



STRONG
MAR

Strengthening Maritime Technology
Research Center

**Winter School on
Underwater System and
Communication Science
Programme**



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1 – WELCOME

Dear all participants, welcome to another Winter School in the **STRONGMAR** series.

The aim of **STRONGMAR** is to create solid and productive links in the global field of marine science and technology between INESC TEC and established leading research institutions in Europe, that are capable of enhancing the scientific and technological capacity of INESC TEC and linked institutions, thereby helping raising research profile of its and its recognition as a European maritime research center of excellence.

The training strategy of the **STRONGMAR** project is based on technical presentations and demonstrations covering multidisciplinary aspects of marine science and technology, followed by sessions focused on specific fields of expertise, allowing researchers to improve their knowledge and preparing them for the research and implementation challenges in the harsh sea environment. This training strategy targets not only theoretical training but also practical aspects with hands-on laboratory demonstrations, enabling direct application of the knowledge acquired and improvement of understanding of the actual requirements of the stakeholders, allowing attendees to design solutions with higher economic potential.

Interchange and interaction among different fields of expertise is fundamental to address the ocean challenges, due to the multidisciplinary nature of the application area. Cross-fertilization among fields of expertise is also key to stimulate the design of better specific solutions.

This winter school (**Underwater System and Communication Science**) will cover the following broad topics: Underwater Communications, Underwater Networking and Underwater Systems in general as well as applications of these topics within CMRE activities. The technologies will be demonstrated through live demos and the participants will have the opportunity to observe several trials. Visits to some of the laboratories of CMRE complement the program.

The **STRONGMAR** team.

2 – VENUES

The winter school programme comprises lectures, demonstrations, research lab visits, and social events. Lectures, demos and visits to the labs will take place at the **NATO STO CMRE in La Spezia** and the social event will take place in San Terenzo.

2.1 – NATO STO CMRE

The core activities of the winter school programme will take place at the **Main Conference Room** of the **NATO STO CMRE**. Lectures will take place in this room, coffee breaks in the bar next to it. Demonstrations will take place in the sea basin of **CMRE** and in the Modelling & Simulation Lab. Visits to the labs will take place in the premises of **CMRE**.

NATO STO CMRE



Address: NATO STO Centre for Maritime Research and Experimentation, Viale San Bartolomeo
400, 19126 La Spezia, Italy

Coordinates: 44.098596' N, 9.862522' E

Maps: [CMRE Website](#) | [Google Maps](#)

Website: www.cmre.nato.int



3 – PROGRAMME

3.1 – Schedule

	4/12/2017	5/12/2017	6/12/2017	7/12/2017
09:30 10:00	Registration	Underwater Communications	AUV Mission Simulation	AUV Docking Demo
10:00 10:30	Opening	Joao Alves NATO STO CMRE, Main Conference Room	Dr. Alberto Tremori NATO STO CMRE, Modelling & Simulation Lab	Vittorio Grandi NATO STO CMRE Sea basin
10:30 11:00	Coffee break	Coffee break	Coffee break	Coffee break
11:00 12:00	Autonomous vehicles at CMRE Per Arne Sletner NATO STO CMRE, Main Conference Room	Operational use of gliders for ocean sensing Bartholome Garau NATO STO CMRE, Main Conference Room	AUV Mission Simulation Dr. Alberto Tremori NATO STO CMRE, Modelling & Simulation Lab	AUV Docking Demo Vittorio Grandi NATO STO CMRE Sea Basin
12:00 13:00	Standard payload prototype Dr. Stefano Fioravanti NATO STO CMRE, Main Conference Room	Underwater Networking Dr. Roberto Petroccia NATO STO CMRE, Main Conference Room	Robotics for ASW Dr. Gabriele Ferri NATO STO CMRE, Main Conference Room	AUV Docking Demo Vittorio Grandi NATO STO CMRE Sea Basin
13:00 14:00	Lunch	Lunch	Lunch	Lunch
14:00 15:00	Multi Domain Control Station and multi vehicle interoperability Francesco Baralli NATO STO CMRE, Main Conference Room	Design and implementation of a Wireless Underwater Battery Recharger Vittorio Grandi NATO STO CMRE, Main Conference Room	Underwater Communications Demo Dr. Roberto Petroccia NATO STO CMRE Sea basin	Visit to CMRE laboratories Dr. Fausto Ferreira NATO STO CMRE Premises
15:00 15:30	Coffee break	Coffee break	Coffee break	Coffee break
15:30 16:30	Middleware for AUV operations at CMRE Alberto Grati NATO STO CMRE, Main Conference Room	Modelling & Simulation at CMRE Dr. Alberto Tremori NATO STO CMRE, Main Conference Room	Underwater Communications Demo Dr. Roberto Petroccia NATO STO CMRE Sea basin	AUV Docking Demo Vittorio Grandi NATO STO CMRE Sea Basin
Evening			School dinner	

