EXCELLABUST

EXCELLING LABUST IN MARINE ROBOTICS

TRAINING 3

"ROVs for Use in Challenging Conditions: I-ROV & ROV ÉTÁIN"

14-15/06/2018

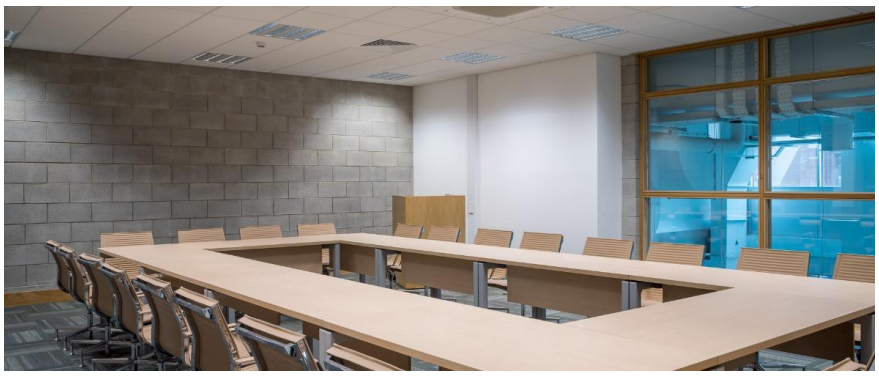
University of Limerick

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691980.

1. VENUE

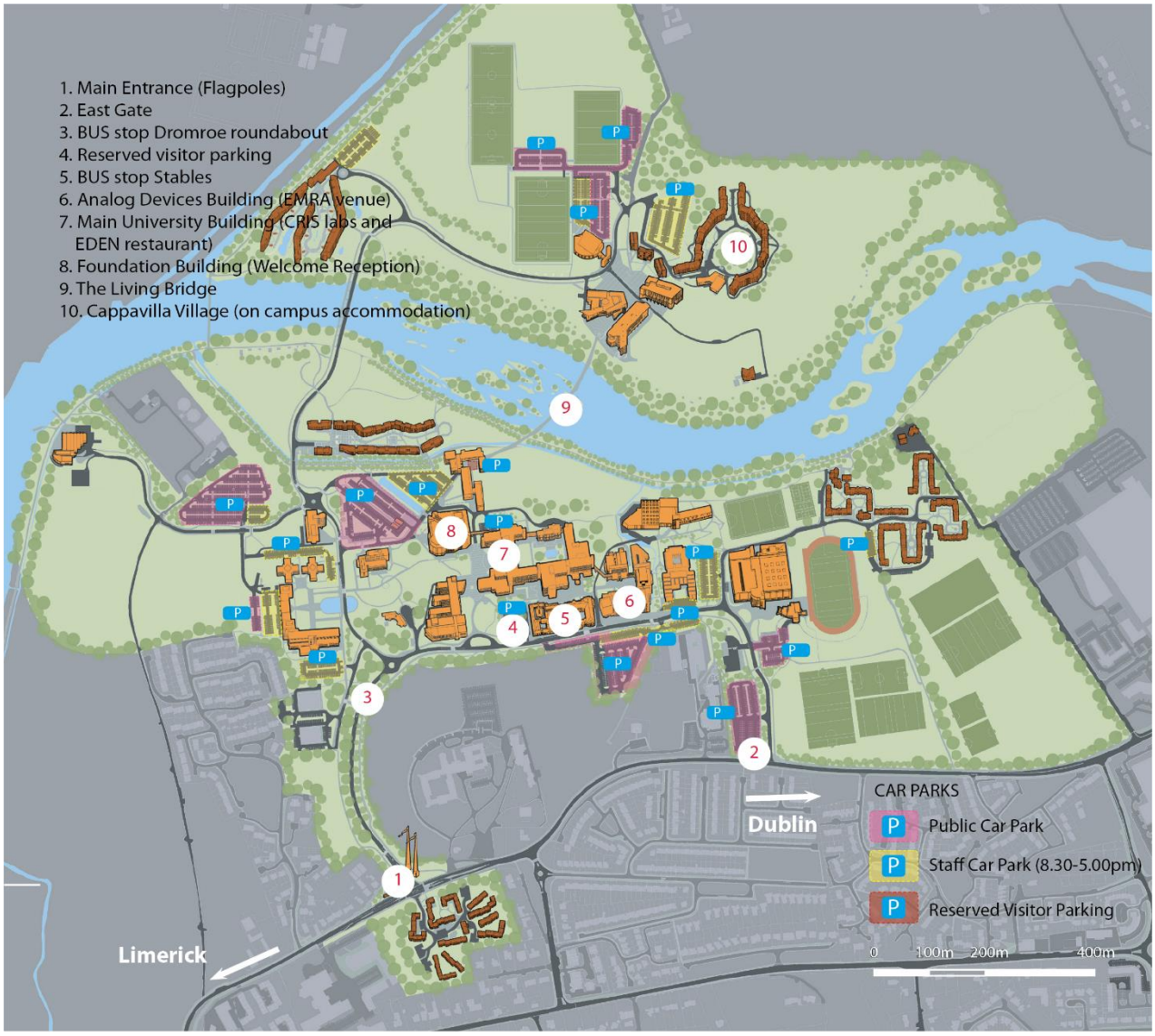
University of Limerick
Analog Devices Building
Room AD1-045 (1st floor)
Bus stop Stables City centre line **308, 307, 304A, 304** (for more details see map below and how to get travel guide on EMRA WEBSITE: http://emra-18.marinerobotics.eu/travel/ .)

