3rd PERIOD PROJECT REPORT Work Package 1 *Deliverable 1.2:* Final Project Report	**7th FRAMEWORK PROGRAMME** **CAPACITIES:** **Research Infrastructures**

Version: **1** **Date: 30/11/2012** **Pages**: **25**	**Responsible authors**: Paolo Favali Laura Beranzoli Pier Luigi Franceschini	**Co-Author(s)**: -	**To**: Agnés Robin

Status: [ ] **Template** [ ] **Draft** [X] **Final / Released to EC**	**Confidentiality**: [ ] **PU** Public [ ] **PP** Restricted to other Programme participants (including the Commission Services). [ ] **RE** Restricted to a group specified by the consortium (including the Commission Services). X **CO** Confidential, only for members of the consortium (including the Commission Services).

Content:
Report for the entire project (m1-54) of EMSO Preparatory Phase project

PROJECT FINAL REPORT

Grant Agreement number: 211816

Project acronym: EMSO

Project title: European Multidisciplinary Seafloor Observation-Preparatory Phase

Funding Scheme: Combination of CSA and collaborative project

Period covered: from 1st of March 2008 to 30th of September 2012

Name, title and organisation of the scientific representative of the project's coordinator:

Prof. Paolo Favali

Istituto Nazionale di Geofisica e Vulcanologia (INGV), via di Vigna Murata, 605 - 00143 Roma (Italy)

Tel: +39-06-51860-341 (secretary); +39-06-51860-428 (direct)

Fax: +39-06-51860-338

E-mail: emsopp@ingv.it

Project website address: http://www.emso-eu.org

Table of content

1. Final Publishable Summary Report

1.1 Executive Summary

EMSO-Preparatory Phase (EMSO-PP) is a project whose main goal is to set the basis for the creation of the organisation that will manage the European Multidisciplinary Seafloor Observatory EMSO, a large scale, distributed, marine Research Infrastructure (RI). EMSO will be based on a European-scale network of seafloor observatories and platforms with the basic scientific objective of long-term monitoring, mainly in real-time, of environmental processes related to the interaction between the geosphere, biosphere, and hydrosphere, including natural hazards. It will be a geographically distributed infrastructure composed of several deep-seafloor and water-column observatories, which will be deployed on specific sites around European waters, reaching from the Arctic to the Black Sea passing through the Mediterranean Sea, thus forming a widely distributed pan-European infrastructure.

The most important achievement of EMSO-PP was the definition of the commitment of different European Countries towards the creation of a fixed point, open ocean observing RI. During the project duration several important milestones towards the creation of the management framework of EMSO were achieved. Close consultation with the partners' Funding Agencies led to the decision of adopting the ERIC (European Research Infrastructure Consortium) as a suitable legal tool to implement the central managing organisation of EMSO.
Countries supported the view of the realisation of a light governing body that will manage in a coordinated fashion the distributed network of observatories. This will set a strong basis for the important scientific goal of ensuring the collection long-term time series of data, and enabling the future open access of the distributed RI to scientists all over the world. EMSO builds its strength on the distributed character and the fact that over the years there has been a consistent investment from different Countries in ocean observing systems that will make the initial backbone of the network of observatories around Europe. In this framework, a small and agile ERIC, operated by a Central Management Office (CMO) was judged as the most appropriate and feasible. An important step towards the establishment of a permanent organisation was the designation of the country that will take the leading role in the realisation of the ERIC. Italy, through the Italian Ministry of Education, University and Research, formally expressed the intention to lead the EMSO-ERIC and host the EMSO Secretariat.
The commitment of the Countries was formally manifested through the signature of a Memorandum of Understanding (MoU), expressing the willingness of different Countries to undertake all the necessary steps required to establish EMSO-ERIC. The MoU is also the document that formally enables the start of EMSO Interim Office, that will be in charge of finalising the application for the EMSO-ERIC. Thanks to the work conducted within the Preparatory Phase, the Consortium has now all the necessary background documentation necessary to submit the ERIC application to the EU. It is expected that the application will be handed once a significant critical mass in terms of participating countries will be reached, and the time estimation is within the first months of 2013,. As of the end of November 2012 seven countries have signed the MoU (Italy, UK, The Netherland, Ireland, Greece, Portugal, Romania). It is expected that 3 additional countries will join between the end of the year 2012 and the first month of 2013. Another substantial indicator of the commitment of the countries was also manifested through the financial figures collected throughout EMSO-PP, which evidenced that 130 M€ of in-kind contribution and more that 50 M€ of in-cash contribution are available for EMSO implementation.

1.2 Summary description of project context and objectives

EMSO Research Infrastructure (RI) is a European-scale network of fixed point observatories, constituting a widely distributed infrastructure for long-term monitoring of environmental processes related to ecosystem life and evolution, global changes and geo-hazards. EMSO is deployed on specific sites around European waters from the Arctic to the Black Sea passing through the Mediterranean Sea. The basic scientific approach is the long-term monitoring, mainly in real-time, of environmental processes related to the interaction between the geosphere, biosphere, and hydrosphere, including natural hazards. Major advances in the understanding of environmental processes require the identification of temporal evolution and cyclic changes and to capture episodic events relative to oceanic circulation, deep-sea processes and ecosystems evolution. Long-term monitoring will allow the capture of episodic events such as earthquakes, submarine slides, tsunamis, benthic storms, biodiversity changes, pollution and other events that cannot be detected and monitored by conventional oceanographic sea-going campaigns. The establishment of the EMSO network of seafloor and water column observatories represents a change of direction in Ocean Science research - considering that over the 70% of Earth's surface is covered by oceans - to provide truly global geophysical and oceanographic coverage. The EMSO infrastructure will enhance our understanding of processes that require long-time series data appropriate to the scale of the phenomena. The new frontier of multidisciplinary understanding of ocean interior, deep-sea biology and chemistry and ocean margin processes will be addressed by permanent monitoring of key areas around Europe. EMSO will be a key component of GEOSS. This RI will be also the sub-sea segment of the GMES initiative and will significantly enhance the accessibility of observational data for the Scientific Community. The EU has been supporting the creation of a multidisciplinary network of seafloor and water-column observatories through different projects, among which the ESONET Network of Excellence (ended in February 2011) aimed at gathering together the community interested in multidisciplinary ocean observatories. EMSO development is based on the synergy between the scientific community and the industry with the aim of significantly improving marine technologies and developing strategies to improve European capacities and competitiveness with respect to countries such as Canada, USA and Japan, which have recently intensively invested in a series of initiatives in the field of deep-sea observation.

The realisation the above-described RI is a complex endeavour, requiring a good deal of resources. EMSO-PP project aimed at addressing all the issues to be faced to achieve the ambitious goal of implementation, operation and management of the distributed RI. The specific objectives to be achieved within the Preparatory Phase were:

1. the definition and agreement on the governance and legal form for the EMSO organisation;
2. the design of a business plan including contributions from national, European, and international funding resources;
3. the achievement of a long-term commitment from the involved Funding Agencies;
4. the definition of the operational procedures with regard to deployed instrumentation, logistic intervention and maintenance;
5. the outline of EMSO implementation plan;
6. the establishment of the engineering specifications for the observatories. These specifications will describe all engineering aspects required for consistent cost estimation and the launching of the implementation phase.

The achievement of the above-mentioned strategic objectives during EMSO-PP was the result of the concerted work conducted by the EMSO-PP partnership who implemented jointly the activities of the Preparatory Phase.

