This project has received funding from the European Union's HORIZON-CL2-2021-HERITAGE-01 research and innovation programme under grant agreement No 101061157

PERCEIVE

Perceptive Enhanced Realities of Colored collEctions through aI and Virtual Experiences

D5.1. PERCEIVE Platform Specifications

Deliverable information	
WP	WP5
Document dissemination level	PU
Deliverable type	R
Lead beneficiary	FORTH
Contributors	CNR, IGD, IMKI, NTNU
Date	December 13, 2023
Document status	RC2
Document version	V1.0
Due Date	December 31, 2023

Project information

Project start date: 1st of February 2023

Project Duration: 36 months

Project website: https://perceive.eu

Project contacts

Project Coordinator

Sofia Pescarin

CNR ISPC

E-mail: sofia.pescarin@cnr.it

Scientific coordinator

Holger Graf

Fraunhofer IGD

E-mail: holger.graf@igd.fraunhofer.de

Project Manager

Ivana Cerato

CNR ISPC

E-mail: ivana.cerato@cnr.it

PERCEIVE consortium

No.	Short name	Institution name	Country
1	CNR	CONSIGLIO NAZIONALE DELLE RICERCHE ISTITUTE OF HERITAGE SCIENCE	Italy
2	FORTH	IDRYMA TECHNOLOGIAS KAI EREVNAS	Greece
3	ANAMNESIA	ANAMNESIA	France
3.1	IMKI	IMKI	France
4	NTNU	NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET NTNU	Norway
5	FRAUNHOFER	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV	Germany
6	MIC-MANN	MINISTERO DELLA CULTURA MANN MUSEUM (MIC-MANN)	Italy
7	OSL-MUNCH	OSLO KOMMUNE MUNCH MUSEUM (OSL-MUNCH)	Norway
8	AIC	THE ART INSTITUTE OF CHICAGO US	USA
9	HOVERLAY	Hoverlay US	USA
10	HSLU	FACHHOCHSCHULE ZENTRALSCHWEIZ -HOCHSCHULE LUZERN CH	Switzerland
11	V&A	VICTORIA AND ALBERT MUSEUM UK	UK

Executive summary

The D5.1 deliverable is a cornerstone of the PERCEIVE project, pivotal in defining the comprehensive requirements and specifications for the PERCEIVE platform. This platform represents an all-encompassing system that integrates both front-end and back-end functionalities. It is intricately designed to actualize the Expected Outcomes outlined in D2.2, playing a central role in the project's mission to preserve and enhance cultural heritage using advanced digital technologies. The primary objective of D5.1 is to establish a clear, detailed framework that meticulously guides the platform's development, ensuring alignment with the diverse needs of various stakeholders.

To accurately define the requirements and specifications of the PERCEIVE platform, a standardized, multi-faceted approach has been adopted, comprising Functional Needs Analysis (FNA), Operational Needs Analysis (ONA), and Technical Needs Analysis (TNA). This holistic methodology, rooted in contemporary best practices and literature, reflects the growing recognition of the need for comprehensive analysis in software engineering and system development.

- **Functional Needs Analysis (FNA)**: This focuses on identifying the essential functionalities of the system, ensuring that the platform's capabilities meet the project's objectives.
- **Operational Needs Analysis (ONA)**: The ONA assesses how the system will operate within its intended environment, concentrating on optimizing system performance, reliability, and user ergonomics.
- **Technical Needs Analysis (TNA)**: TNA delves into the technical specifics required for effective implementation, encompassing aspects such as architectural design, technological frameworks, and scalability.

The integration of these three key analyses ensures the development of a robust, user-friendly, and technically sound platform. This approach caters to the diverse needs of stakeholders, ranging from heritage scientists and ICT specialists to individuals in the creative industries. It aligns with specific scenarios, such as color preservation in artworks and digital reconstructions, detailed in the PERCEIVE project.

The comprehensive approach undertaken in D5.1 is instrumental in addressing the intricate and multifaceted requirements of a project as ambitious and forward-looking as PERCEIVE. This project stands to revolutionize how we interact with and preserve cultural heritage, harnessing the power of advanced digital technologies to create a platform that is not only functionally rich and technologically advanced but also user-centric and aligned with the specialized needs of the cultural heritage domain.

Document History

Version	Release date	Summary of changes	Author(s) -Institution
V0.1	20/09/2023	First draft created	FORTH
V0.5	18/11/2023	Revision based on D2.2	FORTH
V0.9	30/11/2023	First Release Candidate	FORTH
V1.0_RC2	12/12/2023	RC2 - Restructured and enhanced	FORTH
V1.0	28/12/2023	Finalized	FORTH

Table of Contents

1 Introduction

The D5.1 deliverable is a critical component of the PERCEIVE project, focusing on defining the requirements and specifications for the PERCEIVE platform. The PERCEIVE Platform is a comprehensive system, encompassing both front-end and back-end functionalities, designed to disseminate the project's Expected Outcomes identified in D2.2. These outcomes are central to the project's aim of preserving and enhancing cultural heritage through advanced digital technologies. The goal of D5.1 is to establish a clear, detailed framework that guides the development of the platform in alignment with the needs of various stakeholders.

1.1 Methodological Approach

In order to meticulously define the requirements and specifications of the PERCEIVE platform, we have adopted a standardized, multi-faceted procedure that encompasses Functional Needs Analysis (FNA), Operational Needs Analysis (ONA), and Technical Needs Analysis (TNA). This comprehensive approach is rooted in contemporary best practices and literature, reflecting a growing recognition in the fields of software engineering and system development of the necessity for a holistic analysis. The FNA focuses on identifying the essential functionalities of the system, ONA assesses how the system will operate within its intended environment, and TNA delves into the technical specifics required for effective implementation. By integrating these three key analyses, we aim to ensure that the platform not only meets the specific functional demands of its users but also operates optimally within its intended environment and adheres to the highest technical standards. This methodology is crucial in addressing the intricate and multifaceted requirements of a project as complex and forward-looking as PERCEIVE, which aims to revolutionize the way we interact with and preserve cultural heritage through advanced digital technologies.

The combined analysis ensures that the platform is robust, user-friendly, and technically sound, catering to the diverse needs of stakeholders ranging from heritage scientists to ICT specialists and the creative industries. It aligns with scenarios like colour preservation in artworks and digital reconstructions, as detailed in the PERCEIVE project.

1.2 Functional Needs Analysis (FNA):

The Functional Needs Analysis serves as a comprehensive blueprint that delineates the requisite functionalities of a proposed system. This analysis meticulously aligns with the explicit and implicit expectations of stakeholders, encompassing a broad spectrum of project objectives. It involves an in-depth evaluation of the system's intended capabilities, user interactions, and output requirements. By systematically identifying and documenting these needs, the FNA ensures that the proposed system is designed to meet its intended purpose efficiently, thereby bridging the gap between user expectations and technical execution.

The FNA in the context of T5.1 entailed the following analysis steps:

- **Definition of System's Lifecycle Stages**: This segment delineates the comprehensive roadmap of the system's evolution, encompassing inception, development, deployment, and maintenance phases. It ensures alignment with the overarching project timeline and objectives, providing a strategic framework for progress tracking and resource allocation.
- **Definition of System's Users and Roles**: This section methodically identifies and categorizes the system's diverse user groups, such as heritage professionals, museum visitors, and digital artists. It emphasizes understanding their distinct roles and interactions with the system, enabling tailored functionalities and experiences.
- **Definition of System High-Level Functionalities (HLFs)**: This part articulates the system's cornerstone capabilities, such as advanced digital restoration, predictive color analysis algorithms, and immersive augmented reality (AR) experiences. It serves as a cornerstone for the system's value proposition and user engagement strategies.
- **Definition of System High-Level Requirements (HLRs)**: Establishes the fundamental criteria and guidelines that steer the system's development journey. This ensures that every aspect of the system architecture and design converges towards fulfilling its intended purpose and user expectations.

1.3 Operational Needs Analysis (ONA)

The Operational Needs Analysis is an integral process that scrutinizes the operational context in which the system will function. This analysis is pivotal in determining how the system will integrate into the existing or intended operational environment. It focuses on optimizing system performance, ensuring both efficiency and effectiveness in real-world applications. The ONA encompasses aspects such as system adaptability, reliability, user ergonomics, and environmental considerations. This ensures that the system not only meets its functional requirements but does so in a manner that is seamless, user-friendly, and conducive to the operational landscape it is destined for.

The ONA in the context of T5.1 entailed the following analysis steps:

- **Definition of High-Level Architecture**: This outlines the holistic structure of the system, detailing the interplay between various components. It focuses on scalability and robustness, ensuring the system's architecture can adapt and evolve in response to changing needs and technologies.
- **Definition of System's Critical Components**: Identifies and prioritizes key elements crucial for the system's functionality, such as AI-powered color restoration modules and sophisticated data repositories. This focus is essential for ensuring system reliability and performance.
- **Definition of System's Interfaces and Interactions**: Elaborates on the modalities through which the system interacts with users and other systems. This includes user interface design, API integrations, and interoperability standards, all aimed at providing a seamless and intuitive user experience.

1.4 Technical Needs Analysis (TNA)

The Technical Needs Analysis is a rigorous examination of the technical requisites essential for the construction and sustained operation of the system. This analysis delves into the architectural design, technological frameworks, hardware and software components, scalability, and maintainability aspects of the system. The TNA is pivotal in ensuring that the system is not only feasible with current technological standards but also exhibits the robustness and flexibility required for future expansions and updates. By addressing these technical aspects comprehensively, the TNA guarantees that the system is built on a foundation that is both sturdy and adaptable, ensuring long-term sustainability and relevance in an ever-evolving technological landscape.

The TNA in the context of T5.1 entailed the following analysis steps:

- **Definition of Functional Requirements (FRs) for the System Components**: Specifies the detailed, individual requirements for each system component. This section is crucial for ensuring that every component functions optimally and in harmony with the overall system architecture.
- **Definition of Non-Functional Requirements (NFRs) for the System Components**: Addresses crucial aspects like system performance benchmarks, security protocols, and usability guidelines. These requirements are key to ensuring the system's reliability, security, and overall user satisfaction.
- **Definition of Validation Criteria and Methodology for All NFRs**: Establishes a robust framework for validating non-functional requirements, incorporating both quantitative and qualitative metrics. This ensures the system adheres to high standards of quality, performance, and reliability.

2 Functional Needs Analysis

The Functional Needs Analysis (FNA) is an essential component of the PERCEIVE project, serving as a comprehensive blueprint for defining the requisite functionalities of the proposed system. This analysis is intricately aligned with both the explicit and implicit expectations of stakeholders, encompassing a wide array of project objectives. The FNA involves a thorough evaluation of the system's intended capabilities, user interactions, and output requirements, ensuring that the proposed system is designed to meet its intended purpose efficiently and effectively.

In the context of Task 5.1, the FNA encompasses several critical analysis steps:

- **Definition of System's Lifecycle Stages**: This aspect of the FNA delineates a comprehensive roadmap for the system's evolution, covering stages from inception and development to deployment and maintenance. This ensures that the system's development aligns with the overarching project timeline and objectives, providing a strategic framework for progress tracking and resource allocation.
- **Definition of System's Users and Roles**: In this section, the FNA methodically identifies and categorizes the diverse user groups of the system, such as heritage professionals, museum visitors, and digital artists. This step is critical in understanding the distinct roles and interactions these users will have with the system, enabling the development of tailored functionalities and experiences that meet their specific needs.
- **Definition of System High-Level Functionalities (HLFs)**: This part of the FNA articulates the system's cornerstone capabilities. These include advanced digital restoration techniques, predictive color analysis algorithms, and immersive augmented reality (AR) experiences. The HLFs form the foundation of the system's value proposition and are essential for engaging users effectively with the platform.
- **Definition of System High-Level Requirements (HLRs)**: The FNA establishes the fundamental criteria and guidelines that guide the system's development journey. This step ensures that every aspect of the system's architecture and design is directed towards fulfilling its intended purpose and meeting user expectations.

