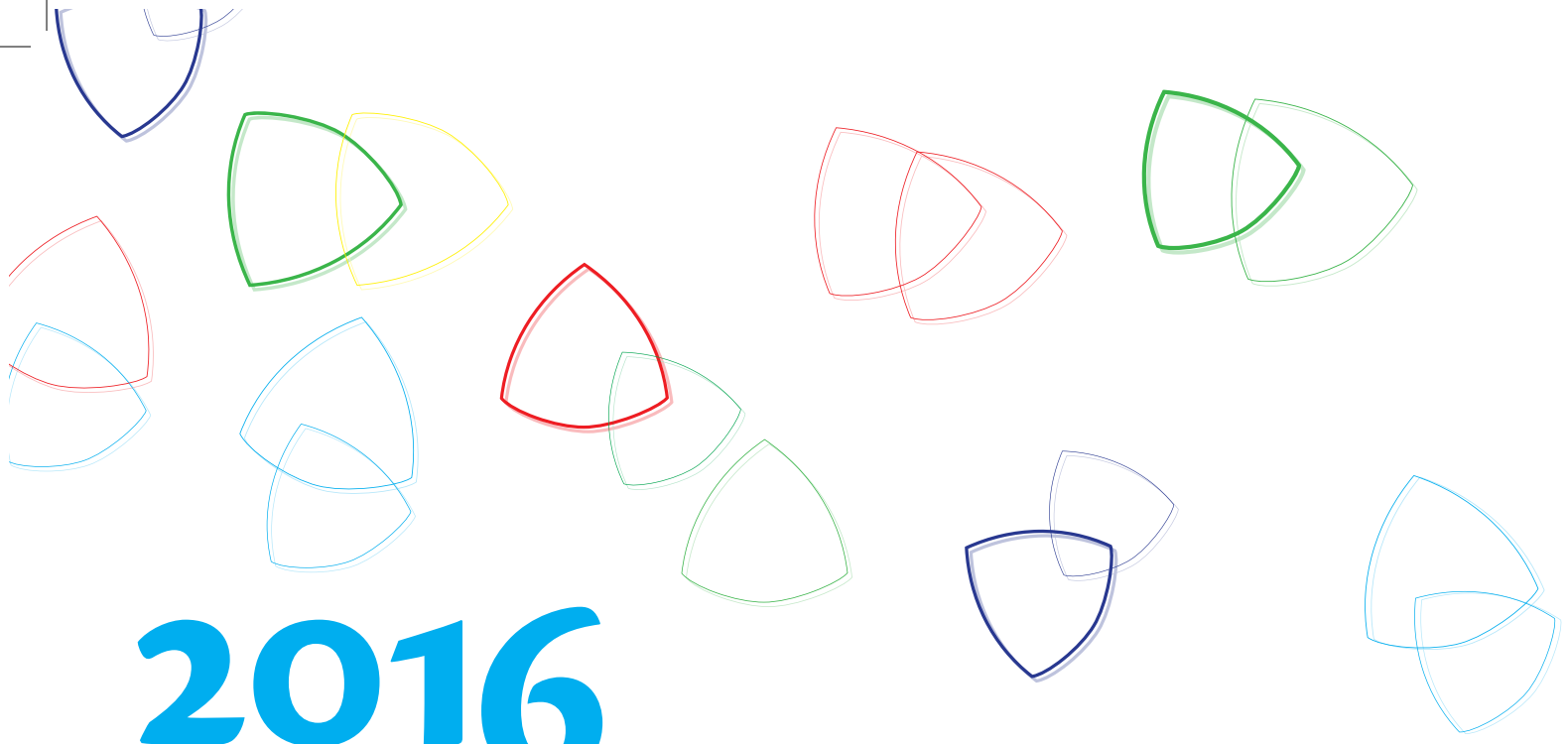


2016 BREAKING THE SURFACE

8th INTERNATIONAL INTERDISCIPLINARY FIELD WORKSHOP OF MARINE ROBOTICS AND APPLICATIONS

2nd - 9th October

ILIRIJA RESORT, BIOGRAD NA MORU, CROATIA

	SUNDAY 02.10.	MONDAY, 03.10.	TUESDAY, 04.10.	WEDNESDAY, 05.10.	THURSDAY, 06.10.	FRIDAY, 07.10.	SATURDAY, 08.10.
09:00 - 09:45		*OPENING SESSION* Mislav Grgić Zoran Vukić Nikola Mišković	*INNOVA 1* **From Research to Revenues - The Puzzle of the Market** David Lane	*MARBIO 1* **Co-existence of top marine predators and humans....and the role of technology** Mark Jessopp	*MAROB 6* **Robotics for challenging ocean intervention in marine renewable energy and other applications** Dan Toal	*MAROB 9* **Unmanned system for maritime security and environmental monitoring** Stjepan Bogdan	
09:45 - 10:30		*MAROB 1* **The H2020 project WiMUST: Widely scalable Mobile Underwater Sonar Technology. An overview** Giovanni Indiveri	*INNOVA 2* **Comments on the Management of Technology Startup Companies** Clayton Stewart	*MAROB 4* **Modular portable marine robotics** Massimo Caccia	*MARBIO 2* **Observations from the Invisible Forest: the diversity of marine phytoplankton** Sunčica Bosak	*MARBIO 3* **Investigating the submarine canyons and seamounts in Spanish waters through non-invasive methodologies** Francisco Sanchez	
10:30 - 10:45		**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**	**COFFEE BREAK**	
10:45 - 11:30		*MAROB 2* **Deep sea sampling with soft robotics: early results and future directions** Stephen C. Licht	*INNOVA 3* **The Art of Innovation** Kemal Delić	*MAROB 5* **The role of underwater robotics in the growth of marine renewable energy** Tim Mundon	*MAROB 7* **Aquatic Micro Aerial Vehicles (AquaMAV) for water sampling and marine exploration** Mirko Kovac	*MAROB 10* **A decade of research in underwater cooperative navigation: what have we learned?** Mandar Chitre	
11:30 - 12:15		*MARCH 1* **Nautical archaeology from the naval architecture point of view** Smiljko Rudan	*INNOVA 4* **Why and how becoming a researcher and entrepreneur?** Asgeir Sørensen	*MARCH 2* **Recording "in the dark". The challenges of recording a submerged 8th century structure in the Schlei Fjord, Northern Germany** Jens Auer	*MARCH 3* **The Underwater Archaeology Centre of Catalonia. The works with AUV and submersibles in archaeological sites** Gustau Vivar	*MARCH 4* **Underwater and Instrumental Archaeology. A Special Relationship** Francesco Tiboni	**FIELD TRIP**
12:15 - 13:00		*MAROB 3* **Methodology of recording and analyzing shipwreck sites using multi-image photogrametry** Kotaro Yamafune	*INNOVA 5* **Value creation from research through university spin-offs** Anders Aune	*MARSEC 1* **Marine Robotics Applications in Humanitarian, Search & Rescue and Civilian Focussed Security Operations – what might the future hold?** Cormac Gebruers	*MAROB 8* **Marine robotics – A tool for increased awareness from land to the deep sea** Alfredo Martins	*MARSEC 2* **Underwater and Instrumental Archaeology. A Special Relationship** Adrian Dann	
13:00 - 14:30		**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**	
14:30 - 14:45		*Tutorial* **University of Girona: Mission planning**	**EvoLogics EviNS workshop**	*INNOVA 6* **OceanScan** Luis Madureira	*Company presentation* **Evologics**	*Company presentation* **Hydroid**	**University of Girona** *Girona500 data analysis*	
14:45 - 15:00							
15:00 - 15:15				*INNOVA 7* **Blueye Robotics** Dyrkoren & Ludvigsen	**OceanScan** Data Analysis	*Tutorial intro* **Edin Omerdić: Thruster Control using LabVIEW Real-Time & FPGA Graphical Programming**	*Company presentation* **Brodarski Institute**
15:15 - 15:30							
15:30 - 15:45		*Tutorial* **OceanScan: Mission planning**		*INNOVA 8* **Bootstrapping SonarSim: A Start-up Journey** Francis Flannery	*DEMO* **Evologics** Group 1	*DEMO* **CNR** Group 2	*DEMO* **subCULTron** Group 3	*Tutorial hands-on* Group 1	*DEMO* **CADDY** Group 2	*DEMO* **AquaMAV** Group 3	*DEMO* **Brodarski Institute: ship demo** Group 1	*DEMO* **Ilmenau Medusa** Group 2	*DEMO* **MORUS** Group 3
15:45 - 16:00													
16:00 - 16:15				**COFFEE BREAK**									
16:15 - 16:30				*DEMO* **Blueye Robotics**									
16:30 - 16:45	REGISTRATION	*University of Girona:* *Girona500 deployment*		*INNOVA 9* **IQUA Robotics: from lab to market** Pere Ridao	*DEMO* **Evologics** Group 2	*DEMO* **CNR** Group 3	*DEMO* **subCULTron** Group 1	*Tutorial hands-on* Group 2	*DEMO* **CADDY** Group 3	*DEMO* **AquaMAV** Group 1	*DEMO* **Brodarski Institute: ship demo** Group 2	*DEMO* **Ilmenau Medusa** Group 3	*DEMO* **MORUS** Group 1
16:45 - 17:00													
17:00 - 17:15													
17:15 - 17:30		*DEMO* **OceanScan**		*INNOVA 10* **Titanrob** Darío Sosa Cabrera									
17:30 - 17:45													
17:45 - 18:00				*INNOVA 11* **Round table** moderated by Asgeir Sorensen	*DEMO* **Evologics** Group 3	*DEMO* **CNR** Group 1	*DEMO* **subCULTron** Group 2	*Tutorial hands-on* Group 3	*DEMO* **CADDY** Group 1	*DEMO* **AquaMAV** Group 2	*DEMO* **Brodarski Institute: ship demo** Group 3	*DEMO* **Ilmenau Medusa** Group 1	*DEMO* **MORUS** Group 2
18:00 - 18:15													
18:15 - 18:30													
18:30 - 18:45	WELCOME DRINK	NORWEGIAN NIGHT											
18:45 - 19:00													
19:00 - 19:15													
19:15 - 19:30											**POOL PARTY:** **DINNER** **+** **CLOSING CEREMONY**		
19:30 - 20:30	DINNER	DINNER	DINNER	DINNER	DINNER		DINNER

LEGEND:

Special sessions	Lecture: MARCH	Tutorial	Hydroid company programme	Brodarski Institute ship demo	CNR demo
Lecture: MAROB	Lecture: MARSEC	EvoLogics company programme	University of Girona programme	CADDY FP7 project demo	NATO SpS MORUS project demo
Lecture: MARBIO	Lecture: INNOVA	OceanScan company programme	AquaMAV demo	H2020 subCULTron project demo	SOCIAL EVENTS

LOCATIONS:

- **LECTURES HALL @ HOTEL ADRIATIC (PURPLE)**
  Programme: **ALL** *lectures and presentations*
- **LAVENDER BAR ROOM @ HOTEL ADRIATIC (PURPLE)**
  Programme: tutorial, mission plannings, data analysis
- **SEA POOL & OPEN WATERS NEARBY**
  Programme: equipment demonstrations
- **LAVENDER BAR @ HOTEL ADRIATIC (PURPLE)**
  Programme: social events

Monday, 3rd OCTOBER

09:00 - 09:45
Opening session

Dean Prof. Mislav Grgić
General Chair Prof. Zoran Vukić
Programme Chair Assoc. Prof. Nikola Mišković
University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

09:45-10:30 MAROB: The H2020 project WiMUST: Widely scalable Mobile Underwater Sonar Technology. An overview

Giovanni Indiveri, Università del Salento (ISME node), Italy

The Widely scalable Mobile Underwater Sonar Technology (WiMUST) project is an H2020 Research and Innovation Action funded by the European Commission. The action's main goal is to develop robotic technologies exploiting Autonomous Underwater Vehicles (AUVs) for geotechnical surveying and geophysical exploration. The novel key feature of the WiMUST system consists in the use of a team of cooperative autonomous marine robots, acting as intelligent sensing and communicating nodes of a reconfigurable moving acoustic network. The talk briefly describes the project and its state of the art after the first year of activities.

