

IFAC World Congress 2017 Invited Open
Track Proposal:
*Marine and Maritime Robotics:
Innovation and Challenges*

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Abstract: Marine and maritime robotics are extremely actual and interesting research fields that pose formidable challenges both from a theoretical and practical standpoint. Many core problems in these areas are still open, and considerable research work is required to address and solve them. The complexity of the problems at hand requires a multifaceted approach to system analysis and design to exploit the use of methods and tools from dynamical systems theory, automatic control, networked systems, identification and estimation, computer vision, communications, sensing and measurements to yield practical systems capable of executing complex scientific and commercial missions at sea in an efficient and reliable manner.

For these reasons, there is considerable interest in bringing together the marine robotics community and specialists on a number of complementary areas (including automatic control and related topics) to foster new synergies and promote joint research activities aimed at solving practical problems with far reaching implications on scientific, commercial, and societal marine-related issues. It is against this backdrop of ideas that we submit an invited open track proposal entitled *Marine and Maritime Robotics: Innovation and Challenges*, aimed at bringing attention to this exciting field of research and promoting the cross fertilization of ideas required to bring new theoretical and practical advances to bear on the development of innovative systems.

1. INTRODUCTION

The marine environment represents a challenging framework for the exploitation of cutting-edge techniques and technologies related to automatic control. The oceans cover more than 70% of the earth's surface and support an estimated 90% of the life forms on our planet. They constitute one of the main resources for food, employment, and economic revenue, and are a potential source of still unknown living and mineral resources, as well as alternative and sustainable energies. From a scientific point of view, the deep ocean is thought to hold the secret to the origin of life. At the same time, the oceans also harbor a vast cultural heritage in the forms of archaeological sites yet to be found and explored. However, the oceans remain largely unknown, with two thirds of them remaining still unexplored. This is especially true in the case of the deep ocean: deep, dark, vast, and subject to tremendous bar pressure, the bottom of the oceans is the largest component of the solid surface of our planet and yet it is also the least known.

2. MOTIVATION

Clearly, much work remains to be done to have a synoptic view of the open sea and the deep oceans over extended

areas of interest and to exploit the resources available in a sustainable manner. This will require the development of new methods and tools for ocean exploration and exploitation, as well as setting up strong cooperative links among universities, research institutes, companies, and stakeholders worldwide towards this goal. For these reasons, there is worldwide interest in the development of new tools to support the exploration, observation, sampling, intervention and persistent monitoring of the marine environment. In fact, the type of operations required is difficult to be accomplished by unaided humans. Thus the quest for the use of advanced technological tools, such as remotely operated vehicles and fully autonomous robots, to improve the capability to enhance the knowledge of such a wide and mysterious environment.

As in the case of space exploration, the ocean environment places formidable challenges to the development of autonomous and/or persistent systems for exploration and sampling. In fact, engineers and scientists must strive to meet the extremely tight design constraints imposed by the harsh conditions that both surface and underwater platforms have to face. Among these, the following are worth stressing:

- (1) High pressure and low temperature related to extreme depths or harsh environments (e.g., polar areas) re-

- quire suitable components and marinized containers and equipment;
- (2) underwater communications mandate the use of acoustic devices that in challenging operational scenarios are plagued with intermittent communication losses and multipath effects and exhibit reduced bandwidth and low reliability;
 - (3) long range missions require that the vehicles be equipped with proper power supply systems (also relying on alternative technologies such as fuel cells, biological batteries, solar panels, etc.) and efficient energy management systems;
 - (4) extended observation and sampling capabilities can be achieved through the use of cooperative multi-segment robotic systems (e.g. underwater, surface and aerial autonomous vehicles), the operation of which relies on the development of reliable and robust coordination schemes.

It is important to stress that the use of autonomous vehicles requires the design and implementation of suitable advanced guidance, navigation, and control systems in order to provide the high level of reliability required to accomplish complex missions. Marine system development embraces many theoretical and practical issues: dynamical systems theory, automatic control, networked systems, identification and estimation, computer vision, communications, and sensing and measurements, to name but a few.