This project gave a fundamental contribution to define the organisational, legal, financial and technical profile of EMSO organisation.
The project addressed governance and legal aspects through a continuous interaction between **WP2 (Governance Structure)** and **WP3 (Legal Work)**. **WP2 (Governance Structure)** performed a survey of selected available RIs in Europe. Existing RIs such as CERN, EMBL, ESO and the synchrotron facility ELETTRA were investigated. Not only organisational aspects were addressed but also staff issues, relationship with the industry and access rules. The subsequent step was the definition of a set of governance scenarios on the basis of the input from the former task. The defined scenarios were benchmarked against the needs of the EMSO RI and it was decided to follow a model in which a light and agile coordinating body (Central Management Office-CMO) will interface with those scientific/governmental institutions around Europe that own and operate observatories at the sites identified by EMSO. EMSO builds its strength on the distributed character and the fact that over the years there has been a consistent investment from different Countries in a set of facilities that will make the initial backbone of the network of observatories around Europe. The EMSO-ERIC will be the central coordination body of the EMSO Research Infrastructure that will be operating through the CMO, with staff directly hired by EMSO-ERIC or provided as contribution in-kind by the participating States. Regional Teams and Service Groups will be the major organisation component within EMSO organogram. Regional Teams will be operating and maintaining facilities whereas Service Groups will address various horizontal topics such as engineering, standardisation, outreach and training. EMSO-ERIC will stipulate agreements with owners of observatories, who will make available measurement time, instrumentation, facilities and services to a large international community of researchers and other stakeholders, fully following the philosophy of an open access mode. This governance concept was used as the basis to draft the ERIC Statutes, which is one of the main deliverables of WP3.

For such as concern **WP3 (Legal Work)**, the evolution of the ERIC legal framework for large European infrastructures was closely monitored. An analysis of the suitability of this framework for EMSO RI was performed. This analysis eventually led to the decision that the ERIC will be the legal framework to be adopted.
Following this decision, WP3 thus developed all necessary documentation needed for the ERIC application and to regulate the relationships among the participating institutions. The EMSO-ERIC Statutes and S&T Description were drafted and revised by the partners, who provided their inputs in close consultation with the respective Funding Agencies. WP3 also developed Implementing Rules, a document regulating some additional details concerning the ERIC organisation and a Benefit In-Kind Contribution guidelines. Another major output of WP3 was a model agreement suitable to regulate at national/regional level the joint management of facilities, with the aim of facilitating the prospective agreements to be implemented among EMSO-ERIC and the Regional Teams.

WP4 (Financial Work) aimed at identifying national funding. The assessment of the suitability of current national funding schemes was also performed along with the assessment of the eligibility for structural funds of the EMSO sites considered. Another major part of the work in WP4 was related to relationships with national funding institutions. Partner performed their own awareness-raising activity towards the respective institutions. It turned out that the process of defining priorities for funding of RIs in the different Countries differs to a great extent. The financial plan of the whole project and of the individual partners were monitored and updated. The in-kind contribution that the Countries are currently capable to make available was determined: this part of the work showed the consistent investments that the States have already devoted to fixed-point ocean observations and the great potential for future implementation of EMSO through coordination of existing facilities. The available in kind contribution, that countries are able to ensure, has been revised and is estimated at a level of € 130 million (as of November 2012). These resources have been estimated taking into account existing facilities, permanent staff to be made available for RI management and operation, and logistic resources such as research vessels and ROVs. The WP4 also concentrates the great effort that the partnership has devoted to fund raising activities. This involved keeping continuous contacts and communication with the Funding Agencies to evaluate the funding perspectives, coordinating with national research institutions interest in EMSO, producing feasibility studies for the realisation of observatory nodes and preparing grant applications for national funding instruments dedicated to research infrastructures. The complexity of the work in WP4 reflects the heterogeneity in funding instruments for RIs (magnitude, timing, application mechanisms, and evaluation procedures) among the different participating countries.

WP5 (Business Plan) was devoted to the continuous refinement of the costing of the ocean observatories and the different rounds of CAPEX and OPEX were developed. A major output of WP5 was the business plan (BP) for the EMSO-ERIC Central Management Office (CMO) and the cost benefit analysis tool and cost benefit analysis report for a regional node which is applicable to other sites. The CMO document illustrates the main tasks, internal organisation, costing, staffing and logistic aspects. Regional-level model BPs were delivered for selected EMSO sites, along with a comprehensive template to be used for future in-depth regional BPs to be finalised in the presence of a clear funding scenario for a distributed node.

WP6 (Logistic Work) activities were focused on the preparation of suitable tools to manage EMSO logistics, which will be a critical part of EMSO activities and will have important consequences on operational and maintenance costing.. The tools to be developed for logistic management were presented in D6.1 (Logistic Needs) and it was suggested to extend the scope and definition of the tool beyond the duration of the task initially envisioned in Annex I. The work was also devoted to survey existing resources. Important advances were made in collecting information about national resources and procedures to increase the benefit of the interchange and interoperable tools. The goal is to improve to some extent the convergence in methods and procedures, if at all possible, by drafting guidelines and standards and harmonized procedures for a more comprehensive system of the European seafloor observatories. The work on the definition of the main logistical needs in the technical sea-procedures related to deployment and set-up of the different laboratories, cabled and/or stand-alone, was continued by focussing on the development and implementation of GIS based cost-efficient strategies. The purpose of this information system is to be able to evaluate in short time the best solutions in terms of cost/benefit for whatever intervention need on the site. Moreover, the sea operational procedures arisen during the demo missions were outlined for the deployment of submarine cables (OBSEA experience) and deep submarine observatories (GEOSTAR experience) in order to start delineate straight and common protocols for submarine observatories operational plans. WP6 addressed also additional logistic aspects related to the future implementation of EMSO-ERIC, covering problems related to staff management of the future organisation and the actual location of the ERIC statutory seat to be established in Italy.

WP7 (Strategic Work) Activities were focussing on exploring the access conditions for comparable research infrastructures as planned for EMSO. The conditions for EMSO are specific in the sense that a distributed infrastructure is planned and therefore the recommendations that should be developed should leave enough flexibility to account for different constraints in different countries or regions (task 7.1). Currently links are built up to other observatory initiatives as for instance EUROARGO using the fact that these projects also seek for long-term establishment of their systems by establishing an ERIC (task 7.2). The identification of sites with operational capabilities was carried out as well. WP7 further addressed the implication related to access rules, in particular by analysing the experience gathered by other research infrastructure. In regard to the integration with other observational programmes, GEOSS was top on the list to find out how future observatories can contribute to this global observational program. Within task 7.3, specific ocean observing sites have been selected to find out the current observational status and how to carry out the next steps to achieve full operational status, meet all the standards according to the descriptions within the ESONET label. WP7 covered also different aspects related to the impact assessment of EMSO infrastructure, from the point of view of the industrial dimension, the integration within international initiatives such as GEOSS and GMES, and the integration with complementary observing techniques. WP7 produced as well the implementation plan of EMSO-ERIC, outlining the tasks and scope of work, considering a phased approach connected to a stepwise construction of the different EMSO sites.

WP8 (Technical Work) produced as a first output (D8.1-Report on System Analysis) a system analysis of ocean observatories. The report provided an overview of the essential infrastructure components to establish ocean observatories in the open sea. Based on existing and planned implementation concepts the document aimed to support the definition of a common base for deciding on alternative implementation concepts according to the scientific requirements. D8.2 reported on the reliability of examined sub-sea infrastructures, in a key document for describing the whole infrastructure. WP8 addressed also additional technical issues. Low reliability components were identified and several predominant failure causes such as parts, design, manufacturing, system management and wearing out. Following these failure causes it also seems very important to choose a reliable designer and manufacturer for the seafloor observatory. Also long-term protection of sensors was address with particular emphasis on existing bio-fouling protection systems and antifouling experiments, which were realized in real conditions on sub-sea observatories for testing purposes. Power utilisation issues were also addressed and three real-life experiments were chosen to illustrate the problem of energy requirement in an undersea observatory. In addition WP8 continued the technical evaluation of critical engineering issues to such as extension scenarios of deep-sea cabled observatories.

