

marinerg-i

Marine Renewable Energy Infrastructure

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ORE e-Infrastructures Strategic and Technical Alignment

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Abbreviations

DRI	Distributed Research Infrastructure
ORE	Offshore Renewable energy
R&D	Research and Development
RI	Research Infrastructure
TRL	Technology Readiness Level

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1. Introduction

Large volumes of data are being created through research and testing activities in the field of ORE technology development. The fundamental characteristics and attributes of datasets generated vary due to the diversity of sources and processes involved throughout the innovation lifecycle and the wide range of apparatus and sensors that are deployed within different facilities. Data volumes are continually expanding as observational capacity and spatio-temporal resolution improve. Prior to MARINET2 and MARINERG-ii, nearly all facilities involved in Offshore Renewable Energy (ORE) Research and Development (R&D) managed the data arising from the various experimental and testing processes on an individual basis, using a wide variety of mainly ad-hoc solutions. Very little consideration had been given to strategic approaches (harmonization, integration, standardization) that would align practices between facilities and externally within the context of broader EU data policy initiatives, to fully capitalize on the intrinsic value inherent in these datasets.

A large amount of data will be generated through the research programs and testing activity that will be carried out in the future MARINERG-i Distributed Research Infrastructure (DRI). This will require suites of tools and e-services to enable efficient and effective data archiving and user access capacity. A dedicated portal is envisioned to manage external end-user access to facilities and information resources, as well as functioning as a conduit for managing internal interactive processes, i.e. between the distributed infrastructure members. This will comprise the core of the MARINERG-i e-Infrastructure and may be expanded to include various other virtual services with accompanying guides, work flows and documentation as required. The objectives is to facilitate the curation; documentation; and delivery of data and data products produced by the infrastructure, preserving an equitable balance between commercial IP rights that protect device developer's interests and the ready availability of datasets of public/common interest. It should also contribute to effective knowledge sharing with all stakeholders.

This report builds on D3.2 "ORE e-Infrastructures User-needs Profile and Integration with Existing e-Infrastructures," which identified existing e-infrastructures and e-services with data management and service offering requirements relevant or analogous to those proposed in the MARINERG-I DRI. This provides examples and references to inform the development of the MARINERG-i e-Infrastructure, including the European Open Science Cloud and the EUDAT collaborative Data Infrastructures. This deliverable presents a more comprehensive survey of the dynamic and evolving e-infrastructure field pertinent to MARINERG-i requirements.

2. Methodology

The primary objectives of the MARINERG-i WP3 were to survey the field and gather the information necessary to develop the most suitable e-Infrastructure that will foster innovation across a large variety of ORE structures and systems and through all key stages of technology development (Technology Readiness Level's 1-9), More specifically the e-infrastructure should:

- Provide a user-friendly and interoperable e-services platform to support a variety of core activities within the MARINERG-i DRI;
- Unlock the intrinsic value of data created during and in association with ORE technology development.

It is thus essential to define the various functions and types of services that should be available to whom and when. These should also be fully aligned to support the delivery of key strategic goals of the DRI, namely: to efficiently contribute to the development of the ORE industry whilst providing practical functionality that takes identified end-user requirements into account.

The central methodology was to identify existing European e-infrastructures that would serve as examples in terms of structure, management and functionality. From the available options, the best approaches can be prioritized considering those most likely to enhance effectiveness and efficiency for the MARIENRG-i e-infrastructure in the short as well as long-term. Such cross-comparison will be essential to inform the DRI's in-house design decisions.

A broad approach was undertaken to reach beyond the capacity of commonly used reference sources such as Eurocean RID. The methodology was mainly based on cross-analysis and review of information obtained from the following sources:

- Existing databases
- Organisation of stakeholder meetings
- MaRINET and MaRINET2 projects
- Questionnaire sent to end-users
- Literature searches

This assessment scheme will be summarised in the following sections (2.1-2.5). It should be noted that particular attention has been given to the e-infrastructure work being undertaken in the MARINET2 H2020 programme. This has identified a number of use cases that are being implemented as pre-operational pilot scale e-services. These can effectively be considered as a case-study for the MARINERG-i DRI.

2.1. Existing Databases Listing EU Research Infrastructures

Within the broad marine science domain, there are many e-Infrastructures associated with European Research Infrastructures (RIs) or projects. They are operated under various governance models by state or semi-state institutions, academic organisations, non-academic R&D institutions and industry. Information on these e-infrastructures is available from a number of sources e.g. dedicated databases and web services. The following initial classification assists in discriminating the most relevant examples. It is worth noting that the quality and currency of information presented is far from consistent, and funding continuity issues are a recurrent theme for e-infrastructures that are resourced and operated on a project-by-project basis.

