



**LONG-TERM VISION
AND STRATEGIC PLAN**

2021
2023

EMSO ERIC LONG-TERM VISION AND STRATEGIC PLAN 2021-2023

Observing the Ocean to Save the Earth

EMSO ERIC

European Multidisciplinary Seafloor and water-column Observatory

European Research Infrastructure Consortium (EMSO ERIC)



ERIC established by
the European Commission
Implementing Decision
(EU) 2016/1757

Designed by Istituto Nazionale di Geofisica e Vulcanologia (INGV)

This work is licensed under Creative Commons Attribution 4.0 International
DOI: [10.5281/zenodo.5654746](https://doi.org/10.5281/zenodo.5654746)

TABLE OF CONTENT

TABLE OF CONTENTS	3
THE VISION	4
THE MISSION	4
REGIONAL FACILITIES	6
SERVICES	7
SCIENCE SERVICES	7
ENGINEERING AND LOGISTICS SERVICES	9
DATA MANAGEMENT SERVICES	10
INDUSTRY AND INNOVATION SERVICES	10
COMMUNICATION SERVICES	11
EMSO AS A PARTNER OF THE LARGE EUROPEAN MARINE AREA	13
PROMOTING BLUE INNOVATION	14
EMSO ERIC AS RESPONSIBLE RESEARCH AND INNOVATION INITIATIVE	14
EMSO ERIC, DRIVEN BY USER NEEDS	15
EMSO ERIC IMPACT	16
EMSO ERIC GOVERNANCE AND SUSTAINABILITY	17
THE NEXT THREE-YEAR PERIOD	20
References	23
Acknowledgements	25

THE VISION

EMSO ERIC will become a world-class Marine Research Infrastructure providing high-quality information on the significance and the dynamics of the deep oceans and the water column, to address global ocean environmental challenges that affect the Earth System, and impact the welfare of society.

High-quality and timely marine environmental information will nourish mitigation and protection strategies in the face of significant challenges and threats, such as natural disasters, habitat loss, human and species migration, and food security, together with the deprivation due to marine-related industry activities, tourism, and recreation.

EMSO ERIC will provide bio-geophysical, and chemical information needed to monitor the impact of climate change on the ocean system, mitigation of geo-hazards risk, and progress in deep-sea habitat mapping.

EMSO ERIC will promote the creation of new hi-tech jobs, and spur the development of innovative applications and services in strategic industrial sectors such as marine robotics, blue biotech, offshore aquaculture, seabed resources, smart submarine cables, marine renewable energy, pharmaceutical, fishing and tourism.

THE MISSION

EMSO ERIC aims at promoting the advance in the knowledge of deep ocean and water column processes, through the monitoring, analysis and dissemination of data retrieved by observatories, or similar instruments, able to ensure long-term repeated observations of the state of the ocean. These observations, which include Essential Ocean Variables (EOVs) and other physical and environmental variables, follow FAIR¹ principles (Findable, Accessible, Interoperable and Reusable).

The overarching goal is to better understand the complex interactions between the geosphere, the biosphere, the hydrosphere and atmosphere, and to address the major environmental challenges in the thematic areas of Climate Change, Marine Ecosystems and Geo-hazards. EMSO ERIC approach is based on the generation of high-value data by a distributed network of regional facilities operated and maintained by its partners, but sharing the same quality level and a harmonized set of observables.

EMSO ERIC continuous time-series multidisciplinary data, going from the sea surface to the deep seabed, and sub-seafloor address many key processes that affect the entire ocean. The volume of data and information provided by EMSO ERIC allows the description of processes ranging from extreme episodic events to slow trends, difficult to distinguish from the underlying variability of short-term processes.

The continuous, high-resolution, long-time-se-

ries collection of multiple variables at chosen fixed sites across a breadth of environments pursued by EMSO, allows for the development of new approaches to shed light on the complexities of the Earth System.

EMSO ERIC multi-parameter long time-series document and study a broad range of critical episodic events that cannot be addressed by classical short-term marine expeditions: climate change, benthic storms, biodiversity changes, anthropogenic pollution, and gas hydrate (methane) release, dense water cascades, plankton blooms, water mass movements and the influence of eddies, earthquakes, submarine slides and tsunamis.

Innovation fostered by EMSO ERIC will provide the means and the skills to study the complex and fragile deep ocean environments, now under scrutiny related to seabed mining exploration.

EMSO ERIC aims at ensuring the following tasks:

- To monitor and sustain *in situ* a long time series of oceanographic and biogeochemical variables, and geo-hazards^{2,3}, enabling the understanding of anthropogenic impacts of climate change.
- To offer comprehensive *in situ* biogeochemical datasets on the European seas to improve biogeochemical and ecosystem modelling. Dissolved CO₂ monitoring is useful to monitor progressive ocean aci

dification and promote the preservation of marine ecosystems.

- To complement national seismological networks data on seafloor acceleration occurring near the EMSO ERIC Regional Facilities that may impact coastal areas within the European Seas.
- To advance science-based Ocean Policy, providing relevant deep-sea information to EOOS⁴.
- To enhance and promote Copernicus applications, products, and services, focusing on the role of deep ocean processes.
- To support the implementation of European research and innovation policies and strategies (e.g., Marine Strategy Framework Directive).
- To develop technologies, fostered by the needs of EMSO ERIC partners, to improve the environmental monitoring, measurements quality, and supporting logistics fostering a multiplatform approach.

Climate change, leading to the alteration of ocean ecosystems in different habitats, increased marine hazards and ocean pollution, is the urgent scientific and societal challenge that is at the heart of EMSO ERIC mission.

REGIONAL FACILITIES

EMSO ERIC distributed infrastructure currently comprises twelve Regional Facilities and three shallow-water test sites, strategically located all the way from the southern entrance of the Arctic Ocean across to the North Atlantic through the Mediterranean to the Black Sea (Fig. 1). Regional facilities provide essential data and services to understand global environmental processes and to stimulate the development of new technology, innovation and knowledge that

will allow Europe to lead marine environmental research. EMSO ERIC is the coordinating hub of this integrated system of specialized regional facilities. Diverse disciplinary and operational expertise and a broad range of marine environments across regional facilities allow the accomplishing scientific and technological objectives on scales larger than those achievable individually by each organization or country.



