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GROOM II
GLIDERS FOR RESEARCH, OCEAN OBSERVATION & MANAGEMENT : INFRASTRUCTURE AND INNOVATION

Project acronym: **GROOM II**

Project title: Gliders for Research, Ocean Observation & Management: Infrastructure and Innovation

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Abstract

Autonomous underwater and surface ocean vehicles have become **essential observational platforms** which contribute to the Global Ocean Observation System (GOOS). These autonomous vehicles have had a very rapid technological development, so adaptation to their use has required some improvisation to establish **the training and capacity development** that would **generate appropriate personnel** (technicians, pilots and data managers mainly) as quickly as possible.

This training activity has been widely **supported by** the institutions that make up the **network of operators** (OceanGliders) and the **main manufacturers** of these technologies, as well as some stakeholders.

This document describes the **existing proposals to direct training and capacity development**, detailing **those intended for beginners** such as Glider Schools or summer schools, **the more complex courses organized by manufacturers** and other courses aimed at generating the **harmonized use of these observation technologies** that seek to achieve an **appropriate use** (Best Practices) and **convenient management of observations** for a globalized context.

Finally, the document explains the **future role of GROOM RI** as **the driving force** and **coordinator of these activities**, supporting existing proposals and helping to fill existing gaps, fundamentally favouring the incorporation of women and reaching developing countries where these technologies would help speed up developments.

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List of Abbreviations

EGO	Everyone's Gliding Observatories
EGU	European Geophysical Union
EMB	European Marine Board
EMSO	European Multidisciplinary Seafloor Obser Observatory
FEUP	Facultade Enginheria Universidade Porto
GOOS	Global Ocean Observation System
GROOM RI	Gliders for Research, Ocean Observations and Management – Research Infrastructure
ICOS	Integrated Carbon Observation System
JERICO	Joint European Research Infrastructure of Coastal Observatories
LSTS	Underwater Systems and Technology Laboratory
MAS	Marine Autonomous Systems
MIT	Massachusetts Institute of Technology
MPP	MIT Portugal Program
OBPS	Ocean Best Practices System
PLOCAN	Oceanic Platform of the Canary Islands
SING	Swedish INternational training in ocean Gliders
SMHI	Swedish Meteorological and Hydrological Institute
SND	Swedish National Data Centre
SOCIB	Balearic Islands Coastal Observing and Forecasting System
SOPs	Standard Operating Procedures
T&CD	Training and Capacity Development
VOTO	Voice Of The Ocean

Table 1 – List of abbreviations

1. Introduction

Autonomous underwater and surface ocean vehicles have become essential platforms in their contribution to the Global Ocean Observation System (GOOS). These platforms join with satellite observations, research vessels, autonomous floats, fixed-point observatories, sea level stations and high frequency radars to coordinate a harmonised and collaborative observational program over the oceans (Figure 1).

Figure 1 -Picture titled "Studio on Ocean Observation Technology" published by Glynn Gorick, who produced it for UNESCO/IOC/GOOS. We have added a new observational platform (Autonomous Surface Vehicles- ASV) *https://goosocean.org/index.php?option=com_oe&task=vie*

These new technologies require precise training for their use and the use of the observations they acquire. All these vehicles are complex devices that need well-trained operators (pilots, technicians, and data managers) for their start-up, use and maintenance. Furthermore, these vehicles aimed at marine observation carry a payload of various marine sensors with different electronic characteristics that also require specific knowledge, as well as a combined use with the rest of the vehicle's sensors and navigation system. Thus, the pilots of these vehicles require complex training to acquire skills both in the management and engineering of these vehicles and in the environmental characteristics of the oceans, in order to understand and achieve the scientific objectives pursued in each mission.

All these needs and the dizzying evolution of autonomous observation vehicles have led to the production of a learning market for the use of these technologies adapted to the urgent needs of having appropriate personnel. Thus, marine scientists have become pilots and technicians of the selected underwater or ASV technologies or technicians who have been required to get involved in the world of oceanography. Despite these adaptations typical of the initial development in the use of the new technologies, their extension both in the scientific and industrial sectors, the labour market is demanding to find formulas that generate new qualified personnel that can be immediately incorporated without extra training.

A future research infrastructure for autonomous vehicles could play a crucial role in the preparation and training of personnel to acquire the skills to pilot, maintain, and adequately disseminate the data generated. GROOM RI has among its members trained people to design and teach the training courses required to cover the personnel needs that both public and private institutions with interests in the marine-maritime sector are already demanding.

This document firstly describes the conclusions obtained in the previous project based on the initial development of generating the European network of glider operators and then analyses the main initiatives that have been generated in the last decade aimed at training new glider users for these technologies, as well as in the attempt to harmonise their use based on the learning of good practices and the establishment of cooperation standards in the processing of the data and metadata that are generated. Finally, the authors present a series of courses for learning and improving existing capabilities as a proposal to be supported by the future Glider Research Infrastructure.

2. RETROSPECTIVE ON THE PREVIOUS PROJECT GROOM FP7

Looking back, the previous project GROOM FP7 already provided a description of actions and suggestions about training and capacity building.

2.1. SUMMARY OF THE REPORT

The activities on Capacity Building during the project GROOM (FP7-Infra-2011-2.1.1 “Design Studies”) were summarized in Deliverable 3.4 titled “Report on capacity building and websites completed”. The partners of task 3.3 had as a goal spreading the real value of the gliders for contributing to the Ocean Observation System. The first activity described by the authors was a survey where partners from the project were inquired regarding the means they had used to disseminate their glider activities to the general audience and stakeholders. They highlighted local TV programs, radio, printed press, meetings, and conferences. In addition, the survey also emphasized open days, laboratory tours and exhibitions as good events to reach young people and the general audience, where the scientists or glider operators explain, in a face-to-face mode, the use of these machines and the outputs achieved by them. However, and despite the proximity, it was not simple to get feedback from people participating in those events, but scientists and operators of gliders consider, even so, the face-to-face events are one of the best ways to communicate about glider activities.

In addition to the results from the questionnaire, the scientific session that took place during the 2013 European Geosciences Union annual Meeting (EGU meeting) was also highlighted as an important event to show the gliders' capacities. The oral presentations and posters, in a total of 25 contributions, were very diverse according to the subjects to deal with. The speakers talked about new technology developments, best practices or scientific studies addressing topics such as ecosystem variabilities, hydrography phenomena or impacts of the volcano eruption on the ecosystem. Another interesting speech was about glider integration in the multiplatform observational programs, pointing out the importance of the high resolution that those vehicles can offer.

From an academic point of view, several partners found a way to introduce the glider operations inside the university studies that focus on oceanography, observational applications and forecasting.

Therefore, University of Bergen in Norway, as well as two universities in Spain added in their marine studies curricula glider technology as a new platform for oceanography applications.

2.2. Lessons learned for GROOM RI

Since the results described in the deliverable 3.4 "Report on capacity building activities and web-sites completed", the authors distinguish between activities organised to spread the benefits that the gliders use produces for the society (mainly for science and for monitoring of ocean changes to evaluate anthropogenic impacts), and the activities addressed to maintain and improve the capacity developments of the glider community by organising training courses, schools of gliders or adding glider training programs to university studies. The authors highlighted the necessity of convincing the students, as soon as possible, about the attractive life of people working in operational oceanography and not wait until they must decide what studies they want to do. For doing that, the glider community needs sharing efforts and funding.

Other things to be considered are web presence. During the GROOM-FP7 project each partner runs an individual website, spending funding and ideas to maintain all the websites active and relevant. However, there are good examples of coordinated webs, for instance the EGO website, where members of the glider community share the virtual platform to disseminate glider activities around Europe/ World, mainly science progress, announcements of events, meetings, conferences, as well as supporting training courses. Finally, specific training for advanced glider users described in the report from the GROOM-FP7 project appears to be missed. Glider schools are organised to be addressed for beginners in the use of main technologies, however, advanced courses are only performed by manufacturers with singular contents according to each technology. There are few courses oriented to coordinate and harmonise the glider community in the several aspects of glider use such as mission planning, piloting, best practices or data management.

3. Mapping the European marine glider training landscape: survey results

To know the existing information about training and capacity development (T&CD) organised in the past or currently working, a survey was created during the GROOM II project, with the purpose to collect training and capacity building events done by the partners in the consortium. Fourteen responses were received from twelve partners. In the survey content, the first question investigated how many partners had participated in the organisation of T&CD activities and what kind of activities (Figure 2). The responses to the participation in T&CD were very positive with 85% of the interviewees responding that had organised/participated in such events.