2.1.1. Eurocean RID

The EUROCEAN-RID Marine Research Infrastructures database (<http://rid.eurocean.org/>) is a comprehensive searchable listing, which holds information on over 900 facilities in Europe that are dedicated to marine science activities. Infrastructures are classified into 8 different categories and those offering data management capacity and services can be found among the 74 entries classified in the “Marine Data Providers” subset. Each of these infrastructures is described in a form providing standardised information (metadata) on the type of service, the scientific fields it addresses or the access conditions. Although regarded as an important resource particularly for the ORE domain, until relatively recently this content could not fully be relied upon as representing a definitive source. Eurocean has undertaken a major update during the latter part of 2019, including more RI’s and facilities. Whilst this reflects a considerable improvement in terms of the quality of ORE related information available, there is still a great deal of work to do on behalf of the participating facilities themselves to ensure that their individual metadata entries have been (self) completed to a consistent level of detail. This work will be ongoing for the foreseeable future, depending on the importance placed on this task by a given facility and/or the availability of resources to ensure entries are maintained in full currency.

2.1.2. MERIL

The MERIL (Mapping of the European Research Infrastructure Landscape) portal provides access to a database that stores information about openly accessible research infrastructures (RIs) in Europe, across all scientific domains. (<https://portal.meril.eu/meril/>)

The MERIL database includes 1008 Infrastructures altogether. Relevant data management infrastructures and services can be found in the searchable database under the terms “database”, “Data archives, Data repositories and collections” and mostly the “Earth, Ocean, Marine, Freshwater, and atmosphere Data Centres”.

2.2. Stakeholders meetings

Over the first eighteen months of the H2020 MARINERG-i project, a series of face-to-face meetings involving key stakeholders was organised by the national representatives of the consortium in collaboration with IFREMER and UCC. The two main objectives of these stakeholder meetings were:

- To gather information necessary to inform the RI profiling process to a) identify the various relevant RIs and institutions; and b) determine end-user requirements and future needs, including aspects related to data access and knowledge sharing,
- To gain a detailed understanding of what would be required to obtain the necessary high level governmental commitments (financial and political at each state's node) to support the MARINERG-i bid to progress onto the ESFRI roadmap and ensure that the consortium would have a solid foundation to operate sustainably as a future ERIC.

Eleven stakeholder meetings were organised in partners' countries [4] over an 18-month period. These meetings comprised two parts. Firstly, a general presentation outlining the aims of the MARINERG-i initiative and describing the longer term objective of building a Pan-European DRI. This was followed by discussions about the main topics of interest for the elaboration of the Design Study and Science Plan including:

- Identification of end-user requirements
- Identification of National RIs of relevance for the project
- National research priorities in the domain of ORE
- National policies regarding the organization and funding of research programs
- National priorities regarding development of the ORE industry

These meetings were used as a reference for identifying end-user requirements and for ORE RI and e-Infrastructure profiling activity. Records of these meetings were compiled and presented in deliverable MARINERG-i D7.5 "Report on Stakeholders Interactions" [5].

2.3. MaRINET and MaRINET2 Transnational Access program

The objective of the MARINERG-i initiative is to create an integrated pan-European DRI, which builds on the foundations and network established under MaRINET (Marine Renewable Infrastructure Network for emerging Energy Technologies), and MaRINET2.

MaRINET (2011-2015) was funded through the EC's Seventh Framework Programme (FP7). The MaRINET network comprised 29 partners, research centres and organisations working together to accelerate the development of Offshore Renewable Energy. A major activity conducted as part of the MaRINET project was the implementation and coordination of a Transnational access program aiming at supporting the development of ORE by providing to developers free-of-charge access to a set of 45 specialist marine research facilities spread across 11 EU countries.

The MaRINET2 project followed-on from the MaRINET initiative, and was started on January 2017, for a 4.5-year period, as part of the H2020 program. The MaRINET2 consortium is composed of 37 institutions offering access to 54 facilities across 12 EU countries (www.marinet2.eu). In addition to the conventional Transnational Access program involving actual models or prototypes being tested in-situ, MARINET2 offers a virtual Access program, with access to three different services and databases. As previously noted the MaRINET2 work programme also contains specific elements on e-Infrastructures that are of particular relevance to this study, which will be discussed in a subsequent section.

2.4. Questionnaires

A dedicated online questionnaire was devised by IFREMER, PLOCAN and Aquaterra and addressed to potential stakeholders identified in the MARINERG-i Stakeholder's database [6] who had signed the data protection and consent form (a total of 216 out of 392).

These stakeholders completed the questionnaire via a web platform over a three-week period from April 18th 2018. Detailed analysis of this questionnaire is presented later in this report in the section on end-user requirements. Other relevant outcomes were used for profiling RIs within WP2 (see [4]). The questions are listed in Appendix 1.

Another, shorter questionnaire was circulated to stakeholders prior to the stakeholder meetings as a preparatory measure. Even though a limited number of questionnaires were returned, some useful information was obtained, and this is presented in the section on outcomes from the stakeholder meetings.

2.5. Desk-Top Study

In addition to the gathering of information from above sources, additional information was obtained from searches on web sites of relevant institutions or projects. A general bibliography was also produced, based on scientific papers and strategic reports. Finally, an analysis of the survey was conducted, based on the statistics derived from the answers to the questionnaire.

3. Identification of the MARINERG-i e-Infrastructure services

MARINERG-i is a DRI bringing together facilities, resources and services that are used by the ORE research community to conduct research and foster innovation in the domain of Offshore Renewable Energy. It is also expected that these services support sharing of knowledge, education and public access services. MARINERG-i includes many important pieces of scientific equipment, most of which have unique characteristics. There are also extensive knowledge-based resources such as archived testing datasets or other scientific data such as monitoring data recorded in-situ at test sites. These information resources are operated and managed by a diverse community of highly experienced staff and technicians who possess unique skillsets and specialist knowledge that enables all of these complex interconnected systems to operate effectively.

