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JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories
Science, Services, Sustainability

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1. Executive Summary

This document provides an overview of the main data management procedures that are recommended to be applied within JERICO platforms and have been applied during the implementation of JERICO-S3. The document is based on the Horizon 2020 FAIR Data Management Plan template, and an update of the earlier draft D6.1. It provides the framework for the JERICO-S3 network partners for data handling from acquisition to publication, during and beyond the lifetime of the project.

The main data types that have been collected during the project are summarised, including their origin, their expected size and their relation to the objectives of the project. Furthermore, the JERICO-S3 recommendations to achieve data FAIRness are extensively described in a separate chapter, together with a number of actions that data providers should strive for during data collection, archiving and long-term maintenance as well as for the interoperability and the re-use of the collected data. Finally, brief information about the necessary allocation of the resources and the rules on the data security is also provided in the document.

2. Introduction to data management in JERICO-S3

The JERICO-S3 project has worked on strengthening the European network of coastal observatories providing a powerful and structured European Research Infrastructure dedicated to observe and monitor the complex marine coastal seas via the following actions:
(i) provide services for the delivery of high quality environmental data,
(ii) provide access to solutions and facilities as services for researchers and users,
(iii) create product prototypes for EU marine core services and users,
(iv) support excellence in marine coastal research to better answer societal and policy needs.

JERICO-S3 has significantly enhanced the value and relevance of the JERICO-RI, through the implementation of the science and innovation strategy elaborated as part of the JERICO-NEXT project. Major user-driven improvements in the new project have focused on facilitating data and quality control procedures for physical data (WP5/7), and establishing data management and best practices for biological and biogeochemical data generated by new technologies (WP6). The work on data and services, best practices and performance indicators, innovative monitoring strategies has been conducted in collaboration with other European RIs (EuroARGO, EMSO, AQUACOSM, DANUBIUS, ICOS, EMBRC, LIFEWATCH) and international scientific communities, industry and other stakeholders, and aligning strategy with data focused infrastructures such as COPERNICUS/CMEMS, SeaDataNet, EMODNET and GEO/GEOSS to better understand the complexity of coastal seas.
A thorough data management strategy supports the data flows from the various platforms involved in the Pilot Super Sites (PSSs) and Integrated Regional Sites (IRSs), and will ensure the FAIR data access through the main European Data Aggregators (INSTAC, SeaDataNet, EuroBIS and EMODNet), and via those in the JERICO-CORE virtual infrastructure and data products produced under JERICO-S3.

This document (based on the Horizon 2020 FAIR Data Management Plan template) summarises the main data management principles that will be recommended and applied during the implementation of JERICO-S3 (and beyond). It provides the framework for the JERICO-S3 data handling from acquisition to dissemination, during and beyond the life that are being managed during the project, with:
(a) the standards that will be applied to achieve FAIRness,
(b) the actions for data archiving and long-term maintenance,
(c) the access policies and
(d) the quality standards.

3. Data Summary

In this section the main data flows that are in scope of the DMP will be listed and discussed.

3.1 Types and formats of data generated/collected

3.1.1 Observation data from platforms

The data management work package (WP6) promotes the free and open access to data generated by the different platforms in JERICO-S3 as much as possible. Furthermore, one of the main objectives of WP6 in the project is to support a FAIR continuous and valuable coastal data flow to stakeholders (researchers, students, policy makers, etc), that allows coupling of the physical, biogeochemical and biological information. Following the path of its predecessors JERICO & JERICO-NEXT, JERICO-S3 should comply with the common principle that collected marine observation datasets should be shared for redistribution via the main European marine data infrastructures:

- EuroGOOS ROOS's and CMEMS In Situ TAC for operational oceanography exchange (NRT)
- SeaDataNet for delayed mode and exchange of validated data sets, for physical, chemical, biochemical and bathymetric data mainly.
- EuroBIS for biodiversity data
- EMODnet (via the above pillars), whereby data will provide extra input for EMODnet thematic data products
- Blue-Cloud which is developing a powerful Virtual Research Environment platform that will be promoted by means of five multi-disciplinary Virtual Lab demonstrators. The Blue-Cloud system will work through access and enabling processing of datasets from the main European marine data infrastructures (EMODnet, SeaDataNet, EurOBIS,...), which underpins the need to JERICO related data to be shared via those channels.

