

2021 26.09. - 3.10.
Biograd na Moru, Croatia
**BREAKING
THE SURFACE**
13th INTERNATIONAL INTERDISCIPLINARY FIELD WORKSHOP
OF MARITIME ROBOTICS AND APPLICATIONS



Breaking the Surface 2021

Biograd na Moru, Croatia
26th September-3rd October

PROCEEDINGS

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1. INTRODUCTION

The Breaking the Surface 2021 was held from 26th September until 3rd October in Biograd na Moru, Croatia and more than 130 people participated. It was the first, successful, post-pandemic edition of Breaking the Surface (Bts), the international interdisciplinary workshop on robotics and maritime innovations organized by the Faculty of Electrical and Computer Engineering (FER) of the University of Zagreb. The programme was divided in three tracks (marine robotics, maritime archeology, marine biology) and included 20 in-depth lectures, 7 tutorials, 5 demos and a full day workshop on Analysis Of Data From Marine Observatories.

Dates: 26th September – 3rd October 2021

Location: Biograd na Moru, Croatia

Website: <http://bts.fer.hr/>

2. REPORT ORGANIZATION

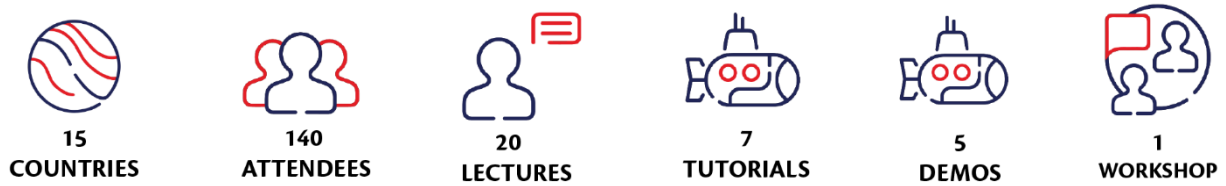
The first part of the report describes the BtS 2021 organization, including the work program. The deliverable is accompanied with abstracts, biographies, and presentations of the program presenters:

3. ABOUT BREAKING THE SURFACE

Breaking the Surface - BtS summer school has been organized by UNIZG FER LABUST for the last 12 years – first three years as a part of FP7-REGPOT CURE project, while in the following years with Office of Naval Research Global and EU funded projects. This year's BTS was financed and supported by Interreg Italy-Croatia InnovaMare project, H2020 EUMarine Robots – Marine Robotics Research Infrastructure Network and IEEE Oceanic Engineering Society. During the years, BtS served as a meeting place of experts and students of marine robotics and the marine robotics application areas such as marine biology, marine archaeology, marine security, oceanography, marine geology, and oceanology. This is the world's first successful, multi-year field training programme that combines academic topics in marine robotics and robotics application areas and hands-on working experience in the sea, doing remote sensing and sampling for various ocean sciences.

The program is organized in the form of plenary talks, hands-on tutorials and demonstrations of marine technologies, e.g. marine robotics (MAROB, marine biology and marine nature protection (MARBIO), maritime, nautical and ship archaeology (MARCH), oceanography (OCEAN), and company presentations

BTS2021 IN NUMBERS:



4. ORGANIZERS

Breaking the Surface is organized under the European Union's Horizon 2020 project EUMarineRobots – Marine Robotics Research Infrastructure Network (GA: 731103), Interreg Italy-Croatia InnovaMare project (ID: 10248782), and IEEE Oceanic Engineering Society. The main organizers are University of Zagreb Faculty of Electrical Engineering and Computing, Laboratory for Underwater Systems and Technologies and Centre for Underwater Systems and Technologies University of Zagreb Faculty of Electrical Engineering and Computing.