EMSO-PP dissemination and outreach activity towards the research community and other relevant stakeholders was consistent during the entire project duration. One of the most outstanding effects of the dissemination campaign was the involvement of an additional country (Romania) among the potential future members of EMSO-ERIC, bringing along important strategic implications related to presence project aimed at establishing a first nucleus of permanent observing systems in the Black Sea.
A diverse mix of dissemination actions were carried out, targeting both the science community at EU and international level as well as a larger public. A dissemination article directed towards a more political audience was produced (an article about EMSO was published on “Eccellenze Italiane” a magazine that was distributed in June 2009 at the G8 meeting held in Italy). Two articles covering complementary aspects about EMSO were published on the “Projects” magazine (in 2009 and in 2012), an EU-projects-dedicated magazine distributed among 38000 stakeholders across all countries in Europe and internationally at every level in the government, policy, research, environment, climate, biodiversity and private sector community. EMSO was also featured in different scientific peer-reviewed articles jointly authored by a large number of EMSO-PP participants, showing a very good collaborative effort from the community (e.g., Ruhl et al., 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, doi:10.1016/j.pocean.2011.05.001). Interactions of EMSO with relevant environmental RIs were increased, especially on data management and e-infrastructure topics. These exchanges led to the active involvement of EMSO community in projects such as ENVRI (common e-infrastructure framework for environmental RIs, www.envri.eu), SCIDIP-ES (long-term data preservation, www.scidip-es.eu) and GENESI-DEC (creation of a single access point for earth science data, http://www.genesi-dec.eu/). One of the most successful outcome of the dissemination activities was the interaction with initiatives analogous to EMSO in other continents. As a result, very strong links have been now established with ONC-Ocean Networks Canada (managing organisation of the NEPTUNE RI). The cooperation with the US led to the start of a dedicated project (COOPEUS) funded by EU, while NSFsill fund the US participation. EMSO-PP representatives also participated to dedicated workshops addressing cooperation with China and Australia (two workshps organised by EU). This intense activity clearly demonstrates the truly global nature of EMSO RI, characteristics that were further underlined during the participation of EMSO at the ICRI conference (International Conference on RI) in Copenhagen during March 2012. It is also worth mentioning that a EMSO RI was cited in a motion at the European Parliament underlying the needs for increased monitoring capabilities in the Arctic regions: EMSO, along with the SIOS research infrastructure, have been mentioned as crucial and essential.

1.3 Description of the main S&T results/foregrounds

1.3.1 Overview of the objectives

The main overarching objective of the EMSO-Preparatory Phase (EMSO-PP) is to establish the organisational, legal and governance framework for the infrastructure serving scientists and other stakeholders in Europe and outside Europe for long-term deep water observation and investigation. This framework will enable the deployment of the infrastructure and its long-term management. Moreover, EMSO-PP will promote the catalytic process and synergic effort at EC and national levels, coordinating and harmonising all available resources.

The Preparatory Phase will solve critical issues that have not been addressed by other projects, for instance:

- The variety of regional sites in terms of available legal frameworks;
- the harmonisation of funding (national, European, international, industrial) with respect to scope, objectives, and timing;
- the logistic constraints regarding available European resources and environmental protection;
- possible technical bottlenecks for which currently no off-the-shelf solution is available will be investigated.

In order to solve the above-mentioned issues, the objectives (for the whole project duration) to be achieved by the preparatory phase are:

1. Definition and agreement upon the governance and legal form for the EMSO infrastructure
2. Design of a funding plan including contributions from national, European, and international funding resources. More specifically, a business plan covering both the investment and the operational expenditures for the first decade of service will be set up.
3. Achievement of a long-term commitment from the involved funding agencies: it will be obtained through the activation of discussion tables where the largest possible political convergence will be reached and formalised in specific agreement protocols and MoUs.
4. The operational procedures with regard to deployed instrumentation, logistic intervention and maintenance will be defined.
5. Definition of a long-term strategy and site selection.
6. Establishment of the engineering specifications for each chosen site. These specifications will describe all engineering aspects required for consistent cost estimation and the launching of the realisation phase.

During EMSO-PP project duration the following results were obtained:

- With respect to objective 1, it has been established that the European Research Infrastructure Consortium (ERIC) will be the legal form characterising the CLE. RLEs (as originally defined in EMSO-PP Annex I) are involved in EMSO overall governance, and will be organised around Regional Teams dedicated to the operation and maintenance of a distributed nodes, and Service Groups addressing horizontal issues (e.g., engineering, standardisation). Implementing Rules have been issued to complement the Statutes.
- For such as concern objective 2, updates of the funding plan were produced, and it has been estimated that the in-kind contribution is about 130 M€, whereas available funding for construction is higher than 50 M€.

- For such as concern objective 3, the overall perspective towards the realisation of EMSO is positive due to the signature of a MoU for the realisation of EMSO-ERIC by 7 Countries as of November 2012.
- Objective 4 was achieved in previous reporting periods, due to the development of a set of tools to optimise logistic intervention. The work on the definition of the main logistical needs in the technical sea-procedures related to deployment and set up of the different laboratories, cabled and/or stand-alone, was continued by focussing on the development and implementation of GIS based cost-efficient strategies. Sea-operational procedures arisen during the demo missions were outlined for the deployment of submarine cables (OBSEA experience) and deep submarine observatories (GEOSTAR experience) in order to start delineate straight and common protocols for submarine observatories operational plans.
- A long-term strategy for EMSO was conceived towards full realisation of objective 5. A phased implementation approach was described, identifying those sites that will be constructed and/or extended in a first round, utilising already-available funding.
- Objectives 6 was addressed by tackling additional technical issues that were not covered during the previous reporting period, and updating previous technical reports that will be of fundamental value for the construction phase. In particular the attention was drawn to power utilisation and on long-term preservation of sensors and cables observatories extension scenarios.

1.3.2 Results of the legal and governance work

EMSO-ERIC legal and governance definition was one of the main outcome of the project. EMSO will coordinate and facilitate access to open ocean fixed point observatory Infrastructures according to selection criteria defined by the participating members. EMSO will be The EMSO-ERIC will be the central point of contact for observatory initiatives in other part of the world to set up and promote cooperation in this field.

The composition of the EMSO-ERIC governing bodies will be the following:

- Assembly of Members (AoM)
- Scientific and Technical Advisory Committee (STAC)
- Executive Board (EB)
- Director General (DG)
- EMSO Regional Team and Service Group Heads

The governing bodies will be supported by a Central Management Office that will collaborate with the Director General to ensure the day-to-day management of the ERIC. The scheme of the governance Structure is depicted in figure 1.1.

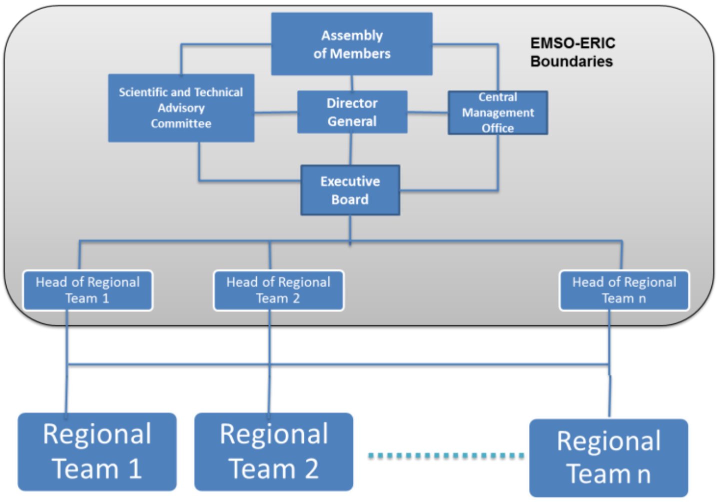


Figure 1.1-Governance of the EMSO-ERIC

The **Assembly of Members (AoM)** will be the highest decision-making body of EMSO-ERIC and will be composed by one representative of the Member and Associate States/Funding Agencies. Each Country shall have a single vote within the Committee. The **Director General**, appointed by the AoM will be a highly qualified professional with an international reputation, vision and high-level profile, with proven management expertise. The Director General will be in charge of the day-to-day management of EMSO and is the contact point for the governing bodies and the operational part of EMSO. The **Executive Board** (RB) will be in charge of EMSO-ERIC day-to-day management in strict collaboration with the Director General. It is composed of the Director General, and one representative for each EMSO site. Additional experts may be called at Executive Board meeting when necessary. It will work with the Director General to formulate the strategies to be proposed to the Assembly of Members that will discuss and ratify them. The Executive Board and the Director General will work to ensure the management and operation of EMSO. The Executive Board discusses and proposes budget and staff issues to be submitted to the Assembly of Members. The Chairperson of the Executive Board is the Director General. The **Scientific and Technical Advisory Committee (STAC)** shall be established as an advisory body, to provide recommendations on the strategy of the RI and to advice on the general scientific activities of the RI. It will be the major representative of EMSO user community and will ensure that the EMSO-ERIC is capable of providing services which will enable Europe to lead the different science domains covered by EMSO. EMSO **Central Management Office (CMO)** will be established at EMSO-ERIC headquarters. It will be composed of the following staff members: i) The Director General; ii) A secretariat for the Director General; iii) A Data Management Unit; iv) A Project Manager will be appointed to deal with managing duties related to EC-funded project; v) A Logistics Manager who will coordinate the logistics aspects of EMSO-ERIC. The Logistics Manager will be in charge of the coordination of the effective ship and ROV time sharing at EMSO sites; vi) A Finance Department, composed of 1 Chief Financial Officer and 2 accountants when the RI will be fully operational.