Analog Devices Building



ROOM AD1-045/046

Limerick Docks



NOTE.

Lunches will be served at **EDEN restaurant** (Mezzanine floor), **Main University Building (7)** at **13:00** on **Thursday** & **12:30** on **Friday.**

2. PREREQUISITES FROM PARTICIPANTS

Participants should read documents (presentations & reports) from the Expert Visit to FER Zagreb by UL team (Edin Omerdic & Gerard Dooly), 18-20 January 2017 (weblink). In particular, participants should be familiar with modelling and simulation of marine craft, ROV kinematics & dynamics, Euler angles and Quaternions, ROV simulation model in Matlab/Simulink, control allocation, modelling and simulation of thruster propulsion system. Participants should visit and explore the website ROV Comanche to gain a better understanding of work-class ROV systems.

3. SCHEDULE

Day 1: 14 June 2018 (Thursday)

09:00 – 09:15	**MORNING COFFEE**
09:15 – 09:45	Introduction & Course Presentation
09:15 – 09:45	OceanRINGS^{+}: Concept & Architecture
09:45 – 10:30	I-ROV Agile Development: Virtual Environment – Rapid Control Prototyping – Hardware-In-the-Loop – Real-World Environment
10:30 – 11:00	I-ROV Fault-Tolerant Control: Active Fault Detection and Isolation
11:00 – 11:15	**COFFEE BREAK**
11:15 – 11:45	I-ROV Fault-Tolerant Control: Passive Fault Detection and Isolation
11:45 – 12:30	Hands on: OceanRINGS^{+} Demonstration Platform
12:30 – 13:00	ROV ÉTÁIN: Introduction
13:00 – 14:00	**Lunch**
14:30 – 16:30	Hands on: ROV ÉTÁIN Operations in Limerick Docks*

*The transport to the Limerick docks will be organised by CRIS team.

Day 2: 15 June 2018 (Friday)

09:00 – 09:15	**COFFEE BREAK**
09:15 – 09:30	Introduction & Course Presentation
09:30 – 11:00	ROV ÉTÁIN: Features & Physical Layout of System Components
11:00 – 11:15	**COFFEE BREAK**
11:15 – 11:45	ROV ÉTÁIN: Standard Operation Procedures & Operation Modes
11:45 – 12:15	ROV ÉTÁIN: Maiden Voyage – First Field Trials
12.30	**Lunch**

4. LECTURE DESCRIPTION:

1. **Introduction & Course Presentation** by *Edin Omerdic*.