ORGANIZERS



University of Zagreb



Faculty of Electrical Engineering and Computing



Laboratory for Underwater Systems and Technologies



Centre for Underwater Systems and Technologies

IN PARTNERSHIP WITH



AMOS – Centre for Autonomous Marine Operations and Systems



Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento



Distretto Ligure delle Tecnologie Marine



Herriot Watt University



Institut Français de Recherche pour l'exploitation de la Mer



Integrated Systems for Marine Environment



Jacobs University



King's College London



Marine Institute Foras na Mara



Norwegian University of Science and Technology (NTNU)



NATO S&T Centre for Maritime Research and Experimentation



National Technical University of Athens



Natural Environment Research Council



Tallinn University of Technology



The Oceanic Platform of the Canary Islands



The Association of Instituto Superior Técnico for Research and Development



Universidade de Lisboa (ULisboa)



University of Bremen



University of Girona (UdG)



University of Limerick (UL)



University of Porto

BREAKING THE SURFACE ORGANIZATION STRUCTURE:

4.1. COMMITTEES CHAIRS



Prof. Dr. Sc. Zoran Vukić
General Chair

*University of Zagreb,
Faculty of Electrical
Engineering and
Computing,
Laboratory for Underwater
Systems and Technologies*



Prof. Dr. Sc. Nikola Mišković
**Programme
Committee Chair**

*University of Zagreb,
Faculty of Electrical
Engineering and
Computing,
Laboratory for Underwater
Systems and Technologies*



Ana Golec,
**Organizing
Committee Chair**

*University of Zagreb,
Faculty of Electrical
Engineering and
Computing,
Laboratory for Underwater
Systems and Technologies*



Igor Kvasić,
**Technical Committee
Chair**

*University of Zagreb,
Faculty of Electrical
Engineering and
Computing,
Laboratory for Underwater
Systems and Technologies*

4.2. PROGRAMME COMMITTEE



Prof. João Sousa

University of Porto
Portugal



Roee Diamant

University of Haifa
Israel



Massimo Caccia

Italian National Research Council (CNR)
Italy



Ralf Bachmayer

University of Bremen
Germany



Prof. Bridget Buxton, PhD

University of Rhode Island
USA



Bill Kirkwood

Monterey Bay Aquarium Research
Institute (MBARI)
USA



Fausto Ferreira

UNIZG FER
Croatia



Irena Radić Rossi

University of Zadar
Croatia

4.3. ORGANIZING COMMITTEE



Ana Golec
UNIZG LABUST

4.4. TECHNICAL COMMITTEE



Anja Babić, mag. ing.

UNIZG FER LABUST



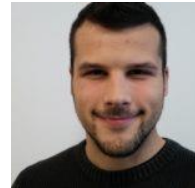
**Nadir Kapetanović,
mag. ing.**

UNIZG FER LABUST



Nikica Kokir

UNIZG FER LABUST



Ivan Lončar, mag. ing.

UNIZG FER LABUST



Igor Kvasić, mag. ing.

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Đula Nad, dipl. ing.

UNIZG FER LABUST

5. PROGRAMME

5.1. PROGRAMME STRUCTURE

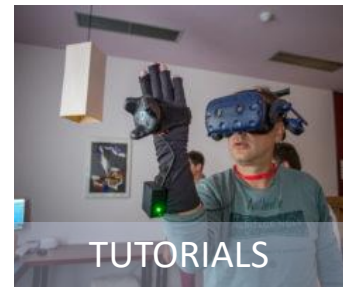
BtS program consists of academic lectures, hands-on tutorials, presentation of projects and equipment, company demonstrations and social activities



LECTURES



MEETINGS



TUTORIALS



EXPERIMENTS AND
TESTING



POOL PARTY

5.1.1. PROGRAMME ABSTRACTS, BIOGRAPHIES AND PRESENTATIONS

The daily lecture programme follows below with the list of talks and speakers and links to the abstracts, biographies, a workshop, and video recordings.