Each EMSO site operation shall be organised by **Regional Teams and Service Teams:**

- Regional Teams, which technically sit outside of the EMSO-ERIC, can own and run EMSO observatories, which may be regionally localised in proximity of the site, shore station, or may be further distributed among different Countries having a specific interest for a given site (e.g., the Arctic).

- Service Groups provide specific services across all regions in thematic areas such as Engineering, Public Outreach, Legal Consultancy, Education, Technology Transfer and Intellectual Property Rights management, Calibration and Testing Groups, etc. Service Groups shall be proposed by the Executive Board and approved by the Assembly of Members.

Regional Teams will not necessarily be located in one geographic location. The Regional Team shall be led by a **Head of Team** who will be a member of the EMSO Executive Board. The Head of Team will be in charge of coordinating the group of scientists, engineers and technicians that are located in each Regional Team. EMSO **Regional Team** and **Service Group** will be represented on the EB.

For such as concern the legal work, one of the most important elements in WP3 was the appointment of legal advisors to the consortium to advise on the necessary elements to consider for an EMSO-ERIC. Following a procurement procedure, Bird & Bird were appointed as legal advisors to EMSO. Following the decision of the consortium to move from an owner/operator model to a coordinating role, Bird & Bird assisted in developing a Model Agreement for benefit-in-kind contributions to the ERIC (identified as part of work undertaken in WP4 & WP5). The model agreement facilitates the sharing of infrastructure between partners or opening it up to scientists (in a similar manner to TNA-TransNational Access schemes operating in current I3 projects). The EMSO-ERIC Statutes was also developed following the indication of the European Commission (e.g., membership, internal structure, members liability, public procurement procedures, fiscal policy (VAT) and excise duty etc.).
The commitment of the Countries to participate to the ERIC has been expressed through a Memorandum of Undestanding (MoU): at the time of writing this report (November 2012), **seven partners** have successfully signed a MoU stating their intention to support the procedure for the EMSO-ERIC submission to EU, and to become full or observer members of the EMSO-ERIC. **Three additional countries** are expected to sign in the

short term. A complete set of legal documentation is available for an EMSO application which will be hosted by INGV in Italy. The intermediate time between the end of the Preparatory Phase and the ERIC application will be managed by an Interim Office, appointed by EMSO-PP Steering Committee. The available legal documentation to support this phase includes a set of statutes, a set of implementing rules, a scientific and technical description of the infrastructure, a model agreement for benefit in kind contributions, model agreements for Regional Teams and the signed MoU, which has entered into force.

1.3.3 Results of the financial work and Business plan

The financial work carried out in WP4 focused on the evaluation of available resources at European and national level to support the creation of EMSO. Partners provided their figures including in-kind contribution like facilities (depreciation rate taken into account), ship and/or ROV time and human resources. The table 1.1 illustrate the last updated for these numbers, which shows a level of overall commitment over 130 M€.

Partner	Facilities	Facilities with deprec.	Ship time	ROV time	human resources	TOT (K€)
INGV	18930	11932	3900	150	1523	36 435
IFREMER	2346	893	5030	1550	6272	16 091
KDM	24000	4836	3000	500	565	32 901
IMI	2000	819	900	300	183	4.202
UTM-CSIC	7290	726	6150	150	1094	15 410
UGOT	108	36	24	50	568	786
HCMR	1300	411	1000	150	1373	4 234
NERC	300	60	760	n/a	12799	13 919
UiT	1750	127	1015	0	199	3 091
FCUL	1590	464	0	0	890	2 944
ITU	0	0	1 200	0	586	586
NIOZ	520	142	n/a	0	854	1 516
	60 134	**20 446**	**21 779**	**2 850**	**26 906**	**132 115**

Table 1.1 - In-kind contribution by partner

For such as concern the available in-cash contribution the partnership periodically updated the status of the respective fund raising activities. One of the major issues arising in this respect is the heterogeneity among the funding sources in the different EU Countries. Different timing and magnitude of funding could cause some difficulties in synchronising the construction phase.

WP5 was devoted to establishing a business plan for EMSO sites and Central Management Office. These activities started with taking into account capital and operational expenditures (CAPEX/OPEX) which were estimated following an iterative process. CAPEX and OPEX estimates were derived from various sources. The earlier assessment of CAPEX (D5.1) was based on a generic set of estimates for standalone or cabled observatories. In the interim, member states continued to plan, build and operate deep sea observatories at different sites around Europe. The results of CAPEX v2 demonstrate that capital investments of over €80M are either already invested or are planned in the coming years at various sites around Europe. From an OPEX v1 perspective, 5 alternative engineering cost solutions were proposed. They included a Standalone Winch Observatory (SAWO), Standalone Acoustic Observatory (SAAO), a Multinode Subsea Cabled Observatory (MSCO), a Simplified Cable Observatory (SCO) and a Cable Extension of an Existing Observatory. An assessment of the various elements making up the total OPEX indicated that ship and ROV time would have the most significant impact on the overall annual costs. These represent up to 39% of the overall costs of EMSO. It is likely that obtaining long term finance for ongoing expenditure in the form of OPEX will present a considerable challenge for EMSO partners and Member States. OPEX v2 was very much focussed on infrastructure already in-situ and from estimates provided by partners and from the FixO3 I3 proposal which merges EMSO, ICOS, also as continuation of EuroSites.

Concerning the business plan for each EMSO site the initial plan for the project was to select a number of specific sites for detailed business plans. However, partners felt this was not appropriate for the project, particularly given that the EMSO-ERIC would be a coordinating body for all sites rather than an owner-operator in its own right. Subcontracted activities were issued for a technical review of the SmartBay project. The SmartBay project is a small scale coastal observatory in Galway Bay in Ireland which is proposed as an interim step before a more substantial observatory can be built in the Porcupine Region (a standalone observatory is already in operation by the UK at the PAP site). A review of the engineering requirements for the infrastructure and identified costs for of all of the various components of the infrastructure was performed. This allowed a second subcontract to be awarded to *Grant Thornton* management consultants who developed a cost benefit analysis (CBA) report and CBA tool. The CBA report looked at the policy drivers for the investment in a national and international context, the capital investment required, operational expenditure, revenues likely to accrue to the project and finally the like benefits in terms of number of users, employment figures and GDP growth. This tool is available for use and modification for other sites if required and the report provided a useful template of some considerations governments may have in advance of making substantial investments in a marine context. In addition, a third subcontract was awarded to SLR Consulting to develop a business plan template for use by partners seeking to get funding from private or other sources. A detailed business plan was provided for the Hellenic site as part of WP5, and material from this was used in CAPEX and OPEX v2. Costings for the Marmara site were also provided and used in alternative reports in WP5. A detailed BP was also produced in conjunction to the request for structural funds by INGV for the construction of the Western Ionian site. A business plan for the interim office of the EMSO-ERIC and the ERIC office itself was also produced. This work was integral to INGV deriving funding for the interim office and in the partners signing the MoU from WP3 whereby they signalled their intention to sign up to the EMSO-ERIC. The impact of moving from an owner-operator to a coordinating body resulted in the deliverable related to draft subcontracts being developed to a desktop study of publicly available material on procurement procedures for some of the international observatory initiatives.

1.3.4 Results of the logistic work

The progress made by the partners concerning the logistics and the operational marine plans, will have significant implications in the deployment, recover and maintenance of seafloor observatories and related infrastructures. Seafloor observatories consist of very expensive and sophisticated pool of equipment's, thus is of crucial importance the development and normalisation of technical logistics for efficient and safety sea operational procedures. The purpose is to open a door to a much better exchange and efficient collaboration between European research fleet dealing with the most important European seafloor observatories. We have made a compilation based on EurOcean on the research academic vessels enable for manoeuvring and deploying large instruments, and providing ROVS, AUVs facilities for supporting submarine laboratories complexes structures. This requires intermediate ships sizes (> 50 metres) with DP positioning system for the installation, maintenance and/or reparation or implementation of new tools and sensors. We made outstanding advances in collect information about national resources and procedures to contrast actions that may improve individual procedures on the benefit of the interchange and interoperable tools in order to increase cost/benefit.