Figure 1. EMSO Regional Facilities (empty circles), Test Sites distribution (solid circles)

SERVICES

The ingredients of EMSO ERIC are:

- The establishment of a comprehensive multi-sensor system in the water column, seafloor, and sub-seafloor as part of an integrated, and distributed ocean observatory.
- The establishment of a single entry-point for the provision of reliable high-resolution data at desirable sampling rates, consistency, comparability, and continuity at the regional scale.
- The assessment of baseline data, and the track of critical changes in the ocean environment.
- The delivery of tools and knowledge to enable Europe to evaluate and develop outlook strategies for the mitigation of harmful global impacts by preparing and adapting to these changes.
- The support and acceleration of innovation through scientific and technological research.

EMSO ERIC coordinates the pooling of resources, capacities and expertise, and the assembling of harmonised and interoperable data into a comprehensive regional ocean image, which will be made available to researchers and stakeholders worldwide via an open and interoperable data access system.

The services are managed through several Service Groups, devoted respectively to Science, Engineering and Logistics, Data Management, Industry and Innovation and Communication.

SCIENCE SERVICES

A central objective of EMSO ERIC is to deliver quality-controlled data, qualified information and knowledge, based on sustained monitoring of environmental processes by EMSO ERIC regional facilities. EMSO ERIC Science Services address three main topics (Ocean-Atmosphere, Biosphere/Marine ecosystems, and Geosphere/seafloor Geo-hazards and Geodynamics). Several environmental indicators are relevant for a wide range of scientific interests (see Table 1).

Five categories of science services are identified:

- Two categories of services addressing the Geosphere and the Biosphere, namely: (1) Geo-hazards and Geodynamics and (3) Marine Ecology and Biodiversity.
- Two categories of services addressing the Atmosphere and the Ocean/Climate Change, namely: (2) Water-column Physics and Biogeochemistry and (5) Meteorological parameters.
- A fifth category corresponds to environmental monitoring services that meet or have the potential to meet statutory obligations under several legislative frameworks (Marine Strategy Framework Directive⁵, Common Fisheries Policy⁶, Habitats Directive⁷, Water Framework Directive⁸, and Maritime Spatial Planning Directive⁹), namely:

SCIENCE SERVICE	MULTINODE SERVICE NAME	WORKFLOW	REGIONAL FACILITIES
Geo-hazards and Geodynamics	Seismicity	Geo-hazard service workflow	Azores, Hellenic Arc, Ligurian Sea, OBSEA, Western Ionian Sea
	Tsunami and geodesy	Geo-hazard service workflow	Azores, Hellenic Arc, Ligurian Sea, Western Ionian Sea
Water-column Physics and Biogeochemistry	Ocean temperature and salinity	Operational oceanography and climate workflow	Azores, Black Sea, Canary Islands, Hellenic Arc, Ligurian Sea, OBSEA, Porcupine Abyssal Plain-Sustained Observatory, SmartBay, Western Ionian Sea, Nordic Seas
	Ocean oxygen content	Operational oceanography and climate workflow	Azores, Black Sea, Canary Islands, Hellenic Arc, Ligurian Sea, Porcupine Abyssal Plain-Sustained Observatory, OBSEA, SmartBay, Nordic Seas
	Ocean CO₂ and pH	Operational oceanography and climate workflow	Canary Islands, Ligurian Sea, Porcupine Abyssal Plain-Sustained Observatory, Nordic Seas
	Ocean Nutrients, chlorophyll	Operational oceanography and climate workflow	Ligurian Sea, Porcupine Abyssal Plain-Sustained Observatory, Nordic Seas
Marine Ecology and Biodiversity	Marine Ecology and biodiversity	Statutory monitoring workflow	Azores, Porcupine Abyssal Plain-Sustained Observatory, OBSEA, SmartBay
Environmental indicators (MSFD⁵)	Marine sound	Statutory monitoring workflow	Azores, Canary Islands, Hellenic Arc, Ligurian Sea, Porcupine Abyssal Plain-Sustained Observatory, OBSEA, SmartBay, Western Ionian Sea
	Marine litter	Statutory monitoring workflow	Canary Islands, Porcupine Abyssal Plain-Sustained Observatory
Meteorological parameters	Meteorological parameters and waves	Operational oceanography and climate workflow	Azores, Black Sea, Canary Islands, Hellenic Arc, Ligurian Sea, Western Ionian Sea, Porcupine Abyssal Plain-Sustained Observatory, OBSEA, SmartBay, Nordic Seas

Table 1. Science service categories vs multinodes service, proposed workflow and Regional Facilities involved

(4) Environmental indicators (Marine Strategy Framework Directive⁵).

EMSO ERIC science services will support:

- marine biologists studying marine fauna, ecology and biodiversity, effects of environmental natural and anthropogenic changes on marine life.
- oceanographers studying the ocean waters circulation and the effects of climate change in the oceans such as ocean acidification.
- geophysicists studying geo-hazards, such as earthquakes and tsunamis, the structure and submarine slope stability of ocean floor and the structure and functioning of submarine magmatic systems and volcanoes.

ENGINEERING AND LOGISTICS SERVICES

All engineering and logistics services are performed according to a set of “best practices” developed earlier within the EMSO community and established in the period 2017-2020. Two categories of services are considered: services for the benefit of the research organizations managing the regional facilities and services for the

benefit of the users and stakeholders, including industry.

Standardization tools when measuring physical and chemical parameters in the ocean increases the potential scientific impact of the data collected at the Regional Facilities. Homogeneous long-term data or *in situ* ocean measurements are critical issues not yet fully solved, since the sensors suffer extreme ambient conditions, corrosion, high pressure, mechanical stress, sudden changes in temperature and their electronic components suffer a remarkable wear.

Long-term maintenance of observatories is planned to be based on a coordinated action plan agreed primarily with European Research Vessel Operators¹⁰. This will optimize a significant part of maintenance and/or equipment and sensor exchange interventions between nearby regional sites and will aim at a better use of the resources reducing the costs of sea operations.

The standard observatory EGIM (EMSO Generic Instrument Module) developed under the EMSODEV¹¹ initiative (Fig. 2) is a step forward of the Engineering Services, to ensure increased coordination, integration, interoperability and standardisation across sites and disciplines, and easy extension to other observation sites.