Overall, the Functional Needs Analysis is instrumental in bridging the gap between user expectations and technical execution, ensuring that the PERCEIVE platform is developed to effectively meet the diverse needs and objectives of its stakeholders.

2.1 Platform Lifecycle stages

The initial step for the Functional Needs Analysis is the identification and definition of the lifecycle stages of the PERCEIVE Platform, each marked by specific goals and activities. This section outlines four distinct phases, spanning from initial studies to full implementation and evaluation, as shown also in Table 1:

Phase	Name	Description	Duration
1	Pre-feasibility Studies	• Requirements Identification and Prioritization • Criteria Definition • Verification Matrix	M4 – M9
2	Feasibility Studies	• Solution Identification & Characterization • Solution Evaluation & Selection • Technical Specifications • Preliminary Design	M10 - M17
3	Design & Preliminary Implementation	• Design Finalization • Individual(offline) Implementation • Mock API Release • Tools & Services Initial Integration	M18 - M24
4	Implementation, Integration & Assessment	• Collaborative Implementation • Components Integration • Project KPI Verification • User Evaluation	M25 - M36

Table 1: Platform Lifecycle Stages

1. **Pre-feasibility Studies (Months 4 - 8):** This phase focuses on laying the groundwork for the platform's development. It involves identifying and prioritizing requirements, defining critical criteria for success, and establishing a verification matrix. These initial steps are crucial for aligning the project's objectives with feasible technological solutions.
2. **Feasibility Studies (Months 9 - 17):** In this stage, the project team engages in comprehensive studies to evaluate potential solutions. This involves characterizing different technological options, selecting the most suitable ones, defining technical specifications, and drafting a preliminary design. This phase ensures that the chosen solutions are both technically sound and aligned with the project's goals.
3. **Design & Preliminary Implementation (Months 18 - 24):** During this period, the focus shifts to finalizing the design and beginning the implementation of individual components in an offline environment. This phase also sees the release of a mock API and the initial integration of Tools and Services. It's a critical stage where the conceptual designs start taking a tangible form.
4. **Implementation, Integration & Assessment (Months 25 - 36):** The final phase involves collaborative implementation efforts, where all components are integrated. This stage is crucial for the holistic functioning of the platform, as it involves verifying the project KPIs and conducting user evaluations to assess the platform's performance and usability. It marks the transition from development to real-world application and user interaction.

Each phase is meticulously planned to ensure a systematic and efficient development process, gradually building towards a fully integrated and user-centric platform. This lifecycle approach allows for continuous refinement and assessment, ensuring the PERCEIVE platform meets its objectives of enhancing cultural heritage engagement through advanced digital tools and services.

2.2 Platform stakeholders

The PERCEIVE Platform will provide the various Tools and Services to a wide range of users, of different disciplines and capabilities:

1. **General Public/Museum Visitors**: A broad and diverse category, encompassing individuals and groups with an interest in cultural heritage, art, and history. They use the PERCEIVE platform to access, engage with, and learn about cultural artifacts and exhibitions, seeking immersive and educational experiences.
2. **Museum Professionals**: Comprising curators, conservators, and exhibition teams, this group is central to the cultural heritage sector. They focus on the curation, preservation, and effective exhibition of artworks and artifacts, requiring tools for color restoration, analysis, and display planning.
3. **Scientific Community/Academics**: This category includes scholars, researchers, and color experts primarily from academic backgrounds. Their interest lies in the scientific and analytical aspects of color theory, material science, and conservation techniques, utilizing the platform for research and educational purposes.
4. **Creative Industries**: Professionals in creative fields such as digital art, design, photography, and cinematography form this group. They leverage the PERCEIVE tools for creative applications, seeking innovative ways to integrate cultural heritage and color science into their work.
5. **PERCEIVE Developers**: The technical backbone of the project, consisting of software engineers and developers. They are responsible for coding, system architecture, feature implementation, and the overall technological development of the platform, ensuring it is user-friendly, efficient, and technically robust.
6. **PERCEIVE Platform Admin**: Including system administrators and project managers, this group oversees the platform's operational aspects. They manage the infrastructure, user access, data security, and compliance with privacy regulations, ensuring the platform's reliability, performance, and security.

2.3 PERCEIVE Expected Outcomes

The following table summarizes the project's expected outcomes and exploitable results, as have been described in D2.2, providing also information about the relevant stakeholders and the corresponding inherent requirements:

Outcome	Title	Summary	Stakeholders	Requirements
O1	**Know-How Webinars and Streaming Lectures**	Series of educational lectures and webinars produced by PERCEIVE, covering tools, services, and design approaches to prototypes.	General Public, Museum Professionals, Scientific Community	Accessible, informative, and engaging content delivery.
O2	**Color Reconstruction Guidelines**	Guidelines for the process of color reconstruction in various heritage objects.	Museum Professionals, Scientific Community	Comprehensive and detailed instructions.
O3	**Tools and Guidelines for Museums**	Tools and guidelines specifically designed for museums and exhibition/light designers.	Museum Professionals	User-friendly tools with practical applications.
O4	**Color Knowledge Repository**	A comprehensive repository of color knowledge, addressing various aspects and themes in color.	All Stakeholders	Inclusive, extensive, and organized knowledge base.
O5	**PERCEIVE API**	The central communication hub of the PERCEIVE platform for data exchange and interaction.	PERCEIVE Developers	Secure, efficient, and scalable data handling.
O6	**Color Reconstruction - Regeneration Service**	Service for automatic or semi-automatic color reconstruction and regeneration on damaged artworks.	Museum Professionals, Scientists	Accurate and reliable color restoration techniques.
O7	**Color Prediction Service**	Service for predicting color changes in artworks to aid in preservation and restoration efforts.	Museum Professionals, Scientists	Advanced predictive algorithms and models.
O8	**Color Restoration and Colorization of Images**	Service for restoring and colorizing images, particularly for artworks undergoing color changes.	Museum Professionals, Creative Industries	High-quality image processing capabilities.
O9	**Analytical Visualization Service**	Service providing visualization tools for analytical purposes, aiding in the understanding of artworks.	Museum Professionals, Scientists	Effective visualization of complex data.
O10	**Light Damage Estimator**	Tool for estimating the impact of light on artworks, aiding in exhibition planning and artwork preservation.	Museum Professionals	Accurate estimation and easy-to-use interface.

O11	**3D Model Optimizer**	Tool supporting the mapping of 2D images on 3D models for web-based 3D exploration.	Museum Professionals, Creative Industries	Efficient 3D modeling and image mapping capabilities.
O12	**Web3D Multi-Texture Interactive Visualization System**	System and editor for interactive visualizations in a web-based 3D environment.	Museum Professionals, Creative Industries	Intuitive design and high interactivity.
O13	**Authenticity Prototype**	Prototype for enabling an authentic experience to the users.	Museum Professionals, Scientists	Advanced analytical and verification tools.
O14	**Caring Prototype**	Prototype focusing on the development of sense of care to the users, referred to colored collections and their fragility.	Museum Professionals	Comprehensive maintenance tools and strategies.
O15	**Open Museum Space Prototype**	A modular physical set-up for outdoor public spaces, enhancing the accessibility and engagement of art.	General Public, Museum Professionals	Modular design and public engagement features.
O16	**Design Toolbox**	A collection of tools for designing museum exhibitions and experiences.	Museum Professionals, Creative Industries	Versatile and adaptable design tools.

Table 2: PERCEIVE Expected Outcomes

According to D2.2, the project's expected outcomes are categorized into three categories of exploitable results:

1. **Learning and Working Resources**:
   - Know-How webinars and streaming lectures [O1]
   - Color reconstruction guidelines [O2]
   - Tools and guidelines for museums and exhibition/light designers [O3]
   - Color Knowledge Repository [O4]
   - Design Toolbox [O16]
2. **Tools and Services**:
   - PERCEIVE API [O5]
   - Color Reconstruction/Regeneration Service [O6]
   - Color Prediction Service [O7]
   - Color restoration and colorization of images [O8]
   - Analytical Visualization Service [O9]
   - Light damage estimator [O10]
   - 3D model optimizer [O11]
   - Web3D multi-texture interactive visualization system and editor [O12]
3. **Prototypes**:
   - Authenticity Prototype [O13]
   - Caring Prototype [O14]
   - Open Museum Space Prototype (a modular physical set-up for outdoor public spaces) [O15].

2.4 PERCEIVE Platform High-Level Functionalities

In this section, we present the High-Level Functionalities (HLFs) of the PERCEIVE Platform, which are fundamental in shaping the platform's capabilities and ensuring it effectively meets the diverse needs of its stakeholders. These HLFs are meticulously crafted to align with the overarching goals of the PERCEIVE project, emphasizing the preservation and enhancement of cultural heritage through advanced digital technologies. Each HLF encapsulates a key feature or capability of the platform, ranging from educational content delivery to advanced colour prediction and analysis, and interactive 3D visualizations. These functionalities not only reflect the innovative aspirations of the project but are also designed to cater to the specific requirements of various stakeholders, including museum professionals, educators, scientists, and the general public. By defining these HLFs, we lay a solid foundation for developing a platform that is both technologically advanced and user-centric, ultimately facilitating a deeper and more engaging interaction with cultural heritage.

HLF ID	Title	Summary	Stakeholders	Related Outcomes	Requirements
PERC-HLF-001	**Educational Content Delivery**	Functionality to deliver educational content, such as webinars and lectures, in an accessible and engaging manner, focusing on teaching tools and services tailored to different stakeholder needs.	General Public, Educators, Academics	O1	User-friendly, accessible, informative
PERC-HLF-002	**Color Restoration Guidance**	Provide comprehensive guidelines for color restoration in heritage objects, including ancient sculptures, paintings, works on paper, and digital born artworks.	Museum Professionals, Academics	O2, O6, O8	Detailed, clear, practical guidance
PERC-HLF-003	**Museum Tools Provision**	Offering tools and guidelines tailored for museum and exhibition design, including lighting impact assessment and exhibition planning.	Museum Professionals	O3, O16	Practical, versatile, user-friendly
PERC-HLF-004	**Color Knowledge Dissemination**	Creation and management of a color knowledge repository that includes a wide range of resources, accessible to different stakeholders, disseminating extensive color knowledge.	All Stakeholders	O4	Comprehensive, organized, inclusive
PERC-HLF-005	**API Development and Integration**	Developing a scalable, secure API for data exchange across the platform to enable engineers to access and exploit PERCEIVE's capabilities.	Developers, Platform Admin	O5	Secure, efficient, scalable
PERC-HLF-006	**Advanced Color Prediction and Analysis**	Enhancement of color reconstruction, regeneration, and prediction services, including the restoration and colorization of images, implementing services for color	Museum Professionals, Scientific Community, Creative Industries	O6, O7, O8	Accurate, reliable, advanced, AI and ML capabilities, high-resolution image processing

		prediction and restoration analysis.			
PERC-HLF-007	**Image Processing and Enhancement**	Providing high-quality image processing for colorization and restoration, offering advanced analytical visualization services for a deeper understanding of artworks.	Museum Professionals, Creative Industries	O8, O9, O11, O12	High-quality, versatile, intuitive, 3D rendering capabilities
PERC-HLF-008	**Analytical Tools for Artworks**	Offering tools for visualization and analysis to aid artwork understanding, including light damage estimation and 3D model optimization for web-based exploration.	Museum Professionals, Scientists	O9, O10	Effective, user-friendly, detailed
PERC-HLF-009	**Artwork Preservation Tools**	Tools for estimating and mitigating environmental impacts on artworks, and prototyping tools for artwork authenticity verification and maintenance.	Museum Professionals	O10, O13, O14	Accurate, practical, comprehensive, advanced, reliable
PERC-HLF-010	**3D Visualization and Interaction**	Developing interactive 3D visualization systems for web-based exploration, including the development of Web3D multi-texture interactive visualization systems and editors for immersive exploration of cultural heritage.	Museum Professionals, Creative Industries	O11, O12	Intuitive, engaging, high-quality, AR/VR integration
PERC-HLF-011	**Outdoor Museum Experience Enhancement**	Creating outdoor museum experiences to enhance public engagement and accessibility, focusing on modular physical setups for outdoor public spaces and enhancing user engagement with cultural heritage through prototypes such as Open Museum Space.	General Public, Museum Professionals	O15	Modular, engaging, accessible, user experience design

Table 3: PERCEIVE Platform High-Level Functionalities

2.5 PERCEIVE Platform High-Level Requirements

In this section, we delve into the High-Level Requirements (HLRs) of the PERCEIVE Platform, which are integral in ensuring that the platform not only achieves its intended functionality but also adheres to the highest standards of quality, usability, and efficiency. These HLRs are established to guarantee that the platform is robust, secure, and scalable, while remaining user-friendly and accessible to a wide range of users, from the general public to specialized professionals. They encompass essential criteria such as data security, interoperability, performance reliability, and compliance with industry standards. The careful consideration of these HLRs reflects our commitment to delivering a platform that not only meets the technical and operational expectations but also addresses the diverse needs of all stakeholders involved in the project. By setting these HLRs, we aim to ensure that the PERCEIVE Platform operates seamlessly, maintains user trust, and stands as a benchmark in the field of digital cultural heritage preservation and enhancement.