The goal was to improve convergence in methods and procedures, if at all possible, by drafting some guidelines on standard and harmonized procedures for a more comprehensive system of the European seafloor observatories. We defined the main logistical needs to set up of the different laboratories, cabled and/or stand alone. We developed a GIS tool based cost-efficient strategies with the purpose to be able to evaluate in short time the best solutions in terms of cost/ benefice for whatever intervention need on the site. We defined a very well structured and organized overall cost-efficient plan of logistics, building up and implemented template through a GIS platform. This GIS tool can include wide range information's on all the specific location (sediments, currents, temperatures, salinity, etc.), distance to port, and large scale infrastructure available, like large ships, ROVs, AUVs, or any other marine infrastructure. The purpose is to be able to evaluate the best solutions in terms of cost/ benefice for whatever intervention need on the site.

We compiled a list of the available Research Vessels and academic ROVs whose characteristics are accountable of being use in the installation, maintenance and/or reparation and implementation of new tools and sensors on seafloor observatories. In this context we received an outstanding feedback from many European Research Institutions. A number of 22 RVs and 8 ROVs from 11 EU countries have been collected. We defined and outlined the main operational procedures to take into account and of critical importance during the pre-lay phase and during the deployment of submarine observatories. Field experiences arisen during the demo missions from ESONET represent the base for the achievement of safe and reliable operations at sea. Experiences from OBSEA test cabled laboratory in the western Mediterranean and standalone laboratory, GEOSTAR deployment, in the Gulf of Cadiz have been considered as examples. Five regional working areas have been defined based of the geographic location of the 12 seafloor observatories (Fig. 1.2). A list of available RVs for each regional area has been produced according to the usual areas of work of the vessels, in order to facilitate a better feasibility and a time and cost-saving employment of the infrastructures. It is relevant to point out that, if we consider the presence of DP systems as a sine qua non condition for the operations with and on the observatories, the number of available ships dramatically reduces for every regional area.

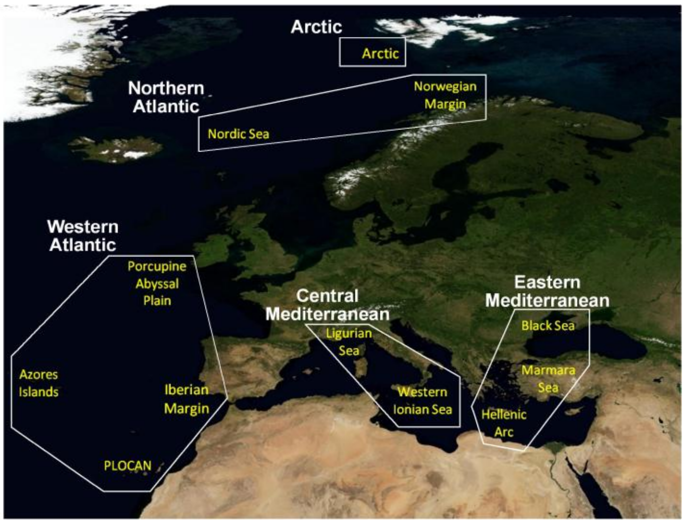


Figure 1.2-The five Regional Areas designed for the 12 EMSO seafloor observatories

We have defined some guidelines for recruitment procedures to harmonise and increase cohesion at the Regional Team scale and at the ERIC level. These distributed infrastructures should provide a high level of efficiency, therefore, manpower needs is of capital importance, therefore, a clear recruitment based on procurement procedures transparent and focused on the experience, competence skills and personal qualities, including the capacity to adapt and evolve over the longer term, will promote competitive large infrastructures aimed to transfer knowledge at a pan-European scale.

1.3.5 Results of the Strategic work

WP7 (Strategic work) had a central role for defining EMSO as a research infrastructure as the concept of operation of the relevant ocean observatories and their relationship to complementary observing systems had to be defined. The idea of having a shared use of the deployed systems is crucial and this has been covered within a dedicated task in this WP, which was aiming at analysing the access rules and impact assessment for new stakeholders/disciplines. In figure 1.3 the process oriented approach of GCOS (Global Climate Observing System) is depicted where the contribution of ocean science is represented through individual programs like the Australian IMOS and the IOOS program of the US. A number of ideas and concepts could be taken up from similar installations as for instance the MARS system at the Monterey Bay Aquarium Institute and NEPTUNE, Canada. However, for EMSO one has to extend the scope as EMSO is dealing with a geographical distributed system. Additional work was also dedicated to assessing the integration with other observation programs: this task was meant to explore synergies with global earth observing programs starting from the ARGO program to the GEOSS initiative. In particular through getting involved in GEOSS activities a number of lessons could be learned for EMSO that for instance applies to how to implement data sharing principles.

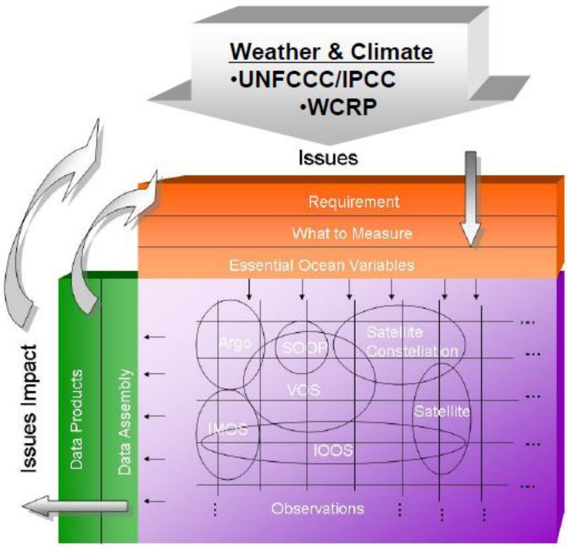


Figure 1.3-the process oriented approach of Global Climate Observing System (GCOS) is depicted where the contribution of ocean science is represented through individual programs like the Australian IMOS and the IOOS program of the US

At this moment only a few installations exist that come close to fulfilling the prerequisites of the ESONET label. Funding plans have been developed but due to the financial crisis that occurred during the lifetime of the project had to be revised.

Impact assessment is of central importance for research infrastructures to allow for sustainability. As this task is necessary for all infrastructures within the ESFRI program the EC decided to give some guidance by organising workshop to this topic. The industrial impact assessment task was benefitting from that significantly in particular by taking into account qualitative and quantitative criteria for the impact assessment. The implementation planning, defined the directions on how EMSO can be established as a permanent organization within the next two years (Fig. 1.4). This task was closely related to other WPs that were addressing the governance structure of a future EMSO-ERIC as well as legal issues in that context.

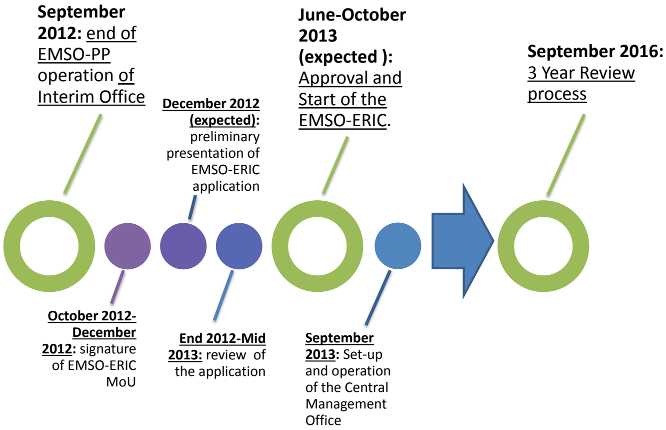


Figure 1.4 - Schematics of implementation phase

At the start of EMSO most involved ocean science institutions still had the thinking that ocean observatories are more or less installations that simply extend the capabilities of existing structures. Through ESONET and EMSO it became clear that due to the technical complexity new management and governance principles have to be introduced to allow for a sustainable operation of the anticipated research infrastructure. WP 7 had a role in that by emphasising the need of sharing infrastructures, data, and information and by describing a roadmap on how to achieve this.