To support MARINERG-i's integrated approach and foster open collaboration between members and other stakeholders, an enhanced e-Infrastructure is needed that facilitates access to shared resources for researchers. In order to define the most appropriate organisational structure and architecture for this e-infrastructure as well as the necessary communication tools (hardware, software, protocols, etc.), the specifics of shared services must be clearly identified, considering both the planned MARINERG-i activity and the end-users' requirements.

3.1. MARINERG-i DRI activities

Three main categories of activities to be conducted by the MARINERG-i DRI can be considered:

- Access to facilities for researching and testing ORE devices and ancillary systems
- Research for the improvement of methods for testing and de-risking ORE systems
- Knowledge sharing and communication

Requirements for specific capacities of the e-Infrastructures associated with these activities is described hereafter and summarized in Table 1.

Table 1: Requested e-Infrastructure services

Activity	Objective	Exchange Portal Capacity	Data Storage	Data Exchange
Access for testing and R&D	National and trans-national access program: Provide access to testing facilities for developers (end-users)	Open to end-users	Long term preservation of data	Secure and controlled access to testing data for IP protection
		Provides information on available MARINERG-i facilities	Standardised comprehensive meta data	Connection with other e-infrastructures for environmental in-situ monitoring or other services
		Dedicated interface for application procedure	Archiving of records according to agreed policy	Adapted common format for interoperability
		Secure data exchange service	Temporary archiving - buffering	
		Access to virtual services		
Research to extend or enhance testing capacity	Research programs conducted by the MARINERG-i DRI members to improve testing methods and develop standards	Open to DRI members only	Long term preservation of data	Secure and controlled access to testing data for IP protection
		Coordination of research activities	Adapted meta data	Connection with other e-infrastructures for environmental in-situ monitoring or other services
		Staff exchange programs coordination	Archived programme records	Adapted common format for interoperability
		Common analysis tools management platform for standardisation & benchmarking	Reference data sets, exemplars	Benchmarking platform
		Common instrumentation management platform		
Outreach/training/ Information	All actions related to Knowledge transfer and sharing	Open to all stakeholders	Long term data curation – reference library	Adapted common format for interoperability
		Management platform for education and training programs (application, webinars, data access, etc.)	Adapted meta data	
		Enquiries	FAQ's library	

3.1.1. Testing

MARINERG-i provides access to principal ORE testing facilities across Europe for national and trans-national users, supporting them throughout the innovation lifecycle. A central access management portal is a key e-Infrastructure component that will streamline the access process for the various categories of users and provide technical information about available facilities.

Systems to enable the controlled exchange of scientific data are also necessary. These must incorporate the very highest practical level of security to ensure IP protection, whilst still enabling sharable information to be accessed by users carrying varying levels of access authorisation. Specific metadata associated with experimental testing is to be developed.

In-situ monitoring data is to be made available and reusable with relevant associated metadata.

Stakeholders involved in the testing activity are mainly the end-users (industry and academia) and the DRI members themselves.

3.1.2. Research

The MARINERG-i strategic research agenda is structured to be aligned with scientific and industry priorities, whilst remaining responsive to fluctuating trends and end-users' requirements in terms of scientific development and improvement of methodologies for testing. This requires an integrated approach, with an effective mechanism enabling interaction between all facilities offering varied capacities and R&D service options at all stages of development of the ORE devices. This in turn calls for dedicated data management procedures adapted to benchmarking programs as well as specific metadata and taxonomies associated with the various use-cases and classes of experimental testing.

A contribution to the applied science research programs is expected from a broader community of stakeholders [3] including end-users, academia and staff from other testing facilities as well as representatives of the industry and value-chain entities who can provide relevant input regarding the development of technologies and the associated needs for new research programs. Hence, a capacity for data and information exchange with external users is also an important feature to be included.

3.1.3. Outreach, training and knowledge sharing

An identified objective of MARINERG-i is to contribute extensively to the global knowledge base on ORE across all categories of stakeholders, including civil society, and to support decision makers at all levels in the elaboration of the longer terms policies and the development of well adapted programs.

Data and information of interest for the broader marine and maritime user communities should especially address future large-scale development scenarios and potential impacts on the environment of the technologies developed throughout the research programmes conducted within MARINERG-i.

Civil society requires information about the social, environmental, political or financial impacts that MARINERG-i may cause in the mid and long term. MARINERG-i should also facilitate access to data to improve the global knowledge and awareness about ORE and develop communication with other communities of stakeholders.

Information available to stakeholders in the public sector should be geared to support decision-making and be adapted to the needs of the economic and societal activities for which they are responsible e.g. environmental monitoring or maritime spatial planning.

Private investors are primarily interested in using the knowledge and outcomes generated by the infrastructure that will contribute to the de-risking of the projects they fund. Hence, quality and consistency are paramount, underling the essential requirement for clearly identified, granular metadata, and standardised vocabularies and procedures which contribute greatly to informed risk assessment.