HLR ID	Title	Summary	Stakeholders	Related HLFs	Related Outcomes	Comments
PERC-HLR-001	**User Accessibility**	Ensuring the platform is accessible to all users, including those with disabilities, through adaptive design and compliance with accessibility standards. Example: Screen reader compatibility, adjustable text sizes.	General Public, Educators, Academics	HLF-001, HLF-003, HLF-010	O1, O3, O11, O12, O15	Critical for user inclusivity and engagement
PERC-HLR-002	**Data Security and Privacy**	Implementing robust security measures to protect sensitive data and user privacy. Example: Encryption, secure login protocols.	All Stakeholders	HLF-004, HLF-005	O4, O5	Essential for maintaining trust and legal compliance
PERC-HLR-003	**Scalability**	Ability to scale resources and functionalities to accommodate growing user demands and data volumes. Example: Cloud-based solutions, modular architecture.	Developers, Platform Admin	HLF-005, HLF-004	O5, O4	Ensures long-term viability and flexibility
PERC-HLR-004	**Interoperability**	Ensuring compatibility with various data formats and integration with other systems or APIs. Example: Standardized data formats, API integration.	Developers, Museum Professionals, Creative Industries	HLF-005, HLF-007, HLF-010	O5, O8, O11, O12	Key for seamless data exchange and system integration
PERC-HLR-005	**Performance and Reliability**	Ensuring the platform operates efficiently and reliably under varying loads. Example: Load balancing, high-availability systems.	All Stakeholders	All HLFs	All Outcomes	Fundamental for user satisfaction and system integrity
PERC-HLR-006	**Usability**	Designing a user-friendly interface catering to both technical and non-technical users. Example: Intuitive navigation, clear labeling.	General Public, Museum Professionals, Educators	HLF-001, HLF-003, HLF-009	O1, O3, O10, O13, O14	Crucial for user engagement and platform adoption
PERC-HLR-007	**Sustainability**	Ensuring long-term maintenance and updates of the platform. Example: Regular software updates, scalable architecture.	Developers, Administrators	All HLFs	All Outcomes	Guarantees the platform's longevity and relevance
PERC-HLR-008	**Compliance with Standards**	Adhering to industry and legal standards, particularly in digital heritage preservation. Example: Following digital preservation guidelines, GDPR compliance.	Museum Professionals, Administrators	HLF-002, HLF-007, HLF-009	O2, O8, O10, O13, O14	Ensures legal and professional standards are met
PERC-HLR-009	**Quality of Educational Content**	Ensuring educational materials are accurate, engaging, and up-to-date. Example: Regular content review, incorporation of latest research findings.	Educators, Academics, General Public	HLF-001	O1	Vital for educational impact and credibility

PERC-HLR-010	**Technological Robustness**	Employing advanced technology for functionalities like 3D visualization and AI-driven analysis. Example: Utilizing cutting-edge AI models for color analysis, high-performance 3D rendering tools.	Scientists, Creative Industries	HLF-006, HLF-007, HLF-010	O6, O7, O8, O11, O12	Key to achieving sophisticated analytical capabilities

Table 4: PERCEIVE Platform High-Level Requirements

3 Operational Needs Analysis

The Operational Needs Analysis (ONA) is a fundamental segment of the PERCEIVE project, meticulously examining the operational context in which the PERCEIVE platform is intended to function. This analysis plays a critical role in determining the platform's integration into both existing and envisioned operational environments, with a keen focus on enhancing system performance to ensure efficiency and effectiveness in practical applications.

The ONA is comprehensive, encompassing aspects such as system adaptability, reliability, user ergonomics, and environmental considerations. These elements are vital to ensure that the platform not only fulfills its functional requirements but also operates in a way that is seamless, user-friendly, and in harmony with the operational landscape it will inhabit.

Within the scope of Task 5.1, the ONA involves:

- **Definition of High-Level Architecture**: This step involves detailing the overarching structure of the system, focusing on the interaction between its various components. Emphasis is placed on scalability and robustness to ensure the architecture is capable of adapting and evolving in response to changing needs and technologies.
- **Definition of System's Critical Components**: This includes identifying and prioritizing the key elements that are crucial for the system's functionality. For example, AI-powered color restoration modules and sophisticated data repositories are identified as essential for ensuring system reliability and performance.
- **Definition of System's Interfaces and Interactions**: This step elaborates on the ways the system will interact with its users and other systems. It covers critical aspects such as user interface design, API integrations, and interoperability standards, all aimed at providing a seamless and intuitive user experience.

Overall, the ONA is integral to the PERCEIVE project, ensuring that every operational aspect of the platform is well-conceived, efficient, and user-centric, thereby aligning with the project's goals of enhancing cultural heritage preservation and interaction through digital technology.

3.1 PERCEIVE Platform Conceptual Diagram

Figure 1 illustrates a conceptual overview of the PERCEIVE Platform, its main modules represented by the corresponding Task along with the task interactions.

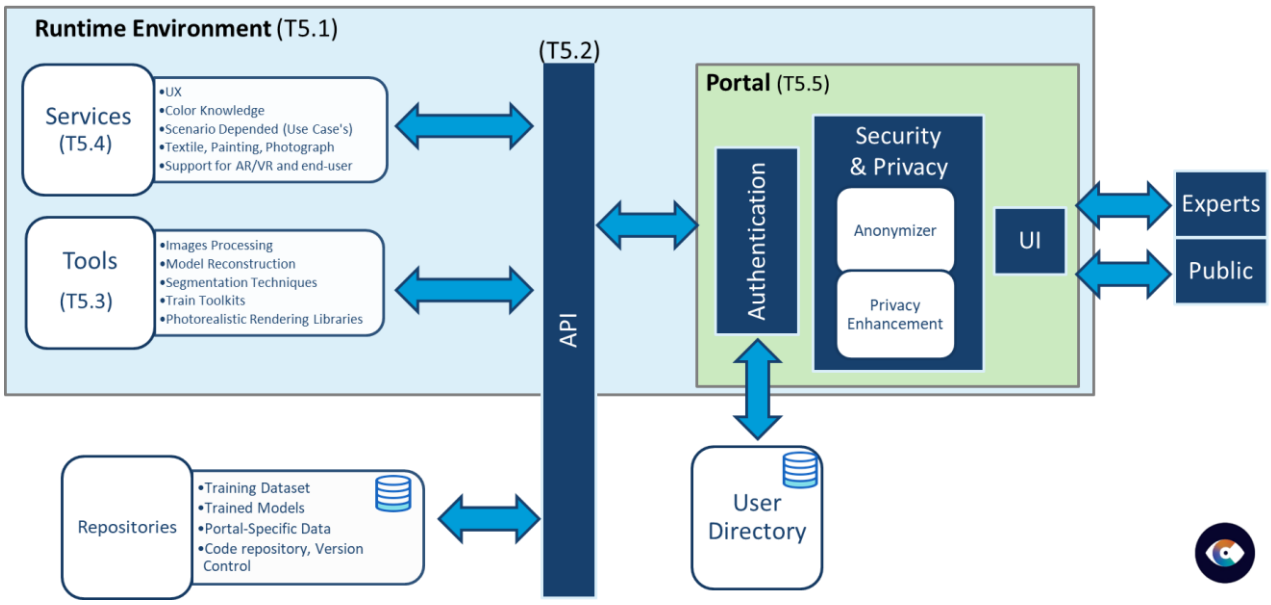

Figure 1: PERCEIVE Platform Conceptual Diagram

PERCEIVE Runtime Environment: The PERCEIVE Runtime Environment is a core infrastructure component that facilitates the execution and operation of PERCEIVE Tools and Services. It provides the necessary computational resources, manages the execution processes, and ensures seamless interaction between various components. This environment is designed to be scalable, reliable, and efficient, supporting the dynamic nature of digital heritage tools and services.

PERCEIVE API: The PERCEIVE API (Application Programming Interface) serves as the primary communication gateway between the platform's components, including Tools, Services, and the Portal. It enables standardized data exchange and function invocation, ensuring interoperability and integration across the platform. The API adheres to modern RESTful principles, offering a flexible, secure, and efficient means of accessing and manipulating data.

PERCEIVE Tools: PERCEIVE Tools are specialized software applications or utilities designed to perform specific tasks related to digital cultural heritage preservation, analysis, and interaction. These tools are integrated into the platform to provide users with advanced functionalities such as 3D modeling, image processing, or data analysis, contributing directly to the project's objective of enhancing cultural heritage engagement and preservation.

PERCEIVE Services: PERCEIVE Services encompass a range of backend functionalities that support the platform's operations. These services include data processing, storage, authentication, and user management. They are designed to be modular and scalable, providing essential support to the Tools and ensuring a smooth, efficient user experience within the PERCEIVE ecosystem.

PERCEIVE Portal: The PERCEIVE Portal acts as the user interface and access point to the platform, offering an intuitive and interactive environment for users to engage with the Tools and Services. It is designed to be user-friendly and accessible, providing a central hub for accessing resources, collaborating on projects, and sharing insights related to cultural heritage preservation and interaction.

3.2 High-Level Architecture

The PERCEIVE platform is an advanced full-stack system engineered to enhance the digital interaction and preservation of cultural heritage. It integrates several key modules, as illustrated in the diagram of Figure 2: Back-End Middleware (BEM), API, Graphical User Interface (GUI), Authentication & Security, Front-End Framework (FEF), Repositories & DBs, and Back-End for Front-End Framework (BEF). This integrated approach ensures a seamless and secure user experience, combining robust backend processing with an intuitive frontend interface. The full-stack nature of the platform facilitates efficient data handling, user interaction, and system scalability.

