



Deliverable D3.1.

Harmonization data report



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Document contributors

DELIVERABLE RESPONSIBLE:

Contributors	Organization	Reviewers	Organization
Sergio Chapela	UVIGO	David Patiño	UVIGO
Jacobo Porteiro	UVIGO	Ilmar Santos	DTU
		Tuhin Choudhury	LUT

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List of Abbreviations

ABBREVIATION	DESCRIPTION
WP	Work Package
KPI	Key Performance Indicator
NAS	Network Attached Storage
SMB	Server Message Block
M.2	M.2 Storage Interface/Format
WORM	Write Once Read Many
DMR	Data Management Repository
P_DR	Project Data Repository
DS	Dataset
MS	Microsoft
LP	Low Pressure



1. Introduction

The digital platform is managed by UVIGO and will serve as a data collection hub for the Primary Datasets. It enables the efficient integration of physical and virtual data streams, which is essential for ensuring efficient, seamless and transparent project and development work.

The task involves developing a digital twin of a power plant by integrating physical and virtual data from its main components to accurately simulate its behaviour and performance.

Data will be collected from various sources, with each key system element being characterized. This model will enable the assessment of operational performance and optimization of system efficiency.

The objectives of the activity WP3: Digital platform for process simulation and system validation are as follows:

1. To establish the data, parameters, and accuracy needed to integrate into the digital twin model.
2. To integrate, together with the experimental data obtained from Task 2.3, the virtual data streams obtained from the modeling processes of the different components of the system (Tasks 1.3 and 1.4).
3. To develop a digital twin with the integration of the different models of the various components of the energy conversion system (KPI: 1 Digital Twin).
4. To validate the technical feasibility of using innovative energy conversion technologies for sustainable carbon-neutral alternative fuels in waterborne transport, which includes:
 - Demonstrating scalability [KPI: 1 scalable MECS; Power: 5.8MWe; Power density: >40 kW/m³, electrical efficiency: 54%¹, total system efficiency: 73-76%].
 - Predicting the performance of the whole system under different load conditions.
 - Assisting in the development of optimal control to achieve the maximum potential of the system in terms of peak power, efficiency, dynamic response to variations in load, reliability, and safety under different scenarios of failure.
 - Validating the resilience of the fueling system to possible fuel impurities and the variability of the power required by the ship (KPI: 1 resilient power conversion system for maritime transport).
 - Validating the safety of the system through verifiable KPIs (KPI: 1 safety power conversion system for maritime transport).

¹ **Fuel-specific efficiency note:** Unless otherwise specified, electrical efficiency values exceeding 50% refer to operation with carbon-neutral fuels (green methane, green methanol). While hydrogen-readiness is a central objective of the project, current material and combustion limitations necessitate lower turbine inlet temperatures for hydrogen, which may result in reduced electrical efficiency.



- Validating emissions during operation and performing a life cycle analysis of the system (KPI: 1 green energy conversion system emissions in range-validated²).

Table 1. WP3 subtask

Subtask	Description
Subtask 1: Data collection and structuring	Collection of empirical, simulation, and reference data on the different components of the physical system. Ensuring the consistency, accuracy, and reliability of data from various sources.
Subtask 2: Characterization of main components	Each key component of the system (compressors, recuperator, combustion chamber, generators, boilers, etc.) will be characterized separately to produce the data required for the digital twin (in other WPs).
Subtask 3: Integration of the collected data	Integration of the collected and characterized data into the digital twin. Validation of the model's behavior against physical data obtained from tests and simulations.

² **Clarification note on using hydrogen as the reference case in component design:** Hydrogen, as the key fuel for zero emissions, is central to the project. MECS components will be designed for hydrogen, though material and combustion constraints may reduce efficiency. Conventional fuels like methane offer higher efficiency but at the cost of increased emissions. This trade-off will be explored by simulating performance with various green fuels in a digital twin environment (WP3) and developing innovative design solutions.



2. Data collection and structuring (requirements)

To establish a robust and effective data management framework, a number of key objectives and structural requirements have been identified. These are essential to support the seamless integration, organization, and utilization of data across the project's core systems. Central to this effort is the implementation of a centralized data collection hub, designed to handle both physical and virtual data streams with high efficiency and transparency.

