cognitive Autonomous Diving Buddy. Her research interests include evolutionary, neural, and bio-inspired robotics, emergent behaviour, task allocation and scheduling, formation control, and communication between both heterogeneous agents and members of a swarm, as applied to marine robotic platforms.*

Ivan Lončar *received an MSc in Control Engineering and Automatization from the University of Zagreb Faculty of Electrical Engineering and Computing – UNIZG FER in Zagreb (Croatia) in 2016. During his studies, he won the country's SIM(P)ATIC PLC+ Challenge 2016 competition, and is now a member of the Centre for underwater systems and technologies – CUST. Even before graduation, he worked at the Laboratory for Underwater Systems and Technologies – LABUST at UNIZG FER. As of 2017, Ivan is pursuing a PhD in Marine Robotics, specifically, in Underwater localization. Currently, he is collaborating on multiple scientific and research projects: H2020 subCULTron, H2020 EXCELLABUST – Excelling LABUST in marine robotics and nationally funded HrZZ project Cooperative robotics in marine monitoring and exploration – CroMarX.*

05.10.2018

TUTORIAL INTRODUCTION
15:00 - 15:30
HANDS-ON
(divided in 3 groups)
15:30 - 18:30

Tutorial

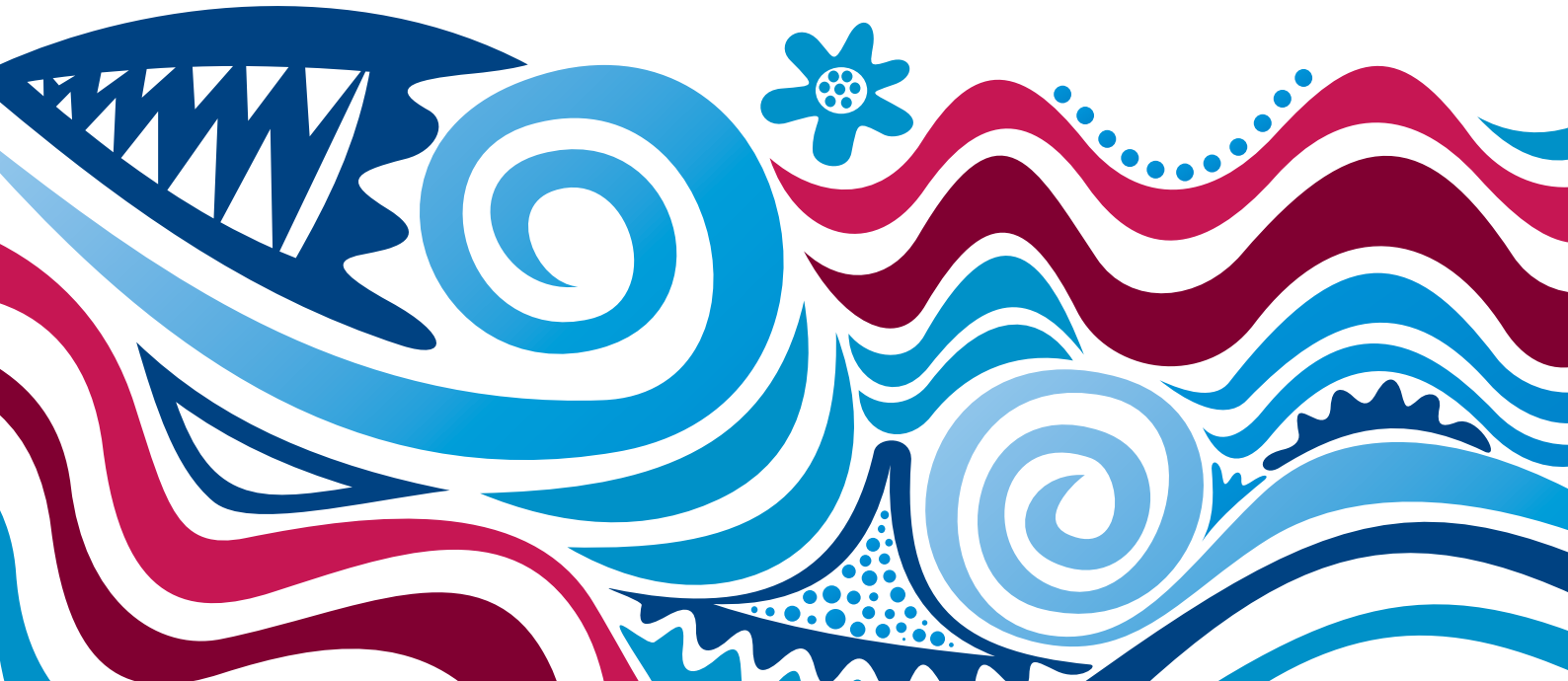
Barbara Arbanas, Anja Babić, Ivan Lončar, Milan Marković, Filip Mandić, Goran Vasiljević