1.3.6 Results of the technical work

The technical work was conducted in WP8, coordinated by IFREMER. The main objective was to define the specifications and the requirements for the upcoming sea bottom observatories in Europe.

A report on system analysis, was produced, whose objectives were to provide an overview of the essential infrastructure components to establish ocean observatories in the open sea. Based on existing and planned implementation concepts the document is aiming to support the definition of a common base for deciding on alternative implementation concepts according to the scientific requirements. There are a number of technical solutions for implementing ocean observatories. It starts with a low communication bandwidth, power limited, and buoy based system up to a high speed fibre optic based cabled system with significant amount of power supplied to the individual instrument. Evaluating the main goal of the planned observation program at the respective location a rationale can be defined for the individual implementation of the according observation system. This document only covered the system engineering aspects of ocean observatories. From that perspective the three main classes of ocean observatories are analysed. This will give rise to a structured approach to the technical implementation as well as cost calculation issues. For each observatory type functional blocks are identified and technical constraints and possible services will be discussed. No specific site was used as a template and because of that the description stays on a more general level. However, certain functional blocks are common to observatories at different sites and this will help in the planning process. Certain design premises have to be addressed within this framework. It will be necessary that:

- the design must include innovative technologies for both the hardware and software components to address anticipated future needs;
- the multidisciplinary science questions used to design the network must be those that require this new technology to make major advances in understanding;

- the design must maintain an appropriate balance between high-risk elements and lower-risk elements which have a high probability of success;
- the design must accommodate mobile systems like AUVs to avoid spatial or temporal aliasing.

EMSO-PP has identified 5 main classes of sea bottom observatories:

- #1: Cabled observatory: distance from coast up to 400 km approx. with several nodes and several junction boxes.
- #2: Simplified cabled observatory: distance from coast up to 20 km approx. with one node or one junction box.
- #3: Stand alone acoustic link observatory, very mobile observatory
- #4: Stand alone observatory with a cable between seafloor and surface, mobile observatory
- #5: Stand alone winch observatory for measurements near polar ice cap (Arctic)

Each European Country, each ESONET/EMSO academic and industrial partner has already different experiences with stand-alone and cabled observatories. We have to take into account each experience and requirement for EMSO. This collaborative task had positive impact to define an “ESONET/EMSO Label”, a quality label that defines a set of standard requirements for seafloor observatories. For sea bottom observatories (one can refer to the 2010 issue of ESONET Label for general specifications)
The most challenging part was to define a generic interface and generic services between the infrastructure under the sea and all instruments attached to this infrastructure. These generic interface and services are required to improve the compatibility and the interoperability between different classes of sea bottom observatories. All these specifications will help partners to design new specific instruments and will improve their existing design/technologies to be compliant with the upcoming EMSO observatories.

A general description about architecture, technologies, cables, communication segment (underwater acoustic modem, wireless technologies…) and detailed specification interfaces were defined: voltages, data interface (serial, Ethernet. CAN Bus…), clock synchronisation and time stamping services and supported software protocols for plug and play capabilities.
The key position of data management in the system has been addressed. It is clear that the distributed architecture envisaged needs preliminary technical work. The implementation of a sensor registry has been described as well.
A deliverable on the reliability of observatories components was issued and from this report, technical description report and specifications for a call for tender can be issued.

Another important aspect addressed was energy consumption. Energy is a major limitation to any long-term observation underwater. Subsea observatories became possible with the increase of capacities in energy storage two decades ago. The long distance power feed through cables was not a success in the pioneer phase of subsea observatories (ref. First version of H2O), leading to active discussions on principles (AC versus DC, converters, resistance at the end of each branch,…). The first years of operation of the new generation (ANTARES, NEMO, NEPTUNE and VENUS Canada, DONET, MARS) are bringing an input for the design principles of EMSO.

The power feeding of multidisciplinary sub-sea observatories is a key topic. The maturity of technologies does not provide yet long term references but allows some orientations. Case by case studies are needed to cope with the specificity of each site configuration. EMSO will bring the possibility to limit the number of components/subsystems to be developed and consequently collect experience from the sake of the whole European consortium.

A general overview of major specifications and necessary tradeoffs to be integrated in the choice of technologies has been performed. It demonstrates the need to keep close cooperation inside EMSO on the energy distribution matters.

The case of cabled observatories is addressed through practical ongoing projects. The main subsystems are: land power feed installation, node, 100W and 500W junction boxes. From what we know of the energy needs in European subsea observatories, these subsystems will cover much of the needs of short and long range cabled observatories. For very large cabled infrastructures, the studies performed in ESONIM project could be updated.

The case of non-cabled observatories is addressed through EMSO/MoMAR experience. The limitation of available power requires to adapt the sampling frequency of the instruments or at least the frequency of transmitted real time data.

The capital expenditure associated to energy in EMSO is a dimensioning factor. It is important also for the choice between cabled or non-cabled solutions.

Long term protection of sensors was addressed as well. For deep-sea research, specialized autonomous stations have the main objectives to provide in real time reliable measurements without costly and or frequent maintenance. Indeed, the maintenance is nearly impossible to provide at such depth, so, the autonomy must be provided up to 1 year. In these hostile environments, autonomous monitoring systems immersed in seawater are affected by a well-known phenomenon, called bio-fouling. Very often, this bio-fouling gives rise to a continuous shift in the measurements. Consequently, the measurements can be out of tolerance and the data become useless. Moreover, video systems, such as cameras, video equipments and lights are also affected by bio-fouling, which make optical systems opaque and unusable. Therefore, equipment system with an efficient bio-fouling protection is indispensable. The work in WP8 in this respect had the main objective to present existing bio-fouling protection systems and antifouling experiments, which were realized in real conditions on sub-sea observatories. Long-term protection of sensors for observatories applications is now possible and has been demonstrated in various situations. A specific method is based on local biocide generation by seawater electrolysis. This protection method has shown efficient results and a good adaptability to seafloor observatories. The local chlorination technique has been applied to various instrument technologies, optics (turbidity, fluorescence, oxygen, video and lights), electrodes (conductivity) and glass membranes (pH). To implement the system on instruments, it is necessary to check for a possible adverse effect on measurements.
The system can be easily adapted to many kinds of instruments. The energy needed is compatible with autonomous monitoring (one D cell for 3 months). The system is now used for autonomous monitoring, providing high-quality measurements at a reasonable servicing frequency.

The Task 8.3: “Improve low reliability components” of EMSO Preparatory Phase has been performed by IFREMER through a general identification of critical components, and a review of experiences gained in similar subsea observatory experiments around the world. Sub-sea connectors, electrical power components, buoys and sensors have not reached an acceptable level of reliability. They are improving thanks to large-scale coordinated projects such as EMSO (and other ESFRI or I3 EU supported projects). This will correspond to a cost of “in-service support”, that is to say more spare parts and more OPEX. It will be necessary inside EMSO during best practices meetings to continue to keep track of failure, failure analysis and remediation actions. The experiments on other sub-sea observatories worldwide will also help to understand the level of readiness achieved; a partnership including deep-sea oil and gas industry could be helpful. The ESONET Label, updated every year will synthesize the corresponding recommendations. **The technical follow–up of the life time of**

components is now an objective of the next 3 years (the consolidation years envisaged in EMSO-ERIC statutes).

The extension procedure of a long-term subsea observatory was analysed as well. This is an intrinsic decision of initial architecture which has a great impact on the future. Technical scenarios on high power supply and high data rate orientate the business plan and financial scenarios. A good example is provided by the DONET project in Japan: DONET 2 includes extensions that were not possible with the DONET 1 network. This is mainly true for high power extension. All the technologies are proven yet on long term deployments. The practices of ANTARES, NEMO, NEPTUNE Canada and DONET are bringing a major input for the technological choices. When possible according to the surface to cover and the requirement of the instruments, low power extension is easier to implement. EMSO will have to settle a policy in this field in order to ease modularity all over the network for its short-range extensions. A remarkable way to extend towards temporary or remote sites or water column instruments is the acoustic extension. It is integrated in the West Ligurian Sea EMSO node at ANTARES extension. In a similar way, Optical extensions may be permanent or temporary. This review can be integrated in the options of EMSO specifications. It must be updated yearly for two reasons: promising technologies are under experiment and the first years of operation in Europe, North America and Japan are bringing data on maintenance cycles and extension appropriateness.