Giovanni Indiveri

Giovanni Indiveri was born in Genova, Italy, in 1970. He holds a Laurea degree in Physics since 1995 and a Dottorato di Ricerca (Ph.D.) in Electronic Engineering and Computer Science since 1998 (both from the University of Genova, Italy). From 1999 to 2001 he was a post-doc Researcher at the Fraunhofer (formerly GMD) Institute for Intelligent Autonomous Systems FhG - AiS of Sankt Augustin, Germany. From December 2001 to January 2011 he was Ricercatore (Assistant Professor) at the School of Engineering of the University of Salento in Lecce, Italy. Since February 2011 he is Associate Professor in Systems and Control Engineering at the same University. He served a member of the Board ("Giunta di Dipartimento") of the DII - Dipartimento Ingegneria Innovazione of the University of Salento in the period 2004-2008. Since December 18th 2013, he is again serving in the same Board. Since 2005 he is member of the Technical Committee (TC) on Intelligent Autonomous Vehicles (TC 7.5 IAV) of IFAC - International Federation of Automatic Control (http://www.ifac-control.org/): he served as Vice-Chair of TC 7.5 IAV in the triennium 2009 - 2011, as Chair in the triennium 2011 - 2014 and is currently Vice-Chair again. He is the Scientific Responsible of the University of Salento Research Unit of the Interuniversity Centre of Integrated Systems for the Marine Environment (ISME) since 22nd November 2007. He is the Coordinator of the H2020 - LEIT ICT 23 Call 1 Project WiMUST: Widely scalable Mobile Underwater Sonar Technology, Funding scheme: Research and Innovation action, Proposal number: 645141 Duration (months): 36, Maximum grant awarded to the Action (Euro): 3,970,081.25 Project start date: 1st, February 2015 (www.wimust.eu).

Contact: giovanni.indiveri@unisalento.it

10:45 - 11:30 MAROB: Deep sea sampling with soft robotics: early results and future directions

Stephen Licht, University of Rhode Island, United States

Biological and archaeological sampling with underwater robots is an inherently difficult task. Remotely operated vehicle (ROV) pilots must contend with poor 3-D information about arm and hand position, and poor visibility in turbid water. The ROV tether, water currents, and fluid resistance cause unpredictable disturbances on the arm and on the vehicle. These problems are compounded when the operator does not have exact knowledge of the shape and condition of the objects to be grasped.

We believe that soft robotic grippers have the potential to transform the way archaeological and biological sampling is performed in the ocean. Soft robotic grippers can be designed to passively limit the force that is applied to fragile or sensitive objects and organisms in these conditions, without the need for complex additional sensing. While soft grippers have been shown to dramatically simplify the problem of grasping complex objects in air, they have only very recently been tested in underwater applications.

In this talk, two soft gripper designs are presented which utilize the physical phenomenon of particle jamming to actively switch different parts of a gripper between soft and hard states. A number of modifications are detailed which are required to translate soft gripper technologies to operation at depth. Results from three field trials on ROVs operating at depths ranging from 50 to 1000m are presented, along with a discussion of future target applications and design concepts.

Stephen Licht

Dr. Stephen Licht is the director of the Robotics Laboratory for Complex Underwater Environments (R-CUE) at the University of Rhode Island. Our goal is to develop maritime robots with the ability to operate in dynamic and unpredictable environments. To this end, we investigate biologically inspired propulsion as a means of providing high authority/high bandwidth thrust; distributed pressure sensing for detection of flow structures and obstacles; model based optimal control and trajectory generation strategies for maneuvering in dynamic conditions; and compliant underwater manipulation and intervention technologies.

Dr. Licht received his Ph.D. in Oceanographic and Mechanical Engineering in 2008 from the MIT/WHOI Joint program, where he created 'Finnegan the RoboTurtle'. Prior to joining the URI faculty, he was a Senior Research Scientist with the Maritime Research group at iRobot, and Senior Robotics Engineer with Vecna Robotics. During his time in the robotics industry, Dr. Licht designed, simulated, and field tested model-based control systems for underwater vehicles and ground robots driven by bladders, fins, flippers, propellers, legs, wheels, and tracks.

Contact: slicht@egr.uri.edu

11:30 - 12:15 MARCH: Nautical archaeology from the naval architecture point of view

Smiljko Rudan, University of Zagreb Faculty of Mechanical Engineering and Naval Architecture (Croatia)

Nautical archaeology examines the archaeological and historical evidence of shipbuilding and seafaring through ages. What seem like material remnants of the past today, were once objects manufactured by the principles of the organization of work and the application of crafts and engineering. In that sense, an interdisciplinary approach including both archaeologists and engineers might provide new insight as to the reconstruction of now gone events. Within the frame of recent cooperation realised in the framework of the AdriaS project, particular attention was given to two topics: first, a structural analysis of the amphorae, as one of the most important and popular containers for trading goods, and second, the evaluation of the wooden ship characteristic properties. In both cases, the analysis starts from the material. Both ceramics and wood are not common materials in modern seaborne transportation and naval architecture. Therefore, the research on their properties today is rather limited. Yet these properties are required for a realistic simulation of the behaviour of ceramic vessels and wooden ships. An overview of the capabilities of the state-of-the-art software packages to evaluate complex behaviour of the structures will be presented. That is the engineering tool that will be used to find answers to questions such as why amphorae have such a unique shape, or what we can learn about the maritime capabilities of an ancient ship by the examination of the wreck. Through the illustrative examples of structural analysis, the talk presents a contribution to the discussion about how the interdisciplinary approach can support nautical archaeology research.

Smiljko Rudan

Smiljko Rudan graduated from the Faculty of Mechanical Engineering and Naval Architecture (FAMENA), University of Zagreb, on February 1997. In April 1997 he started to work as a junior researcher at the Department of Naval Architecture and Marine Engineering, FAMENA.

On three occasions, in years 1998, 1999 and 2000, he visited Instituto Superior Tecnico, Lisboa, Portugal, as a visiting researcher, where he participated in the EU project FatHTS - "Fatigue Based Design Rules for the Application of High Tensile Steels in Ships".

He obtained his Master's degree in 2002 with a thesis entitled "Spectral Fatigue Analysis of Ship Structures" and his PhD degree in 2006 with a thesis entitled "Safety of Cargo Tank Structure on Liquefied Gas Carriers".

In 2008 he was elected to the position of Assistant Professor and in 2013 he was elected to the position of Associate Professor.

His research work is related to structural analysis of ship and offshore structures, ship vibrations, collision and grounding of ships, fluid-structure interaction and advanced use of finite element method in structural analysis. Currently he is a project leader on the EU funded project "Equipping of the Regional centre for the laboratory research in hydromechanics" that aims to equip the FAMENA towing tank.

He is a member of the Croatian Society of Mechanics. As the author or co-author he has published more than 40 scientific and professional papers.

Contact: smiljko.rudan@fsb.hr

Monday, 3rd OCTOBER

12:15 - 13:00 MARCH: Methodology of recording and analyzing shipwreck sites using multi-image photogrametry

Kotaro Yamafune, Texas A&M University, USA

Methodology of recording and analyzing shipwreck sites using multi-image photogrametry
In recent years, applications of multi-image photogrammetry became popular in maritime archaeology. This technology has been repeatedly tested in archaeological surveys and excavations in dry and submerged environments. Yet, there are still active discussions about the efficiency and accuracy of multi-image photogrammetry models.
A team from the Nautical Archaeology Program at Texas A&M University developed a methodology to record and analyze underwater shipwreck sites with off-the-shelf software, including multi-image photogrammetry. This methodology produced reliable archaeological data, based on 1:1 scale-constrained photogrammetry models, such as 2D site plans, hull lines, and timber catalogues.
This presentation details a user-friendly methodology for underwater archaeological recording and explains step by step the task required to produce accurate 3D models, geo-referenced high-resolution photo mosaics, section profiles, and high-quality visual tour animations.

Kotaro Yamafune

Dr. Kotaro Yamafune received his Bachelor of Arts degree in history from Hosei University in Tokyo in 2006. He entered the Nautical Archaeology Program in the Anthropology Department at Texas A&M University in September 2009 and received his Master of Arts degree in August 2012. He continued his studies in the Texas A&M University Nautical Archaeology Program and earned his doctorate in May 2016. His research interests include shipbuilding in Medieval Europe and the European Age of Discovery, and ship reconstruction both manually and through the use of digital tools such as 3D modeling software. Currently, he focuses on photogrammetric recording of both submerged and terrestrial cultural heritage, including shipwreck sites. He also expands his study interest to museology for maritime archaeology and managements of cultural heritage using photogrammetric data. Also, Dr. Yamafune provides photogrammetry workshops in different countries to spread an idea of Digital in situ Preservation in order to protect information of cultural heritage for the next generations.

14:30 - 16:30 TUTORIAL parallel in groups:
Girona Mission Planning
OceanScan Mission Planning

16:30 - 17:15 TUTORIAL:
Girona500 deployment

17:15 - 18:00 DEMONSTRATION:
OceanScan

Tuesday, 4th OCTOBER

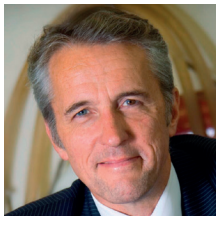
INNOVATION TUESDAY: Innovation Management Trainings

The novelty this year is Innovation Tuesday which is dedicated to the creation of corporate spin-offs, on how to attract investments, and tips and tricks in starting such a company in the form of Innovation Management Training. The topics will include important steps and success factors in the commercialization of research results in terms of technology development, market and sales, organization development, and financing. Start-ups will share their success stories and participants will have a chance to learn about spin-off structures at various institutions.

09:00 - 09:45 INNOVA: From Research to Revenues - The Puzzle of the Market

David Lane, Edinburgh Centre for Robotics, Ocean Systems Laboratory, Heriot-Watt University, UK

The presentation will describe some of the essential ingredients for success in starting, growing and exiting a business using technology and people from the research base. Research is a puzzle, but so is understanding a market, and there's no text book.



David Lane

David Lane is Professor and Founding Director in the Edinburgh Centre for Robotics, a £35M joint venture between Heriot-Watt and Edinburgh Universities training 100 innovation ready PhDs. From 2001 he founded and led SeeByte Ltd/Inc to a multi-million $ UK/US company in defense and offshore markets, winning the 2010 Praxis Unico Business Impact Achieved Award and 2013 Scottish Digital Technology Award for International Growth. At the exit to Battelle in 2013 over 40 shareholders benefited. Previously he established Heriot-Watt's Ocean Systems Laboratory with an international reputation in marine robotics, publishing nearly 200 cited publications with international funding from the UK, EU, US and Japan. He has been a visiting Fellow at the Woods Hole Oceanographic Institution, and Scientific Advisor to the NATO Undersea Research Centre, La Spezia, Italy. In 2013/4 he led development of the UK's national robotics innovation strategy, which has influenced over £200M of UK Govt, spend to date, and was a Director of euRobotics aisbl shaping the €700M EU Horizon2020 Robotics public-private partnership. We was appointed Commander of the Order of the British Empire for services to Engineering in the 2016 Queen's New Year Honours list.