Lectures
Demonstrations
Research lab visits
Social events

3.2 – Lectures

Monday the 4th of December

Autonomous vehicles at CMRE

Per Arne Sletner, NATO STO CMRE

TBD

Standard payload prototype

Dr. Stefano Fioravanti, NATO STO CMRE

Unmanned maritime systems (UMS) are complex systems, which are provided with specific mission planning and monitoring services. Every model or vendor has specifics in mission file formats and offers various interfaces to third party subsystems to interact with the dynamic command and control. In addition to that, when sensors not organic to the platform are added, even more complexity arises from the need to match functions and timings between different types (and vendors) of interfaces. This talk will provide an overview of the generic architecture approach aimed at ensuring interoperability between UXVs and future STANAG instantiations (reference and/or commercial implementations). This talk will also present the implementation of an example ROS-based SOA for a gateway buoy. This gateway buoy enables the interoperability of CMRE's high frequency synthetic aperture sonar (HF SAS) system called *MUSCLE* with standard unmanned mine countermeasures (team of) vehicles.

Multi Domain Control Station and Multi Vehicle Interoperability

Francesco Baralli, NATO STO CMRE

TBD

Middleware for AUV operations at CMRE: MOOS and other standards

Alberto Grati, NATO STO CMRE

TBD

Tuesday the 5th of December

Underwater Communications

Joao Alves, NATO STO CMRE

The talk will provide an overview of the work being done at CMRE in the domain of underwater communications. It starts by setting the problem and laying some of the challenges of the field, going then into specific details on how CMRE is working to tackle them. An overview of the achievements in the last few years will also be provided with emphasis on experimentation and field results. Since interoperability is a key aspect of communications in any domain and a fundamental aspect in an alliance of 29 Nations, the development of JANUS – the first ever standard for digital underwater communications will also be approached in this talk.

Operational use of gliders for ocean sensing

Bartholome Garau, NATO STO CMRE

The talk will provide an overview of oceanography as a field of application for AUVs, especially for underwater gliders. First of all, it will provide a motivation to use gliders in oceanography. Then in the next sections, the concept of underwater gliders will be shown, from their basic principles to their scientific capabilities. Finally, some applications and issues arisen from its operation will be discussed.

Underwater Networking

Dr. Roberto Petroccia, NATO STO CMRE

This talk will present the challenges in building distributed ad hoc underwater networks with special attention to Medium Access Control (MAC) and routing solutions. Difference and commonalities with respect to ad hoc terrestrial Wireless Sensor Networks (WSNs) will be presented and discussed.

Design and implementation of a Wireless Underwater Battery Recharger for eFolaga class AUVs.

Vittorio Grandi, NATO STO CMRE

Despite the growing popularity and widespread use of AUVs, which, in recent years, have found increased use in commercial, military and scientific areas, one significant limitation to the systems remains. In order to operate submerged and untethered, an AUV must carry on an on-board energy source. The energy source is often the driving factor in the size of an AUV, particularly as the trend toward smaller AUVs continues. Most AUV systems in existence today are deployed and retrieved by surface ships or small boats. The deployment and retrieval operations are often hazardous, time consuming and limited by environmental conditions. Therefore, it is desirable to limit the number of deployment/retrieval cycles. This further drives the need for longer-endurance AUVs. One means of solving the problem of extending AUV endurance is to create a means of replenishing the energy source without recovery the AUV to the host platform. The goal of this research was to solve the problem of AUV endurance through the development of an underwater battery recharging system to efficiently recharge AUV batteries in situ. The talk will describe the power supply system using Inductive Power Transfer technology to power up to five Polymer Li-Ion battery chargers over a water gap of 10 mm. With minor modifications, the system architecture allows for scalability in terms of available output power and flexibility.

