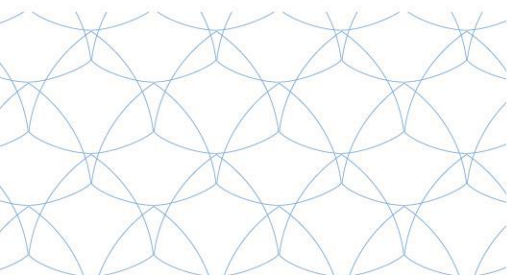


Deliverable D2.2

Nine-month report on the progress of know-how exchange 2

Project Acronym:	EXCELLABUST	
Grant Agreement number:	691980	
Project title:	Excelling LABUST in marine robotics	
Funding:	Horizon2020 Twinning	
Call:	H2020-TWINN-2015	
Type of action:	CSA	
Start date of project:	1 st January 2016	
Duration:	36 months	
Project website:	http://excellabust.fer.hr/	
Delivery date:	30/06/2017	
Version:	1.0	
Lead participant	UNIVERSITY OF GIRONA	
Dissemination level:		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	



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DELIVERABLE DATA SHEET

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Type:		Delivery date	30/06/2017	Version:	1.0
Lead participant		University of Girona (UdG)			
Dissemination level:					
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CO	Confidential, only for members of the consortium (including the Commission Services)				

Version log			
Revision no.	Date	Author (Partner)	Change
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Deliverable summary

EXCELLABUST project has, as one of its main goals, the increase of UNIZG-FER marine robotics scientific excellence and innovation capacity, and raise staff's research profile within the three scientific strategic domains: 1) mapping and perception, 2) advanced NGC, and 3) autonomy and cognition, by implementing strategic measures in the form of staff exchanges, invited talks, on-site trainings and innovation management trainings.

This deliverable covers the activity done within the consortium framework along M10-M18 of the project, from October 2016 to June 2017.

Table of contents

INTRODUCTION

1. SHORT-TERM STAFF EXCHANGES
2. SHORT-TERM TRAININGS
3. INNOVATION MANAGEMENT TRAININGS
4. EXPERT VISITS

INTRODUCTION

This WP is directly linked to EXCELLABUST **Objective 1: “Increase excellence and innovation capacity”**, specifically:

Increase UNIZG-FER marine robotics scientific excellence and innovation capacity, and raise staff's research profile within the three scientific strategic domains: 1) mapping and perception, 2) advanced NGC, and 3) autonomy and cognition, by implementing strategic measures in the form of staff exchanges, on-site trainings and innovation management trainings that will:

Ensure S&T knowledge transfer from internationally leading partners to UNIZG-FER (staff exchanges and expert visits),

Provide hands-on S&T experience by internationally-leading partners (on-site trainings), and

Provide knowledge on innovation management to all involved research institutions (innovation management training)

WP2 objectives will be achieved through the following main activities:

1. Short-term staff exchanges

LABUST staff members visit each partner institution on two occasions, in the duration of 2 months, resulting in a total of 12 months of staff exchanges. Host institutions provide all the administrative assistance for the guest staff members. Researchers at host institutions supervise the guest staff progress and provide them with all the assistance required to ensure high quality know-how transfer. Research topics covered during the short-term staff exchanges are aligned with the defined strategic research domains in which the host institution has expertise. The outcome of these short-term staff exchanges result in joint journal and conference publications.

2. Short-term trainings

Each partner will organize one training at their institution along the project: CNR in year 1, UdG in year 2, and UL in year 3. During "Breaking the Surface" summer schools, all partners will organize training events that will include hands-on experience with real marine robotics equipment. Altogether, 12 trainings will be organized, four by each partner.

As a preparation for trainings, trainers will provide agendas and materials required for training events in a timely manner (at least 2 weeks before the training). Each trainer will provide infrastructure required for the execution of trainings. UNIZG-FER will provide the infrastructure for trainings at BtS while trainers will provide the training materials, and personnel and technology resources.

Research topics covered during the short-term trainings will be aligned with the defined strategic research domains in which the host institution has expertise. Training events will be attended by staff

from all EXCELLABUST partners in order to increase cohesion between the groups and achieve more interaction and knowledge transfer during the trainings.

The outcome of this task will be transferred hands-on knowledge by trainers from internationally-leading partner institutions to all research staff members involved in EXCELLABUST twinning project.

3. Expert visits

Expert visits by each internationally leading partner to UNIZG-FER will be organized twice during the project lifetime. In addition to that, each internationally-leading partner institution will organize an expert visit each year during the BtS workshop. Altogether, this task includes preparation and execution of 15 expert visits to Croatia. Expert visitors will provide lecture materials which will be made public after the completion of the visit. Expert visits will be organized in a form of 2-3 day lecture series with theoretical topics that are aligned with the desired strategic research domains. Tentative titles of the lecture series are given in DoW.

