The proposal for external users application to SOCIB Glider Facility will have to follow the enclosed template. SOCIB strongly encourages potential users to contact the SOCIB glider facility (glider.access@socib.es) to discuss details of existing glider fleet, sensors, feasibility of the proposed mission, etc…

SOCIB Gliders

Application Form for External Scientific Users

PART 1: User group details
Indicate if the proposing user group is best described as ☐ An individual user ☐X A team of two or more users
Information about the applicants (PI and project partners) **Principal Investigator (user group leader)**

Title, Name and Surname:	Professor Joao Tasso de Figueiredo Borges de Sousa
Gender:	Male
Institution:	University of Porto, Portugal
Department / Research Group:	Electrical Engineering, Underwater Systems and Technology Laboratory (LSTS)
Address:	Rua Dr. Roberto Frias s/n, sala I203/4, 4200-465 Porto
Country:	Portugal
Email:	jtasso@fe.up.pt
Telephone:	+351 917 755 406
Website	https://lsts.pt

Project partners
(repeat for each partner of the group)

Title, Name and Surname:	Kanna Rajan
Gender:	Male
Institution:	University of Porto, Portugal
Department / Research Group:	Elecrical Engineering, Underwater Systems and Technology Laboratory (LSTS)
Address:	Rua Dr. Roberto Frias s/n, sala I203/4, 4200-465 Porto
Country:	Portugal
Email:	kanna@fe.up.pt
Telephone:	
Website	https://lsts.pt

PART 2: Additional information about the applicant(s) expertise

Relevant expertise of the user group (max. 200 words)

The participants in this proposal belong to the Marine Technologies, Operational, Marine Robotics and Modelling which develops its activities within the research line of Physics and Technology of the Ocean System: Observation, Prediction and Interactions. The objective of the project is to close the observe-assimilate-predict-sample loop by demonstrating the applicability of adaptively controlled marine robots in the aerial, surface and underwater domains, while sampling the upper water-column 'at the right place and time' driven by ocean models with increasing predictive skill. In doing so, we wish to increase predictive skill of ocean models, leverage advances in Artificial Intelligence and decision-making, robotics and bring to bear recent advances in Machine Learning for adaptation and prediction.

Short CV of the PI (max. 200 words)

João Tasso de Figueiredo Borges de Sousa is a Professor at the Electrical and Computer Engineering Department from Porto University in Portugal. He holds a PhD and an MSc in Electrical Engineering, both awarded by the University of Porto. His research interests include autonomous underwater, surface and air vehicles, planning and execution control for networked vehicle systems, optimization and control, cyber-physical systems, and applications of networked vehicle systems to the ocean sciences, security and defense. In 2002 he was awarded the Luso-American Foundation Fellowship by the Portuguese Studies Program from the University of California at Berkeley. In 2008 he received an outstanding teaching award from Porto University.

He is the head of the Laboratório de Sistemas e Tecnologias Subaquáticas – LSTS (Underwater Systems and Technologies Laboratory). The LSTS has pioneered the design, construction and deployment of networked underwater, surface and air vehicles for applications in ocean sciences, security and defense. Major accomplishments include the design of the award-winning Light Autonomous Underwater Vehicle (LSTS) and of the LSTS open source software tool chain for networked vehicle systems, as well as the organization of large scale experiments at sea, including the annual Rapid Environmental Picture exercise organized in cooperation with the Portuguese Navy since 2010 and with the Centre for Maritime Research and Experimentation since 2014. The LSTS received the Arca second Prize for the best technological realizations Respectful to Environment in 2003 and the national BES Innovation National Award for the design of the Light Autonomous Underwater Vehicle in 2006.

He has been involved in fostering and growing a world-wide research community in this field with yearly conferences and workshops in the areas of Hybrid Systems, Networked Vehicle Systems and Autonomous Underwater Vehicles. He has been lecturing on networked vehicle systems in renowned universities in the United States of America and Europe. He was a Visiting Scholar at the Center for Intelligent Robotics for Space Exploration, Rensselaer's Polytechnic Institute, Troy, New York, in 1991. He had several Visiting Scholar appointments at the University of California at Berkeley since 1997. He is a member of the IEEE Robotics and Automation Multi-robots Systems Technical Committee and of the International Federation of Automatic Control (IFAC) Marine Systems Technical Committee. He was the chair of the 2013 edition of the IFAC Navigation, Guidance and Control Workshop and is the chair of the 2018 IEEE AUV Symposium. He is a member of the Advisory Board of the Swedish Marine Robotics Center. He is in the editorial board of several scientific journals. He is a member of several NATO committees. He has authored over 300 publications, including 30 journal papers.