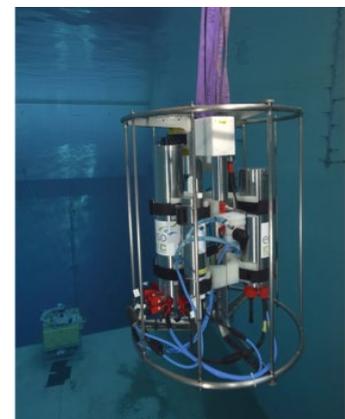
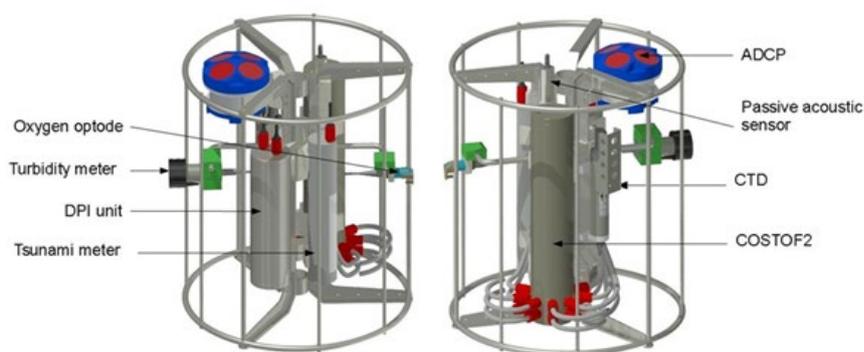


Figure 2. EGIM for the acquisition of different parameters (left) and a photo of the system (right)

DATA MANAGEMENT SERVICES

EMSO ERIC data management e-infrastructure supports a massive volume of data from geographically dispersed, multi-parameter, platforms, to which it directs users via a single central access point for data and data products visualisation and downloading.

The core of the infrastructure, outlined in Fig. 3 includes the EMSO Data Management Platform, complemented with an ERDDAP¹² federation and a series of data, metadata and Quality Control harmonization processes. The users, portals, and tools can access data and products through requests to the platforms' interfaces. EMSO ERIC data are harmonized and standardized, enhancing the interoperability between different oceanographic data platforms, such as EMODnet¹³ and OceanSITES¹⁴.

The main advantages of this platform are:

- harmonized and unified access to EMSO ERIC data;
- application programming interfaces for easy access to data as they are available;

- development of added value services (e.g., visualization and analysis of multi-node data services);

- enhanced interoperability and streamlined processes to interoperate with third-party systems.

INDUSTRY AND INNOVATION SERVICES

Industry's main interests relative to EMSO ERIC marine-related services and applications are focused on key sectors like renewable energy, deep-sea mining, sustainable fisheries, marine traffic, and geo-hazard mitigation. Accordingly, the priorities for EMSO in its interaction with the economic sector are encouraging the development of advanced technological research in marine sensors together with the offshore industry. To develop fruitful relationships with the industry, EMSO plans to establish an Industry Innovation Services Contact Hub, consisting of the EMSO Industry Contact Officer, the Engineering and Logistic Officer and the Science Officer.

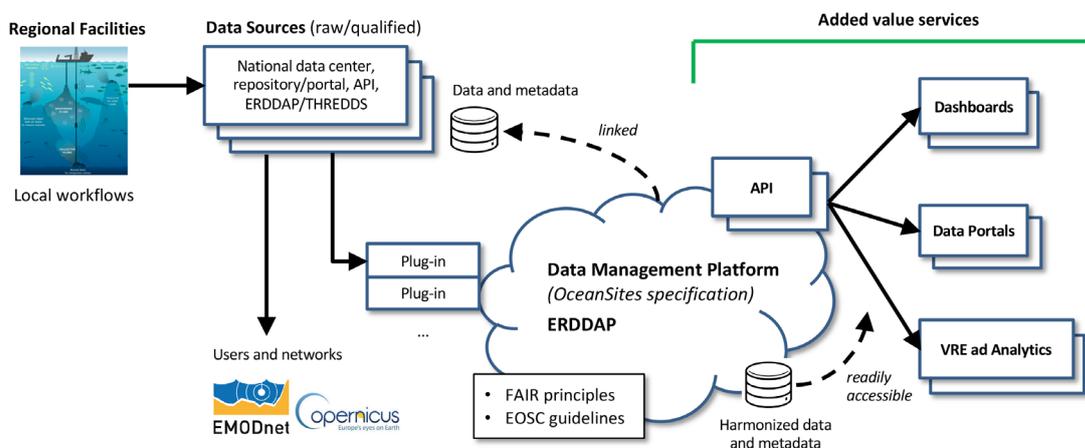


Figure 3. EMSO Data Management: components from the Regional Facilities (left) to the added value access services (right)

The Hub will:

- Produce useful documentations, as providing template documents for frequently occurring technology transfer situations like Material Transfer Agreement, Confidential Disclosure Agreement, or another.
- Organize an annual joint workshop on innovation, knowledge sharing and procurement policy development.
- Develop guidelines for the regional facilities on best practices and lessons learned to build and maintain collaboration with industry.
- Give access to specialist knowledge concerning business development and legal, regulatory, or ethical aspects to the EMSO community.
- Develop, on a case-by-case basis, collaboration and negotiation cases towards the creation of spin-off or start-up EMSO-derived/ owned companies.
- Develop an internal Intellectual Property policy in close connection with the Financial Officer.

The Hub is also part of the vision developed by EMSO as one of the main contributors to the H2020 project ENRIITC¹⁵ that aims to build a permanent pan-European network of Industrial Liaison and Contact Officers enabling the industry to become a full partner of research infrastructures whether it is as a user or a supplier.