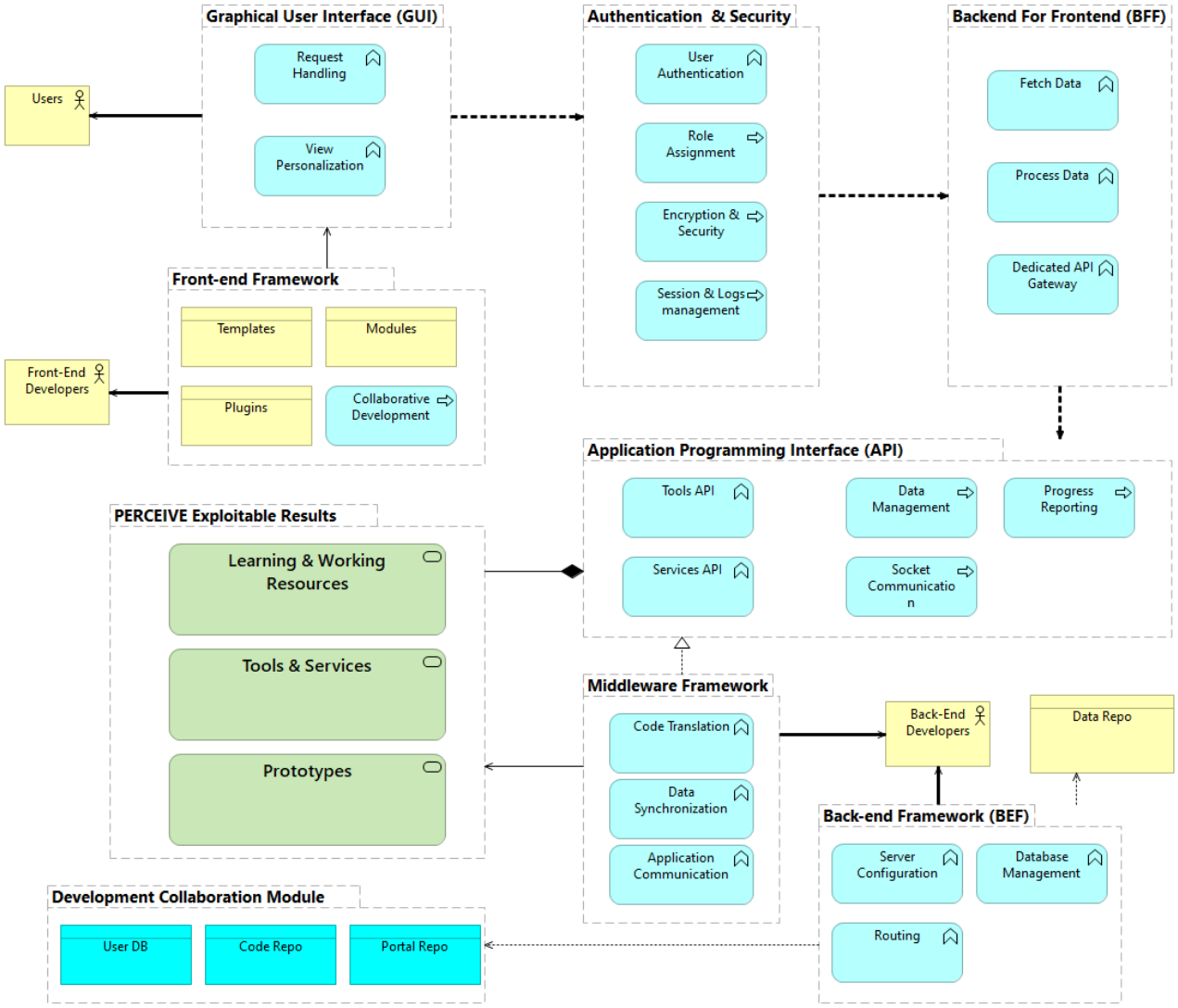

Figure 2: High-Level System Architecture

3.3 PERCEIVE Platform Critical Components

According to the Platform's High-Level Architecture, the identified critical components are:

1. **Back-End Middleware (BEM):** The BEM is the core of the platform's backend, handling server-side processing, data management, and communication between modules. It orchestrates the platform's functionalities, ensuring efficient data handling, security, and integration of various backend services.
2. **Application Programming Interface (API):** The PERCEIVE API is the central communication hub, facilitating data exchange and interaction between frontend and backend components. It standardizes requests and responses, ensuring a cohesive flow of information across the platform.
3. **Graphical User Interface (GUI):** The GUI is the visual front that users interact with. It presents the platform's tools and services in an accessible and engaging manner, emphasizing ease of use and clear navigation to enhance user experience.
4. **Authentication & Security:** This module is dedicated to safeguarding the platform. It manages user authentication, authorization, and overall data security, employing robust protocols to protect sensitive information and user interactions.
5. **Front-End Framework (FEF):** The FEF is responsible for the development and management of the platform's frontend. It defines the structure and appearance of the web interface, ensuring responsiveness, cross-platform compatibility, and a seamless user experience.

6. **Repositories & DBs:** Encompassing Code Repositories, Data Repositories, and Portal-specific Databases, this module is vital for data storage, management, and version control. It securely stores code, user data, and cultural heritage information, supporting the platform's data-intensive operations.
    - **Development Collaboration Module (DCM)**, which is the focus of T5.1 with respect to repositories and databases, is a multifaceted component of the PERCEIVE platform, centralizing the collaborative efforts in software development and information dissemination. It integrates a code repository and version control system for efficient management of the project's codebase, an issue tracking system to organize and address software development tasks, and a Wiki for comprehensive documentation and internal communication. This module ensures streamlined code development, effective problem-solving, and knowledge sharing, forming the backbone of collaborative efforts within the project team.
7. **Back-End for Front-End Framework (BEF):** The BEF acts as an intermediary layer that tailors backend data and services for frontend consumption. It optimizes data delivery for different user interfaces, enhancing performance and user experience.

Each module in the PERCEIVE platform is designed to work in harmony, contributing to the platform's overarching goal of digitally preserving and interacting with cultural heritage in an accessible, secure, and user-friendly manner.

3.4 Operational Scenario: Exemplar User Story

To better understand the role and impact of each of the modules in the operation of the platform, assume the following indicative User Story.

User Story: Accessing a 3D Cultural Artifact Visualization Tool
User Background: Emily, a cultural heritage enthusiast and researcher. **Goal:** Emily wishes to use the PERCEIVE platform to explore and interact with 3D visualizations of cultural artifacts.
User Story: 1. **Logging In (Authentication & Security):** • Emily starts her journey by logging into the PERCEIVE Portal. The Authentication & Security module securely manages her login credentials, ensuring her data and access rights are protected. 2. **Navigating the Interface (GUI):** • Once logged in, Emily is greeted by a user-friendly and intuitive Graphical User Interface. The GUI makes it easy for her to navigate through the platform, with clear menus and options. 3. **Selecting the 3D Visualization Tool (FEF & BEF):** • Using the Front-End Framework, Emily effortlessly finds the 3D Cultural Artifact Visualization Tool. The Front-End Framework, supported by the Back-End for Front-End Framework, ensures the tool loads efficiently and is optimized for her device. 4. **Requesting Data (API & BEM):** • When Emily selects an artifact to view, the PERCEIVE API facilitates the request to the Back-End Middleware. The BEM processes this request, retrieving the necessary 3D model data from the server. 5. **Fetching the 3D Model (Repositories & DBs):** • The requested 3D model is stored in the platform's Data Repository. The BEM efficiently fetches this data, ensuring quick and seamless access. 6. **Interacting with the Tool (GUI & FEF):**

- The 3D model is rendered on Emily's screen through the GUI. She can interact with it, rotating the model, zooming in and out, and exploring different layers. The Front-End Framework ensures this interaction is smooth and responsive.

7. **Saving Preferences (BEM & Repositories & DBs):**
   - Emily adjusts the visualization settings to her preference. Her settings are saved by the BEM, which communicates with the User Database within Repositories & DBs, ensuring her preferences are stored for future sessions.
8. **Logging Out (Authentication & Security):**
   - After her session, Emily logs out. The Authentication & Security module securely terminates her session, ensuring her account remains secure.

Outcome: Emily's interaction with the 3D Visualization Tool on the PERCEIVE platform is efficient, secure, and engaging. All modules of the platform work together seamlessly, providing her with a rich, interactive experience that enhances her understanding and appreciation of cultural heritage.

3.5 Interactions and Interfaces

Identification and definition of the platform's interfaces, based on the Platform's High-Level Architecture, is a crucial step for the Requirement Analysis. Table 5 highlights the identified interfaces, providing also information about the involved modules, the type of interface and the type and format of the exchanged data.

ID	Source Module	Target Module	Interface Type	Data Exchanged	Format	Interface Nature
PERC-INT-01	**GUI**	Front-end Middleware	RESTful API WebSocket	User input data, requests, UI state	JSON, XML, HTML	Direct
PERC-INT-02	**Front-end Middleware**	Back-end Middleware	RESTful API GraphQL Events	Processed user requests, session data, application state	JSON, XML	Direct
PERC-INT-03	**Back-end Middleware**	User Databases	Database Connection ORM	User credentials, profiles, roles, permissions, logs	SQL data, BSON, JSON	Direct
PERC-INT-04	**Back-end Middleware**	Data Repository	API calls DB Access	Datasets, binary files, metadata	Binary, JSON, XML	Direct
PERC-INT-05	**Back-end Middleware**	Tools & Services	Internal API Microservices	Configuration data, tool-specific requests, results	JSON, XML, Custom	Direct
PERC-INT-06	**Tools & Services**	Data Repository	DB Queries API File Transfer	Input data for tools, processed data, logs	Binary, JSON, XML, CSV	Direct
PERC-INT-07	**GUI**	Authentication & Security	Login Form Token Auth	Login credentials, authentication tokens, security logs	JSON, Encrypted	Direct
PERC-INT-08	**Authentication & Security**	Back-end Middleware	Security Protocols API	Authentication data, tokens, authorization info	JSON, JWTs, OAuth tokens, Encrypted	Direct

PERC-INT-09	**Front-end Middleware**	API	RESTful API GraphQL	External data requests, data submission	JSON, XML	Indirect (API Gateway)
PERC-INT-10	**API**	Back-end Middleware	API Gateway Direct API	Data requests, commands, responses	JSON, XML, Custom	Indirect (Back-end Middleware)
PERC-INT-11	**Front-end Middleware**	BFF Framework	RESTful API Web Service	Aggregated data requests, front-end configurations	JSON, XML, HTML	Indirect (BFF Framework)
PERC-INT-12	**BFF Framework**	Back-end Middleware	API calls	Aggregated and optimized data requests for front-end	JSON, XML, Custom	Indirect (Back-end Middleware)

Table 5: PERCEIVE Module Interfaces

4 Technical Analysis

This section is meticulously structured to provide a detailed technical examination of the platform's Functional and Non-Functional Requirements across its various components and service categories, along with the associated Validation Criteria and Methodologies.

The main scope of this document is to identify and define the requirements for the runtime environment for PERCEIVE Tools and Service as well as for the code repository and versioning system. However, for completeness, we include a preliminary analysis for all expected outcomes, i.e. including Learning and Working Resources and Prototypes. Moreover, we also provide a comprehensive overview of the Requirements for three additional modules:

- **Back-End Middleware (BEM):** The BEM is crucial in this phase as it forms the backbone of the runtime environment. It handles the server-side logic, data processing, and ensures seamless communication between the PERCEIVE Tools and Services and the Repository.
- **Front-End Framework (FEF):** The FEF is involved in providing the user interface elements and client-side logic. It's essential for ensuring that the Tools and Services are accessible and usable through the PERCEIVE Portal, facilitating user interaction with the platform.
- **Application Programming Interface (API):** The API is a key component in this phase, acting as the intermediary that allows different parts of the platform, including Tools and Services, to communicate effectively. It ensures standardized data exchange and function invocation across the platform.

These modules collectively support the development and integration of the PERCEIVE Tools and Services, enabling them to function cohesively within the specified runtime environment. Their roles are integral to achieving the objectives of Task T5.1, particularly in establishing a robust and scalable platform for cultural heritage engagement and preservation.

As part of Task 5.1, we also analyze the requirements for the **Development Collaboration Module (DCM)** which plays a crucial role by providing the necessary infrastructure for collaborative interface development, issue management, and knowledge documentation. It supports the development of interfaces and runtime environments for PERCEIVE Tools and Services, ensuring systematic progress tracking and efficient resolution of technical challenges. The DCM's centralized knowledge base is instrumental in defining high-level functionalities, critical components, and interactions, vital for the preliminary architectural setup and decision-making process in the PERCEIVE project.