Moreover, JERICO-S3 data sets (both NRT and delayed mode) could also be accessible through the JERICO-RI portal, in order to promote the results of JERICO-S3 activities and progress in establishing a more streamlined data flow. The data is also being used when processing this into certain data products for coastal research. A brief description of the data portfolio from the involved coastal observation platforms can be found hereafter:

Physical Data

Temperature, Salinity, Currents, Sea level, Waves, Air temperature, Air pressure, Wind speed and direction, Rainfall, Radiative fluxes

Biogeochemical Data

Oxygen, Chlorophyll *a*/fluorescence, Nutrients, Inorganic Carbon, Dissolved Organic Matter, Turbidity

Biological Data – Ecosystem

Taxonomy data, Phytoplankton and zooplankton diversity.

The data description for JERICO-S3 will be under continuous development in order to guarantee a standardised data characterisation with better precision and consistent quality during the lifespan of the project. Data are becoming available in a variety of formats at the source. However, they will have to comply (be converted) with the relevant international standards before being released through the European Data Infrastructures (EMODnet, CMEMS, SeaDataNet).

3.1.2 Data products created under JERICO-S3

During the project, there are data products created using the observation data, e.g. during the scientific work in the PSS's and IRS's, as well as in WP7 in the e-infrastructures. These products will need to be stored according to international metadata and data standards as much as possible and published via metadata services (ISO19115 based metadata) and OGC compliant data access services. This will facilitate cross-disciplinary studies which are essential for a comprehensive understanding of coastal environments. References to the tools used in the data product creation may also be made available through the JERICO CORE e-infrastructure software catalogue. Data products metadata will need to include provenance and uncertainty descriptions so that users understand the potential and limitation of the data.

3.2 Re-use of existing data/Origin of the data

As mentioned in the introduction of this document, JERICO-S3 project aims at strengthening the European network of coastal observatories. Thus, data from existing networks along the European coastline will be used for the JERICO-S3 data portfolio, such as:

- FerryBoxes and Research Vessels
- Underwater Gliders
- Moored buoys
- HF Radars
- Argo profilers
- Surface drifters
- Tide gauges

Specific best practices for data management of these platforms have been described in JERICO-S3 deliverable D6.5.

The above data streams will be complemented by the coordinated activities designed in WP3 (Integrated Regional Sites) and WP4 (Pilot Supersites for innovative coastal monitoring), where multidisciplinary integrated observations will

take place within regions and between regions. JERICO-S3 will provide a number of harmonisation practices for the data originators, but it will strongly rely on the existing data integrators:

- The In-Situ Thematic Assembling Centre (Insitu TAC) component of Copernicus Marine Environment Monitoring Service (CMEMS)
- The SeaDataNet and EMODnet (in particular Physics and Chemistry thematic portals) for the physical and biogeochemical data.
- EUROBIS (EMODnet biology) for marine biodiversity (discrete and continuous sampling)

3.3 Expected data size/Data utility

The expected volume of the data that has been (and will be) collected during the JERICO-S3 activities cannot be estimated. Data size could be varied from a few gigabytes for some providers and networks to a few terabytes for others. Counting at the integrators level, the total volume could be several terabytes, but the existing systems have been set up to efficiently manage such an amount of data.

The challenge for JERICO-S3 is to ensure that data from the different and diverse in-situ observing systems will be findable, accessible, interoperable and reusable (FAIR!) by a wider community which includes the international ocean science community and other stakeholders in this field. In next chapters there is more information about how to achieve this FAIRness.

4. Generating FAIR Data

4.1 The JERICO view on FAIR data

That research and monitoring data should be FAIR (Findable Accessible Interoperable and Reusable) for humans and machines, is nowadays "common good" and accepted as a goal for most research organisations, projects and monitoring agencies. Current developments towards EOSC, Digital Twins, and Virtual Research can only be successful once data they need is FAIR. But how to achieve it is not straightforward. Findable and Accessible is relatively easy to comply to when publishing data in well-accessible catalogues with persistent identifiers, but Interoperability and Reusability demands community agreed extensive metadata, data formats, and agreed semantics (vocabularies), as well as clear metadata on quality, and data usage to achieve full reusable data.