Contact: david.lane@edinburgh-robotics.org

09:45 - 10:30 INNOVA: Comments on the Management of Technology Startup Companies

Clayton Stewart, University College London, (UK)

Managing a technology startup company is akin to walking into a gambling casino with your life savings. One can reduce the associated risks by doing the homework beforehand to minimize the likelihood of catastrophic surprises. This talk will outline the various topics with which the technical entrepreneur should become familiar. Typically, this person is very well qualified technically but may not have managerial experience or knowledge. This person should be a leader, one that others are motivated to follow. If the entrepreneur does not feel they can assume the leadership role, they will need to quickly find a person who can fill that role. In fact, staffing in general, is extremely important. Your most important resource will be your staff! Select technical staff that is bright, knowledgeable, and hard working and then treat them like adults. When you can afford it, you will need to hire an administrative staff member. This person should be broad since they will need to deal with financials, business law, contracts, human resources, and general administration. You will need to secure funding to get your product to market. Funding sources can include venture capitalists, personal sources, and contracts. This will require marketing, which you will likely lead, and a business plan. You will need to manage your financials. Your administrator can help with this, but you will ultimately be responsible. You will need to focus on the development of and protection of your intellectual property. There has to be a sense of urgency here, since time to market is critical. If you master the topics mentioned, you won't eliminate risks associated with the successful launch of your startup, but you can at least minimize them.

Clayton Stewart

Clayton Stewart is currently Visiting Professor Electronic and Electrical Engineering Department, University College London; consultant DARPA, NSF, JHU APL; PI on EU Horizon 2020 SpeechXRays biometrics project; Co-PI with Hugh Griffiths on Radar Vectors Workshop at UCL; member NATO Passive Bistatic Radar and Cognitive Radar panels; Lecturer Cranfield Defence Academy. 2007-2013: Technical Director, US Office of Naval Research Global, supervised 50 engineers/scientists around the world. Administered $60M international S&T grants. 1994-2007: Corporate VP/General Manager Reconnaissance and Surveillance Operation, SAIC; worked with DARPA, ONR, AFRL, NGA, NRO, FBI on Radar, UAV's, Information Exploitation, etc. supervised staff of 500 technical/administrative; $125M annual revenues. 1990-1994: Associate Professor of ECE and Associate Director of Center of Excellence in C3I, George Mason University. 1987-1990: Program Manager Artificial Ionospheric Mirror OTH radar; Air Force/DARPA sponsorship. 1984-1987: PI Signal Processing, Sperry Corporate Technology Center, research on radar, multi-sensor fusion, EW, signal processing. 1982-1984: Deputy Director Tactical Systems Division, Air Force Studies/Analyses, Pentagon, supervised 20 staff doing analyses of C4ISR and EW systems: JSTARS, JTIDS, HARM, Have Quick, Seek Talk. 1978-1982: Associate Professor EE, US Air Force Academy, taught radar, computer architecture, communications systems, EW, signal processing. Director Faculty Research. 1974-1978: Graduate student, MSEE, and PhDEE, Air Force Institute of Technology. 1964-1974: USAF officer, Navigator/EW Officer, EB-57, EB-66, and MC-130CT aircraft including combat tour in SEA. OIC of ELINT cell. Awarded DFC.

Contact: cstewart14@sky.com

10:45 - 11:30 INNOVA: The Art of Innovation

Kemal A. Delic, Hewlett-Packard Enterprise, France

This three-part talk starts with a wide-brush overview of innovation history, where I will stress its importance for the renewal of society, economy, and technologies. Major developments will be described and anecdotal evidence given. Intellectual property (IP) elements will be defined and basic explanations will be given. The second part will address creation and flow from bright ideas to valuable IP items and long-lasting assets. Mechanics of this process will be depicted and explained. Sources of ideas will be mentioned, methods of cultivation, growth, and transformation into product, service or technology will be explained. I will share some of my experiences on patents innovation and provide some good, practical guidance. In the concluding part, I will reinforce the importance of patents for the future developments and address specific field of underwater robotics. I will try to outline some promising directions to explore and cover with sparks of a few innovative ideas. Some key challenges will be given as the central point for technology developments and IP protection. Finally, I will point to the importance of innovation for major technological advances and commercial success.

Kemal A. Delic

Kemal A. Delic is a senior technologist and practicing enterprise architect with Hewlett-Packard Co. He is also an adjunct professor at IAE business school at Grenoble University. He serves as associate editor to ACM Ubiquity magazine. He acted as an advisor and consultant to European Commission on FET programs. He holds 2 US and 1 EU patent. Lives in Grenoble, France. He holds Dipl. El. Ing. Degree from the University of Sarajevo ('81). During the last 30+ years, he has worked mainly in the area of very large scale systems: either on industrial, commercial products or academic research. His principal interest is in architecture, design and engineering of the very large scale systems. In 1989/90 and 1994/96 he was visiting professor and researcher with CNR – Italian National Research Council. He has published 100 + papers, articles, and essays in journals, magazines and conferences. He has given talks, delivered lectures and organized workshops and conferences. In 80ies he has published the original book on Pattern Recognition Principles and lately 3 book chapters on Enterprise Knowledge Clouds (2010, 2011). His recent research interest is in the science and practice of hybrid complex systems.

Contact: kemal.delic@hp.com

11:30 - 12:15 INNOVA: Why and how becoming a researcher and entrepreneur?

Asgeir J. Sørensen, Norwegian University of Science and Technology, Norway

The lecturer has been working with a foothold both in the industry and academia over the span of his entire career. Experience and reflections from a researcher, entrepreneur, and investor point of view will be shared. The lecture covers important steps and success factors in the commercialization of research results in terms of technology development, market and sales, organization development and financing. Experience from the establishment and development of the NTNU spin-off companies Marine Cybernetics AS (founded in 2002 and acquired by DNV GL in 2012), Ecotone AS (founded in 2010) and Eelume AS (founded in 2015) will be shared. Finally, we will show how innovation has been structured as an integrated part of the NTNU Centre for Autonomous Marine Operations and Systems (NTNU AMOS).

Asgeir J. Sørensen

Professor Asgeir J. Sørensen obtained MSc degree in Marine Technology in 1988 and Ph.D. degree in Engineering Cybernetics in 1993 both at NTNU. In 1989-1992 Sørensen was employed at MARINTEK. In the period of 1993-2002 Sørensen was employed in the ABB Group as research scientist, department manager, and Business Area Marine and Turbocharging Technology Manager. In December 2002 Sørensen and 5 partners founded the company Marine Cybernetics AS, where he was acting as President and Chief Executive Officer (CEO) until June 2010. Sørensen is also co-founder of the NTNU spin-off companies Ecotone AS and Eelume AS. Since 1999 Sørensen has held the position of Professor of Marine Control Systems at the Department of Marine Technology, NTNU. He is currently acting as the Director of the Centre for Autonomous Marine Operations and Systems at the Norwegian University of Science and Technology (NTNU AMOS).

Contact: asgeir.sorensen@ntnu.no

Tuesday, 4th OCTOBER

12:15 - 13:00 INNOVA: Value creation from research through university spin-offs

Anders Aune, NTNU Technology Transfer, Norway

Value creation from research through university spin-offs.

Anders Aune

Anders Aune is currently Head of TechTransfer at NTNU Technology Transfer AS and has served as a project manager for more than 70 tech trans projects and spin-off companies. He has also served as board member and Chairman of the Board of several high-tech academic spin-offs of which one of them is Kahoot! AS (www.getkahoot.com). He is currently the Chairman of the Board of the NTNU spin-off Solution Seeker AS focusing on optimizing oil production. Prior to this Aune co-founded the eHealth company Deriga AS which was later acquired by Visma ASA, one of the largest ERP software companies in Northern Europe. Aune also served as an eHealth Sales Manager in Visma before he joined NTNU Technology Transfer to help new university spin-offs succeed.

Aune holds an MSc in chemical engineering and entrepreneurship from the Norwegian University of Science and Technology and has also studied innovation and strategy at MIT as part of the Executive Degrees Program. Aune was one of the initiators of the student organizations Start NTNU and Start Norway working to motivate and inspire students to start their own business. He also initiated the NTNU app-accelerator NTNU Applab (http://applabntnu.no/). Currently, Aune works together with NTNU AMOS to develop Ocean School of Innovation into NTNU School of Innovation.

Contact:anders.aune@ntnu.no

14:30 - 15:00 INNOVA: The Light Autonomous Underwater Vehicle – Affordable technology to address scientific and societal needs

Luis Madureira, OceanScan - Marine Systems & Technology, Lda, Portugal

This presentation will focus on the LAUV (Light Autonomous Underwater Vehicle), a lightweight, one-man-portable underwater vehicle specially designed to be a highly operational and effective surveying tool for oceanographic, hydrographic, security and inspection applications. The presentation addresses the motivation which led to the development of a commercial AUV product meant to be an affordable technological solution that will facilitate access and therefore promote general confidence and acceptance of autonomous systems as efficient tools to answer current scientific and societal challenges.

Luis Madureira

Luis Madureira is one of the founders and manager of OceanScan – Marine Systems & Technology, Lda, a Portuguese company devoted to the development, manufacturing and commercialization of small-sized, one-man portable Autonomous Underwater Vehicles (AUVs).

Luís received his diploma degree in 2000 from the Electrical and Computer Engineering department of the Engineering Faculty of the Porto University, Portugal. In 2005 he completed his master degree in Electrical and Computer Engineering, where he developed his thesis on acoustic navigation systems for multiple underwater vehicles. From 2000 to 2008 he was part of the Underwater Systems and Technology Laboratory research group of the Porto University, where he developed work related with development, deployment and evaluation of underwater vehicles and systems.

Contact: lmad@oceanscan-mst.com

15:00 - 15:30 INNOVA: BluEye Robotics - providing underwater adventures for everyone

Martin Ludvigsen, BluEye Robotics AS and Norwegian University of Science and Technology - NTNU, Norway

BluEye Robotics AS is an offspring from the NTNU AMOS center. The company was founded in June 2015 and have today approx. eight engineers and designers employed. To make underwater vehicles and the underwater environment available to the non-professionals by adapting underwater technology from industrial applications is the central concept of the company.

In the air, UAVs (or drones) have become obtainable to everybody because they are economically accessible and they no longer require experts for successful operation. Modern control systems have lowered the user entry point. BluEye Robotics is convinced we will see a similar development for underwater vehicles. Developing underwater vehicles suitable for the consumer market represents new technical problems, but vehicle technology is only a part of the challenge to open the underwater environment for the general public. To succeed, we believe the user should experience being present underwater as uncomplicated as possible, and it should be compatible with modern digital everyday life shared with our friends on social media.

BluEye Robotics have developed two generations of prototypes to accumulate knowledge and competence concerning vehicle design, operation modes and experiences of our targeted customer segment. One year after the start-up, BluEye Robotics encounters a strong pull from the market for our product and the business idea shows a large potential. From the start, the Technology Transfer Office (TTO) of NTNU, and local investors in Trondheim supported the company. The connection to the TTO is important since they have assisted the company handling typical snags start-ups experience and provided balanced agreements between BluEye Robotics and NTNU for access to groups of experts and infrastructure. Brand building is important to take and hold a position both for our future customers, but also towards funding sources.