The goal of this initiative is to develop a digital representation—or digital twin—of a power plant by consolidating data from its principal operational components. By combining real-time and simulated data, the digital twin will enable comprehensive analysis of system behavior under varying conditions. This integration is critical for accurately replicating system dynamics and enhancing the reliability of performance predictions.

To support this model, data will be sourced from multiple physical and digital interfaces, each contributing detailed insights into specific elements of the plant. These datasets will be systematically characterized and incorporated into the digital framework to enable continuous performance monitoring, operational diagnostics, and system optimization. Through this approach, the project aims to ensure an efficient and scalable method for improving energy system design and management.

2.1. Storage System Specifications

To support the data handling needs of the project, a number of technical and operational specifications were defined for the storage and collaboration system. At a minimum, the platform must offer 100 GB of shared storage capacity and be capable of supporting access for more than 10 users. Accessibility was a key factor, with preference given to solutions that require no local installation—ideally offering a web interface or compatibility with Server Message Block (SMB). Usability was also prioritized, with a requirement for minimal training and a low learning curve to ensure quick onboarding for all users.

File management features were considered essential to ensure the integrity and traceability of project documents. This includes built-in version control and change tracking capabilities, with data retention for a minimum of six months. Additionally, the platform must support granular permission settings at both the folder and file levels, enabling secure and customizable access for different project roles. Optional but desirable features included an integrated collaboration environment and dedicated mobile applications for both Android and iOS, enabling greater flexibility for remote work and real-time updates.

A wide range of off-site and on-site platforms were evaluated against these criteria. The list of options considered includes Microsoft SharePoint, Google Workspace, Airtable, M-Files, Confluence, ClickUp, Coda, Quip, Stackby, Asana, Monday, DocuWare, Notion, Obsidian, Nextcloud Hub, Alfresco, Seafile, OpenProject, and Redmine, among others. These platforms represent a mix of enterprise-level, cloud-based, and self-hosted solutions, offering various combinations of features, scalability, and user experience.

Despite the extensive range of choices, many platforms presented limitations that hindered their suitability. Common issues included steep learning curves, failure to meet the specified technical requirements (such as storage capacity or versioning support), and concerns about the long-term availability of the service throughout the project's duration. Additionally, many cloud-based solutions raised data privacy concerns, particularly regarding the transfer and storage of sensitive project files on external servers. These factors were all carefully weighed to ensure the chosen solution meets both the immediate and strategic needs of the project.



2.2. Selected solution

The chosen infrastructure for the project consists of two dedicated Network Attached Storage (NAS) servers to ensure secure, reliable, and high-performance data access and management. NAS1 is hosted in a professional datacenter environment and is accessible via the external network, allowing remote users to interact with stored data efficiently. NAS2 will serve as a backup unit and will be located at a secondary site, with the exact location to be determined. This setup ensures redundancy and continuity in case of primary server failure or connectivity issues.

To maintain data integrity and system resilience, a robust backup and replication strategy has been implemented. NAS1 will perform weekly replication to NAS2, providing local-only access to backup data to reduce exposure and potential external threats. Both NAS units are configured with redundancy capable of tolerating up to two simultaneous drive failures without data loss, ensuring high availability and protection against hardware malfunctions.

The system provides a total of 4 TB of storage capacity, with the flexibility to upgrade as project demands increase. To support fast and responsive performance, particularly with multiple concurrent users, M.2 drives are integrated as cache. This configuration significantly enhances data read/write speeds and overall user experience, making the system suitable for real-time collaboration and frequent file access.

Access to the storage system is designed for simplicity and versatility. Users can connect via standard web applications and SMB protocols, ensuring compatibility with a wide range of devices and operating systems. Mobile access is fully supported through dedicated Android and iOS applications. Additionally, the infrastructure includes an integrated Office-like suite that enables real-time document editing and collaborative work directly within the platform, minimizing the need for external tools and streamlining team workflows.