The outcome of expert visits will be transfer of theoretical knowledge, through a series of lectures, in the topics defined by the strategic research domains.

4. Participation in innovation management trainings

This task will be devoted to participation in innovation management trainings which are required for efficient and high quality research management. These trainings are organized by professionals, either at partner institutions, or at third sites. Innovation management training will include topics such as proposal writing, project management and implementation, intellectual property protection, patent writing and application, etc. It is expected that young researchers with less innovation management will participate in these trainings. Within this task, research staff members from all EXCELLABUST consortium will participate.

The outcome of innovation management training will be increased level of knowledge in project management, innovation management and IPR issues.

1. Short-term staff exchanges

1.1. Ivan Loncar visited Unievrstat de Girona

Ivan Lončar was a guest researcher during May and June 2017 in the Underwater Vision and Robotics Research Centre (CIRS) at the University of Girona (UdG). Facility is located in Scientific and Technological Park of the UdG, which currently consists of around 24 employees. Their team is composed of: pre-doctoral researchers, engineers, technicians, postdoctoral fellows and permanent staff. They are one of the leading teams in the research and development of Autonomous Underwater Vehicles for accurate seafloor mapping and light intervention. With more than 20 years of experience, they offer research, engineering and field operations experience to companies and institutions. Also, the team is part of the Institute of Computer Vision and Robotics (ViCOROB) and member of TECNIO network of Excellence in Catalonia region.

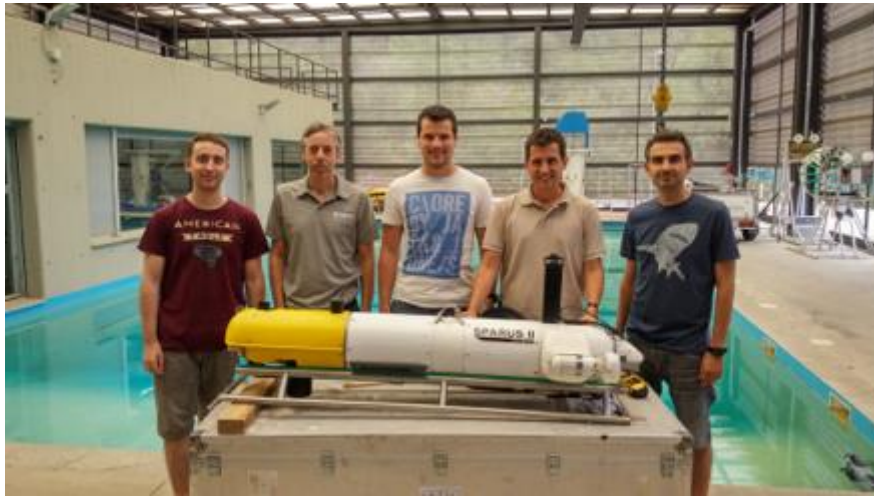


Image 1. Ivan with the UdG team and SPARUS II AUV

During his stay, Ivan Lončar has been involved in research in the field of underwater localization. His research goal was collecting data necessary for testing localization algorithms based on multilateration approach, which were studied prior this staff exchange. His work was supervised by Dr. Marc Carreras. In addition, Lluís Magí and Carles Candela were very helpful with hardware integration necessary for conducting the experiments. Eduard Vidal introduced him with software architecture used in working with AUV (Autonomous Underwater Vehicle) Sparus which was developed in the Underwater Robotics Laboratory of the University of Girona.

In May, work on development and integration of inexpensive acoustic modem with ROS (Robotic Operating System) architecture used on both, Sparus and testbed computer. At the start of June, acoustic modems were integrated in FPGA-based controller. For localization, developed algorithm is using TDOA (Time Difference Of Arrival) and depth measurements. Depth measurements were used to reduce number of beacons at the surface, and most underwater vehicles have pressure sensors.

Experiments at sea were conducted during end of June in Sant Feliu de Guíxols, Spain. The setup consisted of one acoustic modem mounted on the top of the AUV, and three modems mounted on left, right and back side of the boat. For implementation simplicity, AUV was sending a message containing its current depth to three modems on the boat, and FPGA board on the boat was calculating TDOA measurements and relayed it to ROS environment on testbed laptop. Message containing depth measurements were sent directly from three modems to ROS environment.

As suspected, because of the price of acoustic modems, gathered data contains measurements with a lot of disturbances. Also, data contained many reflected signals, due to boat being tied to a pier. Further analysis on acquired measurements will be presented as a joint conference paper.

