



~ MONTenegrin center for
Underwater SEnsor Networks ~

EXPERT VISIT 3

23 – 25 May 2023

NATIONAL RESEARCH COUNCIL OF ITALY



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101060395.





1. VENUE

Room 308, University of Montenegro, Faculty of Electrical Engineering (UoM)
Cetinjska 2, Podgorica 81000, Montenegro

2. PREREQUISITES FROM PARTICIPANTS

The following prerequisite are not mandatory to attend the lectures:

- basic knowledge of system theory and basic concept of automatic control
- basic knowledge of differential calculus
- basic knowledge of Matlab software

3. SCHEDULE

Day 1: 23th May 2023 (Tuesday)

09:00 – 10:20	Automatic Control - Theory by Marco Bibuli Fundamentals of control theory applied to marine systems, starting from simple feedback actions of linear systems, to more complex regulation schemes of non-linear plants. Presentation of model-based and adaptive control systems, introducing the problem of disturbance and parameter uncertainty.
10:20 – 10:35	BREAK
10:35 – 12:00	Automatic Control - Hands-on by Marco Bibuli Application of the theoretical part to a simulative framework developed in Matlab, where students will be able to test and verify the presented concepts. Experimental custom design of control systems will be proposed in order to spark the ingenuity of the students.

Day 2: 24th May 2023 (Wednesday)

09:00 – 10:20	Single-Vehicle Guidance - Theory by Marco Bibuli This part will deal with the kinematic modeling of the guidance problem, with particular reference to a Serret-Frenet frame error representation. On the basis of such a model, a virtual-target based path-following guidance system is designed, evaluating performance and limitations.
10:20 – 10:35	BREAK
10:35 – 12:00	Single-Vehicle Guidance - Hands-on by Marco Bibuli





	Simulative experience on the exploitation of the virtual-target based path-following guidance system will be carried out through the Matlab framework. Students will have the chance to test and modify the guidance system, possibly improving the system capabilities.
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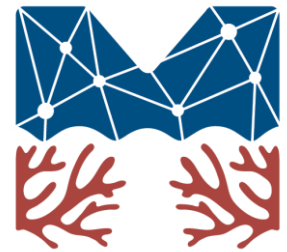
Day 3: 25th May 2023 (Thursday)

09:00 – 10:20	Multi-Vehicle Coordination - Theory by Marco Bibuli Extending the concept studied in the Single-Vehicle Guidance part, different motion coordination schemes will be derived and analyzed, such as Leader-Follower, Wingmen and Swarm approaches. Some hints about the concept of collision avoidance will also be reported.
10:20 – 10:35	BREAK
10:35 – 12:00	Multi-Vehicle Coordination - Hands-on by Marco Bibuli The Matlab framework will be further extended, including more autonomous vehicles thus allowing students to implement the different coordination schemes, testing and evaluating the functionalities.

4. EXPERT VISIT PLANNED OUTCOMES:

- participants will gain knowledge and experience in the development and tuning of automatic controls for autonomous marine vehicles;
- participants will exploit a single-vehicle advanced guidance system for general geometric paths;
- participants will familiarize with multi-vehicle frameworks and related coordination approaches;
- all the topics are composed of both theoretical and practical (simulative) parts, in order to provide fundamental knowledge as well as hands-on experience.





5. LECTURE DESCRIPTION:

Automatic Control by Marco Bibuli

- **Theory** - Fundamentals of control theory applied to marine systems, starting from simple feedback actions of linear systems, to more complex regulation schemes of non-linear plants. Presentation of model-based and adaptive control systems, introducing the problem of disturbance and parameter uncertainty.
- **Hands-on** - Application of the theoretical part to a simulative framework developed in Matlab, where students will be able to test and verify the presented concepts. Experimental custom design of control systems will be proposed in order to spark the ingenuity of the students.

Single-Vehicle Guidance by Marco Bibuli

- **Theory** - This part will deal with the kinematic modeling of the guidance problem, with particular reference to a Serret-Frenet frame error representation. On the basis of such a model, a virtual-target based path-following guidance system is designed, evaluating performance and limitations.
- **Hands-on** - Simulative experience on the exploitation of the virtual-target based path-following guidance system will be carried out through the Matlab framework. Students will have the chance to test and modify the guidance system, possibly improving the system capabilities.

Multi-Vehicle Coordination by Marco Bibuli

- **Theory** - Extending the concept studied in the Single-Vehicle Guidance part, different motion coordination schemes will be derived and analyzed, such as Leader-Follower, Wingmen and Swarm approaches. Some hints about the concept of collision avoidance will also be reported.
- **Hands-on** - The Matlab framework will be further extended, including more autonomous vehicles thus allowing students to implement the different coordination schemes, testing and evaluating the functionalities.





DESCRIPTION OF THE PARTNER INSTITUTION:



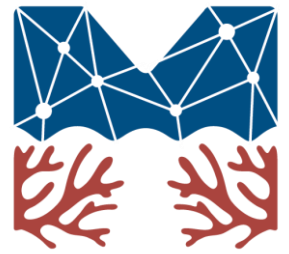
National Research Council of Italy (CNR)

Address: Piazzale Aldo Moro 7
Roma 00185
Italy

Website: <https://www.cnr.it/en>

National Research Council of Italy (CNR) is a public organization committed to carry out, promote, spread and transfer research activities in the main sectors of knowledge growth. CNR is structured in seven departments (Earth and environmental sciences; Bio-Agriculture and food; Biomedicine; Chemistry and Material technologies; Condensed Matter; Engineering, ICT, Energy and Transport; Human, social sciences and cultural heritage), 110 research institutes and about 4000 researchers. The institute involved in MONUSEN is **CNR-INM (INstitute of Marine engineering)**, which was founded in 2018 integrating the expertise, experience, and history of three CNR institutes: the Marine Technology Research Institute (INSEAN), the Genoa and Palermo branches of the Institute of Intelligent Systems for Automation (ISSIA), and the Institute of Acoustics and Sensors “Orso Mario Corbino” (IDASC). CNR-INM mission is to conduct research, foster innovation and competitiveness of the National industrial system, promote the internationalization of the National research system, provide technological solutions to emerging public and private sector needs and challenges, and foster the personal and professional growth of human resources. CNR-INM develops computational tools and experimental setups in order to carry out the research work and to perform service/consultancy for industrial partners. CNR-INM has a long record of research projects funded by EU starting from FP4 framework, by the European Defence Agency (EDA) and by the US Office of Naval Research.





6. BIOGRAPHIES OF LECTURERS



Dr. Marco Bibuli

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Marco Bibuli received his Master degree in Information Technology engineering at the University of Genoa (Italy) in 2005. Since the same year, he joined the National Research Council of Italy, focusing his research activity on the design and development of navigation, guidance and control algorithms for marine surface vehicles and software architectures for supervision and mission control. In 2010 he obtained the PhD degree in Electronic and Computer Engineering, Robotics and Telecommunications. He is co-author of about one hundred international journal and conference publications. He is responsible of various National and European research projects and he participated in many experimental missions and campaigns.