- Infrastructure:
 - Two dedicated NAS servers:
 - NAS1: Hosted in a datacenter, accessible via the external network.
 - NAS2: Backup located in a second site (TBD).
- Backup and Replication:
 - NAS1 replicates weekly to NAS2 (local access only).
 - Protection against two failed drives.
- Storage and Performance:
 - 4 TB storage (upgradable if needed).
 - M.2 drives for cache to optimize performance for multiple users.
- Access Options:
 - Web apps and SMB protocols for seamless access.
 - Android and iOS apps supported.
 - Includes an Office-like suite for online collaboration.



2.3. Operation

Each project member is assigned a unique login credential with a private, editable password to ensure secure and individualized access. The storage system is organized using a structured tree architecture, allowing for clear hierarchy and logical categorization of files and folders.

- Each project member gets a unique login with a private, editable password
- Storage is organized into a structured tree architecture.

To enhance data protection and support recovery in the event of accidental changes or file corruption, a snapshot system has been implemented for the 'Components' folder. Snapshots are automatically created every 15 minutes, capturing the current state of the folder without interrupting user activity. This allows for fast and precise recovery of files in case of unintended edits, deletions, or software-related issues.

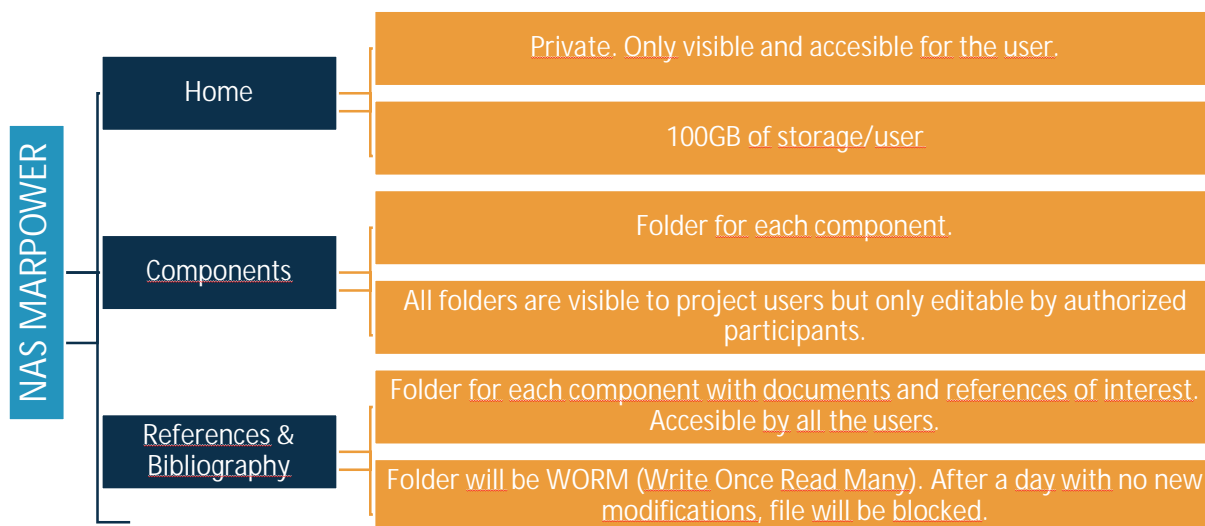
The proposed retention policy ensures a balance between recovery flexibility and efficient storage use. All snapshots are retained for 24 hours, enabling restoration of recent changes throughout the day. Beyond this, a single daily snapshot is preserved for one week, providing a historical view of the data across recent days. Additionally, one weekly snapshot is retained for an entire month, and all monthly snapshots are stored indefinitely, ensuring long-term reference points and support for auditing or rollback if needed.

From a security perspective, changes made on NAS1 are replicated weekly to NAS2. This scheduled replication ensures that backup data remains current while minimizing the risk of compromised data spreading instantly between systems. By avoiding direct or real-time replication, the system maintains a layer of isolation that helps protect NAS2 in the event of malware, ransomware, or unauthorized access on the primary server.

This combination of frequent snapshots, a tiered retention policy, and controlled replication provides a comprehensive safeguard for critical project data—supporting operational continuity, disaster recovery, and long-term data integrity.