Major results accomplished during and shortly after staff exchange are:

- Hardware and software integration of acoustic modem in AUV Sparus.
- Implementation of TDOA measurement acquisition algorithm in FPGA-based controller.
- Data gathering conducted in sea experiments.
- Analyzed results will be presented as a joint conference paper.



Image 2. Using UdG facilities for sea trials

1.2. Anja Babić visited Consiglio Nazionale delle Ricerche, Genova

During February and March of 2017, Anja Babić was a guest researcher at the National Research Council of Italy (CNR), Institute for research of intelligent systems for automation (ISSIA) where she was supervised by Dr. Marco Bibuli and Massimo Caccia.



Image 3. Anja Babić and Marco Bibuli in the research facilities of CNR

The main results of the staff exchange are available in the detailed news content. The [research plan](#) and [report](#) for the visit are available in the repository.

Main results accomplished during and shortly after staff exchange are:

- Development and simulation of an algorithm for task distribution and scheduling for multiple robotic agents based on differential evolution
- Development of a simulation testbed for the purposes of energy management and exchange within the H2020 project subCULTron artificial robotic ecosystem
- Analysed results will be presented as a joint conference paper

2. Short-term Trainings

2.1. Training: “Intervention AUVs” held from May 17th to May 18th, 2017 at University of Girona

As part of H2020 project "[EXCELLABUST](#) - Excelling [LABUST](#) in marine robotics", prof. Pere Ridao, dr.sc. Patryck Cieslak, Albert Palomer, and Dina Youakim held a tutorial titled "Intervention AUVs" on 17th - 18th May 2017 at the University of Girona. Topics of the tutorial were: direct and inverse robot manipulator kinematics, use of robotic manipulators attached to an underwater vehicle, motion planning and control of such systems.



Image 4. Dina Youakim and Pere Ridao in a moment of the training at UdG facilities

3. Expert Visits

3.1. Tutorials

3.1.1. Tutorial: "Underwater Image Processing and Photomosaicing" by UdG

As part of the expert visit within the H2020 project "EXCELLABUST - Excelling LABUST in marine robotics", Rafael Garcia and Dr. Ricard Campos from the VICOROB, University of Girona (Spain) gave a tutorial titled "Underwater Image Processing and Photo Mosaicing" on 11th - 13th April 2017 at the University of Zagreb Faculty of Electrical Engineering and Computing.



Image 5. Ricard Campos and Rafael Garcia with the LABUST team in Zagreb

The agenda, lecture descriptions and materials used during the tutorial are available in the repository. A short report is available in the detailed news content.

The first day started with the presentation by Dr. Ricard Campos of the contents of the seminar and an illustration of their applications in a practical context. This included the analysis of the requirements for carrying out the hands-on learning activities and ensuring that all the participants had installed in their computers all the libraries required to carry out the practical activities. Then, Dr. Rafael Garcia presented the challenges of Underwater Imaging. We saw how the image is formed underwater and what are the interactions between light and water. The participants understood that underwater

images are affected by particular factors such as non-uniform illumination, caustics, blurring, suspended particles and scattering, making impossible the acquisition of images of large seafloor areas in a single shot. As a consequence, images can only be acquired from a short range, and commonly with the support of an artificial lighting source.

The programme on the first day continued with the analysis of feature detectors and descriptors by Rafael Garcia for automatically solving the correspondence problem between pairs of underwater images. The participants were exposed to the fact that given two or more images of the same 3D scene, taken from different points of view, the correspondence problem refers to the task of finding a set of points in one image which can be identified as the same points in another image. To do this, points or features in one image are detected, described using image descriptors and matched with the corresponding points or features in another image. To finish the first day, we addressed the problem of image registration: when an underwater robot takes images of the seafloor while carrying out a mission, the next step for mapping the explored area is to estimate the motion of the scene relative to the camera. In this part we analysed the hierarchy of transformations with different degrees of freedom that can be derived from the estimation of homographies (or planar transformations). The lecture finished by describing the RANSAC algorithm for outlier rejection.

On the second day, Dr. Ricard Campos addressed the problem of Global Alignment. Building a large mosaic without human intervention is a difficult and challenging task that requires a robust (and fully automatic) estimation procedure. Reliable image registration between all possible pairs of overlapping images cannot be automatized. Moreover, tuning the weights for the optimization that generates a globally aligned mosaic is a difficult task, which requires some experience, and therefore a case by case approach is needed, with no possibility of providing a universally usable software, as in the case of navigation-based mosaics. In order to achieve this goal, the core routine is the estimation of the motion between two images, and this is done by robustly detecting the set of common (corresponding) points between pairs images, as detailed on the first day. Based on the results from the previous day, Dr. Campos noted that image processing on its own produces coherent local image alignment, but the trajectory estimated only from the images suffers from serious drift. Therefore, even when image processing is used to improve image alignment, overlapping non-consecutive image pairs should be taken into account to avoid drifts in the localization of the images in the long run.