COMMUNICATION SERVICES

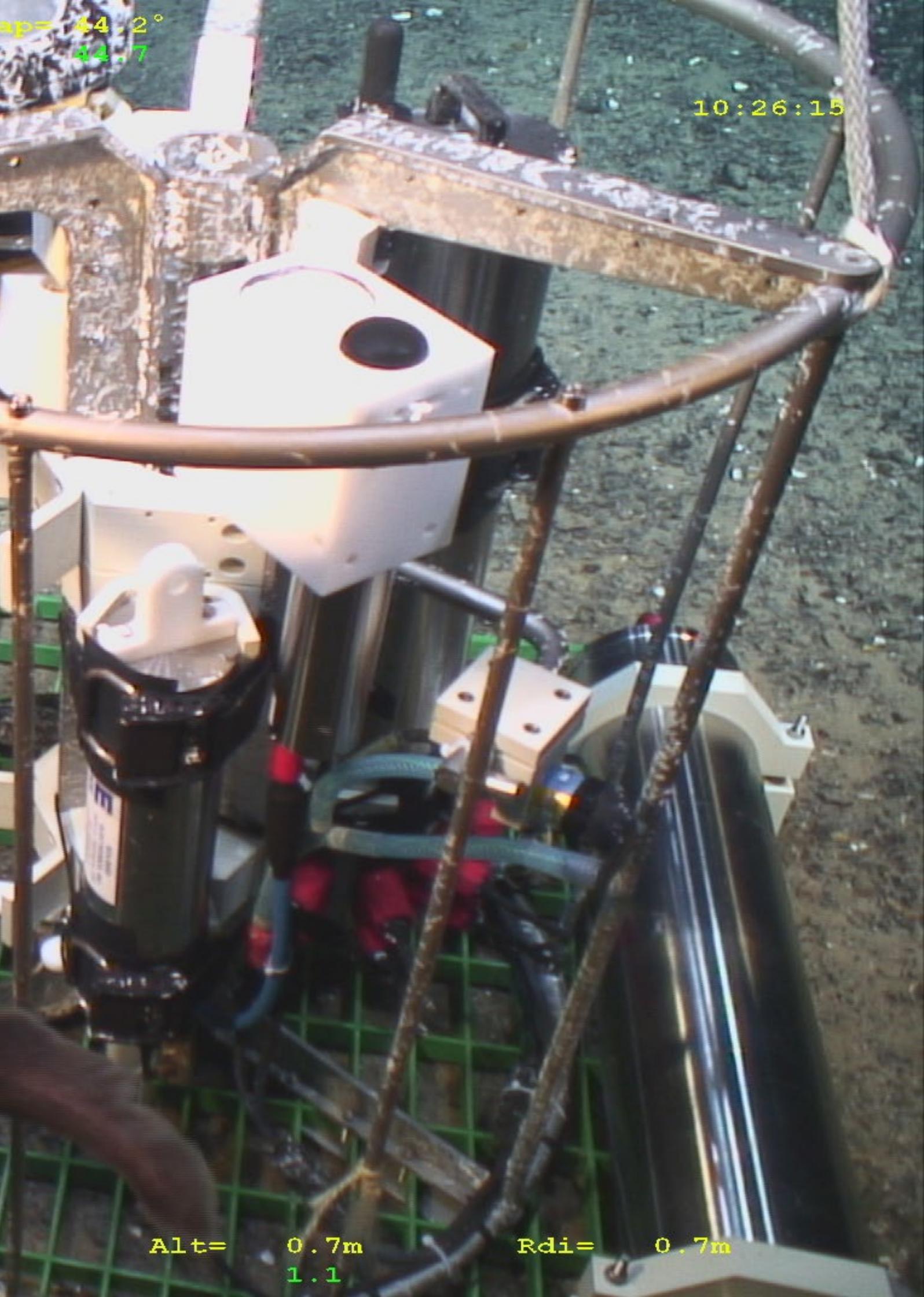
The EMSO Communication Services aim to increase the visibility of EMSO ERIC in the scientific community, the policymakers and business communities, as well as to the wider public at the European and global level. In particular, the Communication Service Group is committed to keeping the stakeholders informed of the EMSO activities and spreading the message that the European marine sciences are entering into a new knowledge paradigm that encompasses a holistic and multidisciplinary approach to studying the Earth and its processes.

To enhance EMSO's socio-economic impact and promote new business development, outcomes are openly made available to scientists, industry, the public, and politicians through EMSO's communication channels made of targeted communications, the institutional website, the EMSO biannual conference, and the social media platforms. The main objective is to involve and inform stakeholders about all EMSO initiatives and to develop closer relationships between them and the infrastructure.

In addition, EMSO established a dedicated platform for internal communication to address the challenges of being a geographically distributed organization to connect the national and European dimensions of infrastructure. To this end, anthropogenic impacts on the marine ecosystems, research programs, funding opportunities and achievements among Regional Facilities are collected centrally to foster and optimize collaboration in achieving EMSO goals. EMSO internal communication aims to be the glue to hold together all the governance entities in an efficient ongoing collaborative dialogue and effort.

Ap= 44.2°
44.7

10:26:15



Alt= 0.7m
1.1

Rdi= 0.7m

EMSO AS A PARTNER OF THE LARGE EUROPEAN MARINE AREA

EMSO ERIC integrates the E00S Operations Committee which is part of the E00S⁴ governance representing the European ocean monitoring data providers. EMSO contributes to long-term observations, and strengthen coordination, strategy and sustainability using state-of-the-art technology.

EMSO ERIC contributes to the sustainable development of the Planet with objectives in line with those of the "UN Decade of Ocean Science for Sustainable Development (2021-2030)"¹⁶. To achieve its goals, EMSO promotes the complementarity and harmonization of information from different European Research Infrastructures as an essential objective.

EMSO ERIC pursues to implement the links between European Marine Research Infrastructures, such as EuroARGO ERIC¹⁷, ICOS-ERIC¹⁸, EMBRC-ERIC¹⁹, LifeWatch ERIC²⁰ and others, to enhance collaborations toward a comprehensive and integrated strategy²¹.

This integration represents a sustainable model to incorporate a variety of ocean variables contributing significantly to fully highlight the 4-D vision of the ocean. EMSO ERIC contributes to ocean observations, from sea-surface to deep-sea, by integrating these observations into comprehensive and manageable data in the European seas in line with the G7 Future of the Oceans initiative. It will also support trans-disciplinary research addressing societal needs to manage a sustainable ocean and to respond effectively to

global environmental changes, according to the Belmont Forum²² and the International Ocean Governance²³.

EMSO ERIC interdisciplinary and inter-sectoral infrastructure will demonstrate integration, capacity and potential (scientific, economic, etc.) in line with the indications of the European Marine Board^{24,25} and with the JPI-Oceans Strategy Framework (2021-2025)²⁶. EMSO ERIC actively works on the harmonization of existing observation tools and systems (e.g., E00S⁴, EMODnet¹³, Copernicus Marine Service²⁷).

Integration is necessary to take advantage of information, data, web services and communities already available or for es, to avoid duplication of effort. Also, effort must be made to the identification of common areas of research, technological development and innovation, through common investments. A great deal of these approaches is already on the way through projects such as ENVRI-FAIR²⁸ and EOSC Future²⁹.

PROMOTING BLUE INNOVATION

The objectives of EMSO ERIC are aligned with the use of new and innovative technologies that integrate the acquisition of a wide range of ocean variables across the entire water column and underneath the seabed. These objectives can be achieved by using multiple sensors frame (e.g., EGIM) to measure key variables for aquaculture, fisheries, micro- and nano-plastics, and marine macro- and micro-litter, and to demonstrate a novel multi-platform approach to observe the ocean with multiple underwater vehicles and observatories.

EMSO ERIC intends to include sensors measuring some in situ biogeochemical and biological EOVs (such as dissolved carbon, oxygen, methane) combining with mobile multi-sensor platforms (e.g., ARGO floats, AUVs and gliders). EMSO ERIC will promote the use of the same sensor devices in these different configurations and platforms as an innovative approach to support SDGs 13 and 14 of the United Nations³⁰.