This strong inter-disciplinarity underlines the importance of rising the interest in the topics related to the marine and maritime field, as well as the importance of encouraging scientists and engineers with different backgrounds to connect, exchange ideas, and define possible avenues for joint research and development work. The present invited open track is proposed with this knowledge enhancement concept in mind.

The trend that is emerging is steadily impacting on the design, development, and operation of advanced technological systems for ocean exploration and exploitation. However, the magnitude of this endeavour has so far not been well reflected in the types and number of sessions devoted to such systems in conferences addressing a vast number of topics at the intersection of control, estimation, and networking. For example, in the IFAC World Congress in 2011 there were only 2 Regular Sessions on “Marine Systems Navigation, Guidance, and Control” I and II plus 1 Invited Session on “Marine Vehicle Motion Planning, Navigation, and Control”, in a total of 379 sessions.

At the time of the IFAC World Congress 2014, the organizers of the present track proposed an invited session on marine and maritime topics, entitled “Navigation, Control, and Sensing in the Marine Environment”. The importance of such marine and maritime topics was especially highlighted by the success of such invited session (that in the end became a full-day track), where the impressive number of 20 papers plus 2 keynote talks was reached. Considering also that three main IFAC conferences/workshops are dedicated to marine robotics, namely NGCUV (Navigation, Guidance and Control of Underwater Vehicles), CAMS (Control Applications in Marine Systems), and MCMC (Manoeuvring and Control of Marine Craft) and that they attract about one hundred of papers each, the

contributions received for the invited track at the IFAC World Congress 2014 represented approximately 20% of the usual contributions provided by the marine robotics community to the above-mentioned conferences. We would like to enhance these statistics for the next World Congress in Toulouse by reaching a larger number of researchers in fields that give support to marine-technology systems, as well as giving the opportunity to the whole IFAC community to join in on the discussions, in order to foster the birth of new ideas and tools for the improvement of automatic control theories and methodologies that can then be applied to the marine robotics domain. On a parallel note, it is worth calling attention to the large number of on-going EC funded projects in the marine / maritime domains. This certainly reflects the increasing interest of the marine robotics community in participating on research and development activities in this exciting field. The importance of the topic is also corroborated by the organization, in the last few years, of the new-born EMRA Workshop on Eu-funded Marine Robotics and Applications, held for the first time by CNR in Rome in 2014 and then hosted by the Instituto Superior Tecnico in Lisbon in 2015 and by the University of Newcastle, UK, in 2016. In this highly successful workshop series, scientists and researchers working on projects funded by the European Commission met together and with representatives of the industrial and stakeholder world, in order to present the most recent results of their activities to colleagues and to show possible industrial fallouts and research follow-up.

It is against this backdrop of ideas that we submit an invited open track proposal entitled *Marine and Maritime Robotics: Innovation and Challenges*, aimed at bringing attention to this exciting field of research and promoting the cross fertilization of ideas required to bring new theoretical and practical advances to bear on the development of innovative systems. We will encourage the presentation of communications on a number of subjects that include: i) cooperative, networked motion planning, navigation, and control; ii) system modeling, identification, and simulation; iii) combined vehicle-manipulator systems; iv) vision systems; v) sensor-based control; vi) geophysical based navigation, to name but a few. This will help steering current cutting-edge research to substantially improve the autonomy and reliability of marine vessels, robots, and systems, instilling little by little in the society a rising sense of confidence on the operation of robots in everyday life thus contributing to raising the awareness on the use of robotic platforms in industrial and civilian contexts.

Our decision to submit the present proposal and thus bring together a group of well known experts on theoretical and practical issues related to the main theme of the invited track proposed was strongly encouraged by the IFAC TCs on Marine Systems and Intelligent Autonomous Vehicles. We expect our initiative to attract a well sized group of world-reknown experts in theoretical and practical issues related to the marine and maritime robotics domain and also to foster the exchange of ideas with experts in other fields. At the same time, given the scope and depth of the issues that we tackle, the track is also expected to attract the attention of the IFAC-related community at large.

3. REFERENCE IFAC TECHNICAL COMMITTEE
FOR EVALUATION

CC7 **Transportation and Vehicle Systems** →
TC 7.2. Marine Systems, TC 7.5. Intelligent Au-
tonomous Vehicles