Monday, 27th September

09:15 – 10:00 [ROBOTS FOR KARSTIC EXPLORATION](#) by [LIONEL LAPIERRE](#)

10:00 – 10:45 [LEVERAGING OCEAN DATA HARVESTING BY HETEROGENOUS ROBOTIC ORGANIZATIONS AND AUTONOMOUS VEHICLES AS SENSOR CARRYING PLATFORMS](#) by [ASGEIR J. SØRENSEN](#), [JENS EINAR BREMNES](#)

11:00 – 11:45 [LOW COST DOES NOT COME CHEAP: WORKING TOWARDS A LOW COST DEEP-SEA AUTONOMOUS OBSERVATION SYSTEM](#) by [RALF BACHMAYER](#)

11:45 – 12:30 [TITANIC REVISITED](#) by [BRIDGET BUXTON](#)

12:30 – 13:15 [PRESENT STATUS AND ACHIEVEMENTS AT THE SWEDISH MARITIME ROBOTICS CENTRE SMARC – AN INVITATION TO COLLABORATE](#) by [IVAN STENIUS](#)

Tuesday, 28th September

09:00 – 09:45 [WHALING IN THE EUROPEAN ARCTIC 1600-1900 – TECHNOLOGICAL INNOVATION AND ADAPTATION](#) by [ØYVIND ØDEGÅRD](#)

09:45 – 10:30 [MAKING SENSE OF MARINE AND MARITIME PROCESSES THROUGH INTELLIGENT INFORMATION ACQUISITION AND SHARING](#) by [IOANNIS KYRIAKIDES](#)

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11:30 – 12:15 [FORMAL AND RISK-BASED METHODS FOR DESIGNING, TESTING AND VERIFYING AUTONOMOUS MARINE CONTROL SYSTEMS](#) by [RENAN G. MAIDANA](#), [TOBIAS R. TORBEN](#), [THOMAS JOHANSEN](#), [ASGEIR J. SØRENSEN](#)

12:15 – 13:00 [UNDERWATER ARCHAEOLOGY AT BTS: A DECADE OF INNOVATION](#) by [JACOB SHARVIT](#), [BRIDGET BUXTON](#)

12:15 – 13:00 [MARINE UNITY SIMULATOR](#) by [IVAN LONČAR](#), [JURAJ OBRADOVIĆ](#), [LUKA MANDIĆ](#), [NATKO KRAŠEVAC](#), [NIKICA KOKIR](#), [KRISTIJAN KRČMAR](#), [MAK GRAČIĆ](#)

Wednesday, 29th September

09:00 – 09:45 [INNOVAMARE PROJECT](#) by MATEO IVANAC, ANGELO ODETTI, FAUSTO FERREIRA

09:45 – 10:30 [ADRIATIC](#) by ĐULA NAĐ

10:45 – 11:30 [UNDERWATER HUMAN ROBOT INTERACTION \(U-HRI\): AN OVERVIEW OF THE HISTORY, CHALLENGES, AND METHODS](#) by ANDREAS BIRK

11:30 – 12:15 [INFORMATIVE SPATIAL SAMPLING WITH AUTONOMOUS UNDERWATER VEHICLES](#) by JO EIDSVIK

12:15 – 13:00 [EXPLORATIONS IN AI FOR MARINE ROBOTICS](#) by KANNA RAJAN

Thursday, 30th September

09:00 – 09:15 [WORKSHOP: INTRODUCTION TO THE WORKSHOP – THE CHALLENGE OF DATA PROCESSING FROM MARINE OBSERVATORIES](#) by ROEE DIAMANT

09:15 – 09:30 [WORKSHOP: INTRODUCTION TO THE WORKSHOP – THE NEED FOR STANDARDIZATION IN MARINE OBSERVATORIES](#) by NUNO ALEXANDRE CRUZ

09:30 – 10:15 [WORKSHOP: MANAGEMENT AND PROCESSING OF GEOPHYSICAL DATA FROM CONTINUOUS MONITORING ONBOARD THE SHIP NRP SAGRES](#) by SUSANA BARBOSA