Briefly, this section consists of:

- **Functional Requirements Identification**: The identification of Functional Requirements (FRs) is a critical step in defining the specific capabilities and functionalities of the PERCEIVE platform. Detailed FR tables have been prepared for each primary component and service category, namely Learning & Working Resources (LWR), Tools & Services (T&S), Prototypes (PRT), Back-End Middleware (BEM), Front-End Framework (FEF), Application Programming Interface (API), and Development Collaboration Module (DCM). These tables present a comprehensive enumeration of the functionalities required for each segment, aligning with the overarching goals of the project to cater to a diverse array of stakeholders including academic researchers, heritage professionals, and the wider public.
- **Non-Functional Requirements Identification**: The Non-Functional Requirements (NFRs) provide insight into the qualitative aspects of the system, encompassing scalability, security, usability, and performance efficiency, among others. NFR tables for LWR, T&S, PRT, BEM, FEF, API, and DCM are included to outline these essential quality attributes. These requirements are pivotal in ensuring that the platform not only achieves its functional objectives but also adheres to the highest standards of operational excellence.

- **Validation Criteria and Methodology**: To ensure the robustness and efficacy of the system, we have established clear Validation Criteria and Methodologies, articulated through Key Performance Indicators (KPIs) for each set of requirements. The KPI tables for LWR, T&S, PRT, BEM, FEF, API, and DCM delineate specific, measurable targets for assessing the fulfilment of each FR and NFR. Validation methodologies, including Testing (T), Analysis (A), Inspection (I) and Demonstration (D), are employed to rigorously evaluate and confirm the system's compliance with these defined criteria.

This section offers a transparent, detailed, and technically rigorous overview of the requirements and validation strategies for the PERCEIVE platform. This comprehensive analysis underscores our commitment to developing a platform that is not only innovative but also robust, user-centric, and aligned with the specialized needs of the cultural heritage domain.

4.1 Exploitable Results Analysis

4.1.1 Functional Requirements Identification

The Functional Requirements Identification phase is a fundamental step in the development process that involves eliciting and documenting the specific functionalities and capabilities that the system or application must possess to meet the project's objectives and stakeholder needs. This phase serves as the cornerstone for the subsequent design, development, and validation processes.

The purpose of the Functional Requirements Identification phase is to establish a comprehensive understanding of the features, behaviours, and interactions that the system will offer. By clearly defining what the system must accomplish from a functional perspective, this phase serves as a blueprint for the project's development, guiding the design, coding, and testing efforts. Effective Functional Requirements Identification contributes to enhanced communication between stakeholders, reduces ambiguity, and provides a foundation for the creation of testable and measurable requirements. Issues inevitably arise during the development phase. To mitigate potential risks, encapsulating the functional needs analysis not only minimizes errors but also enhances focus on the key areas of interest.

4.1.1.1 Learning and Working Resources

The Learning & Working Resources (LWR) category within the PERCEIVE project encompasses functionalities aimed at delivering educational content and tools for professional development. Identifying and defining the correct Functional Requirements (FRs) for LWR is pivotal, as it directly impacts how effectively the platform will meet the learning and professional needs of its users. Accurate FRs ensure that LWR not only aligns with the educational objectives of the project but also enhances user engagement and knowledge dissemination, critical aspects for the success of PERCEIVE.

The FR table for LWR systematically organizes the essential functionalities that the platform needs to exhibit. It includes a detailed description of each FR, highlighting its importance, the stakeholders it affects, and its relation to the higher-level functionalities and requirements. This structured approach provides clarity and direction for developers and stakeholders, ensuring that all educational and professional resource features are comprehensively addressed and aligned with the overall goals of the PERCEIVE project.

LWR	Learning & Working Resources							
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-LWR-FR-001	**Streamlined Content Delivery**	The system shall provide a seamless and intuitive platform for delivering educational content like webinars and streaming lectures.	**M**	General Public, Educators, Academics	HLF-001	PERC-HLR-001, PERC-HLR-005, PERC-HLR-009	O1	Ensures accessibility and engagement for educational content.
PERC-LWR-FR-002	**Interactive Q&A Feature**	The system shall provide real-time interactive Q&A during webinars for audience engagement.	**S**	General Public, Educators	HLF-001	PERC-HLR-001, PERC-HLR-005	O1	Facilitates interactive learning and audience participation.
PERC-LWR-FR-003	**User Access Management**	The system shall manage user access rights, ensuring secure and role-based access control.	**M**	Administrators, Educators	HLF-001, HLF-004	PERC-HLR-002, PERC-HLR-007	O1, O2, O3, O4, O16	Critical for secure and controlled access to resources.
PERC-LWR-FR-004	**Multi-Format Support**	The system shall support multiple video/audio formats, e.g., MP4, AVI, MP3.	**S**	General Public, Educators	HLF-001	PERC-HLR-005, PERC-HLR-008	O1	Ensures compatibility with various media formats for educational content.
PERC-LWR-FR-005	**Engagement Analytics**	The system shall provide analytics on viewer engagement and feedback for webinars.	**S**	Educators, Administrators	HLF-001	PERC-HLR-009	O1	Helps in analyzing and improving the impact of educational content.
PERC-LWR-FR-006	**Guideline Repository**	The system shall include a repository for color reconstruction guidelines	**M**	Museum Professionals, Academics	HLF-002	PERC-HLR-004,	O2	Centralizes guidelines, making them easily

		with search and download capabilities.				PERC-HLR-006		accessible for users.
PERC-LWR-FR-007	**Advanced Search & Filter**	The system shall feature advanced search and filtering for efficiently locating guidelines.	**S**	Museum Professionals, Academics	HLF-002	PERC-HLR-004, PERC-HLR-006	O2	Enhances user experience in finding relevant guidelines quickly.
PERC-LWR-FR-008	**Download and Print Options**	The system shall allow downloading and printing of guidelines for offline access.	**S**	Museum Professionals, Academics	HLF-002	PERC-HLR-006	O2	Provides flexibility for users to access content offline.
PERC-LWR-FR-009	**Multi-Language Support**	The system shall provide guidelines in multiple languages for an international audience.	**S**	General Public, Museum Professionals	HLF-002	PERC-HLR-001, PERC-HLR-006	O2	Increases accessibility of guidelines for a diverse audience.
PERC-LWR-FR-010	**Update Notification System**	The system shall send notifications for updates or new additions to the guidelines.	**C**	Museum Professionals, Academics	HLF-002	PERC-HLR-007	O2	Keeps users informed about the latest resources and updates.
PERC-LWR-FR-011	**Interactive Design Tools**	The system shall provide tools for interactive museum and exhibition design with VR capabilities.	**M**	Creative Industries, Museum Professionals	HLF-003	PERC-HLR-007, PERC-HLR-010	O3, O16	Facilitates creative and immersive design processes for exhibitions.
PERC-LWR-FR-012	**User Feedback Integration**	The system shall incorporate user feedback to improve tool functionality.	**S**	Museum Professionals, Creative Industries	HLF-003	PERC-HLR-006, PERC-HLR-010	O3, O16	Allows continuous improvement of tools based on user input.
PERC-LWR-FR-013	**Comprehensive Tutorials**	The system shall offer comprehensive tutorials and guides for tool usage.	**S**	Museum Professionals, Creative Industries	HLF-003	PERC-HLR-006, PERC-HLR-009	O3, O16	Ensures users can effectively utilize the provided tools.

PERC-LWR-FR-014	**Repository and Toolbox Integration**	The system shall integrate the Color Knowledge Repository with the Design Toolbox.	**M**	Creative Industries, Museum Professionals	HLF-004, HLF-005	PERC-HLR-004, PERC-HLR-007	O4, O16	Streamlines access to resources, enhancing the design process.
PERC-LWR-FR-015	**Extensive Knowledge Database**	The system shall maintain a comprehensive color knowledge database.	**M**	Scientific Community, Museum Professionals	HLF-004	PERC-HLR-004, PERC-HLR-008	O4	Provides a rich resource for research and education in color theory.

Table 6: PERCEIVE Learning & Working Resources Functional Requirements

4.1.1.2 Tools and Services

The Tools & Services (T&S) category is central to the PERCEIVE platform, offering a suite of applications and services designed for color restoration and analysis. The meticulous definition of FRs for this category is crucial as it determines the effectiveness and efficiency of the tools provided. Correctly identifying these requirements is fundamental to ensuring that the T&S module serves its purpose effectively, catering to the specific needs of museum professionals and conservationists involved in the project.

In the FR table for T&S, each requirement is categorized and detailed, emphasizing its relevance to the module's functionality. The table not only delineates what each tool or service should achieve but also contextualizes these functionalities within the broader scope of the project. This organization allows for a clear understanding of the module's capabilities, ensuring that the development aligns with user expectations and the overarching objectives of the PERCEIVE initiative.

T&S		**Tools & Services**						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-T&S-FR-001	**API Functionality**	The system shall provide a PERCEIVE API for efficient data exchange and integration with external systems.	**M**	PERCEIVE Developers, Scientific Community	HLF-006	PERC-HLR-004, PERC-HLR-010	O5	Essential for enabling third-party integration and data sharing.
PERC-T&S-FR-002	**Color Reconstruction Service**	The system shall offer a color reconstruction and regeneration service for artworks.	**M**	Museum Professionals, Creative Industries	HLF-007	PERC-HLR-006, PERC-HLR-008	O6	Supports color restoration of historical and cultural artifacts.

PERC-T&S-FR-003	**Color Prediction Tool**	The system shall provide a tool for predicting future color changes in artworks.	**M**	Museum Professionals, Scientific Community	HLF-007	PERC-HLR-006, PERC-HLR-007	O7	Aids in preservation planning by forecasting color degradation.
PERC-T&S-FR-004	**Image Restoration and Colorization**	The system shall offer services for color restoration and colorization of images.	**M**	Museum Professionals, Creative Industries	HLF-007	PERC-HLR-006, PERC-HLR-008	O8	Enhances visual fidelity and authenticity of historical images.
PERC-T&S-FR-005	**Analytical Visualization**	The system shall provide an analytical visualization service to enhance understanding of artworks.	**M**	Museum Professionals, Scientific Community	HLF-008	PERC-HLR-006, PERC-HLR-008	O9	Facilitates in-depth analysis and interpretation of art pieces.
PERC-T&S-FR-006	**Light Damage Estimation**	The system shall include a tool for estimating light damage on artworks.	**S**	Museum Professionals	HLF-008	PERC-HLR-006, PERC-HLR-008	O10	Crucial for artwork preservation and display planning.
PERC-T&S-FR-007	**3D Model Optimization**	The system shall provide a 3D model optimizer to support mapping of 2D images on 3D models.	**S**	Museum Professionals, Creative Industries	HLF-009	PERC-HLR-006, PERC-HLR-010	O11	Enables detailed 3D representation and exploration of artworks.
PERC-T&S-FR-008	**Web3D Visualization System**	The system shall offer a Web3D multi-texture interactive visualization system and editor.	**M**	General Public, Museum Professionals	HLF-009	PERC-HLR-006, PERC-HLR-010	O12	Enhances public engagement with interactive 3D art experiences.

Table 7: PERCEIVE Tools & Services Functional Requirements

4.1.1.3 Prototypes

The Prototypes (PRT) category within PERCEIVE encompasses the development of innovative prototypes for artwork authentication, care, and enhanced outdoor museum experiences. Defining accurate FRs for this category is essential for guiding the creation of these prototypes in a way that they meet both technological innovation and user experience goals. Properly identified FRs ensure that the prototypes developed are not only functionally effective but also align with the project's vision of enhancing the appreciation and preservation of cultural heritage.