1.4 Potential Impact

1.4.1 Impact of the Preparatory Phase activities

The EMSO-PP will have an important impact on the way the EMSO infrastructure will be managed and organised. EMSO-PP will provide a fundamental contribution towards the creation of the organisational foundations of the EMSO infrastructure. Thanks to the activities implemented by EMSO-PP, it will be possible to create a management structure that will enable an efficient operation of the EMSO infrastructure. EMSO-PP also provided an initial framework towards the financial sustainability of the infrastructure. Seafloor observation has been consisting over the last years of a series of small scale initiatives carried out around several sites in Europe. After 54 months EMSO-PP has laid the groundwork for the creation of a permanent instrument, serving a broad scientific community and promoting the concept of an integrated and distributed operational ocean observing.

For the first years of phased implementation, a model for coordinating the work of Regional Teams (owning and operating RIs at the different sites) and the EMSO-ERIC have been established. This will be the only relevant way to effectively operate a network of observatories with the same quality standards and reliability as those set out internationally by parent initiatives in the US and in Canada.

The resources provided by EMSO-PP were effectively used to stimulate the discussions and a process of consensus-building among funding agencies, another fundamental aspect to secure the long-term sustainability of EMSO. Several national initiatives have already been activated in the field of seafloor observatories and these certainly benefited from the Preparatory Phase initiative. Nevertheless, the real scientific and technological value added by EMSO is the possibility of performing permanent measurements at continental scale in different geographical locations around Europe, generating long-term time series. This can be achieved only by an integrated effort of different countries interested in the field, thus only with the essential resources given by the Commission.

The need for understanding the complex interplay between hydrosphere, biosphere and geosphere systems is the main driver for the creation of the EMSO infrastructure, and this preparatory phase was the first institutional step towards a more effective approach to this problem. The conduction of EMSO-PP represented a unique opportunity to bring together a group of European scientists benefiting from the use of the infrastructure. Gathering this heterogeneous community around a single institution working for a long-term period, is an important step towards addressing and solving scientific issues requiring an integrated perspective from different disciplines. EMSO-PP was very much benefiting from the parent ESONET-NoE EC project and contributed to institutionalise the collaborative effort, and set the basis for a long-term effort, providing a pivotal contribution to the European Research Area (ERA).

EMSO-PP will have an important impact on the development of the technological capacity of the ERA: a bilateral exchange between the EMSO community and the industry has been occurring ever since the initiation of sea observation. During this Preparatory Phase, and subsequently during the implementation of EMSO, the direct involvement of the industry will take place not only because of technological services needed by EMSO end-users, but most importantly because of the potentials for EMSO of becoming a service provider to specific industrial sectors. This approach will give an important contribution to the technological development of the ERA. The most ambitious goal EMSO-PP will pursue in this context, is the involvement of the industry through direct investments in the infrastructure.

Profitable links were maintained throughout the project with the main extra-European long-term seafloor network programmes, like OOI (USA), NEPTUNE (USA-Canada), DONET (Japan) and IMOS (Australia). This allowed cross fertilization of ideas and technological approaches and led to the generation of a collaborative project such as COOPEUS (US-EU collaboration), which aims at increasing the cooperation among environmental research infrastructures.
Another important impact connected to EMSO-PP project, was the possibility to align EMSO to a series of initiatives addressing the fundamental issue of data management. One of the most important outcome from this point of view was the participation of an highly representative part of EMSO partnership into the ENVRI project (www.envri.eu) which will ensure that the new data framework to be proposed in the environmental sciences domain will be aligned with the needs of EMSO RI.

Another important outcome was the links that EMSO-PP promoted aimed at fostering the active collaboration with other ESFRI RIs, in particular KM3NET, EUROARGO, SIOS and EPOS. For different reasons these project present several synergies with EMSO and therefore it is important that continuous collaboration is ensured.

1.4.2 Societal drivers

In the previous paragraph we described the impact of the EMSO-PP FP7-funded project, taking into account the objectives that the Preparatory Phase had set out in its work programme. On top of that we wish to underline the impact on the society and the economy that EMSO will have, which are the major motivation for conceiving the concept of EMSO as a distributed RIs.

The decline of the oceans resources and our ability to use those resources is one of the most urgent problems facing human populations today. The oceans have been playing an increasingly important part in human societies, providing trade routes, living resources, energy, and recreation. Presently, about 40% of the world's population lives within 100 kilometres of the coast and as population density and economic activity in the coastal zone increases, pressures on coastal ecosystems increase. These coastal ecosystems are directly linked to the open ocean forming the largest habitat on earth and an ever-rising number of forcing factors reinforce the societal need for an improved understanding of the oceans.

These factors include:

- Natural disasters (e.g., earthquakes, tsunamis)
- Overfishing
- Pollution
- Habitat destruction
- Invasive species
- Acoustic noise
- Climate change related factors, such as
    - Ocean warming
    - Ocean acidification
    - Ocean deoxygenation
    - Storm intensity and frequency
    - Seafloor stability
    - Sea-level rise

Human societies depend on accurate and timely information to mitigate and protect itself against the resulting socio-economic impacts, such as an increased geo-hazard risk, habitat loss, human and animal migration, food security, damage to marine-related industry activities, reduced tourism, recreation, and aesthetics. It is the societal need to understand the negative effects of these forcing factors that drives the majority of earth and ocean science today. For example, the United Nations Environment Programme (UNEP, 2007) has highlighted the importance of oceanic and deep-sea ecosystems in providing crucial goods and services that translate into socio-economic benefits.

The EMSO network will collect essential data, which will feed into GEO, the IPCC, UNEP, and OSPAR (the Convention for the Protection of the Marine Environment of the North-East Atlantic) to help form and revise policy and legislation. Furthermore, EMSO's open ocean seafloor data will contribute to the Marine Strategy Framework Directive initiated by the EU in 2008, which aims to achieve good environmental status in Europe's seas by 2020. The Directive is supporting the development of coherent approaches to assess good environmental status in a comprehensible and holistic manner thereby supporting an ecosystem-based approach to management. The EU strategy provides the major driver for EMSO and its schedule of implementation. EMSO will pioneer in delivering multidisciplinary real-time data from the sea by providing data from the surface ocean through the water column to the benthos and sub-seafloor. It will facilitate, in part, by advancements made on Eulerian (fixed) observatory infrastructures during the ESONET-NoE, EuroSITES programmes and the potential follow-on project Fixed Point Open Ocean Observatories (FixO3). And it will work alongside other key infrastructures such as EUROARGO, SIOS and EPOS.

1.4.3 Economic drivers

Investment in operational oceanography and the development of ocean observatories is critical to provide information on the global environmental state, climate change, seasonal forecasting, safety at sea, developing applications for the offshore industry and fisheries, responding to accidents and pollution, and to defence requirements.

Below is a diagram that illustrates some of the external developments that present opportunities to the EMSO-ERIC:

Sociological	**Technological**
Recognition of climate change Fears about environmental damage Public fascination with ocean life & secrets Fears about tsunamis & earthquakes Security fears	More smart sensors on the market Improved bandwidth Better power systems for remote subsea Increased access to broadband in homes Reduced costs for fibre optic cabling More off the shelve solutions
Economic	**Political & Legal**
Increasing private sector spend on environmental monitoring Public sector investment in innovation as driver of economic growth Increasing natural hazard insurance claims Investment in bio-prospecting by pharma industry New markets in BRIC economies	Demand for environmental security Need for marine spatial planning Drive for sustainable development of marine resources UNCLOS & need for international oversight of deep ocean resources for common good

In the UK, the GDP attributed to marine-related activities is approximately £46 billion with £19 in oil and gas, £3.3 billion in leisure and recreation, and £1.3 billion in fisheries and other resources (Pugh, 2008).