Modelling and Simulation at CMRE

Dr. Alberto Tremori, NATO STO CMRE

Modelling and Simulation (M&S) is one of the strategic areas of interest for CMRE to support R&D initiatives developed at the centre. The use of M&S techniques allows for a better understanding and a safety implementation and testing of new concepts and technologies. All these developments promote the use of standards and standard based interoperable simulators to enhance the quality of the final simulation environment. This talk will introduce the work of the Modelling and Simulation group.

Wednesday the 6th of December

Robotics for Autonomous Submarine Warfare (ASW)

Dr. Gabriele Ferri, NATO STO CMRE

Traditionally, the task of Anti-Submarine Warfare (ASW) is a capital asset-intensive activity and has been carried out by means of fixed sensors such as sonobuoys and mobile assets such as Marine Patrol Aircrafts and submarines or frigates with towed array. The ASW final objective is to infer from the large amount of collected data if a target is present in the area and to track it for its correct classification. Existing traditional approaches can be expensive and asset intensive.

Recent advances in marine robotics have made small and low-cost AUVs an opportunity. These results suggest that Maritime Unmanned Systems (MUS) can become part of underwater surveillance systems since they can guarantee the persistent monitoring of an area at lower costs than traditional assets and offer the possibility to complement or even substitute current solutions. Compared to traditional assets, these small, low-power and mobile units have usually limited processing and communication capabilities. However, when deployed in a spatially separated network, they can be interconnected to form an intelligent network characterised by scalability, robustness, reliability and adaptability.

This talk analyses the use of autonomous systems in ASW applications, their potentialities and the challenges still open. The talk will focus on how autonomy can increase the performance of the network. Autonomous decisions are indeed necessary when a reliable communication link cannot be guaranteed from a Control Station to the network nodes. Autonomy can increase the network performance allowing the robots to use their mobility to adapt their mission to the changing environmental conditions and to the evolving tactical scene. This can improve the network performance in terms of target tracking/classification and of an increased area coverage (higher temporal and spatial resolution) in area search/patrol tasks.

3.3 – Live demonstrations

The demonstrations will not take place in CMRE's laboratories except for the simulation one. Instead, they will take place in CMRE's sea basin, a real environment as trials will be taking place throughout the week. This will allow the participants to get in touch with real trials as well as to be more flexible in the interaction with the researchers involved in the trials.

Wednesday the 6th of December Morning

Demonstration of AUV mission simulation

Recent developments in Autonomous Systems allow them to complete tasks of increasing complexity, over longer periods of time without direct supervision. For this reason, it is necessary to create new frameworks that will allow behaviours to be tested and eventually trained. Modelling and Simulation (M&S) offers an ideal set of tools to create this framework.

This demonstration shows the capabilities of using a distributed M&S framework to test and train the autonomous engines used in an Unmanned Underwater Vehicle (UUV). The demonstration will be used to explain how the M&S framework can support the testing of the autonomous systems. The ability to evaluate the performance of the autonomous system under different scenarios and conditions will be shown. Furthermore the described framework can be used to train operators to tune or configure the UUV's.

Wednesday the 6th of December Afternoon

Live Demonstration of Underwater Communications

Participants will be able to visit the trials and understand how the concepts presented in the Underwater Communications and Underwater Networking talks are put in practice.

Thursday the 7th of December Morning

Live Demonstration of AUV Docking

Participants will be able to visit the trials and learn how the system presented in the Wireless Underwater Battery Recharging talk works in practice.

3.4 – Research lab visits

Thursday the 7th of December Afternoon

Visit to CMRE's Laboratories

Tour of the facility with visits to several of the laboratories presented in the talks.

4 – SPEAKERS

**SPEAKER'S
BIO**



Stefano Fioravanti

Dr. Stefano Fioravanti graduated from the University of Genova in 1990 where he also received his Ph.D. in image and signal processing in 1993, working within the Dept. of Biophysics and Electronic Engineering. In 1995 he joined the NATO CMRE as a scientist, working on sonar signal processing, image analysis and sonar design for buried object detection and classification, with a particular emphasis on Synthetic Aperture Sonar.