We saw in this seminar that building a large globally-aligned photomosaic requires the detection of corresponding points in consecutive images, prediction of overlaps between non-consecutive images, and detection of corresponding points in non-consecutive images (known as loop detection). Then, a number of verifications should be run to reject any pair of images for which “ill-conditioned” correspondence points have been detected. Next, a large nonlinear optimization function has to be solved to optimally combine image registration information and navigation data. This optimization



recomputes the 3D position and orientation of every image, taking into account both the initial navigation data and the image processing constraints.

Finally, hands on exercises provided more insight into building a complete system for underwater photo mosaicing following the tutorial documentation that was prepared for the participants.

Outcomes of the expert visit:

- Understand the complexities and peculiarities of underwater image formation.
- Explore alternatives for adequate image processing under the presence of different lighting challenges.
- Learn and experiment with real images using a software pipeline that allowed to create globally-consistent underwater photomosaics.

The tutorial allowed meeting many students, researchers and academic staff from both universities, as well as the exchange of ideas and research interests.

3.1.2. Tutorial: "Modelling and Simulation of Marine Craft" by UL

As part of the expert visit within the H2020 project "[EXCELLABUST](#) - Excelling [LABUST](#) in marine robotics", Dr. Edin Omerdić from the University of Limerick (UL), Mobile & Marine Robotics Research Centre (MMRRC) gave a tutorial titled "Modelling and Simulation of Marine Craft" on 18th - 20th January 2017 at the University of Zagreb Faculty of Electrical Engineering and Computing.



Image 6. LABUST team and University of Limerick trainer at University of Zagreb

Summary

The tutorial followed the planned contents about modelling, simulation, and control of marine craft, given by Dr. Edin Omerdić from UL. The first day focused on an introduction to kinematics of marine crafts, including definition and transformation between reference frames. Special attention was devoted to quaternions and their role in vector rotations. Simulation models of open-frame ROVs, based on attitude representation with Euler Angles and Unit Quaternions, were gradually developed throughout the lecture, and finally validated in the hands-on simulation part, including a link to virtual reality underwater scenes to visualise ROV motion.

The second day focused on control aspects of a marine craft, including design and implementation of low-level controllers and fault-tolerant control systems. Autotuning methods for finding optimal gains was described. The hybrid algorithm for control allocation, capable of finding a feasible solution over the entire attainable input control space, was explained in detail. 3D visualisation of input and true control spaces was demonstrated, providing deep insight into the geometry of underlying control allocation optimisation problems. Real-world applications of proposed algorithms were presented. The hands-on section of the day focused on LabVIEW simulation models and interfacing with other languages, as well as work on a specially-developed demonstration platform OceanRINGS.

The third day focused on development of an interface between control software and physical actuators (thrusters). Methods to overcome friction/dead zones for low speed rotations were demonstrated. The hands-on segment featured an overview of using FPGA to generate PWM signals for high precision speed and direction control of Blue Robotics T200 thrusters.

The outcomes of the tutorial were:

- Participants learned basic principles of modelling, simulation and control of marine crafts, including transformation of reference frames, kinematics and dynamics equations of motion, disturbances, control allocation, and low-level motor control.
- Participants explored tools for simulation, control design, and real-time control using MATLAB, LabVIEW, myRIO and ROV thrusters.

The tutorial also presented many opportunities for free discussion exchange of know-how and experiences and allowed meeting students and researchers from University of Zagreb, with several conversations about past and future projects, the state of the art of several research fields of interest, and potential collaborations.

3.1.3. Tutorial by UdG team on Mission Planning, Data Analysis and Girona500 AUV deployment



Pere Ridao, Natàlia Hurtós and Narcís Palomeras from University of Girona (ES) held tutorials "Mission Planning", "Data Analysis" and "Girona500 deployment" during the 1st EXCELLABUST summer school which was organized as part of Breaking the Surface 2016. Breaking the Surface 2016 was held from 2nd until 9th October in Biograd na Moru (Croatia) and more than 220 people participated in the program.

Image 7. Tali Hurtós from the UdG team @BtS

3.1.4. Tutorial by Edin Omerdić, University of Limerick on "Thruster Control using LabVIEW Real-Time & FPGA Graphical Programming"

Edin Omerdić from University of Limerick (IE) held a tutorial "Thruster Control using LabVIEW Real-Time & FPGA Graphical Programming" during the 1st EXCELLABUST summer school which was organized as part of Breaking the Surface 2016. Breaking the Surface 2016 was held from 2nd until 9th October in Biograd na Moru (Croatia) and more than 220 people participated in the program.