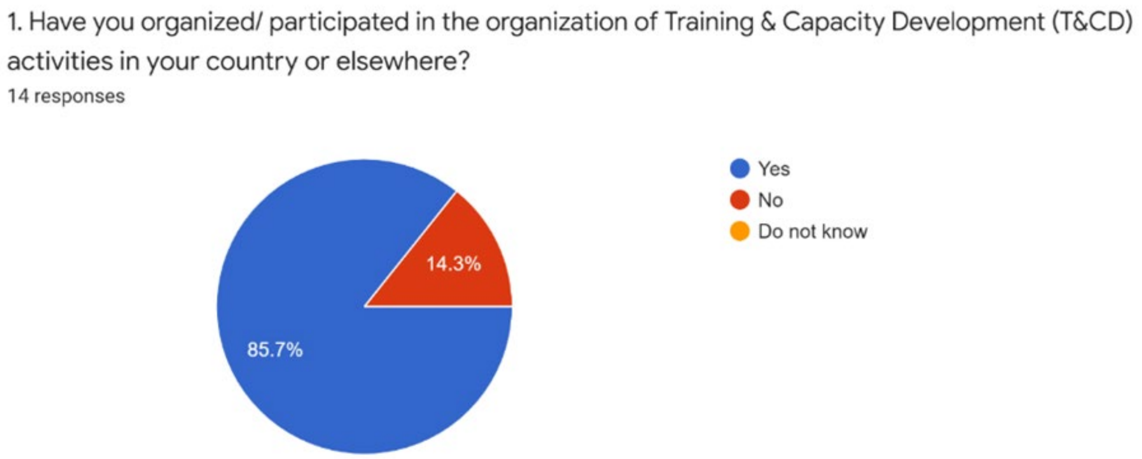


Figure 2 - Percentage of participants with experience in organising/participating in T & CD activities

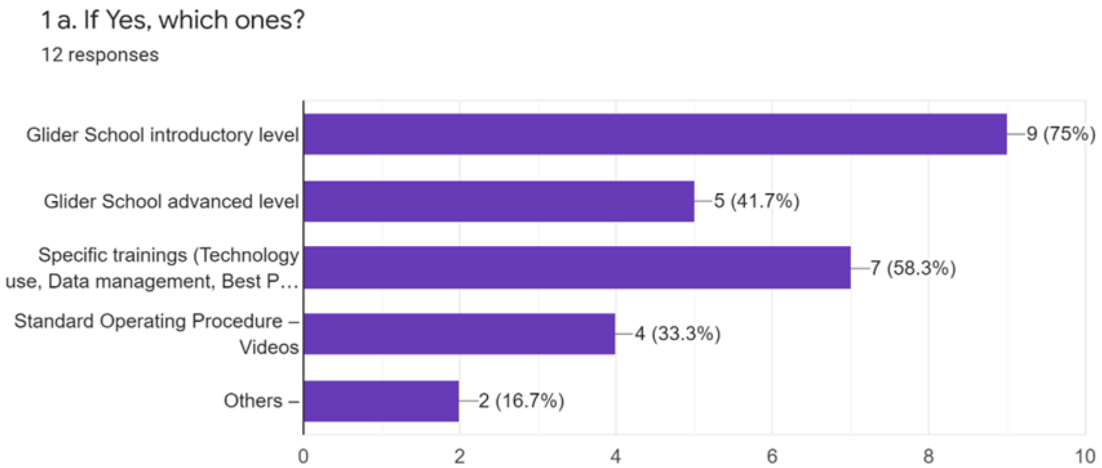


Figure 3 - Participation percentages of GROOM II members in the different existing glider training types

Regarding which activities the partners had organised/participated in (Figure 3), the glider schools aimed at beginners (introductory level of the technologies) obtained the highest percentage of the responses (75%). Most of the interviewees attended this training as a technology provider or student. The second highest percentage was for “specific training” that encompass training from manufacturers and training for best practices, data management, as well as internal refurbishment exercises within some facilities. The following type of training in the table was the advanced level. The distinction with the Glider School for beginners relies on the focus by the advanced level on only one or two technologies, teaching, in addition to the technical characteristics, the piloting operations and applicability fields during a period of one or two weeks. Finally, videos showing Standard Operating Procedures (SOPs) such as glider deployment and recovering, etc and other kinds of courses appear to be less utilised.

3.1. GLIDER SCHOOLS

3.1.1. EGO Glider School

Figure 4 - EGO workshop pictures from several editions

The Everyone's Gliding Observatories (EGO) was a global initiative to create a network for use of the gliders on marine observation activities. To share experiences among partners in the network, bi-annual workshops were organized (Figure 4). The workshops consisted of oral and poster presentations from participants chosen by a committee through selection processes. In addition, the agenda included some commercial presentations and hands-on activities about glider technologies to introduce new developments and basic applications to the attendees.

The first EGO workshop was held in Paris (France) in October 2006. The workshop took two days and around 25 people attended the event. The 2nd EGO Workshop and Glider School was held in the harbour of Calanova, Mallorca, Spain. The event was managed in two parts: two days workshops and three days Glider School. The workshop was attended by around 30 people, whereas nearly 40 people attended the glider school. The workshop agenda included 18 oral presentations and a discussion about foreseen plans from the glider facilities for next year (2008). Regarding the Glider School agenda, the attendees were divided in groups and went through the following topics, one topic every morning/afternoon. The topics were related to opening/closing procedures and ballasting, mission programming on simulators, data visualization, deployments at sea, piloting and data processing. The third EGO event was held in La Spezia, Italy in October 2008 and the number of participants reached

70. The event took five days, three days for the workshop and two days to carry out the Glider School. The next two EGO workshops celebrated in Larnaca (Cyprus- 2009) and Telde (Gran Canaria, Spain- 2011) were the last editions where the EGO workshop included Glider School sessions. The Telde edition in 2011 was followed by 150 attendees, the highest number of participants. The three next editions (Kiel, Germany 2014; Southampton, UK 2016 and New Jersey, USA 2019) changed the format of the workshop reducing from five days to only two days and removing those days addressed to hold the glider school.

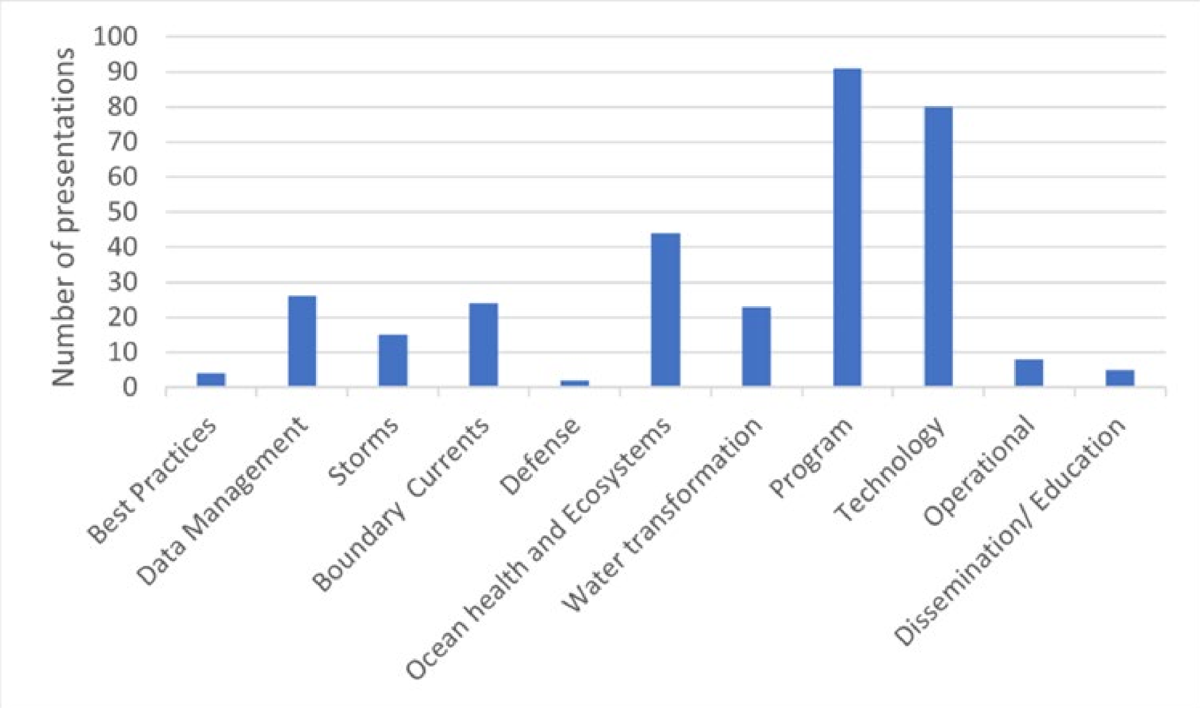


Figure 5 - Classification of the presentations carried out in the editions of the EGO workshop according to the topics covered

Since the double format of the EGO glider workshop covering the scientific exchange acquired from the use of glider (applications) and the Glider School (teaching how work these technologies), most of the presentations were addressed to show the technologies (vehicles and science payload sensors) and to present the observational programs using gliders at the different areas of the world oceans (applications, Figure 5).