EMSO ERIC AS RESPONSIBLE RESEARCH AND INNOVATION INITIATIVE

EMSO ERIC follows and promotes the principles established by the European Commission (EC) for Responsible Research and Innovation (RRI). This implies that societal actors (researchers, citizens, policymakers, business, third sector organizations) work together throughout the research and innovation processes to better align both processes and their results with the values, needs and expectations of scientists, a variety of stakeholders and society.

RRI is being promoted in EMSO ERIC via actions on thematic elements (public engagement, open access, gender, ethics, science, education), specifically applied to the scientific and technological fields of ocean observing and monitoring surveillance. EMSO ERIC implements Responsible Research and Innovation as a "cross-cutting issue" in its work programme and objectives. The activities developed by the multi-node distributed infrastructure can focus on thematic elements, as well as on more integrated approaches to promote uptake. This includes user groups and stakeholders in both the public and private sectors and in multiple scientific, technological, policy and educational fields, that can be organized in the well-known quadruple helix framework:

- European, national, regional and local governmental agencies.
- Research centres and Academia.
- Industry and Private sector.
- Civil Society and General public.

EMSO ERIC DRIVEN BY USER NEEDS

A central objective of EMSO ERIC is to deliver to its stakeholders the data, information, and knowledge that they need, based on sustained monitoring of environmental processes. EMSO stakeholders include marine science researchers, marine technology engineers as well as other ERICs, resource managers, policymakers, marine industries, and the public for both data collection and use, as well as promotion of new uses and users of the infrastructure.

Stakeholders at the European level include those working to meet the statutory obligations of several legislative frameworks including the Marine Strategy Framework Directive⁵, Common Fisheries Policy⁶, Habitats Directive⁷, Water Framework Directive⁸, and Maritime Spatial Planning Directive⁹.

EMSO ERIC will provide a large variety of services of great value not only to scientists but also to academic, institutional and industrial users. The provision of top-quality services is based on high-quality data, data products, instrumentation and physical access will generate a great impact on the furthering of knowledge, capacity building, innovation, literacy and education.

Allowing user access to EMSO Regional Facilities is central to EMSO service operation. The targeted users come from the academic and industrial worlds. Different kinds of access are proposed, ranging from installing and running a scientific experiment or testing an industrial prototype device on a Regional Facility asset -

be it at sea or onshore - to specialized training provided by Regional Team members as well as tailored marine data acquisition.

Providing infrastructure access is a crucial factor in the development and sustainability of the formation of ERICs, including EMSO. The concept of access has been advanced through projects of the Integrating Infrastructure Initiative. Transnational Access is a key issue within a distributed infrastructure offering combined access in different nodes.

To date, technical assistance within the open ocean observing community has until recently been restricted to situations where essentially one Member State can get access to the observatory facility of another Member. Thus, users can access more than one node simultaneously in different EU areas, and EMSO ERIC assists with best practices on how to manage national access in practical terms, as well as guidance on how both national and trans-national efforts can enhance the capability of EMSO in addressing priority themes, activities and services.

In 2016 the EC published a European Charter for Access to Research Infrastructures³¹ with the support of stakeholder organizations such as Science Europe and the European Universities Association. As reported in the document:

"The Charter has the purpose of setting out non-regulatory principles and guidelines to be used, on a voluntary basis, as a reference when defining or re-defining rules and conditions for Ac-

EMSO ERIC IMPACT

cess to Research Infrastructures”.

In line with the Charter, EMSO ERIC will provide access based on science quality and market-drivers. The science quality assessment will be based on the research excellence, originality, ethics and feasibility of an application through peer-review by international independent experts.

The EMSO ERIC has established a web-based management system for access to the regional facilities and services from different end-user categories. The access system has been developed within the activities of the EMSO-Link project³². The access system has some steps, the applicant can select available nodes from the list of the available EMSO sites, choosing the access mode between Remote and In-person (“hands-on”). In the first case, the presence of the user or user group is not required, while in the second is required during the whole access period.

EMSO added value in providing access to regional facilities lies in the harmonization of access information across Europe, enhanced visibility of each regional facility and mutualised legal support, including model contracts with users. Five Regional Facilities were selected for the implementation of access. The access will then be extended to the others.

The main impact expected from EMSO implementation and further development includes:

- Provision of new services and products for stakeholders (e.g., EMODnet¹³ and Copernicus²⁷) in order to (a) understand and manage the consequences of climate change, ocean acidification, natural risks; (b) deliver outstanding information and applications to understand the interacting processes in the marine environment among other key topics.
- Improvement of the health of the European oceans through the research and the interdisciplinary approach in the framework of a European-international collaboration with other environmental research infrastructures, programmes, initiatives and organizations.
- Exploitation of new sources of knowledge, information and education to advance oceanic literacy and understanding of the phenomena that affect our daily life and our economy through initiatives such as the EU Blue Growth³³, and by taking advantage of the potential of Europe's oceans for the creation of blue jobs and economic growth.

Commitment to address major societal environmental demands by encouraging close collaboration with industry by means of joint initiatives or explicit actions in promoting innovation in products and technological processes.

EMSO ERIC GOVERNANCE AND SUSTAINABILITY

The formal structure of the EMSO ERIC Governance is shown below

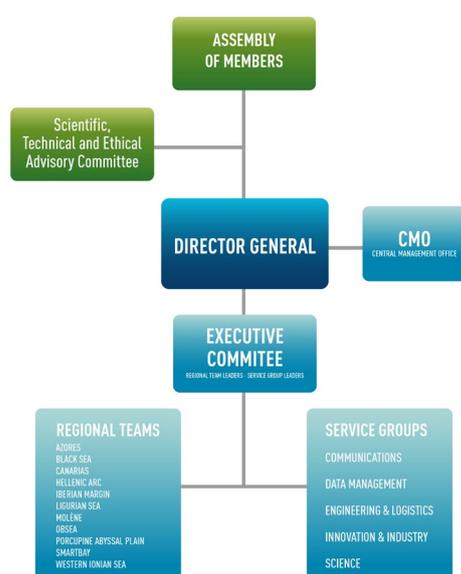


Figure 4. Services connection to EMSO ERIC Governance and Regional Facilities

The funding sources which support EMSO ERIC sustainability are defined as it follows (EMSO ERIC Statutes, art.16). EMSO ERIC's main long-term sustainability goal is to ensure the financial coverage of the following main activities to be carried out by the research infrastructure:

- A. The development and the sharing of data and scientific and technology services** among the participating Regional Facilities

is the core mandate and mission of the Research Infrastructure and should be financed through the direct contributions of the member countries as senior investors, both in cash and in-kind. In the mid-term, the sustainability should also be guaranteed by the funding sources.