11:00 – 11:45 [WORKSHOP: QUALITY ASSURANCE FOR DATA FROM THE THERMO MARINE OBSERVATORY](#) by ROEE DIAMANT

11:45 – 12:30 [WORKSHOP: USING AUVS FOR IN-SITU CALIBRATION OF SENSORS ONBOARD MARINE OBSERVATORIES](#) by NUNO ALEXANDRE CRUZ

14:30 – 15:00 [WORKSHOP: ODYSSEA – OPERATING A NETWORK OF INTEGRATED OBSERVATORY SYSTEMS IN THE MEDITERRANEAN SEA](#) by GEORGIOS SYLAIOS

15:00 – 15:30 [WORKSHOP: NEW FINDINGS FROM THE DEEPLEV DEEPWATER MARINE OBSERVATORY](#) by AYAH LAZAR

15:30 – 16:00 [WORKSHOP: THERMO – SCIENCE DISCOVERIES FROM THE FIRST THREE YEARS OF OBSERVATIONS](#) by STEVE DIMARCO

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09:00 – 09:45 [UNDERWATER HYPERSPECTRAL IMAGING AS A TOOL FOR BENTHIC HABITAT MAPPING](#) by AKSEL ALSTAD MOGSTAD

09:45 – 10:30 [DATA DRIVEN METHODS FOR DERIVING BATHYMETRIC MAPS FROM SIDE-SCAN SONARS](#) by JOHN FOLKESSON

10:45 – 11:30 **AN ROV REVOLUTION? USING THE NEW GENERATION OF LOW-COST BATTERY POWERED ROVS FOR SUBSEA ARCHAEOLOGICAL WORK** by GRAHAM SCOTT

11:30 – 12:15 **ROBOTIC SYSTEMS IN MARICULTURE** by NIKŠA GLAVIĆ, NENAD ANTOLOVIĆ

12:15 – 13:00 **ACCURATE QLBL ACOUSTIC POSITIONING OF MULTIPLE, FAST MOVING UNDERWATER TARGETS IN CONFINED WATERS** by OLEKSIY KEBKAL

VIDEO PRESENTATIONS

The morning lectures were recorded and were made available to the public on YouTube LABUST channel: <https://www.youtube.com/user/LABUSTunizg>.

5.2. SCHEDULE

The table below summarizes the schedule available at <https://bts.fer.hr/schedule-2021/>