Martin Ludvigsen

Professor Martin Ludvigsen obtained MSc degree in Marine Technology in 2001 at NTNU, and PhD degree at NTNU in 2010. His research focus is applications of underwater robotics, cameras and acoustical instruments. He have been working with Sperre AS, providing ROVs to the industry inshore and offshore. He became involved in the field of Inspection Maintenance and Repair (IMR) and from 2012 to 2014 he led the development and delivery of an IMR 70 tons rated heave compensated module handling system for the Åsgård field for AXTech AS. In 2012 Ludvigsen was a guest investigator at Woods Hole Oceanographic Institution on a Fulbright scholarship. June 2015 Ludvigsen was a co-founder of the NTNU technology spin-off Blueye Robotics aiming to providing underwater vehicles to a wider consumer marked, and he is currently the CTO of this start-up. Since 2014 Ludvigsen has held the position of Professor in Underwater Technology at the Department of Marine Technology, NTNU. In 2015 he was announced Adjunct Assoc. Professor in Marine Technology at the Svalbard University Centre (UNIS) In Longyearbyen.

Parallel to his industry activities, Ludvigsen participated in the start-up of the Applied Underwater Laboratory (AUR-Lab) at NTNU in 2009. Running a common pool of advanced underwater equipment and maintaining the interdisciplinary scientific approach, the research group has proven useful for both engineers and scientists. Today, the AUR-Lab is considered an essential asset for multidisciplinary marine research at NTNU, facilitating a large body of research. Ludvigsen has been the manager for the AUR-Lab since its initiation.

Contact: martin.ludvigsen@ntnu.no

15:30 - 16:00 INNOVA: Bootstrapping SonarSim: A Start-Up Journey

Francis Flannery, SonarSim, Ireland

A Startup's journey is never straightforward and never the same. This presentation will cover SonarSim's experience from concept to sales and what we have learned along the way.

How do we fund our product development, see gaps in the market, routes to market, pivot to changing market dynamics, find and collaborate with partners, get customers, and cross the chasm (go from early adopters to scaling across our market).

SonarSim has helped organisations improve their personnel training with our simulators, use deep simulation to determine the most cost-effective configuration to execute a survey plan, automate the control of on-ship sensors and navigation, and use sonar survey simulation to test new designs and strategies before deployment.

Our latest product MAP is an automated vessel runline generator for use during shallow-water multibeam survey planning & acquisition operations. It calculates the optimal vessel waypoints to seamlessly stitch successive run lines together without holes and complete a survey in the minimum amount of time.

Francis Flannery

Francis Flannery is a Director & Co-Founder of SonarSim. He has a Bachelor of Electronic Engineering (2002) and a Research Masters in "Automating the Formal Verification of Security Protocols" (2005) from the University of Limerick. He has over 10 years software R&D commercialization experience across multinationals, research organisations, and start-ups.

Previous to SonarSim he was a Development Programmer at the University of Limerick (2008 -2010) in the Mobile Marine Robotics Research Centre (MMRRC) with core research in the area of sonar simulation. From 2005-2008, he was employed by Intel in cryptographic firmware Research & Development.

Contact: francis.flannery@sonarsim.com

16:15 - 16:45 INNOVA DEMO: Blueye Robotics

Demonstration of Blueye Robotics equipment.

15:30 - 16:00 INNOVA: Bootstrapping SonarSim: A Start-Up Journey

Francis Flannery, SonarSim, Ireland

IQUA Robotics is a start-up company of the University of Girona that commercializes underwater technologies. Recently created, it is the result of the evolution of the research conducted inside the lab to the commercial world. We will give a general idea of the experience of setting up the company from the researcher point of view, considering general IPR issues and time management.

Pere Ridao

Pere Ridao received the Ph.D. degree in computer engineering in 2001 from the University of Girona, Spain. Since 1997, he has participated in 19 research projects (10 European and 9 National), he is the author of more than 100 publications, and he has directed 5 PhDs theses (3 more currently under direction) and 13 MSc theses. His research activity focuses on designing and developing Autonomous Underwater Vehicles for 3D Mapping and Intervention. He is the director of the Computer Vision and Robotics Research Institute (VICOROB) and the head of the Underwater Robotics Research Center (CIRS) and an Associate professor with the Department of Computer Engineering of the University of Girona. Dr. Ridao is the chair of the IFAC's Technical Committee on Marine Systems.

Contact: pere@eia.udg.edu

17:15 - 17:45 Titanrob: 3d printed Titanium Manipulators Innovation in the ROV sector

Darío Sosa Cabrera, ACSM, Spain

TitanRob is a spin-off from ACSM, an ROV service company that has been able to find a niche in the ROV market thanks to its know-how gained in a daily basis servicing work for many different subsea applications: Cable Industry, O&G, Scientific Missions, Archaeology, Rescue, etc. This path is being held together with the University of Vigo, an R&D partner for many years, therefore combining the field know-how of ACSM with the design and R&D management capabilities of the University. The company is selling this year a new pair of manips, being the next steps to find investment to grow in the market with the needed speed.

Darío Sosa Cabrera

Darío Sosa Cabrera obtained his Mechanical Engineer Diploma from the University of Las Palmas de Gran Canaria (2001) with an Erasmus grant at the Institute Français de Mécanique Avancée; he coursed his doctorate in ICTs, focusing on the biomedical field; he defended his Ph.D. on Ultra-Sound Elastography on 2008 after an internship at the University of Texas Health Science Center at Houston. At that time he coursed a Management of Technology Master at the University of Texas at San Antonio.

He has worked at the Institute for Astrophysics of the Canaries (IAC) as a mechanical engineer, participating in the design of different astronomical instrumentation for the GTC (the 10 meter Telescope of the Canaries) and for the European Extreme Large Telescope (E-ELT. The design and integration of the astronomical instruments includes Cryogenics, Mechatronics, and Optomechanics. Later he worked at PLOCAN (Oceanic Platform of the Canary Islands) and his work focused on ROVs, AUVs and Gliders as an operations and maintenance engineer together with duties related to the design and construction of the Offshore Platform that will be the central facility of the infrastructure. He is currently working in ACSM, a company specialized in ROV services and vessel management, a business developer for the UAE base and as R&D manager. At the same time he has co-founded the company Subsea Mechatronics to develop marine technologies with emphasis in robotics.

He has been a judge in SAUC-E since 2011 and he participated in the euRathlon FP7 project. He is a reviewer for the SME oriented EUROSTARS European program, and is very much involved in promoting technological start-ups, one of the means being the marine specialized co-working space Marine Park. He is also involved in technology outreach through the association Lpa Fabrika.

Contact: acsm.ss3@acsmships.com

18:00 - 18:30 INNOVA: Round table moderated by Asgeir Sørensen

Round table discussion.

Tuesday, 4th OCTOBER

14:30 - 18:30 **Evologics seminar**

This year we are hosting EvoLogics company's EviNS workshop from 4th until 5th October 2016.

EviNS (the EvoLogics intelligent Networking Software) is their framework for developing, testing, debugging and implementing underwater acoustic network protocols and customer-specific applications (system integration). Besides seamless integration with EvoLogics underwater modem hardware, EviNS is fully compatible with EvoLogics DMAC Emulator Online and DMAC Emulator Box that allow working with a virtual network of underwater acoustic modems, significantly reducing time and cost for network protocol development.

After the great interest in the first EviNS Workshop, EvoLogics is happy to offer an extended program for a larger audience of SWARMs EU project participants and other users of EvoLogics products. This time they plan a two-day event with a seminar and product demonstrations during the Breaking the Surface 2016 workshop - BtS 2016.

09:00 - 09:45 MARBIO: Co-existence of top marine predators and humans... and the role of technology

Mark Jessopp, University College Cork (Ireland)

Top marine predators such as seals, cetaceans, and seabirds are often considered 'charismatic species' with the general public appeal. They share resources with humans (e.g. habitat, food) and with increases in human activity and dwindling resources globally, potential for conflict and competition grows. Many of these key marine predators are protected by conservation legislation e.g. EU Habitats Directive, therefore interactions with humans and impacts of human activity (e.g. from fisheries, shipping, marine renewable energy and oil and gas industries) need to be assessed and minimised. These marine species spend most of their time at sea and underwater and are generally inaccessible and therefore challenging to study. However, with advances in remote technologies such as biotelemetry, bioacoustics and remote cameras, we can learn more about these key species, their distribution, behaviour, and habitat use, which enables us to predict and assess interactions with human activity. Technology also plays a role in mitigating against negative impacts e.g. acoustic deterrent technology to deter marine mammals from potentially harmful activities such as fisheries and noise generating devices. This presentation will provide an overview of how technology has helped scientists in the North East Atlantic learn more about top marine predator populations and has provided insights into the overlap with specific human activities including fisheries in Irish waters. We will discuss the main challenges yet to be overcome.

Mark Jessopp

Dr. Mark Jessopp is a Research Fellow in the MaREI Marine Ecology Group in University College Cork. Mark Completed his BSc at the University of Melbourne, Australia in 1995, and his Ph.D. at University College Cork, Ireland in 2006. His research has encompassed work across multiple trophic levels including phytoplankton and zooplankton community dynamics through to higher predator foraging ecology. His current research focusses on diet and habitat use of top predators (mainly seabirds and seals), and interactions with fisheries, renewable energy installations, and offshore oil & gas. Dr Jessopp is arguably the most experienced biotelemetry researcher in Ireland, having undertaken tracking studies on a wide range of species, and published over 30 peer-reviewed papers, including papers at the highest level in Science (Impact Factor 31.4) and Currently Biology (IF 10.2).

Mark has successfully secured funding in excess of €2M, and is PI or co-PI on a range of projects including at-sea surveys for marine mammals and seabirds, tracking of seals, seabirds and fish species, and developing census techniques for seabirds. Dr Jessopp's specialised knowledge in seabirds and seals has been recognised through his contribution to prestigious nationally and internationally funded projects (Beaufort Ecosystem Approach to Fisheries Management, FP7 KnowSeas, H2020 RiCORE) as well as being the Irish national representative on the ICES Working Group on Marine Renewable Energy (WGMRE). Mark is also the current Chair of the UCC Research Staff Association, member of the UCC Athena SWAN working group, and member of the UCC Animal Experimentation Ethics Committee.

Contact: m.jessopp@ucc.ie

09:45 - 10:30 MAROB: Modular portable marine robotics

Massimo Caccia, National Research Council of Italy - CNR, Italy

During last Italian polar campaigns portable Unmanned Marine Vehicles (UMVs) proved their effectiveness in gathering data and samples both under the Antarctic ice-pack for studying the Antarctic Silverfish and close to Arctic glaciers for investigating the ice- water-air interfaces. On the basis of this experience, the POP ART robot design & development program aims to provide CNR with a fleet of portable, modular and reconfigurable cooperative UMVs. In particular, the core components of this fleet will be designed, developed and validated at field. Starting from P2-ROV, the Portable/Polar ROV developed in the framework of the PNRA POLE project, a new hybrid unmanned semi- submersible/underwater vehicle will be designed and developed. The resulting robot, constituted by portable modules assemblable at field, will be the basic component of a modular unmanned catamaran able to carry on more heavy payloads.