The FR table for PRT meticulously outlines the specific requirements needed to develop these innovative tools. Each entry in the table provides a clear and concise description of what is expected from the prototypes, thereby setting a defined path for developers and designers. This detailed breakdown helps in maintaining a focused approach throughout the development process, ensuring that each prototype effectively contributes to the PERCEIVE project's objectives.

PRT		Prototypes						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-PRT-FR-001	**Authenticity Prototype Development**	The system shall develop the Authenticity Prototype to enable users to have an authentic experience of the coloured cultural heritage artifacts or artwork.	**M**	Museum Professionals, Scientific Community	HLF-011	PERC-HLR-007, PERC-HLR-010	O13	Ensures the verification and validation of artifact authenticity.
PERC-PRT-FR-002	**Caring Prototype Development**	The system shall provide a Caring Prototype for the creation of a sense of care in the users during a hybrid/virtual experience.	**M**	Museum Professionals, Administrators	HLF-009	PERC-HLR-007, PERC-HLR-010	O14	Aids in the effective preservation and care of cultural assets.
PERC-PRT-FR-003	**Open Museum Space Prototype**	The system shall implement the Open Museum Space Prototype to enhance public engagement in outdoor museum experiences.	**M**	General Public, Museum Professionals	HLF-010	PERC-HLR-007, PERC-HLR-010	O15	Enhances public interaction and accessibility in outdoor museum settings.
PERC-PRT-FR-004	**Interactive Experience Integration**	The system shall integrate interactive experiences in the Prototypes to facilitate user engagement and learning.	**S**	General Public, Museum Professionals	HLF-010	PERC-HLR-001, PERC-HLR-006	O13, O14, O15	Fosters an engaging and educational experience for users.
PERC-PRT-FR-005	**Prototype Performance Optimization**	The system shall optimize the performance of all Prototypes to ensure smooth operation and user interaction.	**S**	PERCEIVE Developers, Museum Professionals	HLF-009, HLF-010, HLF-011	PERC-HLR-005	O13, O14, O15	Critical for the seamless functionality of the Prototypes.
PERC-PRT-FR-006	**Accessibility in Prototypes**	The system shall ensure that all Prototypes are accessible to a wide range of users, including those with disabilities.	**S**	General Public, Museum Professionals	HLF-010	PERC-HLR-001	O13, O14, O15	Ensures inclusivity and broad accessibility in prototype design.
PERC-PRT-FR-007	**Data Integration in Prototypes**	The system shall enable efficient data integration and management within the Prototypes for enhanced functionality.	**S**	PERCEIVE Developers, Museum Professionals	HLF-009, HLF-010, HLF-011	PERC-HLR-004	O13, O14, O15	Facilitates the integration of diverse data sets into the Prototypes.

Table 8: PERCEIVE Prototypes Functional Requirements

4.1.2 Non-Functional Requirements Identification

The Non-Functional Requirements Identification phase is an equally crucial aspect of the development process, focusing on the quality attributes, system performance, or constraints a system must operate under. While functional requirements define what a system is supposed to do, non-functional requirements specify how well the system performs those functions. This phase is vital for the overall user experience and operational efficiency, serving as a key driver for system architecture and design choices.

Within the framework of the PERCEIVE, adhering to the non-functional requirements is instrumental for meeting the quality standards set by the European Horizon program. The Non-Functional Requirements Identification phase aims to offer a detailed understanding of various performance metrics, such as latency, scalability, and reliability, which are often critical for the project's success. These non-functional attributes play a significant role in influencing user satisfaction and system usability. This phase helps in laying down guidelines and expectations for aspects like security protocols, data integrity, availability, and compliance with legal regulations. Unlike functional requirements that guide the "what" of the development process, non-functional requirements concentrate on the "how," providing the quality framework within which the system functionalities operate.

Effective identification and documentation of non-functional requirements contribute to a more thorough system analysis, enabling better communication between stakeholders. This, in turn, reduces misunderstandings and ensures that the system meets not only its functional goals but also performance and quality benchmarks. Like their functional counterparts, non-functional requirements should also be testable, measurable, and traceable to mitigate any risks or challenges that may arise during the development phase.

In the subsequent sections of this document, we will explore essential elements that affect non-functional requirements. These could include infrastructure considerations, performance benchmarking, data storage and retrieval speeds, integration points, security protocols, and internationalization aspects among others. These factors collectively contribute to defining the environment in which our system's functionalities will operate, ensuring that the project not only meets its objectives but does so in an efficient and effective manner.

4.1.2.1 Learning & Working Resources

In the context of Non-Functional Requirements (NFRs) for LWR, the focus shifts from what the platform does to how well it performs these functions. NFRs address aspects like usability, reliability, and scalability of learning and working resources, which are crucial for ensuring a seamless and productive user experience. Properly defined NFRs are essential for the PERCEIVE platform to deliver educational content and tools in an efficient, reliable, and user-friendly manner.

The NFR table for LWR categorizes and details each requirement, providing a clear framework for evaluating the quality and performance standards of the platform’s educational resources. This table is instrumental in guiding developers to not only focus on functionalities but also on the quality attributes that define the user experience. It serves as a checklist to ensure that all LWR aspects meet the high standards expected in a comprehensive educational platform.

LWR	Learning & Working Resources							
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-LWR-NFR-0100	**System Usability**	The system shall provide an intuitive and easy-to-navigate user interface.	**M**	General Public, Educators, Academics	HLF-001, HLF-003	PERC-HLR-001, PERC-HLR-006	O1, O2, O3, O4, O16	Enhances the user experience, making the system accessible to all.
PERC-LWR-NFR-0200	**Accessibility Compliance**	The system shall adhere to international web accessibility standards, such as WCAG.	**M**	General Public	HLF-001	PERC-HLR-001, PERC-HLR-009	O1, O2, O3, O4, O16	Critical for inclusivity and ensuring access to a diverse audience.
PERC-LWR-NFR-0300	**Data Security**	The system shall ensure robust data protection and privacy measures.	**M**	All Stakeholders	HLF-001, HLF-004	PERC-HLR-002, PERC-HLR-007	O1, O2, O3, O4, O16	Protects sensitive information and maintains user trust.
PERC-LWR-NFR-0400	**Scalability**	The system shall be scalable to accommodate growing user numbers and data volumes.	**M**	PERCEIVE Developers, Administrators	HLF-001, HLF-004	PERC-HLR-003, PERC-HLR-005	O1, O2, O3, O4, O16	Ensures the platform can handle increased demand without performance loss.
PERC-LWR-NFR-0500	**Performance Efficiency**	The system shall maintain high performance and quick response times under various loads.	**M**	All Stakeholders	All HLFs	PERC-HLR-005	All Outcomes	Key for a smooth and efficient user experience.
PERC-LWR-NFR-0600	**Content Reliability**	The system shall provide accurate and verified educational content and guidelines.	**M**	Educators, Museum Professionals	HLF-001, HLF-002	PERC-HLR-009	O1, O2	Ensures the credibility and accuracy of educational materials.
PERC-LWR-NFR-0700	**Multilingual Support**	The system shall offer content in multiple languages to cater to an international audience.	**S**	General Public, Educators	HLF-001, HLF-002	PERC-HLR-001, PERC-HLR-009	O1, O2	Expands the platform's accessibility and global reach.
PERC-LWR-NFR-0800	**Analytical Insight**	The system shall provide analytics to monitor user engagement and content effectiveness.	**S**	Administrators, Educators	HLF-001	PERC-HLR-009	O1	Facilitates the improvement of content based on user interaction.

PERC-LWR-NFR-0900	**Interoperability**	The system shall be compatible with various data formats and external systems.	**M**	PERCEIVE Developers, Museum Professionals	HLF-003, HLF-004	PERC-HLR-004	O3, O4, O16	Ensures seamless integration and data exchange with other systems.

Table 9: PERCEIVE Learning & Working Resources Non-Functional Requirements

4.1.2.2 Tools and Services

For the T&S category, NFRs play a pivotal role in ensuring that the tools and services provided are not just functional but also adhere to high-quality standards. These requirements encompass performance metrics, security protocols, and ease of use, which are vital for the effective utilization of the tools and services by museum professionals and conservationists. The NFRs for T&S thus contribute significantly to the overall efficacy and user satisfaction of the PERCEIVE platform.

The NFR table for T&S outlines the essential non-functional criteria that the tools and services must meet. This includes measures of performance efficiency, security safeguards, and user interface quality. By specifying these criteria, the table provides a structured approach to evaluating and ensuring the high quality and reliability of each tool and service offered by the platform, reinforcing the trustworthiness and utility of the PERCEIVE project.

T&S	**Tools and Services**							
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-T&S-NFR-0100	**High System Availability**	The system shall ensure high availability and minimal downtime for all tools and services.	**M**	General Public, Museum Professionals, Creative Industries	All HLFs	PERC-HLR-005	O5, O6, O7, O8, O9, O10, O11, O12	Critical for continuous access to tools and services.
PERC-T&S-NFR-0200	**Robust Data Security**	The system shall implement robust security measures for data protection in all tools.	**M**	Museum Professionals, Scientific Community, PERCEIVE Developers	All HLFs	PERC-HLR-002, PERC-HLR-007	O5, O6, O7, O8, O9, O10, O11, O12	Ensures the integrity and confidentiality of sensitive data.
PERC-T&S-NFR-0300	**Scalability**	The system shall be scalable to handle increasing load and data in tools and services.	**M**	PERCEIVE Developers, Administrators	All HLFs	PERC-HLR-003, PERC-HLR-005	O5, O6, O7, O8, O9, O10, O11, O12	Facilitates growth and adaptability of the platform.
PERC-T&S-	**Interoperability**	The system shall ensure interoperability across various tools and external data sources.	**M**	PERCEIVE Developers,	All HLFs	PERC-HLR-004	O5, O6, O7, O8,	Enables seamless integration and data exchange.

NFR-0400				Museum Professionals			O9, O10, O11, O12	
PERC-T&S-NFR-0500	**Performance Efficiency**	The system shall maintain optimal performance levels for all tools and services.	**M**	All Stakeholders	All HLFs	PERC-HLR-005, PERC-HLR-008	O5, O6, O7, O8, O9, O10, O11, O12	Ensures smooth and efficient operation of the platform.
PERC-T&S-NFR-0600	**User-Friendly Interface**	The system shall provide a user-friendly interface for all tools and services.	**S**	General Public, Museum Professionals	All HLFs	PERC-HLR-001, PERC-HLR-006	O5, O6, O7, O8, O9, O10, O11, O12	Enhances accessibility and ease of use for all users.
PERC-T&S-NFR-0700	**Reliable Analytics**	The system shall provide accurate and reliable analytics for all tools and services.	**S**	Administrators, Museum Professionals	All HLFs	PERC-HLR-009	O5, O6, O7, O8, O9, O10, O11, O12	Critical for data-driven decision-making and improvements.
PERC-T&S-NFR-0800	**Efficient Image Processing**	The system shall ensure efficient preprocessing of images for AI-based color restoration, with low latency and high throughput.	**M**	Museum Professionals, Creative Industries	All HLFs	PERC-HLR-005, PERC-HLR-008	O6, O7, O8	Essential for timely and effective color restoration processes.
PERC-T&S-NFR-0900	**Flexible Image Library Support**	The system shall support essential image processing libraries like OpenCV and Scikit-image.	**M**	PERCEIVE Developers, Creative Industries	All HLFs	PERC-HLR-004, PERC-HLR-010	O6, O7, O8	Enables functional compatibility and feature enhancement in image processing.
PERC-T&S-NFR-1000	**Advanced Reconstruction Techniques**	The system shall provide highly accurate reconstruction and segmentation techniques for color restoration.	**M**	Museum Professionals, Scientific Community	HLF-007	PERC-HLR-006, PERC-HLR-008	O6, O7	Improves the quality and accuracy of color restoration.
PERC-T&S-NFR-1100	**3D Software Integration**	The system shall support integration with third-party 3D reconstruction and deep learning software.	**M**	PERCEIVE Developers, Creative Industries	HLF-007, HLF-009	PERC-HLR-004, PERC-HLR-010	O7, O11, O12	Facilitates model reconstruction and enhances tool capabilities.
PERC-T&S-NFR-1200	**Neural Network Usability**	The system shall offer a user-friendly interface for designing and training neural networks in color restoration.	**S**	Creative Industries, Scientific Community	HLF-007	PERC-HLR-001, PERC-HLR-006	O6, O7	Ensures ease of use in complex AI-driven processes.