JERICO as part of the marine community follows the agreed metadata solutions in the EU aggregators like SeaDataNet, EuroBIS, INSTAC and promotes data to flow through these data infrastructures, but has identified gaps in FAIRness when it comes to metadata elements on data quality like data management software applied, data acquisition standards for imaging data and overview of carbon data best practices. In JERICO-S3 there have been efforts in these areas to support the FAIRness of the data from coastal platforms in these areas.

4.2 JERICO handbooks and best practices

4.2.1 Legacy handbooks

During the last fifteen years, a series of standards for data and metadata formats together with exchange protocols have been suggested by international organisations, initiatives and projects like JCOMM, RDA (Research Data Alliance), EuroGOOS, EMODnet, SeaDataNet Copernicus, OGC which have been adapted by the research marine community. During the previous JERICO and JERICO-NEXT projects, a series of documents have been published (available through the IOC Ocean Best Practices System) with data management guidelines that should be followed by the partners for publishing of their data and their efficient upload to the major European Data Aggregators. These practices and handbooks are still important and were actually focusing on FAIR data flows before FAIR was defined.

JERICO project:

- Delayed Mode Data Handbook V2

- Near Real Time Mode Data Handbook V2

JERICO-NEXT project:

- Report on Data Management Best Practice and Generic Data and Metadata models
- Specifications for a European FerryBox Data Management System
- Recommendation Report 1 for HFR data implementation in European marine data infrastructures
- Recommendation Report 2 on improved common procedures for HFR QC analysis
- Marine biological data: quality control and management practices
- Document describing the biological data

It is evident that the JERICO legacy on data management is rich, ranging from the generic guidelines published during the first JERICO to the more focused and detailed documentation for specific platforms and activities that was produced during the JERICO-NEXT.
The need of developing data management best practices for novel data acquisition methods is widely agreed by the marine observation community. However, it is equally important to keep in mind that it is only by implementing these practices, it can be guaranteed that good quality data which is FAIR will be readily available. All the different phases of data management, whether at the level of the scientist (i.e. data collector) or at the level of the data manager / aggregator, require economic and/or time resources and need to be appropriately funded. However, the lack of appropriate resources continues to be a bottleneck that hampers the publication of data, more specifically interoperable data, after its collection and analysis. This can also be found in JERICO-S3 deliverable *D6.7 Evaluation of FAIRness of data of the PSS and IRS related to the Data Management Policy* which summarises the state of FAIRness via a few test enquiries of existing data flows. Continuous attention on data management is needed, not only at EU level, but especially at institute and national level.

JERICO-S3 has further optimised the FAIRness of its data flow and data management, both for machines and for people. Technological advances provide innovative opportunities for new forms of science, which is one of the drivers behind the European Open Science Cloud (EOSC). However, this demands well-described, accessible data that conforms to community standards and best practices.

4.2.2 Additional best practices under JERICO-S3

Under the JERICO-S3 project the existing FAIR data management practices have formed the basis. However there is room for improvement in certain areas, and

therefore the team in WP6 has worked on extending the set of data management best practices in areas where gaps were identified (at proposal stage):

D6.3 Data Management Best practices report for physical and BGC platforms
This report provides an overview of the best practices on data management with a focus on the physical and BGC platforms, and has captured the latest state of the art of FAIRness actions for such platforms.

D6.4 Data Management Best practices for quantitative imaging systems
This report provides an overview of the latest developments on FAIRness for quantitative imaging systems for plakton like ECOTAXA, and has been developed in close cooperation with other initiatives in this domain. The document is therefore very valuable for the whole community.

D6.5 Data Management Best practices report for biological optical sensors
This report provides an overview of the latest data management practices for biological optical sensors, mainly for observing phytoplankton.

D6.8 Data management Best practices and strategy for coastal carbonate systems
A report summarising the latest state of the art of data management practices observing carbon data. This has been the outcome of organised workshops, and has been produced in close cooperation with the ICOS community.