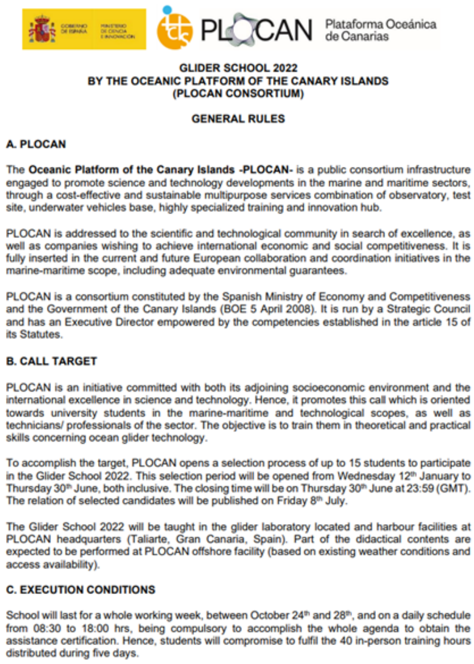
3.1.2. PLOCAN Glider School

PLOCAN Glider School started being the fifth EGO workshop in 2011. After this first edition, this annual event focused the following editions on teaching the glider technologies more used (introductory level) and facilitate the students and professionals from different sectors to have a first experience in the field (Figure 6).

Figure 6 - PLOCAN GLIDER SCHOOL pictures from several editions

The PLOCAN Glider School (Rueda M.J. and Barrera C., 2022) is organised in person sessions for one week (usually five days). The participants are selected from a first enrolment where they have to include, in addition to personal information, some aspects of their academy background or professional experience. Since the selection is done, the participants are supported to find travel and accommodation during the Glider School by the organisers. The participants must pay a fee for their participation in the training. The organisers have the possibility to support students coming from developing countries with some scholarships to cover the fee. The Glider School runs under quality certification rules (Figure 7).

The Glider School program/agenda consists of daily sessions. Each session is divided into eight-hour slots, in which both theoretical and practical sessions in the laboratory, confined and open waters are combined. In these sessions, students have access to learn about Slocum (Teledyne Marine), Seaglider (iROBOT, Kongsberg, HII), Spray (Bluefin Robotics, MRV Systems), SeaExplorer (ALSEAMAR), Wave Glider (Liquid Robotics), Sailbuoy (CMR, Offshore Sensing), OCEANSCOUT (Hefring Engineering) and AutoNaut (Seiche-AutoNaut) technologies, among others. Each of them includes several theoretical-practical sessions given by technical specialists belonging to the development companies themselves, in which they are shown from the concepts and basic principles of operation to mission planning and piloting interface, as well as scientific payload configurations, data management, assembly and disassembly, maintenance, ballasting, etc. from a perspective of basic training for beginners. In addition to the technologies mentioned above, every year the school invites other emerging technologies in order to give updated information about the glider market. The agenda also includes usual applications of these autonomous vehicles.



GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN PLOCAN Plataforma Oceánica de Canarias

GLIDER SCHOOL 2022
BY THE OCEANIC PLATFORM OF THE CANARY ISLANDS
(PLOCAN CONSORTIUM)

GENERAL RULES

A. PLOCAN

The **Oceanic Platform of the Canary Islands -PLOCAN-** is a public consortium infrastructure engaged to promote science and technology developments in the marine and maritime sectors, through a cost-effective and sustainable multipurpose services combination of observatory, test site, underwater vehicles base, highly specialized training and innovation hub.

PLOCAN is addressed to the scientific and technological community in search of excellence, as well as companies wishing to achieve international economic and social competitiveness. It is fully inserted in the current and future European collaboration and coordination initiatives in the marine-maritime scope, including adequate environmental guarantees.

PLOCAN is a consortium constituted by the Spanish Ministry of Economy and Competitiveness and the Government of the Canary Islands (BOE 5 April 2008). It is run by a Strategic Council and has an Executive Director empowered by the competencies established in the article 15 of its Statutes.

B. CALL TARGET

PLOCAN is an initiative committed with both its adjoining socioeconomic environment and the international excellence in science and technology. Hence, it promotes this call which is oriented towards university students in the marine-maritime and technological scopes, as well as technicians/ professionals of the sector. The objective is to train them in theoretical and practical skills concerning ocean glider technology.

To accomplish the target, PLOCAN opens a selection process of up to 15 students to participate in the Glider School 2022. This selection period will be opened from Wednesday 12th January to Thursday 30th June, both inclusive. The closing time will be on Thursday 30th June at 23:59 (GMT). The relation of selected candidates will be published on Friday 8th July.

The Glider School 2022 will be taught in the glider laboratory located and harbour facilities at PLOCAN headquarters (Taliarte, Gran Canaria, Spain). Part of the didactical contents are expected to be performed at PLOCAN offshore facility (based on existing weather conditions and access availability).

C. EXECUTION CONDITIONS

School will last for a whole working week, between October 24th and 28th, and on a daily schedule from 08:30 to 18:00 hrs, being compulsory to accomplish the whole agenda to obtain the assistance certification. Hence, students will compromise to fulfil the 40 in-person training hours distributed during five days.

Figure 7 - PLOCAN GLIDER SCHOOL quality certification procedures

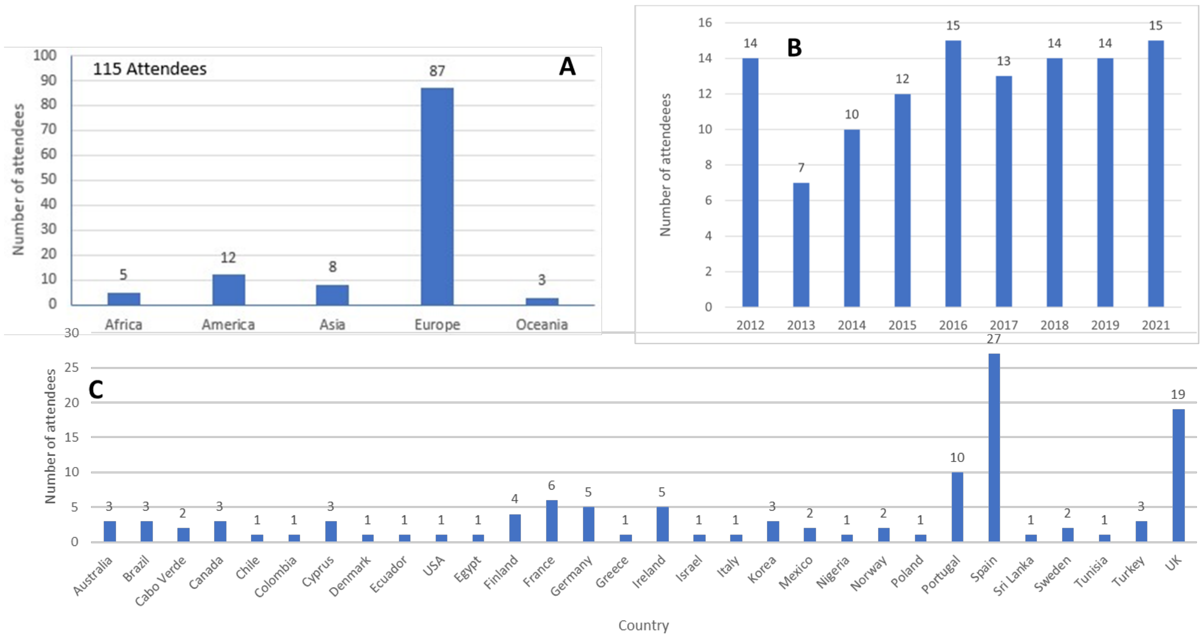


Figure 8 - A-Classification of the attendees by origin continent; B-Number of participants in each Glider School edition; C-Classification of the students by origin country

For its proper development, the PLOCAN Glider School provides a fleet of ocean vehicles from the VIMAS facility (Vehicles, Instruments and Underwater Machines) of PLOCAN, where the main commercial glider technologies are represented, in addition to own boats and facilities specifically designed, such technical and testing laboratories, piloting room, as well as direct, quick and easy access to both confined and open waters for practising in a safe and useful manner.

Nine annual Gider Schools have been held at PLOCAN facilities since 2012, the 2020 edition had to be cancelled because of the COVID pandemic. A total of 115 attendees have participated (165 having in account the fifth EGO celebrated in PLOCAN, Figure 9), coming from five continents, mainly from Europe (75%, Figure 8A). The average of participants has been around twelve and they come from thirty countries (Figure 8B and 8C, respectively).