Image 8. Edin Omerdic in a moment of the tutorial at BtS with UdG and LABUST team

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.

Biography

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).



Image 9. Tutorial from L. Madureira @BtS

3.1.5. Tutorial by OceanScan, PT on "Mission Planning" and "Data Analysis"

Luis Madureira from [OceanScan](#) (PT) held tutorials "Mission Planning" and "Data Analysis" during the 1st EXCELLABUST summer school which was organized as part of [Breaking the Surface 2016](#). Breaking the Surface 2016 was held from 2nd until 9th October in Biograd na Moru (Croatia) and more than 220 people participated in the program.

3.2. Invited talks

3.2.1. Invited talk "High-resolution Sea-floor Optical Mapping using Unmanned Underwater Vehicles"

The H2020 project "[EXCELLABUST](#) - Excelling [LABUST](#) in marine robotics", [Centre of Excellence ACROSS](#) and IEEE Croatia Section, Robotics and Automation Chapter organized the lecture "High-resolution Sea-floor Optical Mapping using Unmanned Underwater Vehicles" given by Prof. Rafael Garcia, *Computer Vision and Robotics Research Institute, University of Girona, Spain*.



The lecture took place on Wednesday, 12th April 2017, starting at 15:00 in Grey Hall at the Faculty of Electrical Engineering and Computing.

Abstract

Robotics has greatly advanced in the last few years as a tool for environmental monitoring and seafloor characterization. Seafloor imagery is routinely acquired during near-bottom mapping surveys conducted by Unmanned Underwater Vehicles (UUVs). Deep-sea hydrothermal fields or shallow-water coral reef communities are, for instance, two scenarios that have long been the target of such studies. Imagery is useful to characterize the nature and distribution of geological features and biological communities, extract ecological indicators, and to provide a permanent visual record of the seafloor condition. However, imaging studies often yield large numbers of images (several tens of thousands, especially in deep-sea cruises) that are frequently underutilized largely because of the difficulties inherent in processing and visualizing large data sets. Moreover, light suffers from a rapid and nonlinear attenuation underwater that affects the acquired images, which forces AUVs to navigate close to the seafloor, thus increasing the risk of the survey mission.

In this talk we will present ongoing work at the University of Girona towards development and application of vision-based seafloor survey methodologies, including large area 2D mosaicing (>1sqkm), monocular-based 3D mosaicing, and omnidirectional mapping. The developed tools set a first step towards detecting and documenting the temporal variations associated with the active processes operating at these sites.

Curriculum

RAFAEL GARCIA graduated in computer engineering in June 1994 at the Autònoma University of Barcelona (UAB), received the DEA (MSc) in Computer Science in July 1996 and the Ph.D. degree in computer engineering in 2001, both at the University of Girona (UdG), Spain. His research activity mainly focuses on robotics in topics such as robot navigation and mapping, sensor fusion, 3D reconstruction, semantic representation of video imagery and large-scale mosaicing. Dr. Garcia was the director of the Computer Vision and Robotics Group (VICOROB) of the University of Girona from March 2009 to June 2015. Currently, he is the director of the Underwater Vision Lab, which belongs to VICOROB. Dr. Garcia has been visiting researcher at the Universität der Bundeswehr (Germany), University College Cork (Ireland), IRISA-INRIA (France), and the University of Miami (USA). He is involved in several national and transnational projects in the field of robotics and computer vision and has participated in the creation of two spin-off companies.



3.2.2. Invited talk "Flying Robot Companions for Future Smart Cities"



The H2020 project "[EXCELLABUST](#) - Excelling [LABUST](#) in marine robotics", [Centre of Excellence ACROSS](#) and IEEE Croatia Section, Robotics and Automation Chapter organized the lecture "Flying Robot Companions for Future Smart Cities" given by Dr. Mirko Kovac, *Aerial Robotics Laboratory, Imperial College London, UK*.

The lecture took place on Friday, 31st March 2017, starting at 14:00 in Grey Hall at the Faculty of Electrical Engineering and Computing.

Abstract

The rise of robotics offers a unique opportunity to re-imagine the design and function of urban environments. Future smart cities will behave like complex ecosystems in which humans, robots and the built-environment exist in symbiosis, performing and collaborating on various tasks that are laborious, dangerous or expensive to do by manual means. In these future cities, swarms of friendly flying robots could for example assist humans to repair and manufacture urban infrastructure, provide delivery methods for logistic systems and perform automated environmental monitoring tasks. Some of the most exciting prospects for these future robotics systems draw their inspiration from energy-efficient, adaptive strategies seen in living organisms that can thrive in complex, changing environments.