Finally, adapted approaches and services are to be developed which facilitate stakeholder engagement and interaction, which in turn will stimulate further synergies.

3.2. End-user requirements

A detailed account of end-user requirements for ORE research infrastructures was presented in D2.1 and requirements for associated e-infrastructures were presented in D3.1. These are briefly summarised in this section.

Analysis of the responses highlighted the demand for generic data other than just data sets recording measurements made during research and testing activities. Users also registered the need for information exchange and knowledge sharing capacity. Information needs can be classified into different categories which translate to broad service areas to be delivered via specific parts of the e-Infrastructure:

- Test site description and access (Location, permitting, etc.)
- Technical requirements (sensors calibration, standard formats, etc.)
- Interaction, collaboration and networking
- Intercomparison procedures requiring networking and collaboration
- Development of new standards requiring collaborative approaches and interaction with external entities (cost of energy, legal and regulations aspects, etc.)

The typical types of information requested about test sites covered a broad range of topics from the location of the site to the incoming energy resource, as well as permitting procedures. There are parallels between these types of information and the technical information that is often requested for laboratory access for testing, however in the case of offshore test sites there is a requirement for specific datasets e.g. based on long term monitoring of the resource for proper characterization of the site and development of associated processed products (e.g. statistical derivatives).

Technical requirements mostly address the detailed capacities of the infrastructures, irrespective of whether they are offshore test sites or land-based laboratories. Typically descriptors provide information on the type and range of available sensors, the quality of these sensors, how and when they were calibrated, the capacity of the wave maker in a

wave tank, the maximum wind velocity and rate of turbulence in a wind tunnel, or flow rates and other critical dimensions for a current flume. All this information must be provided in a standard form for all the available facilities, which requires the definition of specific standardised metadata and controlled vocabulary to facilitate interoperability. It is also require the definition and adoption into practice of standard formats for the storage and transfer of data sets.

The capacity for interaction, collaboration and networking requested by the end-users extends beyond the interaction between the users and the staff operating the facilities, to include tangible networking capacity with other (external) developers and stakeholders. It also encourages collaborative research approaches allowing the development of adapted standards based on inter-comparison (benchmarking) procedures.

A further identified requirement concerned the availability of interactive services that would enable users to monitor and interact with testing programs remotely. Such capabilities fit closely with the technical capacity offered by an e-infrastructure and could for instance, be integrated within a virtual access program.

Finally, a requirement for a coupled approach between numerical and experimental modelling was also identified. In order to develop such coupled approaches, specific links with high capacity computing systems and services should be developed together with adapted data exchange formats.

4. Identification of relevant e-infrastructures and services

In considering objectives and requirements for the development of a MARINERG-i e-infrastructure it was important to survey similar existing structures or services that could serve as examples and synergistic resources to which MARINERG-i may ultimately wish to be interconnected. Analysis of the RI databases such as Eurocean RID or MERIL revealed 14 projects or services of direct relevance in terms of objectives, structure and field of activity.

General information on these projects, including their status, field of activity and web portal address is listed in the table presented in Appendix 1. Details of the services associated with these projects are presented in the following paragraphs.

4.1. MaRINET2

Following-on from the MaRINET initiative under FP7, the MaRINET2 project was started on January 2017, for a 4.5-year period, as part of the H2020 program. The MaRINET2 consortium is composed of 37 institutions offering access to 54 facilities across 12 EU countries (www.marinet2.eu). Activities conducted as part of MaRINET2 include the coordination of both a Transnational Access and a Virtual Access programs. Internal research activity is also conducted by the partners of the project. This research activity includes a specific task aimed at designing and implementing an e-infrastructure for the project as well as demonstrating the deployment of data and virtual services within this e-infrastructure.

In addition to the development and deployment of the technical components necessary to operate this e-infrastructure a Data Management Plan is also being developed [7]. Data to be collected, archived and shared include data produced during experimentation and simulations in partner's facilities as well as datasets and data services made available to users and partners through Virtual Access. Specific formats and metadata are also being developed.

FAIR¹ principles have been adopted, and the MaRINET2 project uses the existing standards and concepts that operate within SeaDataNet. The MaRINET2 e-infrastructure will demonstrate tools and solutions that will be used as a primary reference for MARINERG-i, piloting a number of elements that will directly inform the development of the MARINERG-i e-infrastructure.

4.2. SeaDataNet

SeaDataNet is the Pan-European Infrastructure for Ocean & Marine Data Management. Data is provided by a Pan-European network of professional data centres providing on-line integrated standardised databases through a unique portal, which interconnects an extensive network of interoperable nodes. Guaranteed interoperability between the various data centers is assured by the use of a common set of software tools, protocols, communication standards and methodologies for data checking.

¹ FAIR : 'Findable, Accessible, Interoperable, and Reusable'

Metadata associated with the large distributed archive of datasets is provided via a variety of services tuned to the original production platforms: e.g. Marine Research Organisation (EDMO); permanent observing systems (EDIOS) or CRUISE (CSR). A Common Data Index (CDI) provides unique identifiers and facilities searching. SeaDataNet also develops specific types of advanced data products such as aggregated datasets or climatologies, as well as specific software tools: e.g. data converters, data analysis and data visualisation routines. These features are highly relevant in the context of MARINERG-i requirements, and it is foreseen that MARINERG-i will adopt these standards and concepts in common with SeaDataNet.