D6.9 E-library contribution report
For Reusability it is important to know which data management software is used in order to assess the quality of the data. JERICO-S3 has developed a component "e-library" as part of the CORE to register the data management software with an identifier, so it can be added to the metadata of datasets. This document summarises the approach.

Additional mention should be made of the following document, that has a main focus on data acquisition best practices, but has a strong relation to data management:
D5.2 Technical handbook published within the OBPS Repository of BP for implementing and operating coastal observatories.

4.3 Additional guidance and examples on publishing FAIR data

4.3.1 Making data findable including provisions of metadata

JERICO partners will continue to feed the different European data infrastructures with the relevant coastal data, maintaining and strengthening the operational links with EMODNET and CMEMS (Copernicus Marine Environment Monitoring System)

and the connections with the SeaDataNet network, but also to contribute to the development of standards regarding innovative data types, as in the case of novel acquisition methods on biological data (see above). JERICO partners should make optimal use of existing infrastructures, standards, services, softwares, best practices and initiatives, to compose its data flow through the use of elements of this data management plan.
In order to support and further enhance the connection with the major European data portals, JERICO partners should comply with the existing procedures and principles:

- For real time data (NRT/RT mode) the data providers are advised to contact the regional leaders of the seven geographical domains of CMEMS In Situ TAC (Mediterranean (MED), Black Sea (BS), Iberian-Biscay-Irish Sea (IBI), Atlantic North West Shelf (NWS), Baltic Sea (BAL) and Arctic Ocean (ARC) and Global (GLO)) in order to push their data into the ROOSs data centres The relevant QC/QA procedures can be applied either by the provider or by the above regional data centres before being delivered to EMODNET and CMEMS portfolio when it is applicable. Populating the CMEMS In Situ TAC service will ensure that the NRT-RT observation datasets will become available automatically for feeding and calibrating CMEMS forecasting models, for inclusion in various CMEMS data products, and for EMODnet Physics.

- For delayed mode data, it is recommended to deliver the data to the NODCs where they will be further processed and validated before being pushed to SeaDataNet. Populating the SeaDataNet CDI service will ensure that the delayed mode validated observation data timeseries (e.g. monthly /quarterly) will become available automatically for the relevant EMODnet thematic portals (chemistry, physics, biology) as input for their EMODnet data products and services, for inclusion in SeaDataNet data products such as climatologies, and in the overall SeaDataNet CDI data offer.

Furthermore, by populating CMEMS In Situ TAC and SeaDataNet, the observation datasets in their different levels of validation, NRT with automatic validation, and delayed mode with additional manual and scientific validation, will become automatically available for distribution in the Blue-Cloud and as input for the Blue-Cloud Virtual Research Environment (VRE) and its Virtual Labs, where applicable.

- For biodiversity data: The integration of biological data (planktonic and benthic communities) that were collected during extended focused experiments along the European coastline was one of the key objectives of the JERICO-NEXT project. Substantial efforts were made to integrate biological data into the marine observation networks in order to address pelagic and benthic biodiversity questions. These data were obtained with traditional sampling methods but innovative observation techniques and novel sensor data were

explored, revealing a significant potential to deliver operational (near real-time) data usable for monitoring purposes. The different datasets were screened and considered with respect to their current conformance with the biodiversity data standard (i.e. DarwinCore when applicable). Data from 18 datasets were made accessible using different approaches: a) through a data access link to a local/ad hoc website; b) through documented archiving in the Nature Scientific Data recommended repository: Marine Data Archive; or, c) through EMODnet Biology by means of full standardisation and integration into the EurOBIS database. Fully standardised data can be checked using automatic quality control procedures developed in the framework of EMODnet Biology (i.e. online QC tool).