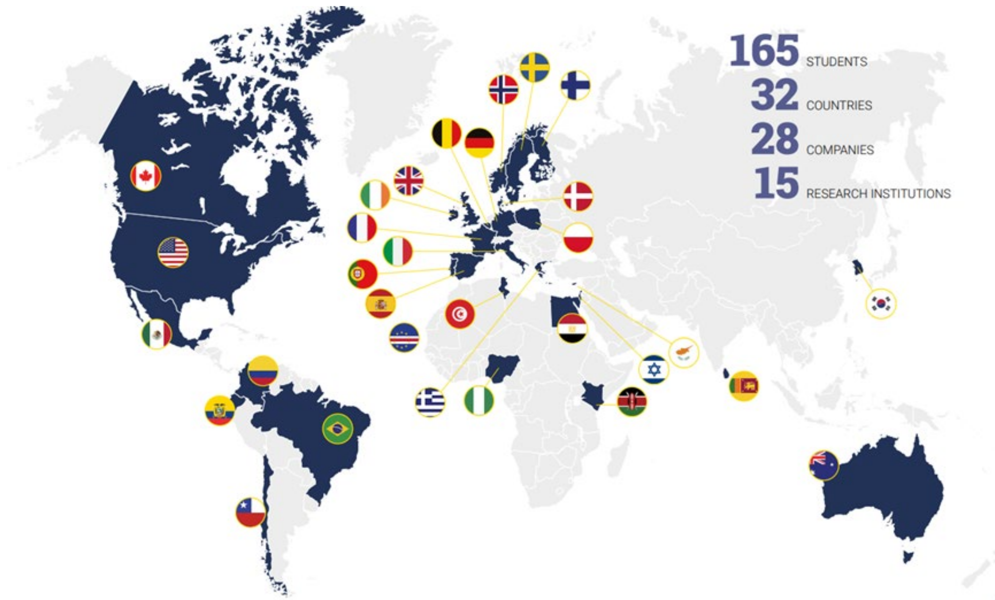


Figure 9 - PLOCAN GLIDER SCHOOL – Numbers adding the fifth EGO celebrated at PLOCAN and the next nine PLOCAN events, geographic distribution of the attendees

Regarding the agenda of the Glider School, this is distributed in five or six days, as mentioned above. The daily schedule is organised in theoretical classes during the morning and practise in the laboratory during afternoon at the four first days, having the last day, the in-situ practises with all of the technologies introduced along the week and using for these practises, the PLOCAN facilities in the port of Taliarte and open waters of the East coast of Gran Canaria.

In total of the editions, the teaching time for the theoretical and practising classes in the laboratory is shown at the figure 10A. The main topic is the introduction to the glider technologies, mainly Slocum, Wave-Glider, Sea Explorer and SeaGlider, being practically the 75% of teaching, the other 25% is focused on emerging glider technologies, applications and data management (Figure 10B and 10C, respectively). In relation to the speakers/ teachers, they mainly came from the USA and Europe and are members of the manufacturers teams, scientists and technicians specialised in the use of the gliders.

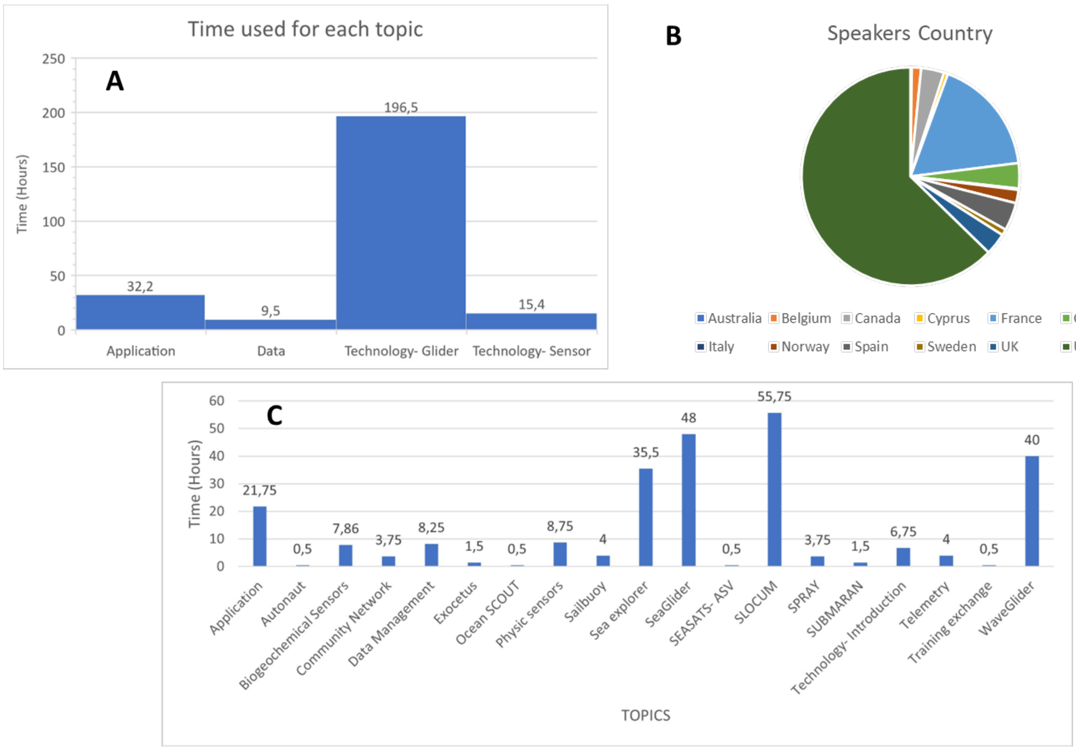


Figure 10 - A-Distribution of time by topic along all Glider School editions; B-Classification of the teachers by origin country; C-Classification of topics by time according to glider technologies and their applications

3.1.3. PLOCAN Glider School 2022. GROOM II Training

The Glider School 2022 was held at PLOCAN, Telde, Canary Islands, Spain in October 2022 from 24th to 28th (Figure 12). This new edition was supported by the GROOM II project. Sixteen participants attended the school, most of them from Europe (Italy, UK, Portugal, Germany and Spain) but three attendees came from Brazil, India and Senegal respectively. Nine of them work in Research Centres and Universities (Science and Education) and four in technological companies, only three were students.

This edition was scheduled in five days (Figure 11), from Monday to Friday, starting every day at 9:00h and finishing around 18:30h. The agenda distributed daily sessions dedicated to each one of the current main commercial ocean-glider and ASV technologies. Thus, Monday started with Seaglider technology (University of Washington- Huntington Ingalls Industries, Inc., represented by Cyprus Subsea), Tuesday sessions were dedicated to Glider Slocum (Teledyne), Wednesday was dedicated to autonomous surface vehicle technologies covering Sailbuoy (Offshore Sensing), Autonaut (Autonaut) and Wave Glider (Liquid Robotics) technologies and Thursday sessions were dedicated to Seaexplorer technology (Alseamar).

Glider School

PLOCAN Glider School-2022

Agenda www.gliderschool.eu

October 24th-28th, 2022. Telde, Gran Canaria, Spain.

Monday 24th (09:00 - 18:30 h.)

- 08:15 h – *Transfer to PLOCAN facilities.*
- 09:00 h – Opening & welcome. *Meeting Room*
- 09:15 h – Keynote. Ocean Gliders contribution to Global Ocean Observations -GOOS- **OCEAN-OPS**. *Meeting Room*
- 09:45 h – Glider Technology: SeaGlider – **CSCS-HII.** *Classroom*
- 11:15 h – *Coffee Break.*
- 11:30 h – Glider Technology: SeaGlider – **CSCS-HII.** *Classroom*
- 13:00 h – *Lunch.*
- 14:15 h – Glider Technology: SeaGlider – **CSCS-HII.** *Classroom/lab*
- 15:15 h – Glider Applications - **University of Alaska Fairbanks.** *Classroom*
- 15:45 h – *Coffee Break.*
- 16:00 h – Glider Technology: SeaGlider – **CSCS-HII.** *Lab*
- 18:30 h – *End session and transfer to the hotel.*

Tuesday 25st (9:00 - 18:30 h.)

- 08:15 h – *Transfer to PLOCAN facilities.*
- 09:00 h – Glider Telemetry – **CLS.** *Classroom*
- 09:30 h – Glider Technology: Slocum – **Teledyne Marine.** *Classroom*
- 11:15 h – *Coffee Break.*
- 11:30 h – Glider Technology: Slocum – **Teledyne Marine.** *Classroom / Lab*
- 13:00 h – *Lunch*
- 14:15 h – Glider Technology: Slocum – **Teledyne Marine.** *Lab*
- 15:15 h – Glider Science Payload: DVL – **Nortek.** *Classroom*
- 15:45 h – *Coffee Break.*
- 16:00 h – Glider Technology: Slocum – **Teledyne Marine.** *Lab*
- 18:30 h – *End session and transfer to the hotel.*

Wednesday 26th (9:00 - 18:30 h)

- 08:15 h – *Transfer to PLOCAN facilities.*
- 09:00 h – Glider Technology: Sailbuoy – **Offshore Sensing.** *Classroom / lab*
- 11:15 h – *Coffee Break*
- 11:30 h – Glider Technology: AutoNaut USV – **AUTONAUT.** *Classroom*
- 13:00 h – *Lunch*
- 14:15 h – Glider Technology: Sailbuoy – **Offshore Sensing.** *Classroom / lab*

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Glider School

- 15:15 h – Glider Applications – **SIO-UCSD.** *Classroom*
- 15:45 h – *Coffee Break*
- 16:00 h – Glider Science Payload – **Rockland Scientific.** *Classroom*
- 16:30 h – Glider Technology: WaveGlider – **EMS/MARUM.** *Classroom*
- 18:30 h – *End session and transfer to the hotel.*

hursday 27th (9:00-18:30 h)