2. **OceanRINGS$^+$: Concept & Architecture by *Edin Omerdic*.**
   This session will introduce the main concept and architecture of OceanRINGS$^+$, including extra features available in a new version relative to the previous version of OceanRINGS. High-level block diagrams will be used to represent interconnectivity between system components.

3. **I-ROV Agile Development: Virtual Environment – Rapid Control Prototyping – Hardware-In-the-Loop – Real-World Environment by *Edin Omerdic*.**
   Researchers from CRIS, UL have designed and developed a reconfigurable, inspection-class ROV (I-ROV) in the period 2014-2018, aimed to perform a periodic and post-storm inspection of offshore MRE converters, moorings and foundations. The I-ROV has been developed using agile development cycles. This session will provide more insight into these cycles, and related benefits (reliability, cost savings, time savings, etc.).

4. **I-ROV Fault-Tolerant Control (FTC): Active Fault Detection and Isolation (FDI) by *Edin Omerdic*.**
   This session will describe the Active thruster FDI subsystem, an important component of FTC, which has been developed and implemented into the I-ROV control system. The FDI subsystem can be employed with thrusters that provide real-time measurements of relevant signals (currents, shaft speeds, bus voltages and temperature of windings, for example). The active FDI subsystem carries out real-time detection of thruster states through the use of a Pattern Recognition Neural Network (PRNN), which classifies thruster data into thruster state targets. The FDI system input signals to the Fault Accommodation (FA) subsystem so that the control accommodation can take place for faulty thruster(s). The FA subsystem is an extension of the hybrid approach for control allocation, based on the integration of the pseudoinverse and the fixed-point iteration method, which compensates the thruster fault effect. The subsystem also provides instant power isolation for faulty thrusters, ensuring that the full I-ROV power system is not compromised.

5. **I-ROV Fault-Tolerant Control (FTC): Passive Fault Detection and Isolation (FDI) by *Edin Omerdic*.**
   This session will describe the Passive thruster FDI subsystem, which has been developed for use with thrusters that cannot provide real-time measurements of relevant signals (shaft speed, current, etc.). The passive FDI subsystem is based on deduction of thruster faulty states in a single thruster layer from the I-ROV's motion during execution of the passive FDI test.

6. **Hands on: OceanRINGS$^+$ Demonstration Platform** by *Edin Omerdic*. This session will provide an opportunity to learn and explore how theoretical concepts about ROV control systems (presented during Expert Visit in January 2017) are implemented in real-time software platform OceanRINGS$^+$. Participants will learn about highly adaptive 3-layer software architecture of OceanRINGS$^+$, including fault-tolerant control allocation algorithms in the bottom layer, transparent interface between an ROV and supporting platforms (surface platforms, surface/subsea garages and/or supporting vessels) in the middle layer and assistive tools for mission execution/monitoring/supervision in the top layer. Software modules have been developed for advanced control modes, such as auto compensation of ocean currents based on ROV absolute motion, robust speed/course controller with independent heading control, semi and full auto-pilot capabilities, auto-tuning procedure for low-level controllers, ROV high precision dynamic position & motion control in absolute earth-fixed frame, or relative to target or support platform/vessel. Participants will learn how to interact with HMI in order to solve simple tasks (go to the point, move I-ROV along a circular arc, inject thruster faults, etc.).

7. **ROV Étáin: Introduction by *Gerard Dooly*.**
   This session will cover a brief introduction to the hardware elements of the UL ROV Étáin and will give attendees an overview of the system prior to travelling into the UL Limerick Docks facility.