Integration of biological data is relatively straightforward for data based on taxonomy and which are collected by traditional sampling methods. However, some methods deployed in JRAPs for measuring the biology component are in an earlier stage of development and present a great variety of new format and variable outputs. Consequently, they were lacking standardisation from data collection (e.g. sensor calibration), to data publication and quality control (e.g. lack of syntactic and/or semantic data standards, data management). Some issues were considerably improved during the JERICO-NEXT project and the vocabulary has been finalised and published under JERICO-S3. For instance, a set of controlled vocabularies was developed and put into practice for FCM data, and some of these FCM datasets are now integrated into SDN and published in BODC. Technical developments were put forward in the EMODnet Biology portal to allow users to search for FCM data. The adoption of new sensor-based biodiversity observations brings further complexities, and additional work on harmonisation of data collection and definition of best data management practices are still needed. This should be a priority in the following phase of the JERICO-RI. Through its direct interaction to wider biodiversity data sharing networks such as OBIS, EMODnet Biology can provide an interface to translate the needs of the observing community for exploration and documentation of data exchange formats for sensor-based biodiversity data.

4.3.2 Making data (openly) accessible

The JERICO-S3 has continued and enhanced the data policy defined during JERICO-NEXT as it is stated in the Recommendation on the free and open access data policy document through a simple and clear statement. The main message of the data policy is that data produced within the project is free and unrestricted with no charge for third parties. The project's partners are committed that all the data collected through the JERICO involved observing nodes or through any of the project's research activities will be available freely and openly to anyone. Observing data holding centres shall provide and enable ease of data discovery of the hosted data. Data published by JERICO-S3 observing nodes shall be made freely available

through relevant data access tools developed by these nodes. Machine to Machine interface will be encouraged.

Important note: Accessible in FAIR does not mean fully open without costs. Specific regulations deviating from this general rule may apply when data is used for e.g. non-scientific or commercial purposes. Separate fees may apply for the reproduction and delivery of data when web-based transfer of data is not possible to cover reproduction costs.
Data that will be collected by the observing nodes contributing to JERICO-S3 or by the foreseen project's research activities shall be made available as soon as possible and without unnecessary delay. All the JERICO-S3 observing nodes and all the project's partners that will be involved in data collection processes, should acknowledge national and international intellectual property rights regulations. Each data infrastructure is responsible for the warranty of copyrights and intellectual property rights which may apply for its data holdings. JERICO-S3 observing nodes will clearly indicate licenses and terms of use for each dataset in the corresponding metadata.
In cases in which data or information provided by JERICO-RI observing components is used in published or unpublished work, attribution for the used resources is required. Data citations shall exclusively use the information provided within the metadata of each data set. Observing nodes and integrators are in charge to provide the necessary documentation and tools to facilitate data access to users.

4.3.3 Making data interoperable

Interoperability of data is all about metadata and vocabulary standards. As mentioned in the previous paragraphs, this has been strived for during JERICO-S3 via the data streams that exist and the application of their standards as early as possible, meaning all elements should be collected at the source. The content in chapters 4.1 and 4.2 should be followed where appropriate.
Furthermore, the JERICO-S3 data products will be also based on the same principles and will be published directly in the JERICO-S3 infrastructure catalogue.

4.3.4 Increase data re-use

Data and products from JERICO-S3 observing nodes will be integrated in the major existing data integrators infrastructures, promoting, and facilitating their re-use and re-distribution. As mentioned above, the data will be distributed with a minimum set of metadata making possible the traceability of their originator and the feedback on their use. Re-use of non-open free data will not be facilitated by JERICO-S3 as the data cannot be integrated in the identified Integrators (CMEMS, EMODnet, SeaDataNet) and to their linked networks or initiatives. The metadata information of those restricted-access data will be published while their discovery will also be supported through the integration in European and international catalogues.

For Re-usability of data it is important to include data quality related information in the metadata. JERICO promotes to add this information immediately at the start of the data life cycle, so when the data is first collected, by including information on the sensor and of the data processing and checks that have been undertaken. In 4.2 the catalogue of data management software is mentioned. This catalogue allows to make reference to an identifier of the software applied.
As mentioned above, another important step for optimising the reusability of the data is the improvement of provenance information in the form of traceability and quality assessment. To improve JERICO data Reusability (and a bit the Findability and Accessibility as well), the adoption of the SeaDataNet Sensor Web Enablement (SWE) software suite is recommended, since the observed data streams will be documented with SWE metadata for sensors and platforms used, for which also dedicated SeaDataNet vocabularies can be applied.
The SeaDataNet SWE software suite will facilitate operators:

- to describe observatories (or networks of observatories) using the SMLE editor
- to operate a local ingestion service with ingestors
    - to receive, decode and check data
    - to use SensorML descriptions of the observatories for data decoding
    - to accept and ingest SWE-based observation data streams
- to receive and store the observations in a local open source database system and in conjunction with the SWE metadata
- to distribute (selections) of observations by means of SOS services
- to retrieve observation data (streams) from the database and using SOS services and to publish these at portals by configuring and customizing the open source Helgoland viewer

This way, data from observing platforms can be ingested, stored locally, and distributed by SOS for publishing as NRT – RT on the portal of the operator, and at the JERICO-S3 portal, using the Helgoland viewer.

JERICO-S3 datasets are available via the data aggregators in the Blue-Cloud and its Virtual Research Environment (including the JERICO version), whereby it has been arranged and well promoted that JERICO-S3l contributes to one or more of the VRE Demonstrators. A pilot implementation has been done as part of WP7/task 7.5.

5. Allocation of resources

Datamanagement and increasing the FAIRness of observation data comes at significant cost, which is often overlooked. JERICO promotes the specific attention

for data management during the complete data life cycle. Especially at the start of data acquisition, during monitoring and projects, the costs of data management need to be covered, and clear protocols (similar to this DMP) should be followed, which will make the FAIRness of data a step closer. During the JERICO projects the costs for enhancing some steps in the data FAIRness are covered, but especially work is done on documenting practices for the coastal platforms. The projects cover the networking cost that allows to define common best practices shared and agreed among all the partners and the other communities involved. JERICO also promotes the use and reinforcement of the data flows to the main EU infrastructures (to which most data centers are connected).
Concerning the cost for the long-term preservation of the data, it is explicitly mentioned in section 3 that the JERICO strategy is to make its data available to the entire marine community through the infrastructures of the major European integrators and not function itself as an operational data node. Consequently, the resources for long-term preservation of the data are covered by those entities.

6. Data security

Since JERICO-S3 streams all the data from its observing nodes to the major European data integrators, the issues related to data security are managed at this level, by professional data centres operating for more than fifteen years and apply state-of-the-art security standards on data exchange.

7. Ethical aspects

Whenever the JERICO-S3 project implements surveys, questionnaires, or collects personal data for any reason (e.g., attendance to organized events), European GDPR law will be used as reference and the user will be informed about the use of personal data. In general, JERICO-S3 will not transfer personal data (e.g. email addresses) to other entities and the only use will be setting up a distribution list to inform users about project progress. Users will be always able to change their consent and ask to be removed from the distribution channel.

8. Other issues

Nothing to report.

APPENDIX: ABBREVIATIONS

AQUACOSM: EU network of mesocosms facilities for research on marine and freshwater
CDI: Common Data Index
CMEMS: Copernicus Marine Environment Monitoring Service
DANUBIUS: International Center for Advanced Studies on River-Sea Systems
EMBRC: European Marine Biological Research Center
EMODNet: European Marine Observation and Data Nework
EMSO: European Multidisciplinary Seafloor and water column Observatory ecosystems open for global collaboration.
ERIC: European Research Infrastructure Consortium
EuroARGO: European Contribution to the Argo programme
EuroGOOS: European Global Ocean Observing System
EuroOBIS: European Node of the international Ocean Biodiversity Information System (OBIS)
FAIR: Findable Accessible Interoperable Reusable
FCM: Flow Cytometry
GEO: Group on Earth Observations
GEOSS: Global Earth Observation System of Systems
ICOS: Integrated Carbon Observation System
JCOMM: Joint Technical Commission for Oceanography and Marine Meteorology
JERICO-RI: JERICO Research Infrastructure
LIFEWATCH: European Infrastructure Consortium providing e-Science research facilities
NODC: National Oceanographic Data Center
NRT: Near Real Time
OGC: Open Geospatial Consortium
QC: Quality Control
ROOS: Regional Ocean Observing System
SDN: SeaDataNet
SWE: Sensor Web Enablement