PERC-T&S-NFR-1300	**Deep Learning Framework Support**	The system shall provide support for various deep learning frameworks like TensorFlow, Keras, PyTorch, and Caffe.	**S**	PERCEIVE Developers, Scientific Community	HLF-007	PERC-HLR-004, PERC-HLR-010	O6, O7	Enhances the flexibility and range of AI tools available for color restoration.
PERC-T&S-NFR-1400	**Photorealistic Rendering**	The system shall include photorealistic rendering libraries to ensure realistic experiences of cultural assets.	**M**	Museum Professionals, Creative Industries	HLF-009	PERC-HLR-010	O12	Vital for creating immersive and authentic digital experiences.

Table 10: PERCEIVE Tools & Services Non-Functional Requirements

4.1.2.3 Prototypes

The NFRs for PRT are instrumental in shaping the quality and effectiveness of the developed prototypes. These requirements encompass the operational excellence of the prototypes, focusing on aspects like performance efficiency, reliability, and user engagement. Ensuring that these NFRs are met is crucial for the prototypes to be successfully implemented and to achieve the desired impact within the PERCEIVE project.

In the NFR table for PRT, each requirement is meticulously outlined, providing criteria for assessing the operational quality of the prototypes. This comprehensive documentation helps guide the development process towards creating prototypes that not only fulfill their intended functions but also excel in terms of user experience, reliability, and compliance with technical standards. It's a key resource for ensuring that the prototypes are robust, engaging, and effective in their application.

PRT		**Prototypes**						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-LWR-NFR-0100	**System Usability**	The system shall provide an intuitive and easy-to-navigate user interface.	**M**	General Public, Educators, Academics	HLF-001, HLF-003	PERC-HLR-001, PERC-HLR-006	O1, O2, O3, O4, O16	Enhances the user experience, making the system accessible to all.
PERC-LWR-NFR-0200	**Accessibility Compliance**	The system shall adhere to international web accessibility standards, such as WCAG.	**M**	General Public	HLF-001	PERC-HLR-001, PERC-HLR-009	O1, O2, O3, O4, O16	Critical for inclusivity and ensuring access to a diverse audience.
PERC-LWR-NFR-0300	**Data Security**	The system shall ensure robust data protection and privacy measures.	**M**	All Stakeholders	HLF-001, HLF-004	PERC-HLR-002, PERC-HLR-007	O1, O2, O3, O4, O16	Protects sensitive information and maintains user trust.

PERC-LWR-NFR-0400	**Scalability**	The system shall be scalable to accommodate growing user numbers and data volumes.	**M**	PERCEIVE Developers, Administrators	HLF-001, HLF-004	PERC-HLR-003, PERC-HLR-005	O1, O2, O3, O4, O16	Ensures the platform can handle increased demand without performance loss.
PERC-LWR-NFR-0500	**Performance Efficiency**	The system shall maintain high performance and quick response times under various loads.	**M**	All Stakeholders	All HLFs	PERC-HLR-005	All Outcomes	Key for a smooth and efficient user experience.
PERC-LWR-NFR-0600	**Content Reliability**	The system shall provide accurate and verified educational content and guidelines.	**M**	Educators, Museum Professionals	HLF-001, HLF-002	PERC-HLR-009	O1, O2	Ensures the credibility and accuracy of educational materials.
PERC-LWR-NFR-0700	**Multilingual Support**	The system shall offer content in multiple languages to cater to an international audience.	**S**	General Public, Educators	HLF-001, HLF-002	PERC-HLR-001, PERC-HLR-009	O1, O2	Expands the platform's accessibility and global reach.
PERC-LWR-NFR-0800	**Analytical Insight**	The system shall provide analytics to monitor user engagement and content effectiveness.	**S**	Administrators, Educators	HLF-001	PERC-HLR-009	O1	Facilitates the improvement of content based on user interaction.
PERC-LWR-NFR-0900	**Interoperability**	The system shall be compatible with various data formats and external systems.	**M**	PERCEIVE Developers, Museum Professionals	HLF-003, HLF-004	PERC-HLR-004	O3, O4, O16	Ensures seamless integration and data exchange with other systems.

Table 11: PERCEIVE Prototypes Non-Functional Requirements

4.1.3 Validation criteria and methodology

Non-functional requirements (NFRs) describe the characteristics of a system rather than what it specifically does. These requirements ensure that the system is efficient, reliable, secure, and otherwise capable of fulfilling the intended purpose in a real-world environment. NFRs need to be validated based on some defined validation criteria, expressed as Key Performance Indicators (KPIs). These KPIs refer to the set of standards or guidelines used to specify and evaluate the qualities or attributes of a system, rather than its specific functionalities. These criteria aim to provide a framework for articulating requirements like performance, security, usability, and reliability in measurable, unambiguous terms. The criteria ensure that the non-functional requirements are specific, measurable, relevant, testable, realistic, and consistent, thus enabling effective validation and verification. There are four ways in the context of the PERCEIVE project to validate and verify the Non-Functional Requirements: **I**: Inspection, **D**: Demonstration, **T**: Test, **A**: Analysis.

- **Inspection** involves manually reviewing the system's architecture, design, or code to check if it aligns with specified non-functional requirements. This method is often used for validating code quality, maintainability, or adherence to security guidelines. Stakeholders or experts typically carry out these inspections.
- **Demonstration** is the act of showing the system in operation to verify that it meets certain non-functional requirements. This method is particularly useful for requirements that are visible and can be easily observed, such as user interface responsiveness or system speed under nominal conditions. Stakeholders like clients or end-users are often involved in demonstrations.
- **Test** is a more formal, often automated, method for verifying non-functional requirements. This includes performance testing, stress testing, security testing, etc. Test scenarios are created to simulate different conditions under which the system will operate, and the system's behaviour is then evaluated against the expected outcomes defined in the non-functional requirements.
- **Analysis** refers to the use of mathematical models, simulations, or theoretical evaluations to verify non-functional requirements. This is often used for requirements that are difficult or costly to test in a real-world environment, such as extreme scalability or reliability conditions. Analysis can provide an abstract but rigorous way to validate that a system will meet its specified requirements under given conditions.

In the following subsections, we present the tables illustrating the Criteria and the selected Verification method for each Non-Functional Requirement. Each table consists of seven columns, Non-Functional Requirement ID (**Non-FR ID**), **Criteria ID**, **Criteria** name, **Unit** that is used to quantify the criteria, **Target Value** and **Verification Methodology.**

4.1.3.1 Learning and Working Resources

The Key Performance Indicators (KPIs) for the LWR category provide measurable targets that ensure the educational content and tools are delivered effectively and meet the required standards of quality and usability. These KPIs are crucial for monitoring and evaluating the platform's ability to deliver educational resources efficiently, maintain user engagement, and achieve the learning objectives set by the PERCEIVE project.

The KPI table for LWR categorizes these indicators, aligning them with specific Non-Functional Requirements. It includes metrics such as user satisfaction rates, content accessibility, and system reliability. This tabulation is instrumental in quantifying the performance of LWR components, serving as an objective measure to assess whether the platform meets the expected educational standards and user experience goals.

LWR		Learning & Working Resources				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-LWR-NFR-0100	**PERC-LWR-NFR-0101**	User Satisfaction Index	Measures user satisfaction with the system's usability and functionality.	Percentage (%)	≥ 85%	**S**
	PERC-LWR-NFR-0102	UI/UX Evaluation Score	Scores the system's user interface and user experience design quality.	Score (1-10)	≥ 8	**I**
PERC-LWR-NFR-0200	**PERC-LWR-NFR-0201**	WCAG Compliance Level	Assesses compliance with Web Content Accessibility Guidelines.	Level (A, AA, AAA)	Level AA	**I**
PERC-LWR-NFR-0300	**PERC-LWR-NFR-0301**	Security Breach Incidents	Counts incidents of security breaches or unauthorized access.	Incidents	0	**T**
	PERC-LWR-NFR-0302	Data Encryption Standard	Verifies adherence to standard encryption protocols for data security.	Standard Compliance	AES or equivalent	**I**

PERC-LWR-NFR-0400	**PERC-LWR-NFR-0401**	Load Handling Capability	Evaluates the system's ability to handle increased user traffic.	Concurrent Users	5x current user base	**T**
	PERC-LWR-NFR-0402	System Scalability Score	Rates the system's capacity to scale resources with demand.	Score (1-10)	≥ 8	**A**
PERC-LWR-NFR-0500	**PERC-LWR-NFR-0501**	Response Time Under Load	Measures the average time the system takes to respond under load.	Milliseconds (ms)	< 200 ms	**T**
	PERC-LWR-NFR-0502	System Uptime	Tracks the percentage of time the system is operational and accessible.	Percentage (%)	≥ 99.5%	**T**
PERC-LWR-NFR-0600	**PERC-LWR-NFR-0601**	Content Update Frequency	Monitors the frequency of updates to educational content and guidelines.	Updates per year	≥ 12	**I**
	PERC-LWR-NFR-0602	Content Accuracy Rate	Assesses the accuracy and reliability of the provided content.	Percentage (%)	≥ 95%	**I**
PERC-LWR-NFR-0700	**PERC-LWR-NFR-0701**	Number of Supported Languages	Counts the number of languages in which the system offers content.	Languages	≥ 5	**I**
PERC-LWR-NFR-0800	**PERC-LWR-NFR-0801**	Analytical Accuracy	Gauges the precision of the system's user engagement analytics.	Percentage (%)	≥ 95%	**T**
	PERC-LWR-NFR-0802	Engagement Metrics Precision	Evaluates the accuracy of metrics tracking user engagement.	Score (1-10)	≥ 8	**A**
PERC-LWR-NFR-0900	**PERC-LWR-NFR-0901**	Interoperability Score	Assesses the system's compatibility with different data formats and systems.	Score (1-10)	≥ 8	**I**
	PERC-LWR-NFR-0902	Data Exchange Success Rate	Measures the success rate of data exchanges with external systems.	Percentage (%)	≥ 95%	**T**

Table 12: PERCEIVE LWR KPIs and Validation Method

4.1.3.2 Tools and Services

For T&S, the KPIs are designed to quantify the efficacy, reliability, and user satisfaction of the tools and services offered. These indicators are essential for ensuring that the tools not only function as intended but also adhere to high-quality standards, thereby enhancing the overall effectiveness of the platform.

The KPI table for T&S provides a structured approach to measuring and validating the performance and quality of the tools and services. It includes specific metrics like tool efficiency, service uptime, and user feedback scores. This detailed framework aids in continuously monitoring and improving the tools and services, ensuring they effectively meet the needs of the stakeholders involved in the PERCEIVE project.