4.3. SeaDataCloud

The SeaDataCloud project (2016-2020), follows on from SeaDataNet and SeaDataNet 2 as an EU H2020 programme. It aims at advancing SeaDataNet Services and increasing their usage, adopting cloud and High Performance Computing technology for better performance.

4.4. Sextant

The Sextant Marine and coastal geographic data infrastructure was developed by Ifremer in order to archive and provide access to a catalogue of marine environmental reference data. Sextant supports marine studies and decision-making covering a range of topics including biodiversity, marine renewable energy, integrated management of coastal areas, fishing, coastal and deep-sea environments, exploration and exploitation of the seabed. It offers data available for download with associated metadata as well as viewers adapted to visualisation of geographic datasets. It is envisaged that the data collections, products and services managed and produced under the MaRINET2 Virtual Access (VA) programme would be registered in the Sextant catalogue.

4.5. EMODnet

The European Marine Observation and Data Network (EMODnet) is a network of organisations working together to pool marine observation and monitoring, process the resulting data according to international standards and make that information freely available as interoperable data layers and data products. EMODnet is supported by the EU's integrated maritime policy.

EMODnet provides access to marine data across seven discipline-based categories including bathymetry, physics, geology or human activities available through gateways to a range of data archives managed by local, national, regional and international organisations.

The core objective of EMODnet to “*Collect data once and use it many times*” is achieved by “developing standards across disciplines as well as within them, validating and processing data at different levels, building on existing efforts where data communities have already organized themselves.”

The following are the EMODNET core values:

- Reduce uncertainty in our knowledge and ability to forecast the behaviour of the sea;
- Improve offshore operators' efficiency and costs in gathering and processing marine data for operational and planning Purposes;
- Stimulate competition and innovation in established and emerging maritime sectors.

These values are in line with the MARINERG-i objectives to support and accelerate the development of the industry in the specific domain of the Offshore Renewable Energy. They also address similar communities of stakeholders, i.e. within the public sector, the private sector, the research community and civil society. As well as the main portal, which offers access to data and other web services, the EMODnet service also includes a data ingestion portal that was developed to increase the quantity and quality of the available marine data. This Data Ingestion portal supports the involvement of new data providers, helping them to upload their marine datasets for further processing, and enabling their publication as open data for public benefit. EMODnet thus seeks to “strengthen its collaboration with other marine knowledge providers, including fisheries, the marine component of the EU’s Copernicus programme and the private sector, to create a common platform for marine data in Europe.”

We anticipate that MARINERG-i services will be designed to interoperate and connect with EMODnet in order to realise mutual benefits and synergies.

4.6. Eurofleets 2

Eurofleets is an FP7 project that *“brings together European Research Fleet owners, to enhance their coordination and promote the cost-effective use of their facilities, namely research vessels and their equipment, so as to support monitoring and sustainable management of the Regional Seas and the Oceans and allow access to all European scientists to carry out ship-based research activities within any field of marine science.”*

The Eurofleets e-infrastructure serves to integrate and structure the operation of European Research Vessels and promote interoperability with regard to data and systems.

The European Virtual Infrastructure in Ocean Research (EVIOR) was developed under the Eurofleets 2 project, providing a specific integrated information portal with information about research vessels (RV); cruise programmes; completed cruises and special equipment. This portal integrates and upgrades a number of existing database modules from other services such as SeaDataNet, EurOcean or Pogo. It integrates searchable databases of European Research Vessels, large expendable instruments as well as cruise programmes, based on multi-criteria queries. The EVIOR system provides a useful and relevant reference which serves to illustrate how similar searchable databases could be developed to provide end-user information on the MARINERG-i research facilities and their capacity.

4.7. Pogo

The Pogo program (Partnership for Observation of the Global Oceans) searchable database provides access to information on cruise programmes for global ocean-going research vessels. In addition to Research Vessels characteristics, the database provides access to planned cruises. A specific format was developed to describe surveys and enable

information to be collected and compiled in a standardised template. There is also a mapping interface, which facilitates spatial searches for information on outcomes/outputs of completed cruises.

4.8. Coriolis

CORIOLIS is a French project that contributes to the French operational oceanography program for in-situ observations, and operates in collaboration with other European services such as COPERNICUS. Coriolis was designed to organise and maintain data acquisition in real-time and delayed mode for in-situ measurements used in operational oceanography. Coriolis activities include R&D to improve operational oceanographic technologies for continuous, automatic, and permanent observation networks as well as the development of an operational in-situ data centre. Specific tools are also being developed to map water quality parameters including temperature and ocean circulation. Operational Oceanographic data is obtained from a variety of field platforms, in many different formats and so requires pre and post-processing in order to supply users with quality assured integrated datasets and products with their associated metadata. An integrated and collaborative approach means that the CORIOLIS Data Centre relies on the various distribution centres to consolidate comprehensive and consistent datasets. The Coriolis data portal provides a single access point for in-situ data and products. Specific data selection tools have been developed and data can be accessed by FTP or through various services.