Milan Marković *is a Researcher at the Laboratory for Underwater Systems and Technologies – LABUST at the University of Zagreb Faculty of Electrical Engineering and Computing – UNIZG FER. He received his BSc Eng (2013) degree and his MSc degree (2017) in Mechatronics and Robotics from the University of Zagreb Faculty of Mechanical Engineering and Naval Architecture. He has worked as a Research Development Mechanical engineer at LABUST from 2010 until 2013. He has been working at this position, developing robotic mechanical and electrical systems since 2013 and he worked on multiple EU and ONR funded projects such as CADDY, UReady4OS, CART, subCULTron, SeaJumper, PLADYFLEET etc.*

Filip Mandić *(MSc 2014) is a PhD student and research and teaching assistant at University of Zagreb, Faculty of Electrical Engineering and Computing. His work is currently funded by the Croatian Science Foundation through the Project for young researcher career development. He is involved in two EU projects, H2020 subCULTron and H2020 EXCELLABUST, as well as the nationally funded HrZZ project CroMarX. His research interests include navigation and localization of underwater and surface marine vehicles, and extremum seeking control.*

Goran Vasiljević *gained his MSc in 2009 and became a research associate at the Laboratory for Robotics and Intelligent Control Systems (LARICS) at FER's Department of Control and Computer Engineering, where he has successfully been working on Croatian and international scientific and research projects, as well as on industrial collaboration projects. In 2009, he enrolled in a postgraduate program at FER and in 2016 earned his PhD. His scientific interests include mobile robot localization and control, special robotics systems control and driver safety assistance algorithms in electric cars. He has authored and co-authored two papers in the Current Contents journals of Q1 category, two book chapters and eight conference papers.*

LIST OF PARTICIPANTS



Registered participants until 19th September:

Aalen University of Applied Sciences, Germany
Felix Bauer
Thomas Biz
Robin Foerstner
Thomas A. Glotzbach
Vincent Jeuk
Tristan Klaassen
Philipp Kugler
Matthias Noe
Sabir Ouchen
Joaquim Pinol Bel
Andreas Rosner
Alexander Staerk
Daniel Treuer

ABB Marine & Ports, Norway
Matko Barišić

Asociación EMERGE, Spain
Miriam Noriega Rueda

Blueprint Subsea, UK
Robin Sharphouse

Blueye Robotics, Norway
Martin Ludvigsen

Centre for Maritime Research and Experimentation - CMRE, Italy
Fausto Ferreira
Jan Sliwka
Marin Stipanov

Center for Underwater Systems and Technologies, Croatia
Tonko Bogovac
Ivan Dominić
Petra Kovačević
Mladen Petr
Ivan Trubić
Valentino Žinić

CNR-INM, Italy
Fabrizio Ortolani

DIBRIS - University of Genova, Italy
Mina Sorial

Ecosub, UK
Jeremy Sitbon
Iain Vincent

EvoLogics, Germany
Ievgenii Glushko
Konstantin Kebkal
Oleksiy Kebkal
Viktor Voronin

GEOmar, Croatia
Marko Bakašun
Ayushman Barua
Matej Ćurić
Nikolaj Diller
Ivor Meštrović

German Research Center for Artificial Intelligence (DFKI), Robotics Innovation Center, Germany
Martin Fritsche
Peter Kampmann´

George Mason University, USA
Daniel Lofaro

Heriot-Watt University, UK
Tomasz Luczynski
Rahul Mourya
Yvan Petillot
Jonathan Scharff Willners

Hewlett-Packard Co, France
Kemal Delić

Huazhong University of Science and Technology, China
Xiang Su
Zhao Wang
Xianbo Xiang

IFREMER, France
Jennifer Greer
Jan Opderbecke

Institut de Ciències del Mar - Consejo Superios de Investigaciones Científicas, Spain
Andrea Gori

Israel Antiquities Authority, Israel
Jacob Sharvit

IQUA Robotics, Spain
Natàlia Hurtós

Kongsberg Maritime S.R.L., Italy
Simone Di Giacomo

KTH Royal Institute of Technology, Sweden
Sriharsha Bhat
Clemens Deutsch

Kyushu University, Japan
Hironobu Kan

Monterey Bay Aquarium Research Institute, USA
William Kirkwood

NASA Goddard Space Flight Center/ USRA, USA
Ivona Cetinić

National Institute of Oceanography and Applied Geophysics, UK
Manuel Bensi

National Oceanography Centre, UK
Alexander Phillips

National University of Singapore, Singapore
Prasad Anjangi
Mandar Chitre
Manu Ignatius
Chinmay Pendharkar