In this talk, Dr. Mirko Kovac will show the newest bio-inspired flying robots that have been developed at the Imperial College Aerial Robotics Laboratory illustrating how the study of natural systems can enable next-generation aerial robots to enhance operations and human wellbeing in future cities.

Curriculum

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 mobility solutions for robotics and agent based autonomous manufacturing. Before his appointment in London, he was post-doctoral researcher at [Harvard University](#) and 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 delivered 24 keynote lectures and 28 invited talks on bio-inspired robotics at leading research institutions and conferences world wide including the World Knowledge Dialogue Symposium 2008, the Robotics Systems and Sciences conference as well as the London Innovation Summit 2014 and 2016. He is also advisor to the U.K. government on the topic of Aerial Robotics and is regularly consulting on technology foresight and strategy development for industry.



3.2.3. Invited talk "Bringing Smart Underwater Manipulators & Vision to Work-Class ROVs: Recent Field Trials"

The H2020 project "EXCELLABUST - Excelling LABUST in marine robotics", Centre of Excellence ACROSS and IEEE Croatia Section, Robotics and Automation Chapter organized the lecture "Bringing Smart Underwater Manipulators & Vision to Work-Class ROVs: Recent Field Trials" given by Dr. Gerard Dooly, *Mobile & Marine Robotics Research Centre, University of Limerick, Ireland.*



The lecture took place on Wednesday, 18th January 2017, starting at 09:00 in Grey Hall at the Faculty of Electrical Engineering and Computing.

Abstract

The MMRRC have recently completed ROV operations using a work-class SMD Quasar in a flooded quarry in North Tipperary, Ireland. The ROV ops were the first in-water trailing of new systems for close quarter underwater automated manipulator tasks. The ROV Ops contained three ocean engineering/technology objectives which are particularly relevant to UL research within the SFI Research Centre, Marine Renewable Energy Ireland (MaREI). The MMRRC research team is specifically addressing the need for ROV systems capable of performing Inspection, Repair & Maintenance (IRM) on subsea infrastructure in harsh sea conditions.

The engineering objectives included:

- Advanced Manipulator Controls
- Smart Navigation & Pose Estimation
- Pressure and Motion Reference Sensor

The trials were carried out in depths of 35m in collaboration with the Marine Institute in November 2016. The invited talk will describe the operations from inception to execution and will detail the various tasks completed over the 3 days of in-water trials.



Image 10. ROV ops site setup

Curriculum

Gerard Dooly has worked extensively in the optical fibre sensors and marine robotics research centres at UL since the completion of his PhD in 2008. His research interests include optical fibre sensors, differential optical absorption spectroscopy, advanced control systems, underwater robotic engineering and advanced sonar operations and processing. He is focused on the design and development of underwater robotics and has engaged in numerous offshore maritime operations and survey missions both here in Ireland and on the continent. Some of his recent research topics include environmental monitoring, subsea event triggered sensing platforms, miniature daughter-ROV's, anti-mine countermeasure ops and remote vehicles for incident response. He also has a keen interest in underwater shipwreck discovery, survey and identification and has participated in many deep water diving expeditions worldwide. He is a qualified closed circuit trimix rebreather diver and has successfully dived and identified newly discovered shipwrecks to depths of up to 135 metres.

3.2.4. Invited talk "Fjord ecosystems on the West Antarctic Peninsula - hotspots of biodiversity and response to climate warming (the FjordEco Project)"



The H2020 project "EXCELLABUST - Excelling LABUST in marine robotics", Centre of Excellence ACROSS and IEEE Croatia Section, Robotics and Automation Chapter organized the lecture: "Fjord ecosystems on the West Antarctic Peninsula - hotspots of biodiversity and response to climate warming (the FjordEco Project)" given by Prof. Craig Smith, University of Hawai'i at Manoa, Honolulu, USA. The lecture took place on Tuesday, 25th October 2016, starting at 10:00 in Grey Hall at the Faculty of Electrical Engineering and Computing.

Abstract

The West Antarctic Peninsula (WAP) has an extensive, rapidly warming system of sub-polar fjords with tidewater glaciers. These fjords appear to be hotspots of biomass and biodiversity, with sustained phytoplankton blooms, massive aggregations of krill and humpback whales, and high abundance and species richness of benthic megafauna. This spectacular marine life attracts >20,000 tourists to individual WAP fjords each summer. Nonetheless, the drivers of high fjord productivity/biodiversity, as well as the sensitivity of WAP fjord ecosystems to climate warming, are very poorly understood. Within the FjordEco Project, we are conducting an integrated field and modeling program to evaluate physical oceanographic processes, glacial inputs, plankton dynamics, and benthic community structure and function in Andvord Bay, a sub-polar WAP fjord, to address two overarching questions: (1) What physical, glaciological, biological and chemical processes interact to enhance fjord productivity and biodiversity? (2) How sensitive are these fjord processes to increased glacial meltwater and sediment inputs expected from climate warming? Our field program will test mechanistic hypotheses concerning