A list of 5 recent, relevant publications of the user group

1) José Pinto, Maria Costa, Renato Mendes, Keila Lima, Paulo Dias, João Pereira, Manuel Ribeiro, Renato Campos, Maria Paola Tomasino, Catarina Magalhães, Fransciso López Castejón, Javier Gilabert, Adriana M. Santos Ferreira, José C. B. da Silva, Paulo Relvas, Trent Lukaczyk, Kay Arne Skarpnes, Emlyn Davies, Alexander Chekalyuk, Bruno Loureiro, Ian G. Brosnan, Jing Li, João Borges de Sousa, Kanna Rajan. 2022 , "Coordinated Robotic Exploration of Dynamic Open Ocean Phenomena", Field Robotics. 2. 843-871. 10.55417/fr.2022028

2) Matheus Reis, R. Praveen Jain, António Pedro Aguiar, João Borges de Sousa. 2019 , "Robust Cooperative Moving Path Following Control for Marine Robotic Vehicles", Frontiers in Robotics and AI, V6, 121

3) Glaucia M.Fragoso, Emlyn J.Davies, Ingrid Ellingsen, Matilde S.Chauton, Trygve Olav Fossum, Martin Ludvigsen, Kristine B. Steinhovden, Kanna Rajan, Geir Johnsen. 2019 , "Physical controls on phytoplankton size structure, photophysiology and suspended particles in a Norwegian biological hotspot", Progress in Oceanography, Volume 175, Pages 284-299

4) R. Praveen Jain, João Borges de Sousa, António Pedro Aguiar. 2021 , "Three Dimensional Moving Path Following Control for Robotic Vehicles with Minimum Positive Forward Speed", in IEEE Control Systems Letters, vol. 6, pp. 79-84, 2021, doi: 10.1109/LCSYS.2021.3050270.

5) Daniel Alcaraz, Gianluca Antonelli, Massimo Caccia, Gerard Dooly, Niamh Flavin, Achim Kopf, Martin Ludvigsen, Jan Opderbecke, Matthew Palmer, António Pascoal, João Borges de Sousa, Roberto Petroccia, Pere Ridao, Nikola Mišković, Sen Wang. 2020 , "The Marine Robotics Research Infrastructure Network (EUMarine Robots): An Overview", IEEE/OES Autonomous Underwater Vehicles Symposium (AUV), St Johns, NL, Canada, 2020, pp. 1-2, doi: 10.1109/AUV50043.2020.9267940.

PART 3: Detailed scientific description of the project

List the main objectives of the proposed research
(max. 300 words)

FRESNEL proposes to close the observe-assimilate-predict-sample loop by demonstrating the applicability of adaptively controlled marine robots in the aerial, surface and underwater domains, while sampling the upper water-column 'at the right place and time' driven by ocean models with increasing predictive skill. In doing so, we wish to increase predictive skill of ocean models, leverage advances in Artificial Intelligence and decision-making, robotics and bring to bear recent advances in Machine Learning for adaptation and prediction. FRESNEL involves a diverse group of seasoned researchers working across traditional disciplinary boundaries. The tight integration between model prediction and assimilation that we foresee occurring as part of this effort, will be enhanced so as to provide realistic forecasts of a range of biophysical variables including temperature, salinity, wind, surface and subsurface currents and bio-optical properties. These in turn will be used to intelligently target sampling with these multi-domain platforms in the air, ocean surface and underwater, augmented by satellite remote sensing including from a recently launched multi-spectral sensor on a Small Satellite. The novelty of this proposed effort is in the integrative aspects of a field exercise which will allow FRESNEL to leap-frog experimental design, autonomous operations, assimilation, modeling and prediction in ways not done before. The project will outreach substantially with local authorities, subsistence fishermen and an NGO in the domain of operation in Nazar´e, Portugal and engage local middle and high-school students, along the lines of previous such field experiments.