- B. The institutional and scientific European networking activities,** to be mostly financed through the participation to EC projects or other publicly funded. This segment of activity should not be prevalent with respect to the overall EMSO ERIC activities.
- C. EC or extra EC grants projects can also support (i) the carrying out of specific and R&D projects enhancing the scientific excellence of the ERIC;** (ii) development of additional technical services and activities.

The long-term financial sustainability model of EMSO ERIC is presently under revision with respect to two major areas:

- A. Financial commitment from Members:** EMSO ERIC financial commitment from Members is ensured for 2021 and 2022. A new mechanism is currently under discussion to secure funding from the Members over periods of 5-years based on the phased delivery of the services. An improved financial support mechanism can be envisaged on a multi-year basis, following a proposal to be presented by the Director-General.

B. Revision of the monetary and non-monetary contributions from member states: Monetary contributions can remain fixed or could be calculated using a combination of criteria and approaches. This will allow all Members and new Members to join on a fair basis, ensuring a balanced contribution from all the Members.

Other possible funding sources, such as national and regional funds - which support the development and the implementation of the Regional Facilities and the achievement of the institutional goals - will also be activated.

EMSO ERIC requires resources over a three-year plan (from 2021 to 2023) according to the full deployment of the services as part of the work programme. Table 2 shows the 2020 (reference as real data) and 2021-2023 (estimate) EMSO ERIC Income Statements: the net results show a sustainable financial and economic perspective for the next three years, though the cash carry-over (net results) by the end of 2023 shows a prudential estimation of -200.000 €. However, this prudential estimate is expected to be offset through the start of new R&D collaborative projects and the activation of private industry contracts.

APPROVED EMSO ERIC 2020 INCOME STATEMENT AND 2021-2023 ESTIMATES AS OF NOVEMBER 30th, 2021			
REVENUES	2020	2021	2022
INGV cash contribution	220.000	220.000	220.000
INGV additional cash contribution (rent)		70.000	35.000
Member state fees	245.000	280.000	280.000
In-kind	251.337	299.000	282.000
CSIC	91.705	92.000	92.000
INGV	159.632	207.000	190.000
Revenues generated by the projects	415.004	280.000	320.000
Other revenues	475	2.000	
Total revenues	1.131.816	1.151.000	1.137.000
OPERATIONAL COSTS			
Personnel	708.347	749.000	930.000
In kind contributions	251.337	299.000	282.000
Personnel	457.010	450.000	648.000
Services (utilities, events, professional services)	111.767	100.000	100.000
Travel and promotional expenses	20.410	30.000	35.000
Other Expenses (including IRAP, office rent, DG indemnities)	157.373	160.000	160.000
Total operational costs	997.897	1.024.000	1.215.000
Net result	133.919	127.000	-78.000
Cash carry over	678.182	805.182	727.182

Table 2. 2021 P&L Accounts & Budget (Budget estimates as of November 30th, 2021)

*) 2P/M to be allocated to the GENDER EQUALITY PLAN deployment

**) The 2022 figure includes an investment of approx. 45,000 Euro to grant physical access to Regional facilities services. Details will be provided in the next AoM



THE NEXT THREE-YEAR PERIOD

According to the High-Level Expert Group assessment³⁴ EMSO is ranked at RL5 and is progressing to RL6 in compliance with FAIR¹ principles for data and services, as defined by the European Open Science Cloud²⁹. This means greater efficiency and effectiveness to the Research Infrastructure must be achieved in the next three years. From the current advanced pre-operational phase, it is foreseen that EMSO ERIC will achieve in the next few years the full operation of the services, guaranteeing the long-term sustainability of infrastructure operations and the continuous updating of its cutting-edge technology.

EMSO Regional Facilities were originally built by different teams of different countries at different times, for various scientific purposes and with site-specific technical constraints. This results in a wide range of technologies, designs and operational procedures employed throughout the infrastructure, which makes them poorly interoperable to the detriment of global efficiency.

The priority actions are:

- Harmonize Quality-Control of multidisciplinary data, to achieve interoperability across the infrastructure and make it easily accessible for data aggregators, such as Copernicus²⁷ and EMODnet¹³, and in view of EOOS⁴.
- To extend the infrastructure to extreme areas and nations by improving understanding of global environmental changes and strength-

ening international collaboration with special emphasis on Polar observations.

- To establish strong links with key marine industries for the benefit of the ocean observing systems.

Therefore, achieving gradual technological and methodological convergence between the Regional Facilities is a major long-term stake for EMSO. To this end, two practical services favouring the use of common equipment and increasing technical interaction between Regional Facilities are being considered.

The milestones to be pursued in the incoming 3 years are summarised in the following:

2021

- Continuous with the Quality Management System (QMS), so that "EMSO" meets the needs of its users and other stakeholders more effectively (ISO 9001).
- Ensure that the EMSO website has a high-level "Industry" or "Innovation" section.
- Define the suitable target of annual revenues (%) that should come from the cooperation with Industry.
- Grant that the Service Level Agreements (SLAs) and the EMSO Intellectual Property

Policy will be clearly presented to the industry on the EMSO website.

- Define an annual Training Action Plan and Program for Industrial Contact Officers (ICOs) as annexes to the Business Plan.

2022

- Start-up services are being deployed with harmonized data management and specific science services backed by the process of establishing the Environmental Management System (ISO 14001).
- Development of the EMSO ERIC “Service Catalogue” which will be published on the EMSO website. The procedures and systems for submitting a proposal to access EMSO Services that require an assessment (for example, physical, virtual or remote access to the infrastructure) will be designed by the end of the first semester of 2022. The cataloguing exercise is meant to help identify what needs to be done to upgrade these services, and to develop EMSO science services in each of the three EMSO domains (Ocean-Atmosphere, Biosphere/Marine ecology and biodiversity, and Geosphere/Geo-hazards and Geodynamics).
- The Communication Services Group will be in charge of both designing and managing the evaluation process launched by the Peer Review Panel, as well as interacting with users to guarantee the success of the entire process. The data model for presenting the EMSO ERIC Catalogue of Services has been already developed and will be deployed on MySQL technology.
- Develop a Research Infrastructure Talent-Attraction Exchange Program with industry and academia as part of the EMSO training planning.