- 08:15 h – *Transfer to PLOCAN facilities.*
- 09:00 h – Glider Technology: SeaExplorer – **ALSEAMAR.** *Classroom*
- 11:15 h – *Coffee Break*
- 11:30 h – Glider Technology: SeaExplorer – **ALSEAMAR.** *Classroom / lab*
- 13:00 h – *Lunch*
- 14:15 h – Glider Technology: SeaExplorer – **ALSEAMAR.** *Lab*
- 15:15 h – Glider Technology: Spray2 - **MRV Systems.** *Classroom*
- 15:45 h – *Coffee Break*
- 16:00 h – Glider Technology: SeaExplorer– **ALSEAMAR.** *Lab*
- 18:30 h – *End session and transfer to the hotel.*

riday 28th (9:00-18:30 h)

- *08:15 h – Transfer to PLOCAN facilities.*
- 09:00 h – Harbour & sea operations.
- *13:00 h – Lunch.*
- 14:00 h – Glider Applications – **Memorial University.** *Classroom*
- 14:30 h – Harbour & sea operations.
- 17:00 h – Diploma awarding and wrap up. *Classroom*
- 18:00 h – *End session and transfer to the hotel.*

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Figure 11 - PLOCAN GLIDER SCHOOL agenda contents from 2022 edition

From Monday to Thursday, the agenda was completed with sessions that were aimed at glider applications provided by leading operators (Memorial University, University Alaska Fairbanks, etc.), sessions for the use of telemetry systems (CLS) and science payload sensors such as the turbulence (Rockland Scientific) or current sensor (NORTEK AS), a session for the contribution of data obtained with gliders observation system of the ocean etc. Finally, Friday was the day dedicated to practical sessions with the available technologies (Sailbuoy, Seaglider, Slocum and Seaexplorer) in the port of Taliarte where the PLOCAN facilities are located and the surrounding open-waters at the East coast of Gran Canaria.

Figure 12 - Photo of the group in the edition 2022 supported by GROOM II

3.1.4. Swedish INternational training on ocean Gliders, SING

The Swedish INternational training on Ocean Gliders (SING) builds from the successful glider training completed near Gothenburg, Sweden in May 2017. This course has previously increased European and Swedish capability in using underwater gliders, their deployment/recovery, piloting and use of their data in science. The course has a focus on demonstrating how glider data is used to generate scientific findings (incl. oceanography and biogeochemistry). In 2017, this course had 16 course participants and 13 instructors/lecturers that came from 10 different countries - a truly international course. During the course SING was able to make use of key research infrastructure, such as the Kristineberg research station and new RV Skagerak (50m vessel), to enhance the glider training.

Main SING training objectives include:

1. Capacity building for using autonomous ocean vehicles and advanced technology for marine science in Sweden and Europe. This is a detailed end-to-end course which incorporates at-sea training on the RV Skagerak. This includes (a) why gliders and what they are, (b) how they are deployed and retrieved at-sea, (c) piloting and operating gliders, (d) how glider sample & experiment design, (e) data processing & conducting quality science using gliders. Lecturers include expert scientists in physical and biogeochemical oceanography using gliders, as well as experienced engineers & manufacturers.

2. International networking access for local & international researchers: new users require extensive exposure and consultation with experts in this field in order to learn and experience using gliders in research. By bringing international experts in glider technology to the Kristineberg research station and onto the RV Skagerak, participants will have continuous access to the experts that may foster

future collaborations and networks. In addition, participant to participant interaction will allow for networking development.

3. Demonstrating use and missions of gliders simultaneously with autonomous surface vehicles (ASV). Previous training included deployments with Autonaut. Future planned training includes using Sailbuoys in the training and demonstrating scientific benefit of using these platforms together.

Figure 13 - Students from SING (EUROFLEET training) are taken on practical glider deployments (RV Svea, 70m, left image, J. Edholm) and taught theory and scientific case studies using gliders (right image, S. Swart)

In October 2022, the latest version of this course was conducted in collaboration with the EuroFleets programme (Figure 13), with dedicated GROOM participant places. During this five-days training at Kristineberg, Sweden, 10 participants attended from a diverse set of countries and backgrounds (Brazil, Turkey, EU, etc). Deployments of a SeaExplorer were made to train students as well as using two modern research ships, the RV Skagerak and RV Svea.

The five days training was organized as follows:

- The first day was addressed for a general background about glider in the morning and glider deployment in the afternoon).
- On the second day we had a class on glider application and the requested information needed for the practical work which consisted of designing our own research cruise (definition of scientific questions, use of the research vessel, definition of stations, instruments needed, planning etc.).
- Day 3 and 4 were the cruise itself as well as data analysis from the glider on the evenings
- Last day focussed on data analysis and reports (we had to give a 30 min presentation about our data at the end of the day).

The full week was nicely highlighting the different applications of gliders in coastal oceanography as well as the incorporation of glider data in a multiplatform as an approach to a scientific challenge.

3.1.5. Summer School (Portugal)

The summer course (Figure 14) is organized by the MIT Portugal Program (MPP) in collaboration with the [LSTS](#) – Underwater Systems and Technology Laboratory (LSTS) from the Engineering Faculty of the

Porto University FEUP, the participation of Colab+ Atlantic, Massachusetts Institute of Technology (MIT), and the School of Engineering from University of Minho.

Figure 14 - Poster-web announcing the latest edition of the Summer School in Portugal

The goal of the course is to provide a comprehensive overview of Marine Robotics with special focus on applications in ocean observation, underwater archaeology and ecosystems mapping. The program includes LSTS overview, marine robotic systems overview, models, sensors, LSTS vehicles, LSTS tool chain, planning and control systems, oceanography, ocean literacy, introduction to underwater archaeology, introduction to ocean observation, introduction to ecosystems mapping, and application.

The course lasts two weeks, students (between 15-20 selected candidates) work on a project related to applications of oceanography, archaeology or ecosystem mapping using an underwater vehicle. Students have to prepare the vehicle, generate the campaign plan, etc. The students finally present their projects and test the vehicles in the water.

The course is structured for senior and grad students, preferably from engineering science fields (e.g., mechanical, electrical, and similar). Nonetheless, students from other science fields such as bio-engineering, geology, marine biology, geophysics and oceanography's areas are welcome.

To participate, a registration procedure is required through this platform https://mitportugal.slideroom.com/#/permalink/program/60818. The students have to provide their identification document, a document that verifies their university degree or the degree and course they are currently undertaking in the case of being a student. A letter of motivation as well as a letter of recommendation are both required in order to join the course.

There have been two editions, the last edition occurred in 2022 and was held on the island of Faial (Azores). The program can be found through this website https://www.mitportugal.org/activity/2022-marine-robotics-summer-school/program/.

3.2. Advanced training courses

3.2.1. *Training from Manufacturers*

Manufacturers of underwater and surface vehicles usually include or offer as optional courses on the use of their technologies as part of the procurement of the vehicle. These courses are designed by the manufacturer and are directed exclusively to the operation for the procured technology. Thus, these courses mainly describe the hardware and software in the vehicle, teach the general way of operating, from their deployment at sea, vehicle command and control operations during missions and subsequent recovery. They often also incorporate mission preparation procedures and vehicle maintenance tasks in land as well. However, the manufacturers do not certify that the participants have acquired enough skills to operate those vehicles, they only certify the participation in the course, thus the purchasing institution or company shares responsibility with the new operators when they begin their operation tasks.

This implies that there is no generic preparation, for example, for a glider or ASV pilot, but rather that pilots must learn the specifically required skills with each of the technologies given the existing differences in hardware and software between them. Despite the singularities of each technology, the knowledge of principles acquired with one technology often helps in training a new one.

Teledyne Webb Research (Slocum glider manufacturer), for instance, provides formal glider training for its customers – typically in the form of a five-day course, which covers Slocum Glider Basics of Operation, Maintenance, Opening/Closing, Ballasting, Troubleshooting, Mission Planning, Data Analysis, and a day on the water to practice Launch, Recovery, and various piloting exercises. They hold this course 3-4 times a year at their facility in Falmouth, Massachusetts, USA. They also offer customers the opportunity to host their trainers at the customer facility for the same course. A beginner training course usually has no more than 10 participants at a time with four instructors from the company. The training is organised with theoretical classes during the mornings and practices in the laboratory during the afternoons. In addition, Teledyne maintains close relationships with several Academic institutions for collaborative projects and training purposes. Most notably, the National Oceanographic Centre in Southampton, UK is Teledyne's European partner and recently opened the Slocum Glider European Service Centre and will be hosting Slocum Glider training activities in late 2023.