In 2000 he moved to the Engineering Department where he is currently Head of the Portable Sensors Branch. Among other projects, he has worked on the system design, autonomy and design/integration/processing of advanced sensor suites for Unmanned Surface Vessels, Autonomous Underwater Vehicles, and on the design of various underwater data acquisition/processing systems. Since 1990, he led many EU funded projects (MAST-WAICS, BRITE-ASSIST, MAST-DEO, FP7-ARGOMARINE, ICARUS et. other)

He is currently CMRE project leader for the CAMELOT H2020 project, dealing with the design of a standard multi-domain control station for unmanned vehicles.

He was also professor of Applied Oceanography for Military Operations at the Naval Academy School of Livorno during the period 2001-03.



João Alves

João Alves, BSc., MSc. in Electrotechnical Engineering, Control and Robotics by the Technical University of Lisbon. He has been working in underwater robotics and associated technologies since 1995. He had a key role in the development of the hardware and software architectures for the MARIUS AUV and DELFIM ASV developed at the Technical University of Lisbon. In 2003 he co-founded a private start-up company – Blue Edge Systems Engineering, offering services and conducting R&D activity in the maritime domain. In 2007 he took scientific leadership for the underwater communications activities of the EC project GREX where pioneering maritime cooperative robotics was demonstrated. In late 2009 he joined the NATO Undersea Research Centre (NURC), now Centre For Maritime Research and Experimentation (CMRE) as a scientist to work on underwater communications. He led studies in support of establishing the first underwater communications standard and developed innovative protocols for underwater ad hoc networking.

In 2014 he took a leadership role as Principal Scientist responsible for the underwater communications activities at CMRE. He conducted several trials as scientist in charge, leading teams of several tens of people during long sea-going campaigns. He led the CMRE underwater communications project through the landmark promulgation of the first ever digital underwater communications standard – JANUS. During this period he also served as PI for different European commission projects (like MORPH and SUNRISE) and was co-general chair for the IEEE OES UComms14 and UComms16 conferences. He is an invited lecturer for the Masters in Ocean Engineering offered by the University of Pisa (ITA), editor of the Elsevier Journal of Ad Hoc Networks and guest editor of the IEEE Journal of Oceanic Engineering. He is a member of the ACM, AFCEA and Senior Member of the IEEE OES. He also serves as an active member of the AUVSI subcommittee for the international regulations for preventing collisions at sea, dealing with the challenging issues of adding robots to our Oceans.

Bartholome Garau



Bartolome Garau, BSc., MSc. in Computer Science by the University of the Balearic Islands. He has been working in underwater robotics and associated technologies since 2004. He started with AUVs and oceanography during this PhD program at IMEDEA research centre. He collaborated there with different scientists in several research project, both at national and European level. He tackled in this period the basics of physical oceanography and the different observing platforms, ranging from moorings, drifters, remote sensing, and gliders. In 2009 he participated into the creation of SOCIB, the coastal observatory in the Balearic Islands, as the Data Centre Leader. In this period, he approached the data management lifecycle for such a heterogeneous observing network. In 2012 he moved to CMRE in order to pursue his interests in the embedded technology development. He has been working in both the operations of the gliders' fleet at CMRE as well as the development of new capabilities for these vehicles.

Dr. Roberto Petroccia



Dr. Roberto Petroccia (M) is a Research Scientist at the NATO Centre for Maritime Research and Experimentation (CMRE). He received a Laurea Degree with the highest honours (2006) and a Ph.D. (2010), both in Computer Science, from Rome University "La Sapienza," Italy, where he has been also affiliated as research staff until 2015. His research interests include wireless sensor networks design, underwater communications and networking, where he has contributed over three dozens papers published in leading venues (hindex=15, i10index = 23, Google Scholar, November 2017). He has participated in several EC projects including the EC IP projects ESENSE, SENSEI, the FP7 STREP CLAM and the FP7 SUNRISE. For the two latter projects on underwater networking, he was in charge of coordinating all underwater experimental activities. In the last seven years Dr. Petroccia has participated to over thirty experimental campaigns at sea where innovative underwater solutions he developed have been extensively tested. He has been actively collaborating with several acoustic modem and underwater vehicle manufacturing companies and research labs to design novel technologies supporting cooperative underwater acoustic networks. Dr. Petroccia has supervised the work of several master thesis and Ph.D. students, he is also a member of IEEE.