- Development of EMSO data-based services offering EOVs up to TRL8, for the rest TRL6-7, they will be fully operational throughout 2022.
- EMSO ERIC strategic priority is to incorporate into the Consortium other European countries such as Germany, the Netherlands, and Sweden.
- Integration of new challenging services and implementation of a wider Quality Control and Risk Management (QARM) Policy. The consolidation of the Services will focus on the links and relations with the industry especially with Small-Medium Enterprises. This can enhance sustainability and appropriate participation of key industrial partners in joining development tools and testing of new devices
- Twelve Regional Facilities out of fifteen use dissolved oxygen sensors. According to the best practices mentioned above, those sensors require periodic calibration. Furthermore, using the same calibration method throughout all Regional Facilities is a necessary requirement for a synoptic exploitation of the dissolved oxygen measurement data. Therefore, EMSO ERIC will offer the service of dissolved oxygen sensor calibration to its Regional Teams. The service will rely on the use of a calibration bench specially designed for EMSO in the framework of the H2020 EMSO-Link project³². The dissolved oxygen bench will be operated by skilled personnel from a selected institute managing a facility by mid 2022.

Moreover, in 2022 the Communication Services Group will participate in the organization of internal and external training sessions on topics of interest to the EMSO community.

2023

- Full operational system and design of a long-term maintenance plan.
- Data-based Science Services are user-specific and in most cases, as is fitting for EMSO, multidisciplinary. They may each be based on several datasets, from both connected and standalone instruments, and from in situ experiments and sampling. Most require adequate Quality Control and metadata, for which standards are still a matter of debate and collective work.
- Development of the Advanced Training Framework (ATF) that aims to support young researchers and engineers in developing knowledge and skills relevant to European Marine science and technology. EMSO Advanced Training Framework components will be: (a) EMSO Doctoral Summer Schools at some of the EMSO observatories to train the young researchers, technologists and technicians on marine environmental science and technology topics, put them in contact with the cutting-edge technology developed in the EMSO Regional Facilities; (b) Onsite Training Camps: oriented towards university students in marine-related disciplines and also to professionals of the sector. The objective is to train in developing theoretical and technological skills to grow the next generations of marine researchers, technologists, technicians and officers.
- Availability of a shared pool of equipment to be used by Regional Facilities.
- Central procurement service for critical or massively used components. Beyond the primary benefit of technical convergence, this service will i) mutualise the solving of legal issues associated with the spending of public money by preparing and launching the corresponding public tenders, ii) increase EMSO's global negotiating leverage in the marketplace.

References

- [1] Wilkinson, M.D., M. Dumontier, I.J. Aalbersberg, G. Appleton, M. Axton, A. Baak, N. Blomberg, J.-W. Boiten, L. Bonino da Silva Santos, P.E. Bourne, J. Bouwman, A.J. Brookes, T. Clark, M. Crosas, I. Dillo, O. Dumon, S. Edmunds, C.T. Evelo, R. Finkers, A. Gonzalez-Beltran, A.J.G. Gray, P. Groth, C. Goble, J.S. Grethe, J. Heringa, P.A.C. 't Hoen, R. Hooft, T. Kuhn, R. Kok, J. Kok, S.J. Lusher, M.E. Martone, A. Mons, A.L. Packer, B. Persson, P. Rocca-Serra, M. Roos, R. van Schaik, S.-A. Sansone, E. Schultes, T. Sengstag, T. Slater, G. Strawn, M.A. Swertz, M. Thompson, J. van der Lei, E. van Mulligen, J. Velterop, A. Waagmeester, P. Wittenburg, K. Wolstencroft, J. Zhao, and B. Mons (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* 3.
- [2] Ruhl, H.A., M. André, L. Beranzoli, M.N. Çağatay, A. Colaço, M. Cannat, J.J. Dañobeitia, P. Favali, L. Géli, M. Gillooly, J. Greinert, P.O.J. Hall, R. Huber, J. Karstensen, R.S. Lampitt, K.E. Larkin, V. Lykousis, J. Mienert, J.M.A. de Miranda, R. Person, I.G. Priede, I. Puillat, L. Thomsen, and C. Waldmann (2011). Societal need for improved understanding of climate change, anthropogenic impacts, and geo-hazard warning drive development of ocean observatories in European Seas. *Progress in Oceanography*, 91(1), 1-33.
- [3] Favali, P., L. Beranzoli, and A. De Santis (eds.) (2015). *Seafloor Observatories: A New Vision of the Earth from the Abyss*. Springer-Praxis books in Geophysical Sciences, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-11373-4, e-ISBN 978-3-642-11374-1, doi:10.1007/978-3-642-11374-1, pp.676.
- [4] E00S is a coordinating framework designed to align and integrate Europe's ocean observing capacity, promote a systematic and collaborative approach to collecting information on the state and variability of our seas, and underpin sustainable management of the marine environment and its resources, <https://www.eoos-ocean.eu/>.
- [5] The Marine Strategy Framework Directive (MSFD) was adopted in 2008 aiming at protecting effectively the marine environment across Europe. There are a set of criteria and methodological standards to help Member States implement the Directive, https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm.
- [6] The Common Fisheries Policy (CFP) was designed by the EC to increase productivity, stabilise the markets, provide a source of healthy food and ensure reasonable prices for consumers. Its latest reform was achieved in 2013 focusing the policy on environmental, economic and social dimensions of fisheries and on sustainable management, https://ec.europa.eu/oceans-and-fisheries/policy/common-fisheries-policy-cfp_en.
- [7] The Habitats Directive was adopted in 1992, on the conservation of natural habitats and of wild fauna and flora aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements, https://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm.
- [8] The EU Water Framework Directive (WFD) was adopted in 2000 to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, https://ec.europa.eu/environment/water/water-framework/index_en.html.
- [9] The Maritime Spatial Planning Directive (MSPD) was adopted in 2014 aiming at improving the management of European seas and oceans coherently and ensuring that human activities take place in an efficient, safe and sustainable way, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0089>.
- [10] The European Research Vessels Operators' Group is a forum that meets regularly joining European managers of research vessels, <https://www.ervo-group.eu/>.
- [11] EMSODEV is the acronym of a H2020 project called "EMSO implementation and operation: DEvelopment of instrument module" (2015-2019), <https://cordis.europa.eu/project/id/676555/it>.