Massimo Caccia

Massimo Caccia (MSc 1991) is the director of CNR-ISSIA since October 2013. He is author of 2 book chapters, and more than 100 international journal and conference papers. Principal investigator of the projects: "SEa Surface Autonomous MOdular unit" funded by the National Program of Research in Antarctica (2002-2004), "Harbour and coastal underwater anti-intrusion system" funded by IARP-FESR (2005-07), "Unmanned Multipurpose Vessel" funded by the Scientific and Technological Park of Liguria (2007-08), MINOAS, CART and MORPH projects (regarding CNR contribution), funded by EC. From 2010 he is member of the IFAC Technical Committee 7.2 Marine Systems, the Board of Directors of the Ligurian District of Marine Technologies.

10:45 - 11:30 MAROB: The role of underwater robotics in the growth of marine renewable energy

Timothy Mundon, University of Washington, USA

Wave and Tidal energy is still in the early stages of development and the current technology is generally focused upon system demonstration, improving reliability, and lowering costs. Difficult and remote operating environments mean that robotic and autonomous systems have the potential to make a significant impact on the various challenges facing this industry. This lecture will provide an introduction to the principles of wave and tidal energy within the context of the current state-of-the-art technology and highlight the extremely interesting challenges faced. A summary of the work being done with underwater systems at the University of Washington will follow, such as ROVs for deployment of environmental monitoring, Autonomous Resource Assessment Systems, and hydrodynamic structure optimization to increase power in wave energy devices. To conclude I will highlight specific challenges where underwater robotics can potentially make a big impact in this field.

Tim Mundon

Dr. Tim Mundon 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 also currently holds a faculty position in Mechanical Engineering at the University of Washington.

Dr Mundon received his Ph.D. from the University of Edinburgh in 2005 where he studied the use of active control to optimize wave energy devices. He has since gained experience working on the design and development of a number of different wave energy devices, plus complementary experience on a number of tidal and offshore wind projects.

He is currently involved with a number of research projects and is an affiliate assistant professor in the Mechanical Engineering department at the University of Washington.

Contact: mundon@oscillapower.com

12:15 - 13:00 MARSEC: Marine Robotics Applications in Humanitarian, Search & Rescue and Civilian Focussed Security Operations – what might the future hold?

Cormac Gebruers, National Maritime College of Ireland, Ireland

The use of marine robotics technology and solutions is well established in certain maritime safety and security applications, for example ordnance disposal, special forces transport, subsea rescue and intelligence gathering. A more recent and increasingly common tasking for a growing number of coastguards and navies has been humanitarian search & rescue and security operations at sea involving civilians displaced by conflict or making journeys by sea for other reasons and in circumstances that are often perilous or where they hope to avoid detection. The role marine robotics could play in this tasking is only beginning to evolve. In this talk, Gebruers will set out what roles marine robotics and related technology are playing in such missions today and considers what roles such systems and solutions could play in future humanitarian search & rescue and security missions such as those currently on-going in the Mediterranean Sea. This talk draws on experience and learning the Halpin Centre has gained from working with the Irish Naval Service in its activities as part of Operation Pontus in the Mediterranean to rescue migrants fleeing North Africa, in search and rescue and drug interdiction operations around Ireland's coast and out into the deep Atlantic, and from projects such as DARIUS (FP7) that considered the use of unmanned air, surface and subsea vehicles to aid maritime first responders in emergency situations.

Cormac Gebruers

Cormac Gebruers is the founding Director of the Halpin Centre for Research and Innovation at the National Maritime College of Ireland (NMCI). NMCI is a partnership between one of Ireland's largest third level technological institutions, the Cork Institute of Technology, and the Irish Naval Service. Through the NMCI partnership, the Halpin Centre is the research and innovation arm of the Irish Navy. Gebruers began his career in the merchant navy and while still at sea became extensively involved in maritime IT and communications related work. After coming ashore, he set up and ran a maritime transport and logistics research and innovation company before then spending time in computer science research specialising in machine learning. Before joining NMCI to set up the Halpin Centre in 2012, he spent a decade with TRANSAS, a maritime navigation systems multinational specialising in Vessel Traffic Services (VTS) and coastal monitoring and surveillance systems. In this period he worked extensively around the World including spending a year in China supporting the company's operations there. Gebruers works closely with the Irish Naval service on a range of projects spanning maritime mechatronics, safety security & defence and human factors.

Contact: Cormac.Gebruers@nmci.ie

14:30 - 15:00 COMPANY PRESENTATION: EvoLogics Gmbh

Cormac Gebruers, National Maritime College of Ireland, Ireland

Evologics is a high-tech enterprise founded in 2000 (as a spin-off of the Technical University of Berlin) to develop innovative key technologies for maritime and offshore industries. It has 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)*

Representatives at BtS:
Oleksiy Kebkal, Veronika Kebkal **kebkal@evologics.de**

15:00 - 15:30 TUTORIAL: OceanScan - Data Analysis

Wednesday, 5th OCTOBER

15:30 - 18:30 **DEMONSTRATIONS of equipment and softwares developed by companies and under scientific research projects are held in parallel, divided in groups:**

1. EvoLogics - see text on the previous page

2. The National Research Council (CNR) is the largest public research institution in Italy, the only one under the Research Ministry performing multidisciplinary activities.
Founded as legal person on 18 November 1923, Cnr's mission is to perform research in its own Institutes, to promote innovation and competitiveness of the national industrial system, to promote the internationalization of the national research system, to provide technologies and solutions to emerging public and private needs, to advice Government and other public bodies, and to contribute to the qualification of human resources.
In the Cnr's research world, the main resource is the available knowledge which means people, with their skills, commitment and ideas. This capital comprises more than 8.000 employees, of whom more than half are researchers and technologists. Some 4.000 young researchers are engaged in postgraduate studies and research training at Cnr within the organization's top-priority areas of interest. A significant contribution also comes from research associates: researchers, from Universities or private firms, who take part in Cnr's research activities.

3. H2020 subCULTron project - 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 agent types:

- On the sea-ground, artificial mussels are the collective long-term memory of the system, allowing information to stay beyond the runtime of other agents, thus allowing to continue learning from previously learned states. These mussels monitor the natural habitat, including biological agents like algae, bacterial incrustation and fish.
- On the water surface, artificial lily pads interface with the human society, delivering energy and information influx from ship traffic or satellite data.
- Between those two layers, artificial fish move/monitor/explore the environment and exchange info with the mussels and lily pads. Artificial mussels are novel class of underwater agents.

We aim to push forward the edge of knowledge with novel sensors (electric sense / electro - communication), novel bio-inspired algorithms (underwater hives) and novel energy harvesting in underwater scenarios.
We will improve the world's record for swarm-size in autonomous collective underwater robotics by almost one order of magnitude. Our application field is a human- and animal-co-inhabited real-world environment of high impact: Venice canals & lagoon. These habitats are highly dynamic and structured, expected to be reflected by a spatial self-structuring of our mussel population. These sub-populations locally perform memetic or cultural learning algorithms on their specific local data. Thus our cultural evolution algorithms will promote sub-culture development, similar to the human society that does the same above the water level in parallel. Overall, we aim for an artificial society underneath the water-surface to the service of a human society above the water.

09:00 - 09:45 MAROB: Robotics for challenging ocean intervention in marine renewable energy and other applications

Daniel Toal, University of Limerick, Ireland

Oil and gas is going further down the slope into deeper waters and under ice. Other emerging sectors with large off shore installations in challenging environments include; Marine Renewable Energy -MRE (wave, tidal, offshore wind) and Offshore Aqua-culture, inter alia. Large infrastructure installed in these environments offer significant challenges for robotic operations in construction/ installation, inspection repair maintenance (IRM), decommissioning, remediation, salvage, search and rescue and more. These require intervention robotic capabilities beyond the challenges addressed in offshore sectors such as oil and gas production which uses ROV technology supported by surface vessels for intervention and uses AUVs for remote survey/inspection. The tasks robots will face will, under many circumstances, be above operating limits of ROV platform technology. AUV solutions will not be capable of addressing the significant challenges on intervention in these environments in a safe manner. Robust, smart semi-autonomous solutions are required as illustrated in this talk. Manipulators for intervention on work-class ROVs use, hydraulic systems and are fully reliant on pilot in the loop for control based on scene feedback through cameras with little/motion/disturbance of the ROV or target infrastructure. Base vehicle motion is generally implemented 'pilot in the loop' from surface support vessels. For high energy wave and tidal MRE, conventional robotic technology system approaches are likely to fail. The target devices for intervention are often in motion. This talk will outline challenges to be faced and solutions to address these challenges under development at the Mobile & Marine Robotics Research Centre at the University of Limerick. Developments for base vehicle control and operation, with real-time video and high-resolution sonar serving systems to develop control strategies for intervention in motion are described amongst others.

Daniel Toal

Daniel Toal is a chartered engineer in Electrical and Systems Engineering: (Hons Dip Elec Eng, Dublin Institute of Technology; BSc (eng) University of Dublin (TCD); MSc - Manufacturing Systems Engineering, Cranfield University, UK; PhD Marine Robotics, University of Limerick (UL)). He is currently an Associate Professor at UL and has taught: Automation, Robotics, Instrumentation, Avionics, Sensors, and Electrical Machines. Daniel is also a Co PI of the SFI Centre MaRIE - Marine & Renewable Energy Ireland (www.marei.ie).

Daniel is the founder and director of the Mobile & Marine Robotics Research Centre (www.MMRRC.ul.ie) at the University of Limerick. With the MMRRC research team, Dan has led the design & build of ROV Latis - a 1,000m depth rated 'smart' vehicle along with many other platforms. On-going research addresses unique challenges of operating in 'high energy' wind, wave and tidal regimes of marine renewable and airborne wind energy. Research also addresses robotic platform development for response in offshore marine incidents, search and rescue (SAR) and marine salvage. Daniel has been chief scientist for numerous off shore research surveys on Celtic Explorer, Celtic Voyager, INS LÉ Eithne, and other vessels. His vision is that the Marine, Marine Technology, Ocean Environment, and Renewable Energy Sectors will grow in crucial importance.

Contact: daniel.toal@ul.ie

09:45 - 10:30 MARBIO: Observations from the Invisible Forest: the diversity of marine phytoplankton

Sunčica Bosak, University of Zagreb Faculty of Science, Department of Biology (Croatia)

Marine phytoplankton are tiny, microscopic plant-like organisms found mostly in the sunlit layer of the water column. Although minute in size, they are immensely significant players in the Earth's ecosphere. These organisms are by far the most abundant and the most taxonomically and genetically diverse organisms in the marine realm. They play a critical role in regulating the Earth's climate, almost as though their photosynthesis consumes carbon dioxide on a scale equivalent to land plants. Some of this carbon is carried to the deep ocean when phyto cells die and some is transferred to other organisms, since the microalgae are the foundation of the aquatic food webs, feeding everything from microscopic, animal-like zooplankton to huge mammals. The phytoplankton are the only ocean life form that can be assessed at all scales – from a drop of seawater, in situ sensors on autonomous platforms/ships, to global satellite observations due to the presence of pigments such as chlorophyll a. Future efforts are focused towards an integrated approach that combines conventional analyses of discrete samples through microscopy, flow cytometry and molecular identification methods with optical tools, deployed in situ, and from remote sensing platforms. The talk will present phytoplankton biological and functional diversity over the size spectra via the most representative examples, together with an overview of different tools used in the research of particular phyto groups.