Figure 15 - Left- Alseamar training at PLOCAN; Right- Teledyne training at PLOCAN; Bottom-Seaglider training in Tasmania

Seaglider manufacturing has shifted over the years from the original developers, the University of Washington to several licensees: iRobot, Kongsborg, Hydroid, and lastly Huntington Ingalls Industries Unmanned Systems, Inc (HII). In 2023, the license for manufacturing was given up by HII, and manufacturing returned to the University of Washington Applied Physics Laboratory (UW-APL). Customer support and training are now supported by both UW-APL, and Cyprus Subsea Consulting and Services C.S.C.S. Ltd (the only commercial representative of Seaglider manufacturers prior to 2023). CSCS offers both basic pilot training for everyday operations and maintenance and data management, as well as advanced maintenance training. Like other manufacturers, courses consist of both theoretical (general and Seaglider-specific) and hands-on training with gliders, servers, and data sets. Courses have been arranged on customer sites, and in other locations where a glider is available and sea trials can take place. In 2022 and 2023, courses were held in Tasmania (piloting and maintenance over 10 days, Fig. 15), Saudi Arabia, and Seattle (both piloting over 5 days). A day of Seaglider introduction was provided at the PLOCAN Glider School by CSCS in both 2022 and 2023. APL-UW offers training on demand, according to specific customer requirements.

PLOCAN, one of the partners participating in the GROOM II project and responsible for this report, contracted two courses from Kongsberg, the manufacturer of Seaglider at the time, after purchasing the vehicles: one for everyday operations, and one for maintenance (both at the PLOCAN facilities in the Canary Islands). Similarly, PLOCAN contracted another training with the purchase of a Sea Explorer Glider through Grafinta, Spanish representative of Alseamar (manufacturer of the Sea explorer technology). The training program lasted five days to introduce hardware and software of this vehicle according to piloting and maintenance, as well as other learning necessities relative to its use (Figure 15 left). Typical Alseamar training following purchase of a Sea explorer consists of 2-to-5-day workshops based on the experience and desired skills of the trainees. The main two day workshop focuses on pre-mission operations, mission planning and piloting while the longer workshop also includes training on opening and performing basic servicing of the vehicle (i.e. sensor changes on the payload bay).

The courses taught by the manufacturers have clearly similar content given the function that these vehicles serve and the similar characteristics that they have, differentiated by the singularities of each technology. There is also a pattern in the courses, the manufacturers have no responsibility for the learning of the participants, that is, the manufacturers do not control the skills acquired by the participants, they only certify their training participation and completion (Figure 16).

Figure 16 - Image of the training completion certificate provided by a manufacturer

3.2.2. Data management courses

Even though training focusing on glider data and metadata management is essential for the European glider infrastructure, such courses do not exist yet in Europe and abroad. That said, it does not mean that nothing has been done at the European level to support the glider data/metadata management. Below is a list of a decade of sessions/events dedicated to this topic.

- Glider School in Plocan - 2014 to 2016 - First attempts to demonstrate the real time data and metadata flows during the practical training day of the PLOCAN glider school.

During the week of the PLOCAN glider school, one day is dedicated to the operation at sea. Gliders are deployed and piloted by the student during this day. For 3 years we promoted along with the training on piloting and deployment the real time flow (from metadata registration to data processing) of gliders data. Despite the success in the processing, this was not convincing enough to be continued. The PLOCAN glider school students are more interested in discovering and learning on the technology than in the data management. After 3 years, it seems that data management can be introduced during events like the PLOCAN glider school, but it really deserved a dedicated training course.

- OceanGliders meeting in Genoa - 2018 - European Glider data management meeting (Figure 17).
  (https://www.ego-network.org/dokuwiki/doku.php?id=public:egodmmeeting:september2018).

Figure 17 - Participants in the OceanGliders meeting in Genoa

In 2018, a week of meetings dedicated to glider data management has been organized by the European community. The last day of this meeting was dedicated to "hands on" training on data management. During this day, both SOCIB and Coriolis had a slot to train the audience on their toolboxes.

- OceanGliders meeting in Rutgers (USA) 2019 - Breakout session

The 8th EGO meeting was organized in Rutgers University, New Jersey, USA.

This event also dedicated a session on data management and breakout session on data management, focusing on the practical aspect of metadata management. This was not exactly a "training session", but the focus was made on solving practical issues on this topic (Figure 18).

- EU Glider Data Management meeting June 2022 - Virtual meeting

European Glider Data Management Workshop Agenda Week 1

by GROOM RI - EuroSea - EuroGOOS Glider Task Team

Monday June 20 2022

14:00 – 15.30 CEST - Plenary - introduction

- OceanGliders and GROOM RI – EuroSea – EuroGOOS context
- Status of the European Real Time glider data management system in the international context
- OceanGliders BP and SOPs
- OG1.0 the common format for gliders

16:00 - 17:30 CEST GitHub Training

Tuesday June 21 2022

11:00 - 12:30 CEST Metadata management and controlled vocabularies

- The concept and the benefit of common vocabulary

Quick review of the existing vocab

- OceanOPS vocab and tools
- Current OG1.0 vocabulary
- NERC Vocabulary Server (NVS) introduction

NVS demo and governance - 20 min

- Vocabulary governance (example Argo)
- NVS search
- Adopting a vocabulary

EGO form to facilitate metadata management

- Online tool demonstrator

15:00 - 16:30 CEST T&S RTQC and Data Management

Wednesday June 22 2022

11:00 - 12:30 CEST Chlorophyll-a RTQC and Data Management

15:00 - 16:30 CEST Real Time QC – toward harmonization in Europe

Thursday June 23 2022

15:00 - 16:30 CEST O2 RTQC and Data Management

Friday June 24 2022

14:00 – 15.30 CEST Plenary

Figure 18 - Agenda for the first week during the European Glider Data Management Workshop

This event was organized under the auspice of the GROOM II project. It brought together most of the EU glider community involved in glider data management. This very successful event covered all the aspects of data management with some sessions dedicated to very technical issues on management of Essential Ocean Variables delivered by glider. This event was very much connected and complementary to the OceanGliders Best Practices effort made in 2021 with the support of EuroGOOS glider task team and EuroSea project.

Again, even though these are not “training sessions” only, these sessions highly contribute to the improvement of the glider data management in Europe.

- UG2 meeting in US September 2022 - breakout session on data management

In October 2022, the US glider community organised its bi-annual meeting.

Again, a dedicated breakout session on data management was organised, focusing on technical aspects of data management and global harmonization. This is not exactly a training session, but this kind of discussion increases the general knowledge of the attendees and can clarify some blocking points for data managers.

- VOTO workshop

In January 2023, the Swedish Meteorological and Hydrological Institute (SMHI) and Swedish National Data Center (SND) and the Voice of the Ocean Foundation (VOTO) organised a day devoted to ERDDAP, a data server used for physical, chemical, and biological marine and atmospheric data. ERDDAP is a data server that gives you a simple, consistent way to download subsets of scientific datasets in common file formats and make graphs and maps. ERDDAP acts as a middleman between the user and various remote data servers. Glider data is easily delivered and accessed via ERDDAP and a part of the workshop focused on accessing VOTO data through ERDDAP. Training and a codebase were also provided to allow other scientists, including glider users, to establish their own ERDDAP server.

- OceanGliders metadata tutorial videos

In this section dedicated to training on data and metadata management, it is also worth mentioning the tutorial video related to metadata management at OceanOPS. The videos are available under the OceanGliders playlist of the OceanOPS channel on YouTube here: https://www.youtube.com/playlist?list=PL89LpWLL5SSMZumIyOd7J-vuU03h5sjLK

With a decade of activity around glider data and metadata management training, what is clear is the constant appetite from the data management community on this topic and the lack of dedicated, structured and coordinated training at the European level. Even if the impact of such a gap is hard to assess, it is clear that with such support to operators and data managers, the flow of standardised, high quality, real time and delayed mode glider data flow will grow faster in Europe and beyond.

3.2.3. SOPs videos

Videos on standard operating procedures (SOPs) have been suggested internally as a way to help harmonize operating procedures. Many of the operations that are carried out with the gliders are usually recorded, in order to examine the good practices achieved, as well as to serve as a guide for new operators who are beginning these tasks. In this way, it seems easy to establish a dynamic that generates specific videos that visualize standard operations some basic glider-related steps such as installing wings, removing sensor caps, but are mainly designed to show the field operations, for example, launching and recovering vehicles from different vessels or under diverse sea-weather conditions, verification of the proper functioning of the sensors, etc. SOPs in the format of a video are much easier to use.

To this end, GROOM RI will establish an internal protocol that defines how to prepare said SOPs videos (maybe with a specific template) and the procedure by which they will be reviewed, approved and endorsed to form part of a repository of Good Practices. The repository must be chosen by the GROOM RI community, although it may be the already existing Ocean Best Practices System (OBPS) where numerous documents related to good practices in ocean observation already exist.

Once the repository has been chosen, the name for the GROOM RI community would be defined. Once informed, the community will then be required to follow the official procedures including any assembly, review and endorsement procedures carried out by GROOM RI for these Best Practices videos identified with the name of this Community.

3.2.4. *Academic Training*

There is significant glider-related training occurring during student studies at various institutions and universities across Europe. Most research groups require students to be trained as glider pilots or field assistants on using gliders in order to maintain a critical mass for research using gliders. This training occurs mostly around the Masters, PhD and Postdoc level. In addition, certain institutes (e.g. VOTO, Gothenburg, Sweden) employ Masters students as their principal piloting team, under oversight of one staff pilot thereby providing an indirect, yet important and consistent training capability to the glider community.