A key feature of the Coriolis portal is the suite of data management tools that facilitate:

- data formatting
- real-time quality control
- data distribution to individual users, operational oceanography community such as GTS or Copernicus
- data discovery and data access services

The Coriolis web portal also provides information on the research projects conducted with and for Coriolis products.

4.9. Euro-Argo

The Euro-Argo ERIC is responsible for coordination of the European contribution to the Argo programme (<http://www.argo.ucsd.edu/>). Main activities include logistics necessary for preparation and deployment of the Argo floats, field operations, and the management of associated data streams and data centres. The Argo data system integrates Global Data Centres such as Coriolis, National Data Assembly Centres, and Regional Centres in order to deliver data and products in Near-Real-Time. Data is accessed via a dedicated portal, with a multi-criteria query interface based on referenced metadata and mapping of the Argo floats provides convenient user access. The Euro-ARGO ERIC portal also provides access to other European research projects under collaborative arrangements and it is the most important in situ observing system required for the Copernicus Marine Environment Monitoring Service (CMEMS).

4.10. COPERNICUS Marine Monitoring Service

The Copernicus Marine Monitoring Service (CMEMS) operates in response to issues emerging in the environmental, business and scientific sectors. The integrated service provides state-of-the-art daily analyses and forecasts, based on information from both satellite and in situ observation, addressing both public and private sector requirements across four main domains: Maritime safety, Marine Resources, Coastal and Marine Environment and Weather, Seasonal Forecasting and Climate.

Offshore energy is considered as part of the Coastal and Marine environmental activity and CMEMS provides enables provision of ocean energy resource estimates, risk assessments and information relevant to mandatory environmental monitoring of offshore sites. CMEMS relies on a network of European data producers, classified into two categories:

- The Thematic Data Assembly Centers (TAC) who process data acquired from satellite ground segments and in-situ platforms, so as to provide real-time and reprocessed products;
- The Monitoring and Forecasting Centres (MFC), in charge of running ocean numerical models assimilating the above TAC data to generate reanalyse (20 years in the past), analyse (today) and 10-day forecasts of the ocean.

Data is made available through a dedicated web portal. Datasets available in the catalogue can be searched via a search engine based on different categories of criteria such as regional domain, parameters or temporal coverage.

4.11. EMSO

The European Multidisciplinary Seafloor and water column Observatory (EMSO) ERIC consists in a system of regional facilities placed at key sites around Europe to explore the oceans. These facilities or observatories are platforms equipped with multiple sensors, placed along the water column and on the seafloor to monitor different biogeochemical and physical parameters that address natural hazards, climate change and marine ecosystems.

The scientific activity carried out within EMSO is multidisciplinary and covers four main scientific disciplines: geosciences, physical oceanography, biogeochemistry and marine ecology.

Data produced by EMSO is made available to different groups of users, including the research community, the private sector and the industry as well as the public sector.

Among the services made available by EMSO is a Transnational Access programme through which free-of-charge access to the EMSO facilities is offered, and for which a specific application portal was designed and has been made operational.

This portal provides information relevant for the preparation of applications and including a description of the selection process. It also provides a technical description of the available facilities. Having recently been constituted as a European Research Infrastructure Consortium (ERIC), EMSO is seen as being of particular relevance as a model to inform various aspects of MARINERG-i, which also plans to become an ERIC.

4.12. ECCSEL

The ECCSEL ERIC is a European integrated Research Infrastructure comprising distributed Centres of Excellence on Carbon Capture and Storage research (CCS) from nine EU countries. The objective of ECCSEL is to conduct research on CO₂ capture, storage and transport, in response to both short- and long-term Pan-European CCS R&D requirements. A dedicated portal was developed for the management of access to facilities, which also provides comprehensive metadata describing the Technical capacities of the available facilities.

4.13. IRP WIND

The aim of the IRPWIND is to foster better integration of European research activities in the field of wind energy research. The IRP Wind project conducts integrating activities, which facilitate, coordinate and align existing and planned national and European activities in the domain of Wind energy research. It also promotes alignment of national research activities with the European effort through joint experiments carried out in European research facilities. This involves the creation of access protocols to selected European research facilities, and the definition of prioritization procedures for selecting the most urgent and relevant experiments in the European context. Calls for Joint Experimentation are organised periodically and a specific application portal has been developed.

Activity related to knowledge transfer includes development of facilities to enable open access to data. A taxonomy of the relevant topics as well as standard metadata are being developed to support deployment of a metadata search portal with advanced search and data access functions. These elements are considered highly relevant in the context of MARINERG-i.

4.14. WindScanner DRI

The WindScanner project is led by DTU, Denmark. The objective is to develop, establish and operate a joint European distributed (and mobile) Research Infrastructure for experimental research in wind and turbulence fields for wind energy. The WindScanner.eu Infrastructure will consist of a set of National Nodes including leading European wind energy research organisations operating mobile, deployable WindScanner field monitoring units, bound together by the WindScanner Central Hub.

WindScanner lidar scanning systems generate very large amounts of data which requires a dedicated e-infrastructure for managing and supporting effective work-flow processes. The proposed WindScanner e-Infrastructure and User Platform will consist of a data storage structure coupled with an e-Science web service. The purpose of the database is to secure, validate, store and structure the data. Access to data is controlled, and user profiles and various levels of access and rights are defined.