	MON, 27.09.				TUE, 28.09.				WED, 29.09.				THU, 30.09.				FRI, 01.10.			
09:00 - 09:15	Lecture				MARCH 1				MAROB 1				Workshop on Analysis of Data from Marine Observatories				MARBIO 1			
09:15 - 09:30	(Lionel Lapiere, University of Montpellier)				Lecture				INNOVAMARE								(NTNU-AMOS, Aksel Alstad Mogstad)			
09:30 - 09:45																				
09:45 - 10:00	MAROB 1				MAROB 1				MAROB 1								MAROB 1			
10:00 - 10:15	Lecture				Lecture				Lecture				Lecture							
10:15 - 10:30	(Aageir Sorensen, Jens Einar, NTNU-AMOS)				(Ioannis Kyriakides, MARISense)				(Dula Nad)				(John Folkesson, KTH)							
10:30 - 10:45																				
10:45 - 11:00	MAROB 1				MARBIO 1				MAROB 1				Workshop on Analysis of Data from Marine Observatories				MARCH 1			
11:00 - 11:15	Lecture				Lecture				Lecture								(Graham Scott, Wessex Archaeology)			
11:15 - 11:30	(Ralf Bachmayer, MARUM)				(Francesca De Pascalis, F. Madricardo, ISMAR)				(Andreas Birk)											
11:30 - 11:45	MARCH 1				MAROB 1				MAROB 1								MARBIO 1			
11:45 - 12:00	Lecture				Lecture				Lecture				Lecture							
12:00 - 12:15	(Bridget Buxton, University of Rhode Island)				(NTNU-AMOS Thomas Johansen, Simon blindheim, Tobias Rye Torben, RenanGuedes)				(Jo Eidsvik)				(Nikiša Glavić and Nenad Antolović, University of Dubrovnik)							
12:15 - 12:30	MAROB 1				MARCH 1				MAROB 1				MAROB 1							
12:30 - 12:45	Lecture				Lecture				Lecture				Lecture							
12:45 - 13:00	(Ivan Stenius, KTH)				(Koby Sharvit, Israel Antiquities Authority, Bridget Buxton, URI)				(Kanna Rajan)				(Oleksiy kebkal, konstantin kebkal)							
13:00 - 14:30																				
14:30 - 14:45	Company presentation				T2 intro				T4 intro				T5 intro							
14:45 - 15:00	(H2O)				(Ilias Alexopoulos, AI Zerocaliber)				(EUMR e-infrastructures, University of Porto)				(CNR, innovaMARE, SWAMP tutorial)							
15:00 - 15:15	T1 intro				T3 intro				Company presentation				T6 intro							
15:15 - 15:30	(KTH)				(Marine Unity Simulator)				(Hydromea)				(Dan Hayes and Ehsan Abdi, Cyprus-Subsea)							
15:30 - 15:45	Group 3	Group 3	Group 3		Group 3	Group 3	DEMO		Group 3	Group 3	Group 3		Group 3	Group 3	T7					
15:45 - 16:00	DEMO	T1	DEMO		T2	T3			DEMO	DEMO	T4		T5	T6	ADRIATIC					
16:00 - 16:15	H2O	KTH	Statim		Zerocaliber	Simulator	Korkyra		Hydromea	EvoLogics	e-Infra		CNR	Cyprus Subsea						
16:15 - 16:30																				
16:30 - 16:45																				
16:45 - 17:00	Group 3	Group 3	Group 3		Group 3	Group 3	DEMO		Group 3	Group 3	T4		Group 3	Group 3	T7					
17:00 - 17:15	DEMO	T1	DEMO		T2	T3			DEMO	DEMO	e-Infra		T5	T6	ADRIATIC					
17:15 - 17:30	H2O	KTH	Statim		Zerocaliber	Simulator	Korkyra		Hydromea	EvoLogics			CNR	Cyprus Subsea						
17:30 - 17:45																				
17:45 - 18:00	Group 3	Group 3	Group 3		Group 3	Group 3	DEMO		Group 3	Group 3	T4		Group 3	Group 3	T7					
18:00 - 18:15	DEMO	T1	DEMO		T2	T3			DEMO	DEMO	e-Infra		T5	T6	ADRIATIC					
18:15 - 18:30	H2O	KTH	Statim		Zerocaliber	Simulator	Korkyra		Hydromea	EvoLogics			CNR	Cyprus Subsea						
18:30 - 18:45																				
18:45 - 19:00																				
19:00 - 19:15																				
19:15 - 19:30																				
19:30 - 19:45																				
19:45 - 20:00	dinner				dinner				dinner				dinner				dinner and closing ceremony			
20:00 - 20:15																				
20:15 - 20:30																				

6. BTS PARTICIPANTS

In 2020, over 130 participants from various fields joined Breaking the Surface.



7. SUPPORTERS

SUPPORTED AND FINANCED BY



Financed in the scope of the project EUMarineRobots – Marine robotics research infrastructure network (GA 731103) which has received funding from the European Union's HORIZON 2020 Research and Innovation Programme.



8. PRESENTATIONS

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UNDERWATER ARCHAEOLOGY AT BTS: A DECADE OF INNOVATION by JACOB SHARVIT, BRIDGET BUXTON

TUTORIAL 3 INTRO: [MARINE UNITY SIMULATOR](#) by IVAN LONČAR, JURAJ OBRADOVIĆ, LUKA MANDIĆ, NATKO KRAŠEVAC, NIKICA KOKIR, KRISTIJAN KRČMAR, MAK GRAČIĆ

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