Figure 1. Synthetic overview of the NAS MARPOWER system



▪ **Snapshot System:**

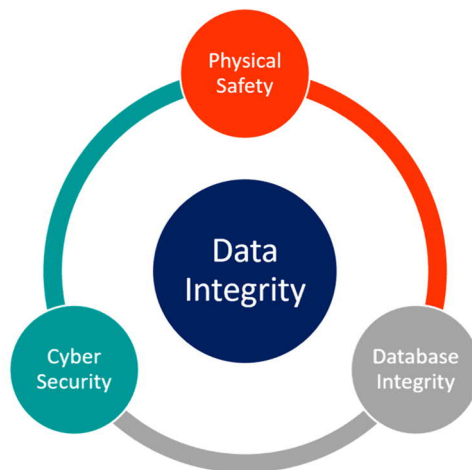
- Automatic 15-minute snapshots of the 'Components' folder.
- Proposed retention policy:
 - Keep all snapshots for 1 day.
 - Retain the last daily snapshot for 1 week.
 - Retain the last weekly snapshot for 1 month.
 - Retain all monthly snapshots.

▪ **Security:**

- Changes on NAS1 replicated weekly to NAS2.
- No direct replication to prevent spreading of attacks.



Figure 2. Considered Parts in Data Integrity.



2.4. Hierarchical Folder Structure for Effective Data Classification and Access

To ensure a well-organized, secure, and accessible data environment aligned with the objectives of the MARPOWER project, the NAS-based storage infrastructure is structured around a hierarchical folder system. This architecture supports efficient classification of datasets and facilitates controlled access to information according to user roles and project needs.

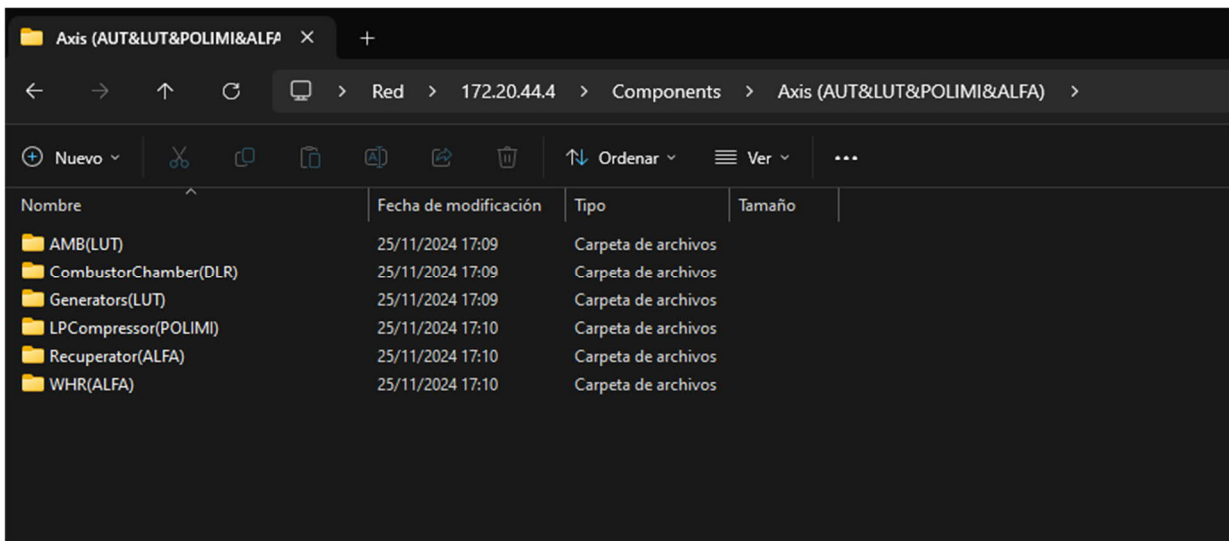
The folder system is organized as follows:

- **"Home" Folder:** Each project participant is assigned a personal workspace within the system, located in the "Home" directory. This folder is private and uniquely linked to the individual user account. It offers 100 GB of dedicated storage capacity per user and is intended for preliminary analysis, individual contributions, or temporary file storage. Access to this folder is restricted to the designated user, preserving the confidentiality of drafts and working documents prior to their integration into collaborative spaces.
- **"Components" Folder:** This folder serves as the central repository for all data related to the key subsystems and hardware components of the energy conversion system under study (e.g., low-pressure compressors, combustion chambers, recuperators, turbines, and generators). It is organized into subdirectories for each specific component, following a naming convention that includes the component name and responsible partner entity (e.g., "\Components\LP Compressor (POLIMI)\Compressor"). While the folder is visible to all authorized users to support cross-institutional collaboration, editing rights are restricted to selected contributors assigned to each component, ensuring the integrity and consistency of the technical content.
- **"References & Bibliography" Folder:** This directory functions as a shared knowledge base containing supporting documents, scientific references, bibliographic files, and regulatory standards relevant to the project. It is accessible to all users for consultation purposes. To ensure content reliability and avoid post hoc alterations, this folder operates under a WORM (Write Once Read Many) policy. Files stored in this folder become read-only after 24 hours without modification, guaranteeing the long-term stability of reference materials used in the project's analyses and simulations.



All datasets stored in the “Components” folder are subject to an automatic snapshot system that captures the state of the folder every 15 minutes. Snapshots are retained according to a tiered policy (24 h for all snapshots, 1 week for daily, 1 month for weekly, and indefinite for monthly), allowing recovery of previous versions when needed. When uploading an updated dataset, partners should keep the same file name and indicate the version in the dataset metadata or dataset card, ensuring traceability of changes without disrupting automated import processes. This combination of structured naming, metadata documentation, and snapshot-based backups guarantees full version control and auditability.

Figure 3. Components Folder Structure.



3. Harmonization Data

In multi-partner engineering projects such as MARPOWER, where numerous components are developed by different institutions and later integrated into a unified simulation platform (digital twin), ensuring harmonized data is critical. Simulation platforms—especially one-dimensional modeling tools—rely on coherent input parameters and consistent data formatting to function correctly. Discrepancies in units, naming conventions, parameter definitions, or missing data can cause major errors in the digital model, misleading simulation results and ultimately compromising system design and validation.

The harmonization process in WP3 addresses this challenge by standardizing how component data is collected, stored, and integrated. Each component—such as compressors, combustion chambers, turbines, generators, and recuperators—requires a set of specific parameters to be defined. These parameters are used to build parametric models and connect them in the digital twin environment.

To facilitate this, UVIGO developed a structured and simplified **component datasheet** template for each system element. This datasheet ensures consistency across contributions from different partners and supports the automation of data import into the simulation platform. The harmonized datasheets serve as the interface between experimental data, design specifications, and the digital modeling framework.

These datasheets are designed to:

- Include **only essential parameters**, reducing complexity.
- Provide **clear unit definitions** and **expected formats** to avoid misinterpretation.
- Be stored in **text-based format (.txt)** to allow automatic parsing by scripts.
- Include **embedded references to explanatory material**, when needed (e.g., a PDF guide).
- Be placed in the specific component folder within the **NAS infrastructure**, ensuring secure and organized access.

3.1. Component Datasheet

Each datasheet is composed of two main blocks:

1. Operational Information and Fixed Parameters

This section includes fundamental physical or design constants, such as:

- Moment of inertia
- Type of inertia variation
- Initial angle of rotation
- Initial rotational speed

2. Adjustable Parameters

These allow users to fine-tune simulation behavior, conduct sensitivity analyses, or explore design alternatives. They are meant to be modifiable within pre-defined boundaries, ensuring flexibility without compromising model consistency.



To ensure correct usage of the datasheets, the following procedure is provided:

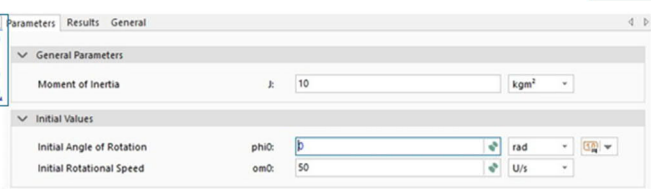
- **Step 1:** Consult the accompanying help document (PDF) linked in the datasheet to understand the context and relevance of each parameter.
- **Step 2:** Fill in or modify the required values using appropriate units and formats.
- **Step 3:** Save the completed datasheet as a .txt file.
- **Step 4:** Upload the file to the correct **component subfolder** inside the "Components" directory in the NAS system.