Sunčica Bosak

Sunčica Bosak is an assistant professor at the University of Zagreb, Faculty of Science where she teaches courses related to marine microbiology and biological oceanography. She received her MSc degree in Biology, Ecology in 2006 at UniZg with a thesis dealing with the photosynthetic regulation processes in cyanobacteria. In 2013 she received her PhD degree in Natural Sciences, Geosciences, Oceanology at the same university. She had active roles in the framework of different national and international projects, and was a visiting researcher in several occasions at Stazione Zoologica Anton Dohrn, Naples, Italy (EU ASSEMBLE project). She participated at scientific conferences with more than 30 presentations and authored/co-authored more than 15 publications in international peer reviewed journals. Dr. Bosak's research interests include biology, taxonomy and ecology of marine phytoplankton, especially focusing on the planktonic diatoms. Her research also includes distributional studies of picophytoplankton, smallest photosynthetic organisms, in relation to ecological conditions in the oligotrophic waters of the Adriatic Sea. In her investigations of microalgal diversity and ecology she uses a variety of methods such as several types of microscopy (AFM; TEM; SEM; LM), flow cytometry, chemotaxonomical (HPLC) and molecular tools using both laboratory cell cultures and field- based oceanographic research.

Contact: suncica.bosak@biol.pmf.hr

10:45 - 11:30 MAROB: Aquatic Micro Aerial Vehicles (AquaMAV) for water sampling and marine exploration

Mirko Kovac, Imperial College London, UK

Most robots are designed to either move in air or in water. Multi-modal mobility in both air and water and across fluid boundaries would allow for unprecedented mission capabilities that can not be done with only flying or swimming robots. For example, it would enable autonomous water sampling in inaccessible coastal areas, between floating ice in the arctic sea and during urban flooding situations where obstacles in the water inhibit access with single-mode robots. However, the conflicting design requirements for operation in air and water has prevented the demonstration of a fully functional aerial-aquatic robot. In this talk, I will present how biological inspiration can help in the design of such vehicles and what we can learn from aerial-aquatic animals to build multi-modal robots. I will also present the current state of the Aquatic Micro Aerial Vehicle (AquaMAV) research at Imperial College London where we demonstrated successful transition principles from air to water and back to air enabling aerial-aquatic mobility in robotics.

Mirko Kovac

Dr. Mirko Kovac is director of the Aerial Robotics Laboratory at the Aeronautics Department at Imperial College London. His research interest is the conception and implementation of novel morphologies and locomotion methods for mobile robots and their analogy in biological systems. With his group he has developed multi-modal robots that can move in air, on ground and in water using multi-functional propulsion systems and locomotory modules. His research focus is in bio-inspired robot development, fluid-structure interaction and manufacturing with aerial robots. Before his appointment in London, he was post-doctoral researcher at at Harvard University in Cambridge, USA. He obtained his PhD at the Swiss Federal Institute of Technology in Lausanne (EPFL). He received his M.S. degree in Mechanical Engineering from the Swiss Federal Institute of Technology in Zurich (ETHZ) in 2005. During his studies he was research associate with the University of California in Berkeley USA, RIETER Automotive Switzerland, the WARTSILA Diesel Technology Division in Switzerland, and CISERV in Singapore. Since 2006, he has presented his work at numerous international conferences and in journals and has won several best paper and best presentation awards. He has also advised the UK government on aerial robotics opportunities and he is founding member of the London Robotics Network that acts as the community building hub in the larger London area for robotics in academia and industry. He has been invited lecturer at more than 35 research institutions worldwide and has been representative speaker on education and innovation at the World Knowledge Dialogue Symposium 2008 and the London Innovation Summit 2014.

Webpage: www.imperial.ac.uk/aerialrobotics

Twitter: @AerialRobotics, @MKovacRobotics

11:30 - 12:15 MARCH: The Underwater Archaeology Centre of Catalonia. The works with AUV and submersibles in archaeological sites

Gustau Vivar, Centre d'Arqueologia Subaquàtica de Catalunya, Catalonia (Spain)

We present the results of the collaboration with Vicorob, University of Girona, and the Ictineu Sumersibles, Barcelona, Spain. We have done surveys in Cap del Vol shipwreck and the Cala Cativa shipwreck, both are ships sunk in the first Century BC. The first is -25 meters of depth and the second is -33 meters of depth.
We have tested this instruments with the objective to go with these submersibles and AUV to deep-sea archaeological exploration.

Gustau Vivar

Gustau Vivar was born in Barcelona, Spain. He finished his bachelor in History in 2000 at the University of Barcelona, and he studied a Master in Mediterranean Nautical Archaeology at the same University (2007-2008). In April 2013 concluded the PhD at the University of Barcelona. Member of the Scientific Commission in the National Plan for the Protection of Underwater Heritage, of the Culture Ministry of Spain. His main interests address the nautical archaeology with emphasis on trade and maritime transport in the classical time. He works on the research, protection, preservation and dissemination of the underwater cultural heritage. He is commissar of exposition Deltebre I. "History of a Shipwreck", and manager to the archaeological underwater visit of Aiguablava shipwrecks (Girona). He is co- manager of Deltebre I shipwreck excavation (in process), Cap del Vol shipwreck excavation (finished), Cala Cativa I shipwreck excavation (in process).He participated in several great numbers in national and international conferences and symposia.
From 2010, Director of the Underwater Archaeology Center of Catalunya. (Department of Culture, Generalitat de Catalunya).

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(2015), (With Ciarlo, Rosa, Martí) Cast iron production for artillery: The analysis of shot from early Modern shipwrecks, SAS Bulletin 38, 1
(2014), Deltebre I. La història d'un naufragi, Catàleg de l'exposició, Girona.

LIST OF CURRENT RESEARCH PROJECTS (selection)

- Study of trade, export and redistribution of wine between first century BC and second century D.C in the Conventus Tarraconensis; Responsible for the project: Gustau Vivar (2014-2017).
- Deltebre I, a shipwreck of the Napoleonic Wars, Responsibles for the project: Xavier Nieto, Gustau Vivar and Rut Geli; 2009- 2017.

Contact: gvivar@gencat.cat

12:15 - 13:00 MAROB: Marine robotics - A tool for increased awareness from land to the deep sea

Alfredo Martins, INESC TEC / ISEP, Portugal

Robotic tools provide efficient means for information retrieving in the marine environment, from localized inspection tasks to large scale surveying or monitoring, robots allow us to deal with the challenges of the environment such as immense areas or hostile and dangerous scenarios. These tools contribute to increased awareness of human activity and presence at sea.

Surface, underwater and aerial robots play a relevant role not only at sea but also in many water environments such as rivers, dams, lakes or other water reservoirs. Perception and awareness issues are a key factor driving the development of such systems.

This talk will present some of the INESC TEC experience in marine robotics from the perspective of increasing awareness for water environment operations. Challenges and recent developments will be addressed for applications where we have been actively involved, ranging from land-based underwater mining, to search and rescue applications, maritime border patrol or deep sea systems.

Alfredo Martins

Alfredo Martins is an Adjoint Professor at the Engineering School of Porto Polytechnic and senior researcher at the robotics and autonomous systems group of INESC TEC in Portugal.
His research interests are in the areas of perception, navigation, control and coordination of mobile robots with particular emphasis on marine robots.
He has a vast experience in marine robotics, having worked with autonomous underwater vehicles since 1998.
Currently is actively involved in various marine robotics research projects and related initiatives such as the European FP7 project SUNNY, addressing robotic systems marine border surveillance or the H2020 VAMOS and UNEXMIN projects addressing robotic tools for underwater mining exploration and exploitation. He also is involved in research projects for the deep ocean, namely in the TURTLE project, an EDA (European Defence Agency) and national project aiming to develop new materials and technologies for locomotion in the deep ocean.

Contact: aom@inesctec.pt

14:30 - 15:00 COMPANY PRESENTATION: Hydroid

HYDROID
A KONGSBERG COMPANY

KONGSBERG

Hydroid, Inc. (Hydroid) is a US customer-focused, engineering-based manufacturer of REMUS innovative commercial underwater systems commonly known as Autonomous Underwater Vehicles (AUV) systems. Hydroid offers its customers extensive experience in design, manufacturing, and shipboard integration of AUV systems. Hydroid has successfully developed and fielded over 280 AUVs since 2001, along with supporting ancillary equipment including Launch and Recovery Systems (LARS).

A subsidiary of Kongsberg Maritime, Hydroid is the world's most trusted manufacturer of advanced Autonomous Underwater Vehicles (AUVs). REMUS AUVs provide innovative and reliable full picture AUV systems for the marine research, defense, hydrographic and offshore/energy markets.

Along with our success and exponential growth, our product offerings have also expanded significantly. Not only do we offer the REMUS 100 AUV system, a robust, man-portable AUV for shallow water operation we also offer the REMUS 600 and the REMUS 6000 AUV systems. The REMUS 600 and 6000 also include AUV launch and recovery systems, docking systems, and supporting equipment. Similar to the base functions of the REMUS 100, the REMUS 600 AUV system is the mid-range solution for rapid mobilization from vessels of opportunity; and the REMUS 6000 AUV system is the ultimate deep ocean workhorse solution with the ability to reach depths of up to 6000 meters.

Company representatives: Graham Lester and Simone Di Giacomo

15:00 - 15:30 TUTORIAL: Tutorial intro: Thruster Control using LabVIEW Real-Time & FPGA Graphical Programming

Edin Omerdic, University of Limerick, Ireland

Any control system for underwater vehicles must be properly interfaced with actuators (thrusters). Using the Bottom-Up approach, this tutorial is focused on the development of a interface between control software and physical actuators (thrusters). Hands-On Tutorial will demonstrate generation of FPGA-based PWM signals for high precision speed and direction control of Blue Robotics T200 thrusters. Two approaches will be explained: (i) approach based on Express VI (RT only, without need to develop FPGA code), and (ii) approach based on RT & FPGA code development. Methods to overcome friction / dead zone issues for low speed rotations will be demonstrated for both approaches.

Edin Omerdic

Edin Omerdic (MSc 2001, PhD 2004) is a Senior Research Fellow at the Mobile & Marine Robotics Research Centre, University of Limerick. He is the main developer & designer of OceanRINGS concept & software suite, including design of state-of-the-art control architecture for ROV LATIS. His research interests include modelling & simulation of dynamic systems (marine platforms, ocean dynamics & disturbances), renewable energy, real-time simulators, virtual reality, development and design of guidance, navigation and control system for marine vessels, nonlinear control systems, implementation of soft-computing techniques in intelligent systems, underwater robotics, fault-tolerant systems. He received five awards for his work, including First Prize Winner in National Competition in Mathematic (Bosnia, 1985), Society of Underwater Technology (SUT) Prize for Best Multimedia Presentation (GCUV 2003), IFAC prize for best on-line demonstration (MCMC 2003), IMarEST SMI Donald Maxwell Award Prize for Best Journal Paper (2004) and Curriculum Paper Contest National Instruments International Competition LabVIEW in the Curriculum 2006 (First Prize Winner). Thruster Control using LabVIEW Real-Time & FPGA Graphical Programming Any control system for underwater vehicles must be properly interfaced with actuators (thrusters). Using the Bottom-Up approach, this tutorial is focused on the development of interface between control software and physical actuators (thrusters). Hands-On Tutorial will demonstrate generation of FPGA-based PWM signals for high precision speed and direction control of Blue Robotics T200 thrusters. Two approaches will be explained: (i) approach based on Express VI (RT only, without need to develop FPGA code), and (ii) approach based on RT & FPGA code development. Methods to overcome friction / dead zone issues for low speed rotations will be demonstrated for both approaches.