The direct economic value of the Irish ocean economy in 2007 was €1.44 billion or approximately 1% of GDP. The combined direct and indirect value of the sector was €2.4 billion and provided employment for approximately 17,000 individuals (Ireland's Ocean Economy, 2010). Established Ocean Industries represented 94% of turnover in 2007 and including shipping & maritime transport, water-based tourism and leisure, seafood processing, fisheries, aquaculture, marine manufacturing, marine services and oil and gas. New & Emerging Ocean Industries (represented 4% of employment and 6% of GDP) such as Renewable Ocean Energy, Marine Commerce, High-Tech Services and Marine Biotechnology and which, according to global market forecasts, have very significant potential to contribute to tomorrow's ocean and coastal economies (Morrissey *et al.*, 2010).

A large study conducted in the US showed that in 2004, the ocean-dependent economy (six industrial sectors) generated $138 billion or 1.2% of U.S. GDP (Kildow *et al.*, 2009). Coastal tourism & recreation dominated both employment and GDP in the ocean economy sectors with 1.7 million jobs (75%), of employment and nearly $70 billion (51%) of GDP. Marine transportation had the second largest GDP, with $27.6 billion, 20% of the ocean economy. Total U.S. offshore oil production was valued at >$27 billion in 2004. Total landed value of fish caught in U.S. waters was $3.7 billion in 2004, half the value of imported fish for the same year. Currently available data indicate that the non-market economic value that the US's ocean and coastal resources provide through "consumer surplus"[1] is at minimum tens of billions of dollars a year, and likely over $100 billion. Environmental services and non-use values probably add tens of billions more to these numbers.

Studies like these show that the market for ocean based services is very significant in terms of value to the overall economy of individual countries. Member states of EMSO would benefit directly from providing services to a research infrastructure (RI) during the design and build phase. For example, employment opportunities for

[1] Consumer surplus definition: Non-market values reflected in the difference between what consumers pay for a good and the maximum that they would be willing to pay for the same good.

staff to work on the RI will be available and vessels as well as other marine services will be required for maintenance and research to be carried out on a regular basis. In addition, the EU supports the development of small and medium-sized businesses (SMEs), a trend that will be strongly promoted in EMSO. In ESONET-NoE, several SMEs from member states have formed an association, PESOS (Providers of Equipment and Services for Observatory Systems), and ESONET has established a database of suppliers of equipment and services for ocean observatories that meet ESONET standards (www.esonetyellowpages.com). Initiatives linked to industry will be maintained through PESOS and updated through the FixO3 project where dedicated.

Indirect effects for EMSO member states include scientific and technological innovation, networking opportunities, standardization and interoperability methods, and the availability of a critical mass of scientists and engineers. Moreover, users of an RI are not only partners of the infrastructure but the entire ESONET-Vi community (ESONET the Vision), which aims at integrating European science by linking geographically scattered complementary research as well as industrial and governmental elements using data collected by deep-sea observatories. A prognosis from a 2008 ESFRI report predicts that over 70% of the operational costs (personnel, supplies, and utilities) end up in the local community as a long-term economic return in all the regions of observatory science. Additionally, the so-called 'network effect' generates unexpected new users by making data more readily available and thereby enhancing integration. Table 1.2 illustrates schematically the chain of relationships from currently measurable forcing factors, through supporting and socio-economic services, down to direct impact on ecosystems. It is also illustrated at which level in the decision-making chain (from science to policy) these impacts have to be addressed.

Forcing factor →	Supporting services →	Socio-economic services →	Socio-economic impacts
Natural disasters	Photosynthetic production	Provisioning services	Increased geohazard risk
Climate change	Chemosynthetic production	Food resources	Reduced biogeochemical pump efficiency
Ocean warming	Nutrient cycling	Hydrocarbon energy	Respiratory stress
Ocean acidification	Carbon sequestration & storage	Minerals	Altered heat and nutrient transport
Storm intensity	Biodiversity resilience	Genetic resources	Heath risks from toxic compounds
Seafloor stability	Habitat	Chemical recourses	Food web destabilization
Sea-level rise	Sediment transport	Waste disposal sites	Habitat loss
Overfishing	Organic matter transport	Regulating services	Human and animal migration
Pollution	Geomorphology	Water circulation & exchange	Reduced tourism, recreation, aesthetics
Habitat destruction		Climate & weather regulation	Food security
Acoustic noise		Carbon sequestration & storage	Marine-related industry activity
		Waste absorption & detoxification	
		Biological control of harmful species	
		Geoengineering	
		Cultural services	
		Employment	
		Education	
		Scientific advancement	
		Quality of life	
		Recreation	
Science & Policy ←	Science ←	Science & Policy ←	Policy

Table 1.2 - Connections between forcing factors, supporting services, and socio-economic impacts and how these factors influence policy and ocean observatory science (from Table 2 by Ruhl et al., 2011).

1.4.4 Industrial Impact

The study conducted within WP7 provided a measure of the potential industrial impact of EMSO.

The present study shows a growing worldwide interest towards the sustainable use of the marine environment and a consequent growth of markets directly related to it. The need for sustainable exploitation of the sea, the need to increase and improve the monitoring of marine hazard (e.g., tsunami) and the challenges put forward by climate change, provide many opportunities for service delivery and products development for technologies of high relevance to EMSO. In particular, the data showed that:

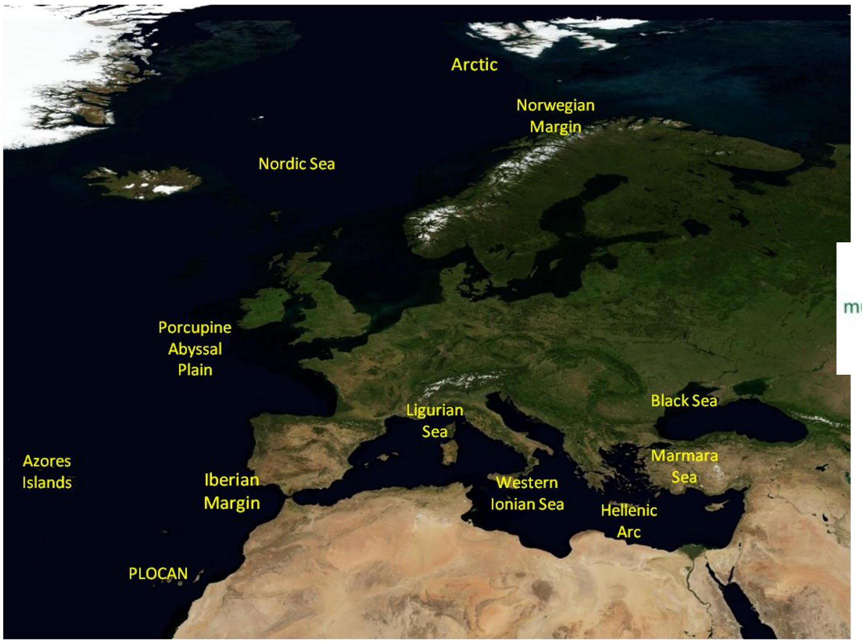
- The scientific initiatives in the US, Canada, Australia and Japan related to the construction of cabled observatories, show that total investment in research to reach nearly 1 billion € over a period of 5 years (2010-2015);
- The monitoring of the marine environment in real time represents a real market opportunity, quantifiable around 245 M€ in 2015;
- Global production for offshore oil & gas is growing and will arrive to about 34 million barrels per day in 2020 (with regard to crude oil), while for the gas to 1500 Bcm per day: this indicates the growing need for access to marine resources pushing the limits of existing technologies;
- 8% of wind energy is currently produced in offshore and global offshore wind sector investment is expected to grow six-fold between 2010 and 2025, rising from about 6.1 billion dollars to more than 37, $ 5 billion;
- the field of marine biotechnology (blue biotechnology) currently represents a market of 2.8 billion globally, with a growth potential up to 12% per annum.

Considering these figures, it is pretty clear how the impact of the establishment of a network of distributed infrastructures such as EMSO positively contributes to the economy in different regions around Europe with respect to the global market.

1.5 Contact Details

Paolo Favali
Istituto Nazionale di Geofisica e Vulcanologia (INGV)
Via di Vigna Murata, 605 - 00143 Roma (Italy)
Ph.: +39-06-51860-341 (secretary); -428 (direct)
Fax. +39-06-51860-338
e-mail: emsopp@ingv.it

EMSO website: www.emso-eu.org



EMSO sites (at November 2012)

european multidisciplinary seafloor observatory emso

EMSO logo