Figure 6. Information of the datasheet

Component datasheet:

Ident	Comment	Unit	Value
J	Moment of Inertia	kgm ²	10
kind	Kind of Inertia Variation	-	Energy
phi0	Initial Angle of Rotation	rad	0
om0	Initial Rotational Speed	U/s	50

Parameters setting



1. Component operation information and parameters in SimulationX

2. Ajustable parameters

SimulationX_help

How to use the datasheets:

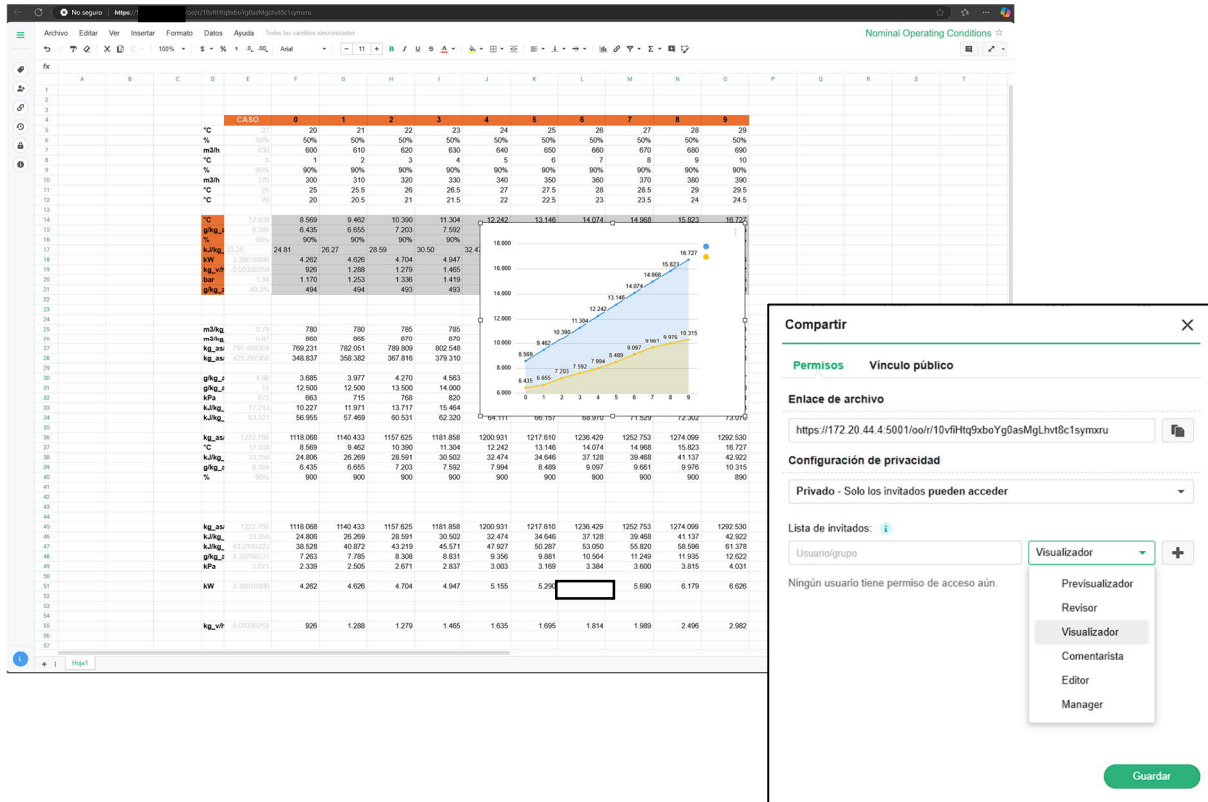
1. If necessary, read the information needed to understand the parameters requested in the help pdf.
2. Modify the parameters.
3. Save the sheet as a .txt file in the components folder.