oceanographic/glaciological forcing, and phytoplankton and benthic community responses, within the fjord, and includes: (1) Deployments of moorings (physical oceanographic, sediment traps, seafloor time-lapse camera), weather stations, and glacial and sea-ice time-lapse cameras to obtain an integrated view of ecosystem processes in the fjord and adjacent Gerlache Strait over 15 months; and (2) spring and fall process cruises using shipboard CTD, towed Acrobat system, AUV glider, and intensive studies of phytoplankton and benthic species composition and production/respiration to elucidate fjord ecosystem structure and function during different seasons. We will then use a coupled physical/biological modeling approach (ROMS/NEMURO) to evaluate drivers of biogeochemical cycles in WAP fjords and to explore their potential sensitivity to enhanced meltwater and sediment inputs.

I will present results from our spring and fall cruises to Andvord Bay in Dec 2015 and March 2016, to deploy instruments and evaluate ecosystem processes. Our findings thus far are as follows:

- Despite major glacial fluxes and recent warming along the Antarctic Peninsula, there is only weak influence from meltwater and sediment plumes in Andvord Bay.
- Phytoplankton blooms can occur very early (Dec) in Andvord Bay and yield intense pulses of phytodetritus to the basin floor.
- Sediment respiration, mega benthic abundance and sediment chl-a inventories indicate very high export flux in Andvord Bay compared to the open shelf, especially in the innermost fjord basin nearest large glaciers.
- Climate warming and increased meltwater production will ultimately alter these patterns of high export flux in the inner fjord; we plan to elucidate fjord sensitivity to climate warming through ecosystem modeling.

Curriculum

Craig Smith obtained his Ph.D. from Scripps's Institution of Oceanography in 1983 and is currently a Professor of Oceanography at the University of Hawai'i. He has strong interests in biodiversity, disturbance ecology, and human impacts in seafloor ecosystems. Craig has conducted research in Antarctica, mangroves, submarine canyons, organic-fall communities, cold seeps, continental slopes, and abyssal plains to obtain a broad perspective of natural and stressed marine ecosystems. He has lead over 50 research expeditions from the equator to Antarctica, and has conducted over 100 HOV, ROV and AUV dives. Craig has also published over 140 papers in the scientific literature on seafloor ecology, biodiversity, climate-change impacts, and the design of marine protected areas.



3.2.5. Breaking the Surface (Summer School) - Invited talks:

1	The H2020 project WiMUST: Widely scalable Mobile Underwater Sonar Technology. An overview @BtS'16	03/10/2016	Giovanni Indiveri	Università del Salento (ISME node), IT
2	Deep sea sampling with soft robotics: early results and future directions @BtS'16	03/10/2016	Stephen C. Licht	University of Rhode Island, USA
3	Nautical archaeology from the naval architecture point of view @BtS'16	03/10/2016	Smiljko Rudan	FSB, HR
4	Methodology of recording and analysing shipwreck sites using multi-image photogrammetry @BtS'16	03/10/2016	Kotaro Yamafune	Texas A&M University, USA
5	Co-existence of top marine predators and humans... and the role of technology @BtS'16	04/10/2016	Mark Jessopp	University College Cork, IR
6	Modular portable marine robotics @BtS'16	04/10/2016	Massimo Caccia	CNR, IT
7	The role of underwater robotics in the growth of marine renewable energy @BtS'16	04/10/2016	Tim Mundon	University of Washington, USA
8	Recording "in the dark". The challenges of recording a submerged 8th century structure in the Schlei Fjord, Northern Germany @BtS'16	04/10/2016	Jens Auer	University of Southern Denmark, DK
9	Marine Robotics Applications in Humanitarian, Search & Rescue and Civilian Focussed Security Operations – what might the future hold? @BtS'16	04/10/2016	Cormac Gebruers	National Maritime College of Ireland, IR
10	Robotics for challenging ocean intervention in marine renewable energy and other applications @BtS'16	05/10/2016	Dan Toal	UL, IE
11	Observations from the Invisible Forest: the diversity of marine phytoplankton @BtS'16	05/10/2016	Sunčica Bosak	PMF, HR
12	Aquatic Micro Aerial Vehicles (AquaMAV) for water sampling and marine exploration @BtS'16	05/10/2016	Mirko Kovač	Imperial College London, UK
13	The Underwater Archaeology Centre of Catalonia. The works with AUV and submersibles in archaeological sites @BtS'16	05/10/2016	Gustau Vivar	Centre d'Arqueologia Subaquàtica de Catalunya, Catalonia, ES
14	Marine robotics – A tool for increased awareness from land to the deep sea @BtS'16	05/10/2016	Alfredo Martins	INESC TEC / ISEP, Portugal
15	Unmanned system for maritime security and environmental monitoring @BtS'16	06/10/2016	Stjepan Bogdan	UNIZG FER, HR