8. **Hands on: ROV ÉTÁIN Operations in Limerick Docks by *Gerard Dooly*.**
   This is a follow-up session to the in-class module and will be a look at the ROV Étáin at the UL limerick docks facility. The focus of this session will be to get a hands-on look at the equipment. The attendees will get an understanding of both hardware and software elements of the ROV and an overview of how the ROV works offshore. Additionally, attendees will get a brief training on how to operate the ROV and sub-systems (manual pilot control, co-pilot interfaces, LARS operation & manipulator control).

9. **Introduction & Course Presentation by *Gerard Dooly*.**

10. **ROV ÉTÁIN: Features & Physical Layout of System Components by *Gerard Dooly*.**
    Modern work-class ROV systems are quite complex in both hardware and software implementations. This session will look at the design of the Comanche ROV system (UL ROV Étáin) and will look at the various technologies and sub-systems, which are used throughout the build. The session will cover design of the ROV, TMS, LARS and topside cabin & controls as well as reviewing technologies and sub-systems throughout. A more in-depth look will focus on communication systems, safety systems, thruster configurations, topside and bottom side power distributions, payload integrations, garaging and launch & recovery systems. Upon completion, the attendees will have a broad understanding of how ROV Étáin is designed, and an overall understanding of where commercial work-class ROV systems are in terms of technology and capability.

11. **ROV ÉTÁIN: Standard Operation Procedures & Operation Modes: by *Gerard Dooly*.**
    This session will cover the offshore operations elements, logistics of mobilising, ship integration, safety procedures and team-based task loading. Additional elements include modes of operations and emergency planning.

12. **ROV ÉTÁIN: Maiden Voyage – First Field Trials by *Gerard Dooly*.**
    A look at the first offshore trials with the ROV Étáin and a look to future projects, commercial work and research operations.

5. DESCRIPTION OF THE PARTNER INSTITUTION:

University *of* Limerick

Address: **University of Limerick**
V94 T9PX
Limerick
Ireland

Website: http://www.ul.ie

The University of Limerick (UL) with over 13,000 students and 1,300 staff is an energetic and enterprising institution with a proud record of innovation and excellence in education, research and scholarship. The dynamic, entrepreneurial values which drive UL's mission and strategy ensure that we capitalise on local, national and international engagement and connectivity. Research at UL is renowned for its close alignment to real world problems and the university has an enviable reputation in fundamental research, which can have real impact on society and the economy alike. This strong focus allowed UL to gain a five-star rating for innovation and excellence from QS, the international ranking body. UL has a strong international reach and Involvement in the European Framework actions from FP2 to FP7, and current involvement in Horizon 2020 has grown UL's international network of collaborators.

CRIS Centre for Robotics & Intelligent Systems

Address: **Centre for Robotics & Intelligent Systems**
ECE Department
University of Limerick
V94 T9PX
Limerick
Ireland

Website: http://www.mmrrc.ul.ie

Established in 2000 by Director Dr. Daniel Toal, the Centre for Robotics & Intelligent Systems (CRIS, previously known as Mobile & Marine Robotics Research Centre (MMRRC)) in the University of Limerick is the only research centre focused on the application and development of marine robotics within the island of Ireland. This research centre consists of a mix of academics, postdoctoral researchers, research engineers and PhD students from various disciplines including electronic, computer, mechanical and aeronautical engineering backgrounds. The research centre brings together a highly capable engineering group focused on developing innovated, practical and industrial relevant marine technologies and field robotics. From marine robotics to navigation, sensor development, emergency response planning, remote operated vehicle (ROV) and unmanned aerial (UAS) technologies, they are actively involved in developing a diverse range of practical technologies in national funded, European funded and industry collaborative projects. The core research activities of the research centre are listed below:

- Remotely operated vehicle smart systems- fault tolerant control, auto tuning, one-click auto survey, augmented reality visualisations (transparent ocean).
- Remote & auto flight control of tethered parafoil kites for airborne wind energy & aerial sensor/comms platforms.