The WindScanner e-Science and User Platform is a gateway that provides:

- user access to information and knowledge about the technology,
- access to the windscanner systems
- acquired measurements and other research data,
- support for communication and collaboration with peers, as well as the possibility to contribute to the project activity.

4.15. WindBench

The WindBench platform supports verification and validation (V&V) services mainly used by wind energy model developers and users as a guide to best practice in model evaluation and benchmarking. The platform offers: *“an updated inventory of models, a repository of quality checked test cases for model evaluation and documentation to orient the user. Best practice guidelines are built from model intercomparison benchmarks with different levels of complexity.”*

WindBench is led by CENER, Spain, who are partners in WindScanner. WindBench is a highly evolved and sophisticated system that exemplifies advanced best practice in terms of system architecture, interoperability and standards compliance. Whilst it is thematically tuned to wind research, there is a high degree of correlation with MARINERG-i requirements, and some common partners. These direct and specific linkages have in the latter part of 2019 proven to be of great value as a conduit for adapting and tuning the WindBench system to the broader range of MARINERG-i observation/modelling V&V requirements.

E-infrastructure related activities under MARINET2 have now advanced to the stage of practical implementation with a focus on 4 specific use-cases that are described in the MARINET2 deliverable D6.3 (currently in draft). This work is closely coordinated between IT and data specialists in IFREMER, DTU, Seadatanet, and CSC, and is scheduled to deliver key operational elements for a functional pilot scale system in 2020. Fundamental developments that are facilitating this include: digital object identifiers (DOI) which are unique identifiers being implemented within the metadata for each facility held on the Eurocean RID; a virtual laboratory (VRE) which is being set up in SeaDataCloud, and specialized tools adapted to convert text-file format serial time series data outputs from a wide range of laboratory sensors into the NetCDF common standard.

Some of the key characteristics of this collaboration which testify to its importance and relevance for both MARINET2 and MARINERG-i are elaborated in the following diagram and the conclusions drawn from a presentation by the Windbench team (which participates in support of Virtual Access activities within the MARINET network).

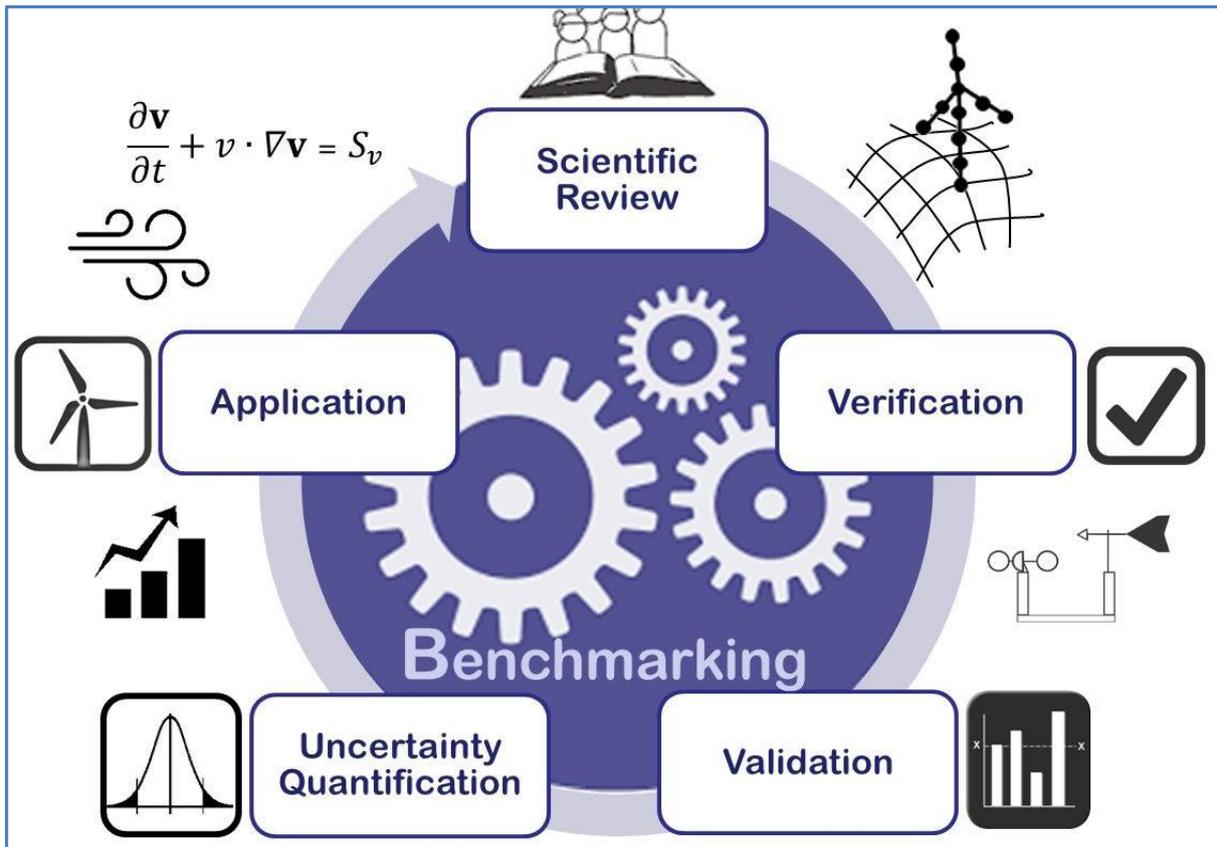


Figure 1. International framework for verification and validation (V&V), as used in Wind Energy European projects (EERA-DTOC, AVATAR, NEWA, IRPWind, etc)