Contact: edin.omerdic@ul.ie

Thursday, 6th OCTOBER

15:30 - 18:30 **DEMONSTRATIONS and TUTORIAL are held in parallel, divided in groups: TUTORIAL: Tutorial hands-on: Thruster Control using LabVIEW Real-Time & FPGA Graphical Programming** - see text on the previous page

FP7 CADDY project - Divers operate in harsh and poorly monitored environments in which the slightest unexpected disturbance, technical malfunction, or lack of attention can have catastrophic consequences. They manoeuvre in complex 3D environments, carry cumbersome equipment, while performing their mission. To overcome these problems, CADDY aims to establish an innovative set-up between a diver and companion autonomous robots (underwater and surface) that exhibit cognitive behaviour through learning, interpreting, and adapting to the diver's behaviour, physical state, and actions.

The CADDY project replaces a human buddy diver with an autonomous underwater vehicle and adds a new autonomous surface vehicle to improve monitoring, assistance, and safety of the diver's mission. The resulting system plays a threefold role similar to those that a human buddy diver should have:

1. the buddy "observer" that continuously monitors the diver;
2. the buddy "slave" that is the diver's "extended hand" during underwater operations performing tasks such as "do a mosaic of that area", "take a photo of that" or "illuminate that"; and
3. the buddy "guide" that leads the diver through the underwater environment.

The envisioned threefold functionality will be realized through S&T objectives which are to be achieved within three core research themes:

- the "Seeing the Diver" research theme focuses on 3D reconstruction of the diver model (pose estimation and recognition of hand gestures) through remote and local sensing technologies, thus enabling behaviour interpretation;
- the "Understanding the Diver" theme focuses on adaptive interpretation of the model and physiological measurements of the diver in order to determine the state of the diver; while
- the "Diver-Robot Cooperation and Control" theme is the link that enables diver interaction with underwater vehicles with rich sensory-motor skills, focusing on cooperative control and optimal formation keeping with the diver as an integral part of the formation.

Multimodal Aquatic Micro Air Vehicle AquaMAV - Locomotion in unstructured terrain is one of the most significant challenges to robots operating in an outdoor environment. Whilst many amphibious robots exist, these robots are not able to cross large, sheer obstacles, and can only exit the water on a gentle incline.

We are aiming towards the development of an Aquatic Micro Aerial Vehicle (AquaMAV), a fixed wing vehicle designed to fly to a target, dive into the water and subsequently execute an impulsive leap om the water surface, transitioning back to flight. This robot will find use in disaster relief, and oceanography, particularly in areas such as flooded collapsed buildings, or rocky, littoral ecosystems, where obstacles impede the free movement of conventional aquatic vehicles and prevent close observation by purely aerial robots.

09:00 - 09:45 MAROB: Unmanned system for maritime security and environmental monitoring

Stjepan Bogdan, University of Zagreb, Croatia

In this talk we will present a design and development of a fully operational complex robotic system prototype comprised of an Unmanned Aerial Vehicle (UAV) and Unmanned Underwater Vehicle (UUV) capable of autonomous and cooperative mission executions related to environmental, border and port security, taking place in dynamic and nondeterministic environments.
The presentation will be mostly focused on design and construction of an UAV, a heavy lift multirotor platform capable of lifting over 50kg of payload. Such a system requires a paradigm shift in the design of the UAV. Therefore we propose using miniature two stroke internal combustion engines to supply the necessary lift and endurance and combine them with a novel control concept based on the variations of the center of gravity (CoG) of the system (so called Moving Mass Control - MMC). We will present a detailed stability and sensitivity analysis of the proposed control scheme and discuss its underlying effect on the construction design parametrization. At the end, simulation results from a Gazebo based simulator will be given, that confirm the results of our mathematical analysis.

Stjepan Bogdan

Stjepan Bogdan is Full Professor at the Laboratory for Robotics and Intelligent Control Systems (LARICS), Dept. on Control and Computer Engineering, Faculty of EE&C, Univ. of Zagreb. His research interests include autonomous systems, aerial robotics, multi-agent systems, intelligent control systems, bio-inspired systems and discrete event systems. He spent one year as Fulbright researcher at the ARRI, Arlington, USA, in Prof. Frank Lewis' lab.

He is a co-author of 3 books and more than 160 conference and journal papers. He was the Principal Investigator and a researcher on 24 national and international scientific projects. Currently he is involved in 2 EU FP7 projects (ASSISI, no. 601074, 2013-2018, EOLO, EuRoC, no. 608849, 2014 – 2017), 1 EU H2020 project (subCULTron, no. 640967, 2015 – 2019) and coordinates 1 NATO-SpS international project (MORUS, no. 984806, 2015 – 2018).

He served as an Assoc. Edt. of IEEE Trans. on Automation Science and Engineering. Currently he is an Assoc. Edt. of J. of Intelligent and Robotic Systems; Int. Review of Mechanical Eng. (IREME); Trans. of the Institute of Measurement & Control; J. of Control Theory and Applications. He was Prog. Chair of IEEE ISIC2011, Denver, USA, and Gen. Chair of IEEE MSC2012, Dubrovnik, Croatia. He is a member of KoREMA and IEEE senior member. He is appointed as a member of IEEE TC on Intelligent Control, representative of Croatia at EU Control Association and was a vice-chair of Croatian Robotics Society.

He is recipient of the best young scientist award from The Croatian Society of University Teachers, 2000; Science Award for exceptional achievement in scientific research – FER Faculty Council, 2013; Fran Bosnjkakovic award for exceptional achievements in science and education – University of Zagreb, 2015.

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09:45 - 10:30 MARBIO: Investigating the submarine canyons and seamounts in Spanish waters through non-invasive methodologies

Francisco Sánchez Delgado, Instituto Español de Oceanografía (IEO), Spain

Seamounts and submarine canyons are deep-sea areas that can exhibit high biodiversity and high levels of endemism. These marine features are potentially vulnerable to fishing impacts and other human activities which exacerbate their need for protective conservation measures. The establishment of a marine network of conservation areas under Natura 2000 needs to identify habitats and species described in the EU Directives for protection. Currently MPAs are being created to conserve and manage these ecosystems but this implementation is not an easy task due to the difficulty of obtaining valuable information on them. We show the different technological approaches employed by the IEO to study these ecosystems to a maximum depth of 2000 m. In the first approach, the study of characterization and mapping of the deep-sea habitats has been conducted. Different towed vehicles (ROTVs) were designed and built in order to perform controlled transects very close to the seabed in areas of strong currents and complex topography. For this reason, these vehicles need to incorporate a very precise real time bidirectional telemetry and video monitoring to avoid the risk of their loss. It is also necessary to identify the species that occupy these habitats, which in many cases are unknown to science. The collection of samples for these species is done using ROVs equipped with special arms. Finally, it is necessary to know the oceanographic dynamic close to the seabed and its influence on the presence of species with special environmental requirements. For this particular purpose we have designed benthic underwater platforms (landers) with different sensors and cameras that allow us to obtain time series data for long periods.

Francisco Sánchez

Dr. Francisco Sánchez has broad experience in coordinating multidisciplinary research projects and he is an expert in deep-sea studies. Currently his research is focused on developing non-invasive sampling techniques to work on complex hard bottoms, using photogrammetric sledges (ROTVs), ROVs, and multi-parametric submerged platforms (landers) to up to 2000 m depth. He has conducted many surveys, being the leader of 42, using large research vessels of the EU fleet. He has patented a towed submarine vehicle for the study of the deep sea through photogrammetry. He is the promoter of the research group ECOMARG (www.ecomarg.net) and is currently the scientific coordinator of several research projects oriented towards the creation of Marine Protected Areas in Spain. He has actively participated in 25 research projects, national and international, and has been the coordinator of 15 of them. The main objectives of these projects have been the study of fish communities of the Cantabrian Sea shelf, multidisciplinary studies of the marine ecosystem or the impact of oil spills. He has published 108 articles in scientific journals and has made 94 conference presentations. In 2011 the ECOMARG research group was awarded the "BBVA Foundation Award for Projects on Biodiversity Conservation" for devoting eight years of research to collecting and analyzing information needed to create and establish the first oceanic MPA in Spain: "El Cachucho", a seamount in the Bay of Biscay, included in both the OSPAR Network of MPAs and the European Natura 2000 network.

Contact: f.sanchez@st.ieo.es

10:45 - 11:30 MAROB: A decade of research in underwater cooperative navigation: what have we learned?

Mandar Chitre, National University of Singapore, Singapore

Due to unavailability of GPS signals underwater, navigation is a challenging problem and an active research area in the development of autonomous underwater vehicles (AUVs). Inertial navigation systems (INS) and Doppler velocity logs (DVLs) address this problem to a fair extent, but tend to be very expensive, and suffer from long-term error accumulation. Beacon-based systems such as long baseline (LBL) and ultra-short baseline (USBL) are also commonly used, but have limitations due to the complexity and cost of deployment for large area operations.

At the ARL (National University of Singapore), we started research in this area about a decade ago. Our focus has been on low-cost cooperative underwater navigation; the key idea is to use multiple AUVs cooperatively to improve navigation accuracy, while keeping the need for expensive sensors to a minimum. We started off with single-beacon range-only navigation problems, where one AUV in a team is either at the surface, or has high-accuracy navigation sensors. This AUV aids other AUVs in their navigation. We then explored terrain-aided cooperative navigation, where an AUV team might navigate using a bathymetric map of the area of operation. We also derived inspiration from schools of fish larvae, and developed methods for a team of low-cost AUVs navigate in a group without any explicit communication or accurate navigation sensors.

In developing and testing these ideas, we have learned many lessons on what works and doesn't in AUV navigation. In this talk, I will provide an overview of several of the ideas we have tried, and outline the key lessons that we have learned in the process.

Mandar Chitre

Mandar Chitre is currently the Head of the ARL at Tropical Marine Science Institute (TMSI) and an Associate Professor at the Department of Electrical & Computer Engineering (ECE) of the National University of Singapore (NUS). Prior to joining the ARL in 2003, he headed the technology division for a Singapore based telecommunication software company for 5 years.

Mandar was awarded a Ph.D. by NUS for his research in the field of underwater acoustic communications in warm shallow waters. Prior to this, he obtained a Masters degree from NUS developing simulations and algorithms for Ambient Noise Imaging, and another Masters degree in Bioinformatics from the Nanyang Technological University (NTU). Mandar's research interests include underwater acoustic signal processing, underwater communications & networking, ambient noise imaging (ANI), and cooperative underwater robotics.

Mandar serves as an IEEE OES technology committee co-chair of underwater communication, navigation & positioning. He also serves on several editorial boards, including the IEEE Journal of Oceanic Engineering, and the IEEE Communications Magazine, and on many conference TPCs such as IEEE OCEANS, IEEE ICRA, ACM WUWNet, IEEE ICCS and OTC Asia.