Newcastle University, UK
Dave Graham
Gavin Lowes
Jeff Neasham
Ben Sherlock

Nido Robotics, Spain
Enrique González Sancho

Northeastern University, USA
Milica Stojanović

NTNU AMOS, Norway
Øyvind Ødegård

OceanGate, USA
Joel Perry
Steve Phelps

Scuola Superiore Sant'Anna, the BioRobotics Institute, Italy
Marcello Calisti
Giacomo Picardi

SeeByte, UK
Scott Reed

SINTEF, Norway
Walter Caharija

Sonardyne International Ltd, UK
Tom Bennetts
Colin Sutherland

Soprintendenza del Mare (Regione Siciliana), Italy
Sebastiano Tusa

SSC Pacific, USA
Thomas Pastore

ST - System Technologies, UK
Marcus Cardew

Tel Aviv University, Israel
Niv David

Texas A&M University, USA
Megan Lickliter Mundon

The Hatter Department of Marine Technologies, University of Haifa, Israel
Morel Groper

University of Alicante, Spain
Paula Quevedo

University of Applied Sciences Kiel, Germany
Uwe Björn Ruhland
Jonni Westphalen

University of Auckland, New Zeland
Iain Anderson

University of Bath, UK
Yu Miao
George Rossides

University of Bremen, Germany
Arne Kausche

University of Calabria, Italy
Rosario Aiello
Marino Mangeruga

University of Cyprus - Oceanography Center, Cyprus
Gregory Konnaris

University of Florence, Italy
Matteo Bianchi
Alessandro Ridolfi
Nicola Secciani

University of Girona, Spain
Marc Carreras
Nuno Gracias
Lluís Magí
Lászlo Neumann
Narcís Palomeras
Pere Ridao
Joseta Roca
Guillem Valacrosa

University of Haifa, Israel
Yevgeni Gutnik

University of Limerick, Ireland
Isela Ibrahimović
Cathal W. Odonnell
Edin Omerdić
Daniel Toal
Anthony Weir

University of Nevada, Las Vegas, USA
Paul Oh

University of Padova, Italy
Filippo Campagnaro

University of Plymouth, UK
Yogang Singh

University of Porto, Portugal
António Sérgio Ferreira

University of Rhode Island, USA
Bridget Buxton

University of Rostock, Germany
Torsten Jeinsch
Martin Kurowski
Sven Lack
Thilo Müller
Erik Rentzow

University of the Balearic Islands, Spain
Francisco Bonin Font
Eric Guerrero

University of Washington, USA
Tim Mundon

University of Zadar, Croatia
Marija Oštarić
Marta Sutlović
Franka Trcera

University of Zagreb Faculty of Electrical Engineering and Computing, Croatia
Barbara Arbanas
Anja Babić
Marin Bek
Stjepan Bogdan
Matej Celega
Gordan Gledec
Mislav Grgić
Nadir Kapetanović
Nikica Kokir
Zdenko Kovačević
Igor Kvasić
Filip Mandić
Milan Marković
Ivana Mikolić
Anamarija Miličević
Nikola Mišković
Đula Nađ
Matko Orsag
Juraj Oršulić
Frano Petric
Goran Ranogajec
Antonio Vasilijević
Goran Vasiljević
Mario Vražić
Zoran Vukić
Alan Vukić
Ante Zglav

US Coast Guard Pacific Area, USA
Philip McGillivary

Xocean, Ireland
James Ives

Organized by
University of Zagreb
Faculty of Electrical Engineering and Computing
Laboratory for Underwater Systems and Technologies
Centre for Underwater Systems and Technologies

In partnership with
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Financed *in the scope of projects EXCELLABUST – Excelling LABUST in marine robotics (GA 691980) and EUMarineRobots – Marine robotics research infrastructure network (GA 731103), which have received funding from the European Union's Horizon 2020 research and innovation programme*

Supported by
Embassy of the United States Zagreb – Croatia Centre for autonomous marine operations and systems (AMOS)
Norwegian University of Science and Technology (NTNU)
Royal Norwegian Embassy in Zagreb
Foundation of the Croatian Academy of Sciences and Arts – HAZU
Rakije Perković
Proizvodno trgovački obrt Nekić
Pivovara Medvedgrad