- Sensored telemetry streaming from fixed wing aircraft, system identification, controller design.
- Emergency response exercise planning & coordination. UAVs deployed in segregated airspace over three-day exercise. Key partners: Irish Aviation Authority, Irish Naval Service, Irish Coast Guard, Commissioner of Irish Lights.
- Long Range High Bandwidth comms- remote presence, live interaction with distant robotic vehicles independent of existing infrastructure.
- Ocean sensing platforms with daughter mini ROVs- for persistent remote presence offshore with global satellite comms (controlled & monitored anywhere in world).

Over the last eleven years the CRIS research centre has developed OceanRINGS – a suite of smart technologies for subsea operations, designed to be integrated with any ROV – support vessel combination. It includes advanced control solutions for full range of ROVs – from mini ROVs used for remote monitoring & inspection to full-size work-class ROVs. Remotely Operated Vehicle (ROV) LATIS is a 1000 m depth-rated underwater robot developed at CRIS and has been used to test and validate OceanRINGS. Researchers from CRIS, UL have designed and developed a reconfigurable, inspection-class ROV (I-ROV) in the period 2014-2018, aimed to perform a periodic and post-storm inspection of offshore MRE converters, moorings and foundations. System validation and technology demonstration has been performed over the last six years through a series of test trials with different support vessels off the north, south and west coast of Ireland and in the Mediteranean sea. Recently, CRIS researcher launched a light work-class ROV ÉTÁIN, funded by the Science foundation Ireland, for operations in challenging conditions. I-ROV and ROV ÉTÁIN are driven by OceanRINGS^{+} control software engine.

6. BIOGRAPHIES OF LECTURERS

Dr. Edin Omerdic
Senior Research Fellow

Website: http://www.mmrrc.ul.ie/dotnetnuke/mmrrc/People/PostdoctoralResearchers/EdinOmerdic.aspx
Email: edin.omerdic@ul.ie

Edin Omerdic received the Dipl. Eng. and M.S. degree in Electrical Engineering from the University of Zagreb, Croatia, in 1997 and 2001, respectively. In 2001 he joined the Mechatronics Research Centre, University of Wales, Newport, UK and took part in the EPSRC funded IMPROVES project. He received his PhD in Electrical Engineering from the University of Wales in 2004, with the thesis titled "Thruster Fault diagnosis and Accommodation for Overactuated Open-frame Underwater Vehicles".

Edin is currently employed by the University of Limerick as a Senior Research Fellow at the Department of Electronic and Computer Engineering. He is engaged in numerous research projects funded by the Higher Education Authority and the Marine Institute in the area of submersible robotics, he is also the main developer & designer of OceanRINGS^{+} concept & software suite, including design of state-of-the-art control architecture for ROV LATIS.Edin's 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.

Up to date he has 24 journals, 6 book chapters, 2 books, 62 papers in conference/workshop proceedings, 14 invited lectures, 4 keynote/plenary talks, 11 tutorials, 21 presentations & technology demonstrations, 2 articles in business magazines, 2 online articles and 1 desk study. Dr. Omerdic received five awards for his work, including First Prize Winner in National Competition in Mathematics (Bosnia, 1985), Society of Underwater Technology (SUT) Prize for Best Multimedia Presentation (GCUV 2003) 'Thruster Fault Accommodation for Underwater Vehicles', IFAC prize for best on-line demonstration (MCMC 2003) 'Fault Detection and Accommodation for ROVs', IMarEST SMI Donald Maxwell Award Prize for Best Journal Paper (2004) 'A Fuzzy Track-Keeping Autopilot for Ship Steering' and Curriculum Paper Contest National Instruments International Competition LabVIEW in the Curriculum 2006 (First Prize Winner) 'Virtual Underwater Lab: Efficient Tool for System Integration & UUV Control Development'.

Dr. Gerard Dooly
Senior Research Fellow

Website: http://www.mmrrc.ul.ie/dotnetnuke/mmrrc/People/AcademicsandPostDocs/GerardDooly.aspx
Email: gerard.dooly@ul.ie

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.