Ident	Comment	Unit	Value
J	Moment of Inertia	kgm ²	10
kind	Kind of Inertia Variation	-	Energy
phi0	Initial Angle of Rotation	rad	0
om0	Initial Rotational Speed	U/s	50

Format of the .txt file to be entered into SimulationX



Figure 7. Datasheet



3.2. Benefits of Harmonization

The harmonization effort ensures that:

- All component models use **consistent assumptions**.
- Data is **interoperable and traceable**, facilitating updates and audits.
- The digital twin operates **robustly and reliably**, integrating physical and virtual data sources.
- Cross-partner collaboration is **streamlined**, reducing delays caused by data incompatibility.



4. Data Management Plan - DMR

The **Data Management Plan (DMP)** for the MARPOWER project outlines the strategy for organizing, storing, sharing, and preserving the data generated and collected throughout the project, ensuring its integrity, traceability, and accessibility. The DMP is aligned with the FAIR data principles: **Findable, Accessible, Interoperable, and Reusable**.

4.1. Datasets repository

The MARPOWER project includes two data repositories, each serving a distinct role in data management.

a) MARPOWER Project Data Repository (P_DR)

This repository, based on Microsoft Teams and SharePoint, is used to store **secondary datasets** (e.g., regulatory references, bibliographic content, public deliverables, and shared documentation). It is updated and managed by the Project Coordinator and ZABALA to accommodate the evolving needs of the consortium.

- **Access and Storage:** Accessible via web browsers and Microsoft 365 tools.
- **Structure:** Follows a hierarchical folder system by Work Package and Task.
- **Use:** Ideal for storing documents generated for dissemination or project coordination.

b) MARPOWER Data Management Repository (DMR)

Managed by UVIGO, the DMR is the central hub for **primary datasets** generated from simulations, experiments, modeling, and system characterization. It is built on a dedicated infrastructure using two **Network Attached Storage (NAS)** servers, ensuring high-performance, secure, and scalable data handling.

- **NAS1:** Hosted in a professional datacenter, accessible externally.
- **NAS2:** Backup server at a secondary location (TBD), for local-only access.
- **Performance:** 4 TB expandable storage, with M.2 cache drives to support concurrent users.
- **Accessibility:** Available via web applications, SMB protocols, and mobile apps (Android/iOS).
- **Collaboration:** Includes integrated office-like tools for real-time editing.

While both repositories have a distinct role in the data management related tasks of the project, each serves as a centralized storage system designed to collect, manage, and maintain the various datasets produced by the project with the following key objectives:

- **Centralized storage:** Providing a single location for storing data from various sources, making it easier to manage and access.



- **Data management:** Ensuring data is organized, secure, and easily retrievable for analysis and reporting.
- **Collaboration:** Facilitating data sharing and collaboration among team members and stakeholders.
- **Data preservation:** Maintaining data integrity and ensuring long-term preservation for future use.
- **Compliance:** Supporting adherence to data governance and regulatory requirements by providing structured and controlled data access.

4.2. Instructions for uploading datasets to the repository

All MARPOWER partners generating datasets are responsible for ensuring that those datasets are correctly uploaded to the appropriate repository and structured according to project guidelines. This is essential for maintaining consistency, traceability, and accessibility of data across the consortium and for supporting the FAIR principles (Findable, Accessible, Interoperable, Reusable). The following instructions define the protocol for uploading datasets.

Uploading Primary Datasets

Primary datasets—those generated directly from simulations, experiments, measurements, or component modeling—must be stored in the **Data Management Repository (DMR)** managed by UVIGO.

Folder Structure:

Each dataset must be uploaded to the appropriate folder within the DMR's structured hierarchy. This structure includes the following key directories:

- **Home:** A private folder allocated to each user. This space is intended for preliminary files, internal notes, and working documents not yet finalized for shared use. Each user is allocated 100 GB.
- **Components:** The main repository for system-related data. It contains a dedicated subfolder for each key component of the energy conversion system (e.g., compressors, combustion chambers, recuperators). These subfolders are named according to the format: `\Components\[Component Name] ([Partner Acronym])\[Subcomponent]`
Example: `\Components\LP Compressor (POLIMI)\Compressor`
- **References & Bibliography:** A centralized repository for literature, standards, and regulatory documents. Files here are managed under a WORM (Write Once Read Many) policy and become read-only after 24 hours of inactivity.