Rutgers University (USA) offers a specialty in Marine Sciences (undergraduate and graduate) where its students, in addition to ocean sciences, learn on the use of technology to carry out marine observation. In these studies, the students also learn the use of gliders and even get to participate in missions aimed at the observation programs in which the University participates (endurance lines, Hurricane season, etc.). Rutgers University offers a master's degree in operational oceanography where students learn glider management, from start-up, ballasting, piloting and mission preparation. Also, they learn to handle and process the data collected during the missions and its scientific interpretation. This university, finally, also offers a five-day summer campus for students not trained in the use of gliders.

4. TRAINING TYPES FOR FUTURE GROOM RI PROGRAM

The European Marine Board (EMB) published in 2018 a document titled ”Training the 21st Century Marine Professional: A new vision for marine graduate education and Training programmes in Europe”. The authors of this document included in section three called "The future of marine training in Europe: key challenges and opportunities" a description of the main objectives for marine training. Among the objectives related to the content of the courses, they focused on the need to incorporate interdisciplinary research, emphasize training in relevant transferable skills and bring graduates closer to industry and other relevant labour sectors, in order to achieve a guarantee of integrated quality. Other objectives were aimed at ensuring and promoting excellence in marine research, creating attractive institutional environments, and using innovative training methods. Finally, they suggested, as a method to achieve the objectives, to encourage the creation of networks and international collaboration.

Among the objectives described above, we have to take into account when we talk about capacity building in ocean research, the implementation of teaching linked to new technologies and increasingly aimed at attracting a younger audience, in order to inspire elementary and secondary school students to pursue careers in marine sciences to ensure generational change. At the same time, the participation of women in this sector of innovation must be supported from various labour, scientific or technological aspects. Nor should we forget to promote the growth in capabilities and innovation of those countries that are less equipped but whose contribution is required to improve knowledge of the ocean. To achieve all these objectives, greater mobility of personnel will be required, generating exchanges between industry and academia that facilitate the transfer of knowledge. It is very important to form operational networks that coordinate and support Training activities, generating global, homogeneous and harmonious growth that allows said exchange and the progress of learning.

This section provides a table summary of some of the key training to be organized or supported by the GROOM RI.

TRAINING TYPE	TRAINING CONTENT	TRAINING CONDUCTED BY WHOM	POTENTIAL PARTICIPANTS	TRAINING FORMAT AND FUNDING
GLIDER SCHOOL FOR BEGINNERS	Introduction to establish glider/USV technologies: - Operating principles - Sensor payloads - Applications - Limitations	Manufacturers/ Distributors and GROOM RI experts.	Students, scientific researchers and industry professionals without previous knowledge.	Generally, in-person courses, 1 to 2 weeks. Participant fees and some scholarships.
TRAINING FOR NEW USERS	<u>Platform-specific: training</u>: - Pilotage - Maintenance - Ballasting - Launch & Recovery - Data processing	Manufacturers and GROOM RI experts.	Students, scientific researchers and industry professionals with or without previous knowledge.	Generally, in-person courses, 1 week. Participant fees. Typically, alongside purchase of new vehicles or when hiring new staff.
TRAINING FOR ADVANCED USERS/ EXPERTS	<u>Platform-specific training</u>: - Advanced piloting - Advanced maintenance - Sensor–specific topics e.g. ADCP - Development	Manufacturers and GROOM RI experts.	Users with previous knowledge of the vehicle.	In-person or remote courses. 3 to 5 days. Participant fees.
SPECIALIZED COURSES BEST PRACTICES AND OPERATIONS	Training relevant to specific sensors (may be vehicle-specific or not): - Microstructure, ADCP, Oxygen, Acoustics, etc. - Piloting	Manufacturers and GROOM RI experts.	Students, scientific researchers and industry professionals, with previous knowledge of sensors or vehicles.	In-person or remote courses. 3 to 5 days. Participant fees.
DATA MANAGEMENT FOR HARMONIZATION PROCEDURES	Procedures for data and metadata management using the international protocols and formats	Data management experts	Data managers, Scientist and Industry professionals	In-person or remote courses. 1 to 3 days.
SOPs VIDEOS	Operational video repository with embedded SOPs: - Vehicle specific to size of vessel - Examples for different weather	GROOM RI experts.	Scientific researchers and industry professionals with previous knowledge (not necessarily the same vehicle or vessel type).	On-line resource.

Research-based University degree courses (Bachelors, Masters and PhD)	Platform-specific training: - Pilotage - Maintenance - Ballasting - Launch & Recovery - Data processing	GROOM RI experts and University teachers	Marine Sciences Students. Engineers (Telecommunication, electronic, mechanical, etc).	Generally, in-person Participant fees.

4.1. GLIDER SCHOOL FOR BEGINNERS AND TRAINING FOR NEW USERS

As already mentioned in the introduction to this document, the use of autonomous vehicles to conduct marine observations has required significant learning, not only for the maintenance or piloting of these vehicles but also in adapting their use to scientific missions/ Observation programs required as main specific objectives. Given the rapid evolution of the technology of these autonomous vehicles, their market has proliferated so much that initially required are training courses in the knowledge, management, and appropriate use of the existing technologies as an introduction regarding their capacities and applications. This introductory need on the part of interested parties without previous knowledge (such as students, scientific researchers, or industry professionals) are being covered by Glider or Summer Schools (mainly PLOCAN Glider School that is organized annually, but there are others also mentioned above in the section 3).

The audience of these courses seeks to have a general knowledge of the different technologies in both technological and operational aspects and possible applications. The typical profile of the participants is scientists already linked to observational tasks, marine science students with a certain interest in technology, as well as technical personnel (mainly engineers) from marine-maritime industry sector with an interest in the use of these vehicles to add them to their usual tasks. The registration fee for these glider/ summer schools is around €1,000, which may cause problems for some of the participants regarding travel and stay expenses, as well as the need to obtain Visas required to enter the country. Most of these schools are being organised in European countries, the United States or Australia, so participants from Asia, Africa or Latin America have to travel to participate in them as a condition to enable real capacity building and engagement worldwide.

The role of the future GROOM RI for this introductory level could be to support the current Glider School or similar efforts already operating based on providing teachers that meet the needs of these schools, as well as finding resources that can provide financial aid (scholarships) to low-income students, as well as students from developing countries. Another function, although this one is more complicated, would be to help establish new schools or perhaps a mobile school concept with a different location depending on the edition, which could extend the spatio-temporal framework of these schools.

4.2. ADVANCED TRAINING: BEST PRACTICES, PILOTING, MAINTENANCE AND APPLICATIONS

Based on the input of the survey addressed to the GROOM II consortium (Figure 19), it was observed the need for the future GROOM RI to support advanced training where progressive knowledge of piloting, techniques of launching and recovery of the vehicles is imparted, as well as the maintenance of the available sensors and adaptation of new sensors in the vehicles.

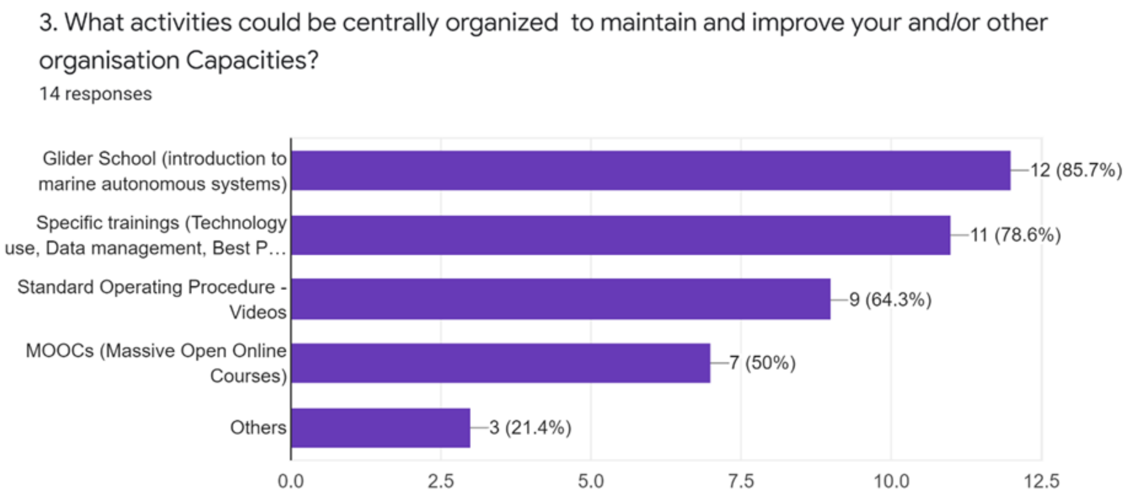

Figure 19 - Question carried out during the task 2,3 survey addressed to institutions in the consortium

It is true that initially specific learning for each vehicle can be exclusively provided by the manufacturer or by a partner of said manufacturer. However, it is increasingly necessary that the operation activities of these vehicles related to the design of the mission, piloting in accordance with the objectives pursued, the operational procedures that ensure the proper functioning of the vehicle and the sensors it carries, as well as the harmonization in the structure of the metadata and the data of the missions, require more and more effort on the part of the operators to train their scientists, technicians and data managers in the necessary knowledge so that the resources invested in the missions can correspond to the services that both science, industry and society demand for these observation platforms.