- [12] ERDDAP (Environmental Research Division Data Access Program) is an open-source data server that gives users a simple and consistent way to download subsets of scientific datasets in common file formats and make graphs and maps. This data server is commonly used by major ocean data providers.
- [13] EMODnet. The European Marine Observation and Data Network, <https://emodnet.eu/en>.
- [14] OceanSITES is a worldwide system of long-term, open-ocean reference stations measuring dozens of variables and monitoring the full depth of the ocean from air-sea interactions down to the seafloor, <http://www.oceansites.org/>.
- [15] ENRIITC is the acronym of a H2020 project called "European Network of Research Infrastructures and Industry for Collaboration" (2020-2022), <https://enriitc.eu/>.
- [16] UN Decade of Ocean Science for Sustainable Development (2021-2030), <https://en.unesco.org/ocean-decade>.
- [17] The Euro-Argo ERIC allows active coordination and strengthening of the European contribution to the international Argo programme. The program promotes real-time acquisition of physical and biogeochemical parameters of the water column by profiling floats, <https://www.euro-argo.eu/>.
- [18] The Integrated Carbon Observation System ERIC (ICOS), aims at producing standardised, high-precision and long-term observations and facilitate research to understand the carbon cycle and to provide necessary information on greenhouse gases. <https://www.icos-cp.eu/about/icos-in-nutshell/mission>.
- [19] The European Marine Biological Resource Centre ERIC (EMBRC) was established in 2013 to advance fundamental and applied marine biology and ecology research – while promoting the development of blue biotechnologies. This is achieved by enabling access to services, facilities, and technology platforms in its 45 marine stations in 9 European countries in support of robust, cost-effective and efficient research, <https://www.embrc.eu/about/who-we-are>.
- [20] LifeWatch ERIC is a European Infrastructure Consortium providing e-Science research facilities to scientists seeking to increase our knowledge and deepen our understanding of Biodiversity organisation and Ecosystem functions and services in order to support civil society in addressing key planetary challenges, <https://www.lifewatch.eu/who-we-are>.
- [21] Dañobeitia, J.J., S. Pouliquen, T. Johannessen, A. Basset, M. Cannat, B. G. Pfeil, M.I. Fredella, P. Materia, C. Gourcuff, G. Magnifico, E. Delory, J. del Rio Fernandez, I. Rodero, L. Beranzoli, I. Nardello, D. Iudicone, T. Carvalho, J.M. Gonzalez Aranda, G. Petihakis, J. Blandin, W.L. Kutsch, J.-M. Rintala, A.R. Gates, and P. Favali (2020). Toward a comprehensive and integrated strategy of the European marine research infrastructures for ocean observations. *Frontiers in Marine Science*, 7, 180, <https://doi.org/10.3389/fmars.2020.00180>.
- [22] The Belmont Forum is an international partnership that mobilizes funding of environmental change research and accelerates its delivery to remove critical barriers to sustainability, <https://www.belmontforum.org/>.
- [23] International Ocean Governance is about managing the world's oceans and their resources together so that they are healthy and productive, for the benefit of current and future generations, https://ec.europa.eu/maritimeaffairs/policy/ocean-governance_en.
- [24] EMB-European Marine Board (2019). Navigating the Future V: Marine Science for a Sustainable Future. Position Paper 24 of the European Marine Board, Ostend, Belgium, ISBN 9789492043757, ISSN 0167-9309, doi:10.5281/zenodo.2809392.
- [25] Nieuwejaar, P., V. Mazaauric, C. Betzler, M. Carapuço, A. Cattrijsse, F. Coren, J.J. Dañobeitia, C. Day, A. Fitzgerald, S. Florescu, J. Ignacio Diaz, M. Klages, E. Koning, O. Lefort, G. Magnifico, Ø. Mikelborg, and L. Naudts (2019). Next Generation European Research Vessels: Current Status and Foreseeable Evolution. In: Heymans, J.J., P. Kellett, C. Viegas, B. Alexander, J. Coopman, and A. Muñiz Piniella (eds.). Position Paper 25 of the Eu-

ropean Marine Board, Ostend, Belgium, 140 pp., ISBN: 978-94-92043-79-5, doi:10.5281/zenodo.3477893.

- [26] JPI Oceans (Joint Programming Initiative "Healthy and Productive Seas and Oceans") is an intergovernmental platform that strives to increase the impact of national investments in marine and maritime research and innovation, https://www.jpi-oceans.eu/sites/jpi-oceans.eu/files/public/Strategy%20Launch%202021/20210329_JPI_Oceans_Strategic_Framework_Final.pdf.
- [27] Copernicus Marine Service is providing free and open marine data and services to enable marine policy implementation, supporting Blue Growth and scientific innovation, <https://www.copernicus.eu/en>.
- [28] ENVRI-FAIR is the acronym of an H2020 project called "Environmental Research Infrastructures building Fair services Accessible for society, Innovation and Research" (2019-2022), <https://envri.eu/home-envri-fair/>.
- [29] EOSC EB-European Open Science Cloud Executive Board (2020). Solutions for a Sustainable EOSC. European Commission Directorate-General for Research and Innovation, Directorate G - Research and Innovation Outreach, Unit G.4 - Open Science, PDF ISBN 978-92-76-25594-9, doi:10.2777/870770 KI-02-20-999-EN-N.
- [30] UN ESC-United Nations Economic and Social Council (2019). Special edition: progress towards the Sustainable Development Goals, Report of the Secretary-General. E/2019/68, pp.39.
- [31] EC-DG R&I (2016). European Charter for Access to Research Infrastructures, doi:10.2777/524573.
- [32] EMSO-Link is the acronym of the H2020 project called "Implementation of the Strategy to Ensure the EMSO ERIC's Long-term Sustainability" (2017-2020), <https://cordis.europa.eu/project/id/731036/en>.
- [33] The EU Blue Growth Strategy. Blue Growth is the long term strategy to support sustainable growth in the marine and maritime sectors as a whole, <https://blue-action.eu/policy-feed/blue-growth>.
- [34] HLEG-High-Level Expert Group assessment, https://ec.europa.eu/info/publications/sustainable-finance-high-level-expert-group_en.

Acknowledgements

EMSO ERIC Long-Term Vision and Strategic Plan 2021-2023 is a significant effort of synthesis and has been carried out mainly with the participation of the Science, Technology and Ethics Advisory Committee (STEAC), the Executive Committee (ExCom) and the Central Management Office (CMO) under the leadership of the Director-General Juan José Dañobeitia.

Juanjo Dañobeitia | DG | EMSO ERIC

Paolo Favali | EMSO ERIC

Nicolas Pade | EMBRC

Christos Arvanitidis | LifeWatch ERIC

Maria Incoronata Fredella | EMSO ERIC

Marco Galeotti | EMSO ERIC

Alessandra Giuntini | INGV

Francesca Di Laura | INGV

November 2021