5. Conclusion

The work carried out within Task 3.1 of the MARPOWER project represents a foundational milestone for the integration and management of both physical and virtual datasets required for the development of an advanced digital twin of a novel energy conversion system for maritime applications. The outcomes described in this deliverable provide a framework for the structuring, storage, accessibility, and governance of project data, ensuring consistency, transparency, and robustness throughout the data lifecycle.

The design and implementation of a distributed data storage infrastructure, based on dual Network Attached Storage (NAS) servers, offers a high level of data availability, redundancy, and performance. The primary server (NAS1), hosted in a secure datacenter environment and accessible through web applications and standard protocols (e.g., SMB), ensures reliable data interaction for all project participants, regardless of their location. The backup server (NAS2), deployed at a separate site and configured with a one-way replication mechanism, contributes to the protection of critical datasets against potential cyber threats, technical failures, or human errors.

Special attention has been given to the organization of data through a structured and hierarchical folder system, which facilitates intuitive navigation, role-based access, and functional categorization of content. The separation into “Home,” “Components,” and “References & Bibliography” directories allows for parallel workflows, secure individual workspaces, and consolidated repositories of component-specific and bibliographic data. Furthermore, the adoption of WORM (Write Once Read Many) policies and automatic snapshot systems strengthens the traceability and integrity of key information, especially in collaborative environments involving multiple institutions and disciplines.

Another key achievement of this task is the formalization of procedures for uploading, naming, and updating datasets, aligned with FAIR data principles and good practices in research data management. The combination of version control mechanisms, metadata guidance, and synchronized access protocols ensures that all datasets remain coherent and easily retrievable during project execution and beyond.

The harmonization of data collection procedures across different technological domains—compressors, combustion chambers, recuperators, generators, and other components—also enables a coherent integration of empirical and simulated data streams. This harmonized approach is essential for the proper development of the digital twin, which will serve as a real-time simulation environment and decision-making tool for the validation, optimization, and predictive control of the complete power conversion system.

Finally, the infrastructure and organizational model described in this deliverable provide a solid and scalable foundation for the subsequent tasks in WP3 and for the broader objectives of the MARPOWER project. It enables a seamless interface between experimental campaigns, component modeling, system integration, and virtual testing. Moreover, it establishes a reliable digital environment that supports innovation, traceability, and long-term knowledge preservation.



Annex: List of MARPOWER partners

1. LAPPEENRANNAN-LAHDEN TEKNILLINEN YLIOPISTO LUT, the Coordinator of MARPOWER, with legal address at Yliopistonkatu 34, 53850 Lappeenranta, Finland
2. POLITECNICO DI MILANO with legal address at Piazza Leonardo Da Vinci 32, 20133 Milano, Italy
3. DEUTSCHES ZENTRUM FÜR LUFT - UND RAUMFAHRT EV with legal address at Linder Höhe, 51147 Köln, Germany
4. DANMARKS TEKNISKE UNIVERSITET with legal address at Anker Engelunds Vej 101, 2800 Kongens Lyngby, Denmark
5. UNIVERSIDAD DE VIGO with legal address at Lg Campus Lagoas Marcosende, 36310 Vigo Pontevedra, Spain
6. AURELIA TURBINES OY with legal address at Höyläkatu 1, 53500 Lappeenranta, Finland
7. ALFA LAVAL AALBORG OY with legal address at Kaivopuistontie 33, 26100 Rauma, Finland
8. RINA SERVICES SPA with legal address at Via Corsica 12, 16128 Genova, Italy
9. RINA CONSULTING SPA with legal address at Via Cecchi 6, 16129 Genova, Italy
10. CHANTIERS DE L'ATLANTIQUE with legal address at Avenue Antoine Bourdelle, 44600 Saint Nazaire, France
11. ZABALA INNOVATION CONSULTING SA with legal address at Paseo Santxiki 3 bis, 31192 Mutilva Alta Navarra, Spain