Give a brief description of the scientific and/or technical background to, and rationale for, your project

(max. 300 words)

Our objective in FRESNEL is to demonstrate the applicability of adaptively controlled marine robots in the aerial, surface and underwater domains, while sampling the upper water- column 'at the right place and time' driven by ocean models with increasing predictive skill. In doing so, we wish to:

1. Increase the predictive skill of coastal ocean models
2. Leverage the advances in Artificial Intelligence driven dynamic-decision making to place mobile assets in the 'right place at the right time'
3. Close the sense-assimilate-predict-sample loop
4. Advance the efforts to bring modern Machine Learning methods for adaptation and prediction in the advancement of our understanding of coastal ocean processes

Present the proposed experimental method and working plan with detailed information on the number of gliders requested, the sensors needed, mission plan, maximum depth (200 or 1.000 m).

(max. 500 words)

The basic payload for the glider should include CTD, oxygen and FLNTU sensors. The mission plan consists of performing a repeated section between in the west boundary of the Operation Model away from the shipping lines, flying from surface to 1000 meters depth, surfacing every 6 or 12 hours (depending on marine traffic and the data assimilation requirements). Figure (a) & (b) below show detailed views of the proposed study area for FRESNEL off the coast of mainland Portugal. The Nazar´e Canyon is a significant feature of this area and a driver for the bio-geophysics of the domain. The shaded blue area is the expected glider operations region which will inform the model about boundary conditions and off-shore waters being entrained into the canyon. This tentative sampling is not fully fixed, the final separation between gliders and the exact waypoints of the glider mission will be defined a few weeks before the deployment based also on the analysis of satellite data (altimetry, SST and ocean colour).

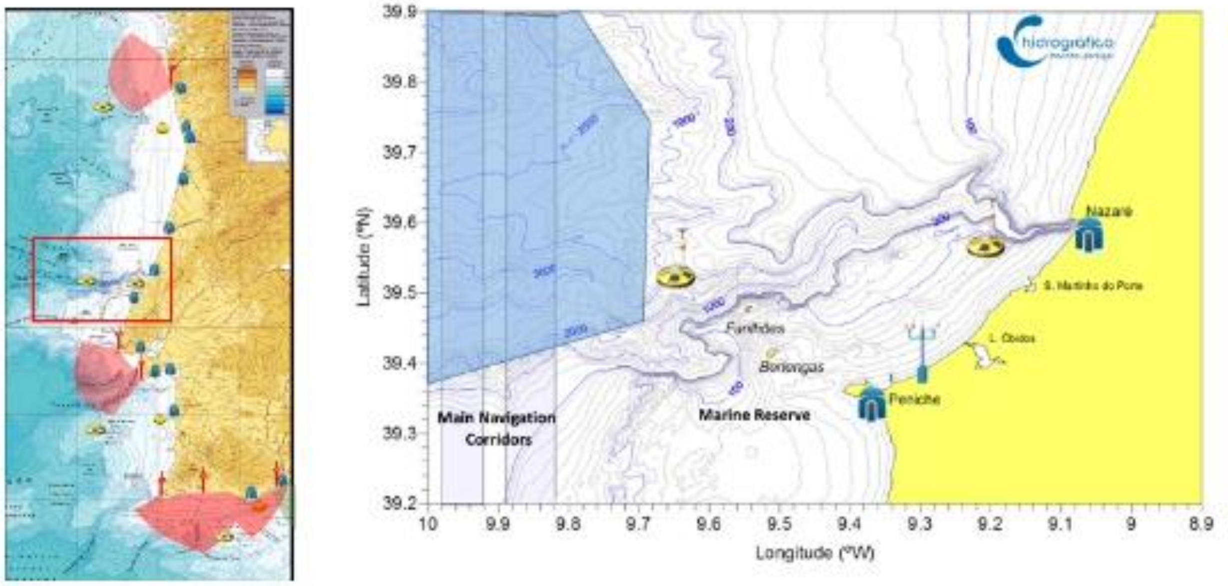
Indicate the type of access applied for

☐ remote *(the measuring programme is implemented by SOCIB and the presence of the user group is not required)*