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11:30 - 12:15 MARCH: Underwater and Instrumental Archaeology. A Special Relationship

Francesco Tiboni, ATENA CuMaNa - University of Genova (Italy)

The speech proposed by the author deals with the "special relationship" nowadays linking Underwater Archaeology and Maritime Robotics. The aim is to discuss with experts and students what archaeology can ask of robotics in the near future and, on the other hand, how maritime and naval engineers, scientists, physicists, and geologists can help archaeologists to establish new operating protocols. The opportunity of working in many different projects around the Italian coast since 2004, directing the operations with ROVs, with SSS, SBP, MBES, and magnetometers on board the vessels, as well as of re-reading and interpreting data and sonograms acquired for different scopes, has made it possible to obtain important information about how different devices operate in different scenarios. Further, the possibility of often acting as an SSS technician and ROV pilot, as well as an archaeological consultant during Archaeological Impact Evaluation, has permitted the author to compare how different tools can be used, on the basis of the different goals of the projects. Thus, the author would like to discuss with an audience of experts the results achieved from a technical point of view. Particularly, the idea is to put in evidence some of the limitations of some of the instruments normally used in archaeology, as well as to discuss how it could be possible to surpass the difficulties linked to the proper limits of the underwater archaeologists involved in their use and interpretation. To do so, this speech will deal with the problems linked to the interpretation of acoustic reliefs, the reading of photogrammetry, and to the actual efficiency of different instrumental techniques in use in archaeology, but born for other scopes. The idea is to compare what can be expected and what is actually obtained.

Francesco Tiboni

Francesco Tiboni is a Naval and Underwater Archaeologists working in Commercial and Institutional projects around the coasts of Italy and abroad since 2004. As an underwater and maritime archaeologist, he has directed more than 50 campaigns, and he has been the Italian member of the International Scientific Board of the UNESCO Pile Dwelling Sites of the Alps project. He has directed and conducted the complete excavation and recovery of a Roman wreck in Sicily, of a Post-Medieval wreck in Puglia and of other important sites in Italy, as well as the excavation of the harbours of Genova, Taranto, Ponza, and Piombino. Since 2004 he has been working in maritime instrumental archaeology and he has directed the instrumental operations of the Archeomar projects, the ESIA of about ten Submerged strategic infrastructures and pipelines in Italy and abroad, working with different private companies and institutions. As the chairman of ATENA CuMaNa and of the Centre Camille Jullian in Aix en Provence, he has published more than 20 scientific papers, most of them in peer-reviewed journals.

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12:15 - 13:00 MARSEC: Mitigation of UXO in the Offshore Industry

Adrian Dann, EORCA (UK)

The lecture will centre on the problem of Unexploded Ordnance (UXO) which faces the Offshore Renewables Industry, the management and disposal of items of UXO from initial Survey to Re-Location, Identification, and Explosive Ordnance Disposal (EOD).
Several case-studies will be presented which have amounted to over 400 disposals of Live items of UXO in the Baltic and North Sea areas.
The Versatile Explosive Neutraliser Ordnance & Munitions (VENOM) will also be presented along with its Radio Frequency and Through-Water Initiation means. Adrian will also present and discuss the necessary environmental mitigation measures which are required to reduce the impact of offshore EOD Operations upon fauna and flora in the vicinity.

Adrian Dann

Adrian Dann is a former Special Duties Royal Navy Lieutenant Commander Bomb & Mine Disposal Operator who completed 26 years operating as a Maritime Minewarfare & Clearance Diving Officer in Minehunters and Shore-Based Bomb & Mine Disposal Teams.
Having left the Royal Navy in 2002, he has worked consistently in the Offshore Industry specialising in the relocation, identification and Explosive Ordnance Disposal (EOD) of Unexploded Ordnance (UXO) particularly in support of the Renewables Wind and Tidal Energy Offshore Wind and Tidal Projects. Adrian has considerable experience in the Baltic Sea and North Sea areas and in addition the Arabian Gulf where in 1990, the Mine Countermeasures Vessel HMS BICESTER on which he was the Operations Officer, conducted the main Mine Clearance Operations in the approaches to Kuwait Harbour.
He has developed and operates his own Bomb & Mine Disposal System called Versatile Explosive Neutraliser Ordnance & Munitions (VENOM) which is used in Commercial and Military EOD Operations.
Contact: eorcaeodsystems@gmail.com

14:30 - 15:00 TUTORIAL: University of Girona: Girona500 data analysis

15:00 - 15:30 COMPANY PRESENTATION: Brodarski Institute

BRODARSKI INSTITUT

Brodarski Institute is an institute of applied technical sciences in the fields of maritime and green technologies. As a research and development and technology organization it has 65 years of experience.
Range of activities from experimental development of products to prototype making, turn-key projects, computations, supervisions, tests and measurements are among the main Institute's activities.
Brodarski Institute dominantly supports domestic industry, but it is also recognized by foreign partners as a reliable partner in development projects and technology transfer.
The Institute as a limited liability company generates its revenue through commercial contracts with the clients. About 40% of the Institute's revenue is generated from foreign markets.
A high competitive capability of Brodarski Institute is ensured by its experts and scientists in the fields of shipbuilding, marine engineering, green technologies and environmental protection, mechanical engineering, electrical engineering, chemical engineering, physics, metallurgy, industrial design and other specialized fields.
The highly professional staff and a number of well-equipped laboratories with measurement and other specialized equipment have enabled the Institute to become a regional scientific and expert centre in the fields of maritime and green technologies.
In the scientific and higher education system of Croatia, Brodarski Institute represents a steady support in creation and training of professionals whose excellence guarantees reliable partnership for economic development.

15:30 - 18:30 DEMONSTRATIONS in parallel, divided in groups:

1. Brodarski Institute ship demo

2. Illmenau Medusa - Surface-aided AUV path following: theory and practice. Demo with a Medusa-class vehicle

Thomas Glotzbach, Technische Universitaet Ilmenau, Germany

The operation of autonomous underwater vehicles is still a big challenge, especially for universities which might not have access to Doppler Velocity Logs or high-class Inertial Navigation Systems. In our demo, we show the operation of a submerged marine robot which receives position data via a towed buoy equipped with a GPS antenna. The buoy was newly designed to feature the GPS antenna additionally to a WiFi antenna for supervision and safety features. The employed robot system is a MedusaD, developed and made available for our university by the Instituto Superior Técnico, Lisbon, Portugal, under a special agreement.

The demo is an intermediate step in our approach to realize cooperative navigation and control between a surface and a submerged robot. In the end, we are aiming for a mission scenario in which the submerged robot moves autonomously on a path unknown to the surface craft. The surface craft has to estimate the position of the diver based on range-only measurements, while at the same time planning its own trajectory to optimize the conditions for the position estimation. For this scenario, we need at first a vehicle with the ability to move autonomously underwater. This is why we developed the described buoy which we will demonstrate.

Thomas Glotzbach

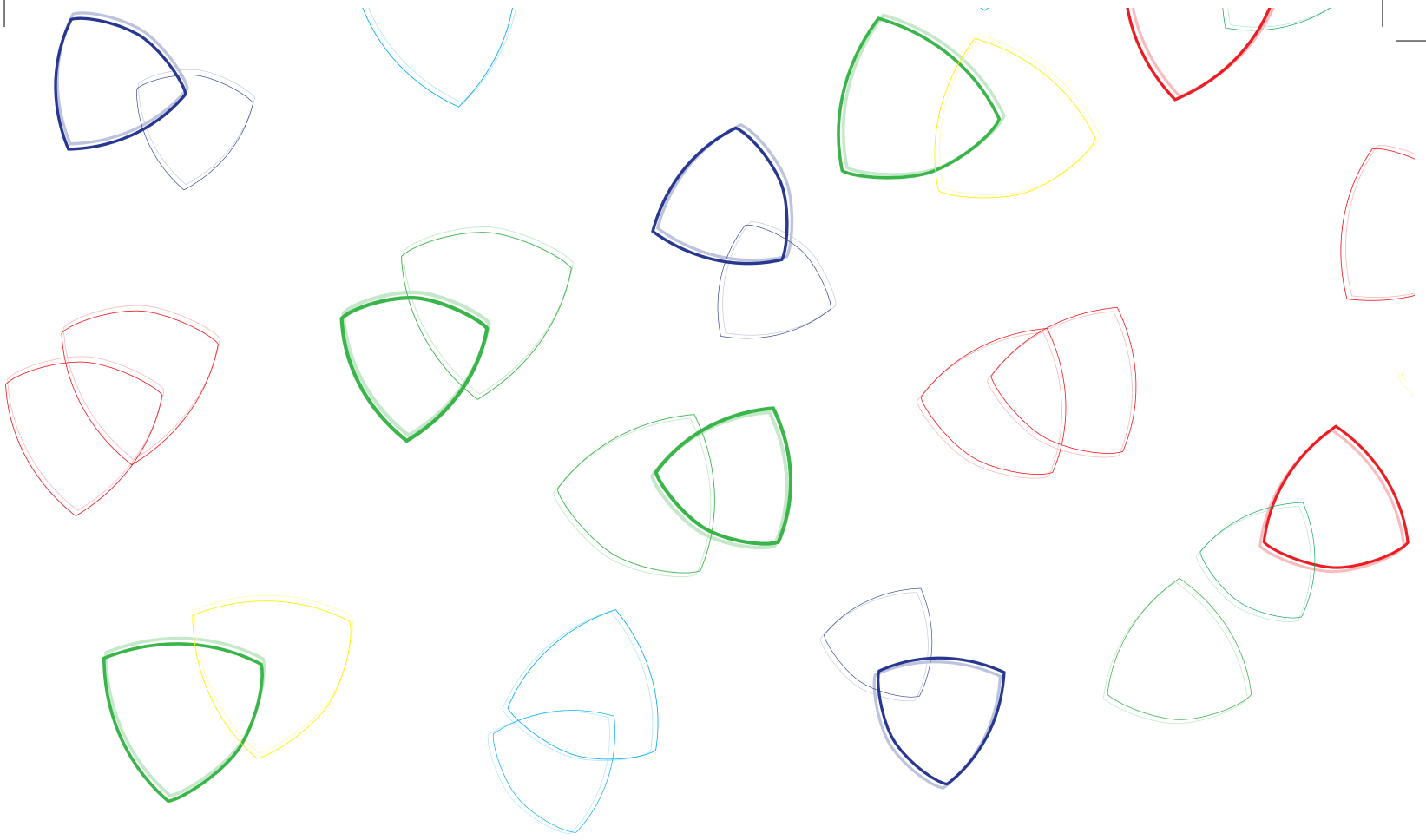
Thomas Glotzbach studied electrical engineering with the focus on automation engineering at the University of Applied Sciences in Fulda. Since 2001 he was with the Technische Universitaet Ilmenau, and from 2004 on he was also a member of the Fraunhofer Application Center System Technology (AST). He received 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. Since 2011, he is back at Technische Universitaet Ilmenau in preparation of his Habilitation, 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.

Contact: thomas.glotzbach@tu-ilmenau.de

3. NATO SpS MORUS - the main goal of MORUS project is a design and development of a fully operational complex robotic system prototype comprised of an Unmanned Aerial Vehicle (UAV) and Unmanned Underwater Vehicle (UUV) capable of autonomous and cooperative mission executions related to environmental, border and port security.

The proposed research is in internationally competitive field with the main objective to design and develop autonomous aerial and marine robotic system, capable of collective engagement in missions taking place in dynamic and nondeterministic environments.

The design will focus mainly on payload enhancement and UAV autonomy which is mandatory for UUV transport. Besides that, a docking system and cooperative control algorithms will be developed enabling autonomous deployment, re-deployment and data exchange at the open sea. Operating environment of the proposed prototype is an unknown, uncertain and remote, i.e. far from a human operator. Therefore, a whole set of novel cooperative control algorithms, combined with augmented human machine interface, will be designed and implemented in order to ensure safety and recoverability of the described system.



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University of Girona
University of Limerick

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