Therefore, courses on metrology aspects aimed at sensors commonly installed on sailplanes, addressing monitoring strategy, sensor configuration basics, validation procedures, traceability and uncertainty, in collaboration with other IRs, adding details specific to mobile platforms. For this purpose, links should be established with the Minke community (Collaboration between Observatories and NMIs), as well as for other variables (e.g. Carbon), and emerging ones, e.g ocean sound (soundscapes, noise). Given the shared interest of these courses/training with other observation infrastructures, GROOM RI could co-sponsor them with EMSO, JERICO, EuroArgo, ICOS, etc. Best practice communities are already being organized around particular types of observations made by autonomous vehicles (e.g. salinity, dissolved oxygen, passive acoustics) in the frame of OceanGliders task teams, and should be supported by GROOM RI.

4.3. DATA MANAGEMENT FOR HARMONIZATION PROCEDURES

A good data and metadata management of MAS observations is essential to make the most of the data acquired by the instrument at sea. Data and metadata management is a complex and very diverse topic deserving proper courses. Metadata management, real time QC, delayed mode QC, variable specific, fleet data management training are examples of courses that could be delivered at the RI level. Each of them being adapted to the audience, beginners or expert users.

Generally speaking, there is a significant amount of work required to improve the common knowledge and capacity of the MAS community in terms of data and metadata management. After more than a decade of MAS operation in Europe, the availability of training about data and metadata management is still limited. This strongly advocates for a coordinated approach at the GROOM RI level.

In the long term, building a collective basic knowledge shared across the GROOM RI community is fundamental to grow a MAS community efficiently and demonstrate the capacity of MAS to answer the challenges ocean observers are and will be facing in the future. The GROOM RI community will need to do a gap analysis to identify where additional training is needed and would be most effective e.g. under the remit of existing mechanisms like glider schools, dedicated training, or collaboratively delivering training with other RIs.

The exemplar of the MEDIN (Marine environmental data and information network) group, running regular online workshops on data discovery and data handling, could inspire GROOM RI in the development of such courses to the MAS community and beyond. Cooperation with existing services like MEDIN training, and existing infrastructure like EuroArgo, EuroFleet, EMSO ERIC, OceanOPS, Coriolis, EMODNET, SeaDataNet should be fostered to offer a broader catalogue of training to marine data users in general and MAS data user in particular.

4.4. RESEARCH BASED UNIVERSITY DEGREE (BACHELOR, MASTER AND DOCTORATE)

In the document published by the European Marine Board (EMB) ”Training the 21st Century Marine Professional: A new vision for marine graduate education and Training programmes in Europe”, it was mentioned that degree programs related to marine sciences were less than 1% of the offer of higher education programs. The authors, based on a survey, found 210 training courses offered of which 60% were master's programs, 17% were doctoral programs and the remaining 23% were Bachelor's programs or occasional events such as summer schools. If we transferred these numbers to training aimed at learning and improving the use of gliders for marine observation, we would find some master's degrees, as well as some doctoral programs as was described in section 3.2.4, but, above all, occasional events such as glider schools or courses aimed at data management (harmonization) as well as establishing dynamics of good practices in the use of these observation platforms.

Having into account the potential of these new technologies and their progress in the last 10 years, we must understand that the labour market is already demanding qualified personnel (technicians, pilots and data managers) who should cover the needs of personnel of companies, scientific institutions, etc., to direct the monitoring of marine observation programs related to scientific studies, management of marine resources (e.g. European directives) or industry needs (e.g. wind farms).

Most of the qualified personnel (technicians, pilots or data managers) are currently prepared thanks to the efforts of the institutions or companies that operate the gliders, by contracting the courses offered by the manufacturers. However, the true training of these personnel occurs during the performance of their activity, since the courses only provide them with knowledge of the vehicle and its operation. Furthermore, the experience that leads them to correctly interpret the conditions of the work environment, as well as the specific scientist requirements of each mission, is only obtained from the accumulation of mission hours and the exchange with scientists and other experts.

Training organised through the GROOM RI curricular or extracurricular courses, as mentioned in the chapter 3, will benefit from this accumulated experience and knowledge of the vehicle and its operations, given the participation, among teachers, of specialists in the use of vehicles (manufacturers), as well as scientists and data managers with extensive experience in both scientific and private sector applications. The combination of the teaching staff expertise will create a more fit-for-purpose training, connecting purely technical knowledge with real scientific and professional scenarios, leading the student to a better understanding of the activity.

GROOM RI must have as a main goal to drive knowledge and capabilities at a multi-domain level (and therefore related services). To achieve this, in proportion to the benefits expected, joint commitments towards the GROOM RI are required at different levels, and in the first instance at the national level, to make it possible to address European and international policies regarding the certification of highly qualified vocational training.

As medium-term vision, and taking as reference what has already been implemented in other technological disciplines within the marine-maritime sector (IMCA), it is certainly evident that the need to consolidate a regulated training procedure endorsed at national, European and international level involves defining and agreeing on certification standards by existing (or new) competent bodies. This implies a common recognition of agreed entities -probably as highly specialised (public and private) academies- through which all those interested could be able to address and focus their knowledge and general skills to a more specialised level with the aim to finally obtain the requested (as mandatory) professional certification. This involves defining and implementing clear, solid and long-term agreements between developers, operators, policy makers and end users, which will ultimately enable a RI such as GROOM to provide the best approach in terms of scientific, technical and operational support services.

RIs, in any of their areas or domains, are by definition and function part of a complex value chain that undoubtedly requires the interconnection enabling multidirectional flows between the sectors that comprise it, not being the glider technology an exception. Therefore, the professional training certification of every member performing a function as part of this value chain, and therefore in the IR, implies, among others, solid and standardised agreements (including successive updates thereof) at multidisciplinary and sector level, which ultimately means to guarantee the best capabilities when it comes to training highly qualified staff as required by the GOOM-RI.

5. Conclusions and Overall Recommendations

Underwater glider and ASV capabilities allow scientists to significantly improve ocean observing strategies at national, regional and international level. In order to maintain and develop this observing capacity in a sustainable and efficient way, **it becomes mandatory to set up skilled (and certified) training** dedicated to staff and that takes over on the different technological and scientific disciplines related to operation, application and services that these autonomous platforms cover.

Up to now, different initiatives have been conducted in this way, but suffering from a clear **lack of coordination in terms of standardization** and **support to ensure continuity** and **integration into a broader training strategy**. In order to improve in this aspect, agreements between leading institutions (operators and end-users), industry (developers and service providers) and regulatory bodies (government agencies) becomes key in order to finally **develop a robust infrastructure allowing to enhance skills and building capacities**.

Research infrastructures that concentrate the main Marine Autonomous System "MAS" operators such as GROOM RI, together with international initiatives, such as OceanGliders, UG2 or EuroGOOS Task Team, have to **support and coordinate Training and Capacity Development** efforts. They must help **sustain already consolidated training courses introducing these new technologies** to many students and scientists themselves. In addition, they must continue to **consolidate the harmonization and efforts in the quality assurance of observations through the establishment of good practice manuals/sessions**. Although research infrastructures have ideal **capabilities to lead capacity building and training activities**, this requires the right coordination set-up with other involved entities from the public and private sector due to the multidisciplinary context. At the time of the conclusion of this report, the intended organization of the future GROOM RI, with a **Central Hub coordinating the trainings provided by decentralised Nodes** upon request and needs, would perfectly answer this requirement, optimizing the efforts in Training and Capacity Development at European level and beyond.

MAS technologies, as expressed at the beginning of this manuscript, are developing at a dizzying pace and every day there are more applications in which they can be used. However, this development effort will not be effective if there is no corresponding response from the set of organizations involved (operators, manufacturers, etc.) **in promoting the continuous training and development of capabilities** of their workers and the work environment. One of GROOM RI's objectives is to be a **link with manufacturers in all innovation processes** and will **act as a promoter of the new training required** that facilitates harmony between new developments and use capabilities.

This infrastructure must **ensure the incorporation of women** in this type of activities, encouraging them from the early levels of education and throughout their development. Also, it must **consolidate efforts for the development of less favoured regions**, **supporting students** from these regions in their professional development and **seeking routes for access to these technologies** from these developing countries.

Finally, definition and agreement between public entities that regulate the use of these autonomous vehicles, industry and the scientific community at international and national level on the **common contents and procedures to officially certify skills** of any involved staff member working with underwater gliders and ASV platforms **becomes mandatory and key**. The best and probably most efficient way to undertake and achieve this aimed framework should run under the unique capabilities that a Research Infrastructure such as GROOM RI will be able to provide.

6. References

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