Vittorio Grandi

Vittorio Grandi was born in La Spezia on 1953 and received the M.Sc. degrees in electronic engineering at the University of Pisa, Italy, in 1977.

After 15 years' experience as analog and digital designer in various local companies, he joined CMRE (formerly SACLANT CENTRE) in 1993 as head of the Electronics and Data Acquisition Section of the Engineering Department.

His responsibilities include:

Design, development, construction and/or procurement, test and operation of acoustic, magnetic and electronic sensors and systems with their conditioning circuitry, acquisition and processing package, telemetry systems and computer interfaces in support to the ED activity.

General laboratory and human-resources management (e.g. electronics cabinets assembly & wiring, multilayer PCB design, PCBs components mounting, etc.).

Project leadership.

Participation to the SPOW sea trials as Engineering Coordinator.



Dr. Alberto Tremori

Alberto Tremori is an electrical engineer with a PhD in Modelling and Simulation (M&S). He has more than 20 years' experience working on innovative projects with international organizations, industries and academia. After his master, he worked for different ICT companies (IBM, Xerox, IDC...). In 2007 he co-founded and managed a start-up linked to the University of Genoa. He was also manager of a consortium providing simulation based training in Logistics and Transportation.

In 2010 he moved to academia as a researcher at the University of Genoa - Simulation Team managing international R&D projects and as a lecturer (project management, logistics). In 2012 he completed his PhD.

In 2014 he joined NATO as M&S Scientist at CMRE where he is currently Project Leader focusing on future trends of simulation in NATO, interoperability, autonomous systems and standards.



Dr. Gabriele Ferri

Dr Gabriele Ferri received the Laurea degree (M.S.) in Computer Engineering (with Honors) from the University of Pisa, Italy, in 2003. From 2003 to 2005, he worked as a Software/System Consultant Engineer for WASS company (a Finmeccanica group company) in Livorno, Italy, developing a new System of Control and Guidance for a light-weighted torpedo. He earned a Ph.D. in Biorobotic Science and Engineering jointly from Scuola Superiore

S. Anna, Pisa, Italy and IMT Advanced Studies, Lucca in 2008. In 2007 he was a visiting researcher at Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA. After a period as a Postdoctoral Investigator at Scuola Superiore Sant'Anna in which he worked as Project Leader of the HydroNet project, in 2012 he won a position as Research Scientist at the CMRE to investigate novel approaches for the autonomy of AUVs in ASW applications. His research interests include robotic systems for environmental monitoring/exploration, control theory and robot navigation topics. He has been the Technical Director of SAUC-E from 2014 to 2016 (Student Autonomous Underwater Vehicle Challenge-Europe) (<http://sauc-europe.org/>) and of euRathlon 2014 and 2015 robot competitions (www.eurathlon.eu) and Technical Director of the European Robotics League Emergency 2017.

5 – SOCIAL PROGRAMME

5.1 – School dinner (TBC)

The school dinner will be in Ristorante Cristobal, San Terenzo (<http://www.ristorantecristobal.it/>) on the evening of 6th December. The restaurant is located in the seafront between San Terenzo and Lerici. It serves a fish and sea food based menu that we hope the participants will enjoy!

Please be there at 7:30 pm for 8:00 start. The address is as follows:

Via S. Biaggini, 42, 19032 Lerici (<https://goo.gl/maps/U73BknnKMk>)



6 – PARTICIPANTS

6.1 – Speakers and trainers

N°	Name	Institution	E-mail
1	Per Arne Sletner	NATO STO CMRE	PerArne.Sletner@cmre.nato.int
2	Stefano Fioravanti	NATO STO CMRE	Stefano.Fioravanti@cmre.nato.int
3	Francesco Baralli	NATO STO CMRE	Francesco.Baralli@cmre.nato.int
4	Alberto Grati	NATO STO CMRE	Alberto.Grati@cmre.nato.int
5	João Alves	NATO STO CMRE	Joao.Alves@cmre.nato.int
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11	Fausto Ferreira	NATO STO CMRE	Fausto.Ferreira@cmre.nato.int

6.2 – Participants

N°	Name	Institution	E-mail
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CAP (Centre for Applied Photonics), **CRAS** (Centre for Robotics and Autonomous Systems), **CSIG** (Centre for Information Systems and Computer Graphics).