- Development activities in WP6 are devoted to the integration of Windbench as a MARINET e-infrastructure within the VRE-SeaData network ecosystem.
- The NEWA-ALEX17 benchmark, conducted under the umbrella of the IEA Task 31 “Wakebench” will be launched in July and used as a pilot of the VRE using IFREMER Jupyter hub.
- We welcome other benchmarking opportunities coming from the MARINET Virtual Access application process

Attention is drawn to the following important links.

- The Wind Vane Blog: <https://thewindvaneblog.com/>. Where benchmarks are curated and launched.
- Wind Energy Model Evaluation Protocol (WEMEP): <https://wemep.readthedocs.io/en/latest/index.html>. Where best practices for verification and validation are documented.
- Windbench Github site: <https://github.com/windbench> Where we publish open-source evaluation scripts

5. Conclusions

A survey was conducted as part of the MARINERG-i Work Package 3 activity to identify, review and characterise existing e-infrastructures or e-services developed with similar objectives for data management and service offerings, across a range of relevant thematic areas. This report presented the results of this desk top study in the form of a high level summary outlining services to be developed as part of the e-infrastructure, and deemed necessary for the integrated activity to be conducted by the MARINERG-i DRI. This was firstly based on the analysis of the survey of end-users' requirements and identification of the main classes of activities conducted within MARINERG-i: namely access to facilities, coordinated research and knowledge sharing.

Secondly, a set of relevant e-infrastructures, databases and services were listed and their salient features assessed with regard to identified priorities for MARINERG-i e-infrastructure development.

Finally, reference was made to the most detailed and relevant ongoing development work being undertaken within the framework of MARINET2, which is in the process of adapting the very latest and most sophisticated assemblage of internationally standards compliant tools, work flows, codebases, as a sophisticated package of advanced best practice techniques for specific and direct uptake and use in the ORE domain.

Furthermore these initiatives are inherently aligned for long term sustainability within the wider ambit of strategic and very recent flagship EU initiatives under EOSC (European Open Science Cloud) including; EGI (<https://www.egi.eu/>) and the Blue Cloud initiative. (Blue-Cloud is the recently funded European H2020 project aiming to federate and pilot innovative services for Marine Research & the Blue Economy, which began in early October 2019.)

The body of information contained in D3.4 provides a useful synthesis and a key reference to support all aspects of MARINERG-i in terms of strategic and technical alignment, integration and interoperability, common policies and standards with other European e-Infrastructures.

It at supports and cross-link directly with the evolving Science Plan and Design Study being undertaken in WP4, addressing specific areas in these documents where e-Infrastructure requirements are outlined in detail.

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Appendix 1

A1. Identified e-Infrastructures and services

Table 2: Identified e-Infrastructures and services

Project Name	Framework	Field of activity	URL
MaRINET2	Horizon 2020 - Research and Innovation Framework Programme - INFRAIA	Offshore Renewable Energy	www.Marinet2.eu
SeaDataNet	FP6 Integrated Infrastructure	Marine Data	https://www.seadatanet.org/
SeaDataCloud	H2020 Research Innovation Action	Marine Data	https://www.seadatanet.org/
Sextant Spatial Data Infrastructure	French Programme	Marine and coastal geographic data	http://sextant.ifremer.fr/
EMODnet	Funded by European commission	Marine Data	http://www.emodnet.eu/
Eurofleets 2	FP7 Research Infrastructures project	Research Vessels	http://www.eurofleets.eu/
Pogo		Research Vessels and International cruises Information	http://www.pogo-oceancruises.org
Coriolis	French operational oceanography program for the in-situ observations	In-situ data for operational oceanography	http://www.coriolis.eu.org/
Euro-Argo ERIC	European Research Infrastructure Consortium (ERIC)	Argo programme Ocean in-situ monitoring	http://www.euro-argo.eu/
COPERNICUS MEMS	Part of the EU Copernicus programme	Marine Environment Monitoring	http://marine.copernicus.eu/
EMSO ERIC	European Research Infrastructure Consortium (ERIC)	Ocean monitoring	http://emso.eu/
ECCSEL ERIC	European Research Infrastructure Consortium (ERIC)	Carbon dioxide capture, storage & transport	http://www.eccsel.org/
IRP Wind	European Integrated Programme on Wind Energy Research – Part of the EERA Joint programme on wind energy	Wind Energy	http://www.irpwind.eu/
WindScanner	Proposed ESFRI Infrastructure	Wind Energy	http://www.windscanner.eu/
WindBench	Verification and Validation and platform	Wind Energy	https://windbench.net/windbench-vv-repositories-wind-energy