16	Investigating the submarine canyons and seamounts in Spanish waters through noninvasive methodologies @BtS'16	06/10/2016	Francisco Sanchez	Instituto Español de Oceanografía (IEO), ES
17	A decade of research in underwater cooperative navigation: what have we learned? @BtS'16	06/10/2016	Mandar Chitre	National University of Singapore, SG
18	Underwater and Instrumental Archaeology. A Special Relationship @BtS'16	06/10/2016	Francesco Tiboni	University of Genova, IT

4. Innovation Management Trainings

4.1. Innovation Management Training 2 - “University Entrepreneurship” was held at University of Girona on May 19, 2017 at University of Girona



On Friday, May 19, 2017, the 2nd Innovation Management Training named “University Entrepreneurship” was held at University of Girona, under H2020 project "EXCELLABUST - Excelling LABUST in marine robotics". This highly interactive training was held by Mr Jeff Skinner, who is the Executive Director of the Deloitte Institute of Innovation and Entrepreneurship at London Business School. Besides this, he leads MBA entrepreneurship electives and many co-curricular student activities at the School.

The goal of the training was to: get into the mind-set of an investor who is asked to finance a new idea for business, develop a commercial strategy for a technology being commercialized, brainstorm a minimum viable product, and finally discuss dos and donts of launching a new venture.

4.2. Participating in a Design Thinking Workshop

Ivana Mikolic from LABUST UNIZG FER participated in a Design Thinking Workshop organized by UNIZG FER student startup incubator SPOCK and IBM Hrvatska held on 11th November 2016 at UNIZG FER premises.



Image 11. UNIZG FER team in IBM Croatia

4.3. Coordinators' Day (Amendments / Reporting and Payments) in Brussels on 14th February 2017

UNIZG FER LABUST Project Manager Ivana Mikolić participated in information session **Coordinators' Day (Amendments / Reporting and Payments) in Brussels** for Grant Coordinators on **14th February 2017**. The session covered legal aspects, business processes and IT tools used to prepare amendments and reports, with particular attention to the financial aspects and eligibility of costs.



Image 12. Coordinator's Day in Brussels

4.4. Innovation Tuesday at Breaking the Surface summer school

During the 8th edition of Breaking the Surface 2016 summer school we organized an Innovation Tuesday program and dedicated the whole day to lectures about 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.

Innovation Tuesday was held for the first time on 4th of October while Breaking the Surface was held from 2nd until 9th October in Biograd na Moru (Croatia). More than 220 participants from marine robotics field and its applications - marine biology, archaeology, security, oceanology etc. participated in BtS programs.



Image 13. Asgeir Sorensen (AB of EXCELLABUST) in a moment of his presentation

As part of Innovation Tuesday, 10 lecturers presented their experience and knowledge, together with one demonstration of robot developed by a start-up company.

LECTURES:

1.	Value creation from research through university spin-offs @BtS'16	04/10/2016	Anders Aune	NTNU, NO
2.	The Art of Innovation @BtS'16	04/10/2016	Kemal DeliĆ	Hewlett-Packard Co, FR
3.	BluEye Robotic – providing underwater adventures for everyone @BtS'16	04/10/2016	Erik Dyrkoren and Martin Ludvigsen	Blueye Robotics, NO
4.	Bootstrapping SonarSim: A Start-up Journey @BtS'16	04/10/2016	Francis Flannery	SonarSim, IR
5.	From Research to Revenues - The Puzzle of the Market @BtS'16	04/10/2016	David Lane	Heriot-Watt University, UK
6.	The Light Autonomous Underwater Vehicle – Affordable technology to address scientific and societal needs @BtS'16	04/10/2016	Luis Madureira	OceanScan - Marine Systems & Technology, Lda, PT
7.	IQUA Robotics: from lab to market @BtS'16	04/10/2016	Pere Ridao	UdG, ES
8.	Why and how becoming a researcher and entrepreneur? @BtS'16	04/10/2016	Asgeir J. Sørensen	NTNU, NO
9.	Titanrob: 3d printed Titanium Manipulators Innovation in the ROV sector @BtS'16	04/10/2016	Darío Sosa Cabrera	ACSM, ES
10.	Comments on the Management of Technology Startup Companies @BtS'16	04/10/2016	Clayton Stewart	University College London (UK)