☐ partially remote *(the presence of the user group is required at some stage)*

X 'in person/hands on' (*the presence of the user group is required / recommended during the whole access period*)

Indicate the proposed time schedule including expected duration of access time (max. 200 words) Expected deployment end September 2023 15-19 mission days: split in 3 phases: a) 5-6 pre-experiment phase b) 5-7 experiment phase and c) 5-6 post-experiment phase
Add a jpeg or pdf diagram of the idealised glider deployment track



(a) Map of Portugal and the study area highlighted with the red rectangle.

(b) Zoomed in bathymetry showing the Nazaré canyon-Berlengas area (isobaths with depth in meters) and its environment including the placement of the two buoys.

Additional information

Is there another facility in your country similar to the one you wish to utilize?

☐ Yes ☐X No

If yes, please indicate your reasons for requesting access to the SOCIB glider (max. 150 words)

SOCIB glider facility has a more 10 years of experience and perform more than 130 missions in different areas in the Mediterranean. In addition, it has well trained personnel with strong background in operational oceanography.

Is this a resubmission of a previously rejected proposal?

☐ Yes ☐X No

If yes, please provide the reference number and submission date of the original proposal. Briefly describe the changes made in comparison to the rejected version (max. 200 words)
Is this a continuation of an earlier successful project? ☐ Yes X☐ No
If yes, please provide the reference number and submission date of the earlier proposal. Briefly describe the principle achievements of the earlier project and any objectives that were not fully met. (max. 200 words)

PART 4: Technical information
List of the glider instrumentation of most importance to your proposal CTD, Oxygen, and FLNTU sensors
List of any additional instrumentation that you have discussed and agreed with the Glider Facility N/A
Provide details of your preferred sampling intervals, glider excursion depths and surfacing/communication intervals - Glider excursions depth between surface and 1000 m. This target depth is tentative and could be modified after checking first hydrographic profiles. - Downcast and upcast sampling. - Communications every 12 hours. - CTD and Oxygen sampling at 1/4 Hz from 0-1000m - FLNTU sampling at 1/8 Hz from 0-300m depth
Details of your Data Management specific needs Measurements on surfacing of the glider to be sent to shore for assimilation in ocean models (MSEAS and HOPS). Preferable that the full transect be sent via Iridium (or Wifi if available offshore). Specific sensor streams will depend of course on the sensors on the glider, but also on what can be assimilated in at least one of the two models.
Chose the data access and distribution (one option only) ☐ Public *(open access through the public SOCIB thredds and Coriolis portal (GDAC))* ☐ Partially public *(public SOCIB thredds (only))*

Balearic Islands Coastal Observing and Forecasting System

☐ Restricted (public SOCIB thredds with authentication required)
☐X Temporally restricted (restricted during predefined period. In that case, after this period, public or partially public distribution should be chosen by the client)
Embargoed until the full group will publish results of the experiment and then made available, ideally in one of the data portals in the EU

DOI minting (highly recommended)
☐ X Yes *(Data Centre will be in contact for the metadata information)*
☐ No

Risk Evaluation (marine traffic, fishing grounds, etc.) and Contingency Plan
1) There are 2 major maritime traffic lines (highways) and then 3 or 4 intense fishing areas.
2) Bathymetry is very demanding, with several areas to avoid, either due to traffic, currents, or. shallow areas.
3) There are two islands in front of Peniche: The Berlengas and Farilhoes and on a 100 m
4) The slopes get quickly steeper around the islands and the canyon.

Emergency Logistics for immediate recovery (time to action, radius of action planed, etc.)
- Deployment and recovery of the glider from a big vessel using rib.
- 12h response time for emergencies

Date of compilation 21/November/2022__________________________________

Signature of the PI

Signature of an appropriate authorised person
(e.g. Head of Department, Research Office) ________________________________

This section reserved for the SOCIB Glider Facility

Date of proposal receipt by email ________________________________

Assigned reference number ________________________________

Signature of receiving officer ________________________________