T&S		Tools and Services				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-T&S-NFR-0100	**PERC-T&S-NFR-0101**	System Uptime	Measures the percentage of time the system is operational.	Percentage (%)	≥ 99.9%	**T**
PERC-T&S-NFR-0200	**PERC-T&S-NFR-0201**	Security Incident Count	Counts incidents of security breaches.	Incidents	0	**T**
	PERC-T&S-NFR-0202	Encryption Compliance	Verifies system's compliance with encryption standards.	Standard Compliance	AES-256 or equivalent	**A**
PERC-T&S-NFR-0300	**PERC-T&S-NFR-0301**	Load Capacity	Evaluates how many users the system can handle simultaneously.	Concurrent Users	5x current capacity	**T**
	PERC-T&S-NFR-0302	Scalability Testing Score	Rates the system's ability to scale under testing.	Score (1-10)	≥ 8	**A**
PERC-T&S-NFR-0400	**PERC-T&S-NFR-0401**	Integration Success Rate	Measures successful integration with third-party systems.	Percentage (%)	≥ 95%	**T**
	PERC-T&S-NFR-0402	API Compatibility Score	Assesses compatibility of the system's API with external software.	Score (1-10)	≥ 8	**A**
PERC-T&S-NFR-0500	**PERC-T&S-NFR-0501**	Response Time Efficiency	Measures the average time the system takes to respond.	Milliseconds (ms)	< 200 ms	**T**
	PERC-T&S-NFR-0502	Performance Under Load	Measures system response time under peak load conditions.	Milliseconds (ms)	< 300 ms	**T**
PERC-T&S-NFR-0600	**PERC-T&S-NFR-0601**	User Interface Satisfaction	Rates user satisfaction with the system's interface.	Score (1-10)	≥ 8	**A**
PERC-T&S-NFR-0700	**PERC-T&S-NFR-0701**	Analytical Accuracy	Assesses the accuracy of the system's analytics.	Percentage (%)	≥ 95%	**A**

PERC-T&S-NFR-0800	**PERC-T&S-NFR-0801**	Image Processing Speed	Measures the time taken to preprocess images for AI.	Seconds	≤ 5 Seconds	**T**
PERC-T&S-NFR-0900	**PERC-T&S-NFR-0901**	Library Compatibility	Evaluates compatibility with key image processing libraries.	Score (1-10)	≥ 8	**A**
PERC-T&S-NFR-1000	**PERC-T&S-NFR-1001**	Technique Accuracy	Measures the accuracy of color restoration techniques.	Percentage (%)	≥ 95%	**A**
PERC-T&S-NFR-1100	**PERC-T&S-NFR-1101**	3D Integration Efficiency	Evaluates efficiency in integrating 3D reconstruction software.	Seconds	≤ 10 Seconds	**T**
PERC-T&S-NFR-1200	**PERC-T&S-NFR-1201**	Neural Network Training Usability	Assesses the usability of neural network training interfaces.	Score (1-10)	≥ 7	**A**
PERC-T&S-NFR-1300	**PERC-T&S-NFR-1301**	Framework Support Flexibility	Rates the system's support for various deep learning frameworks.	Score (1-10)	≥ 8	**A**
PERC-T&S-NFR-1400	**PERC-T&S-NFR-1401**	Rendering Realism Quality	Scores the quality of photorealistic rendering.	Score (1-10)	≥ 8	**D**

Table 13: PERCEIVE T&S KPIs and Validation Method

4.1.3.3 Prototypes

KPIs for PRT focus on evaluating the operational excellence and user impact of the developed prototypes. These indicators are crucial for ensuring that the prototypes are not only innovative and functional but also user-centric and reliable. They play a key role in validating the effectiveness of the prototypes in enhancing the appreciation and preservation of cultural heritage.

The KPI table for PRT outlines the specific performance metrics that these prototypes must achieve. This includes measures such as prototype usability, innovation index, and stakeholder satisfaction levels. This comprehensive categorization ensures that each prototype is rigorously evaluated against defined standards, contributing to the overall success and impact of the PERCEIVE project.

LWR		Learning & Working Resources				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-PRT-NFR-0100	**PERC-PRT-NFR-0101**	User Engagement Level	Measures the level of user engagement and interaction with prototypes.	Score (1-10)	≥ 8	**D**
PERC-PRT-NFR-0200	**PERC-PRT-NFR-0201**	Prototype Response Time	Assesses the response time of prototypes for user interactions.	Milliseconds (ms)	< 300 ms	**T**
PERC-PRT-NFR-0300	**PERC-PRT-NFR-0301**	Accessibility Compliance Score	Evaluates how well prototypes meet accessibility standards.	Score (1-10)	≥ 8	**A**
PERC-PRT-NFR-0400	**PERC-PRT-NFR-0401**	Integration Efficiency	Measures the efficiency of integrating prototypes with other systems.	Percentage (%)	≥ 95%	**T**
PERC-PRT-NFR-0500	**PERC-PRT-NFR-0501**	Scalability Test Result	Tests how well prototypes can scale with increased user load.	Score (1-10)	≥ 8	**T**
PERC-PRT-NFR-0600	**PERC-PRT-NFR-0601**	Security Compliance Rating	Rates the security features and compliance of prototypes.	Compliance Level	Full Compliance	**A**
PERC-PRT-NFR-0700	**PERC-PRT-NFR-0701**	Data Accuracy Score	Measures the accuracy of data presented or processed by prototypes.	Percentage (%)	≥ 98%	**A**
PERC-PRT-NFR-0800	**PERC-PRT-NFR-0801**	Real-Time Interaction Quality	Assesses the quality and fluidity of real-time interactions.	Score (1-10)	≥ 8	**D**
PERC-PRT-NFR-0900	**PERC-PRT-NFR-0901**	Maintenance Efficiency	Evaluates the ease and efficiency of maintaining and updating prototypes.	Score (1-10)	≥ 8	**A**

Table 14: PERCEIVE PRT KPIs and Validation Method

4.2 Platform Modules Analysis

4.2.1 Functional Requirements Identification

4.2.1.1 Back-end Middleware

The Back-End Middleware (BEM) serves as the backbone of the PERCEIVE platform, handling data management, server-side processing, and inter-module communication. Establishing precise FRs for BEM is critical as it ensures the robustness and efficiency of the backend operations. Properly defined FRs are key to achieving a seamless integration of various platform components, thereby enhancing the overall functionality and user experience of the PERCEIVE platform.

The FR table for BEM lays out a structured framework of requirements essential for the module's optimal performance. Each requirement is detailed with its purpose, impact, and the stakeholders it affects, ensuring a comprehensive understanding of the backend functionalities. This systematic arrangement facilitates an efficient development process, enabling the BEM to robustly support the diverse needs of the PERCEIVE platform.

BEM		**Back-end Middleware**						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-BEM-FR-001	**Data Processing Efficiency**	The system shall efficiently process and manage data transactions within the BEM.	**M**	PERCEIVE Developers, Administrators	HLF-003	HLR-005	O1, O3, O5	Critical for maintaining operational speed and reliability.
PERC-BEM-FR-002	**Modular Integration Support**	The system shall support modular integration of various backend services and components in the BEM.	**M**	PERCEIVE Developers, Museum Professionals	HLF-004	HLR-004	O2, O4, O6	Enables flexibility and scalability in backend operations.
PERC-BEM-FR-003	**Secure Data Handling**	The system shall ensure secure data handling and storage within the BEM.	**H**	Administrators, Museum Professionals	HLF-002	HLR-002	O7, O9, O10	Prioritizes data security and user privacy.
PERC-BEM-FR-004	**API Interface Optimization**	The system shall optimize the BEM for effective API communication and data exchange.	**H**	PERCEIVE Developers, Creative Industries	HLF-005	HLR-006	O8, O11, O12	Enhances interoperability and system integration.
PERC-BEM-FR-005	**Scalability and Load Handling**	The system shall be scalable and capable of handling varying loads in the BEM.	**M**	Administrators, Scientific Community	HLF-006	HLR-003	O13, O14, O15	Ensures the system can adapt to growing user demands.

PERC-BEM-FR-006	**Request Logging Middleware**	Implement middleware to log detailed incoming requests in the BEM.	**S**	PERCEIVE Developers	HLF-007	HLR-010	O16	Facilitates tracking and analysis of system usage.
PERC-BEM-FR-007	**Authentication Middleware**	Develop middleware for user credential validation and access authorization in the BEM.	**H**	PERCEIVE Developers, Administrators	HLF-008	HLR-002	O1, O5, O9	Essential for maintaining user access control and security.
PERC-BEM-FR-008	**WebSocket Communication**	Support WebSocket for real-time server-client communication in the BEM.	**M**	PERCEIVE Developers, General Public	HLF-009	HLR-005	O2, O6, O10	Enhances real-time data exchange capabilities.
PERC-BEM-FR-009	**HTTP/2 Protocol Support**	Incorporate HTTP/2 in the BEM for enhanced performance and efficiency.	**M**	PERCEIVE Developers, Creative Industries	HLF-010	HLR-005	O3, O7, O11	Improves system performance and user experience.
PERC-BEM-FR-010	**Error Handling Middleware**	Implement error management during request processing in the BEM.	**S**	PERCEIVE Developers	HLF-011	HLR-007	O4, O8, O12	Ensures robustness and reliability in operations.

Table 15: PERCEIVE BEM Functional Requirements

4.2.1.2 Front-End Framework

The Front-End Framework (FEF) in the PERCEIVE project encapsulates the user interface and experience aspects of the platform. Defining the Functional Requirements (FRs) for the FEF is a critical task, as it directly influences how users interact with and perceive the platform. Accurately identified FRs ensure that the FEF is not only aesthetically pleasing and user-friendly but also effectively communicates the purpose and functionalities of the PERCEIVE platform to its diverse user base.

The FR table for the FEF methodically documents each requirement, detailing its significance, related stakeholders, and how it ties into the overarching goals of the platform. This comprehensive categorization provides clear guidance for the development of the front-end interface, ensuring that every aspect of user interaction is thoughtfully designed and aligns with the user experience objectives of PERCEIVE. The table serves as a blueprint, aiding in the creation of a front-end that is both intuitive and informative.

FEF		**Front-end Framework**						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-FEF-FR-001	**Component-Based Architecture**	The system shall implement a component-based architecture	**M**	PERCEIVE Developers,	HLF-004	HLR-007	O1, O3, O5	Facilitates logical UI hierarchy and ease of maintenance.

		in the FEF to ensure maintainability.		Museum Professionals				
PERC-FEF-FR-002	**Virtual DOM Rendering**	Utilize virtual DOM (e.g., React.js) in the FEF for efficient component rendering and updates.	**M**	PERCEIVE Developers, Creative Industries	HLF-005	HLR-006	O2, O4, O6	Enhances UI performance and responsiveness.
PERC-FEF-FR-003	**TypeScript Integration**	Develop the FEF using TypeScript in Angular for enhanced readability and strong typing.	**M**	PERCEIVE Developers	HLF-006	HLR-005	O7, O9, O11	Improves code quality and maintainability.
PERC-FEF-FR-004	**Dependency Injection**	The FEF shall utilize Angular's dependency injection for efficient management of components and services.	**M**	PERCEIVE Developers, Administrators	HLF-007	HLR-004	O8, O10, O12	Promotes modularity and reusable code.
PERC-FEF-FR-005	**Intuitive Interface Design**	Design the FEF with a user-friendly interface to enhance user experience and reduce the learning curve.	**H**	General Public, Museum Professionals	HLF-008	HLR-001	O13, O14, O15	Critical for user engagement and satisfaction.
PERC-FEF-FR-006	**Cross-Platform Compatibility**	Ensure the FEF's compatibility across various devices and platforms, including mobile responsiveness.	**H**	General Public, Scientific Community	HLF-009	HLR-002	O16	Ensures broad accessibility and usability.
PERC-FEF-FR-007	**Modular and Reusable Components**	Create modular and reusable components in the FEF to facilitate updates and new feature integration.	**S**	PERCEIVE Developers, Creative Industries	HLF-010	HLR-003	O1, O3, O5	Enhances the framework's adaptability and extensibility.
PERC-FEF-FR-008	**Collaborative Features**	Integrate collaborative tools in the FEF to support real-time user interaction, enhancing partnership.	**S**	General Public, Museum Professionals	HLF-011	HLR-008	O2, O4, O6	Fosters a collaborative and interactive user environment.

Table 16: PERCEIVE FEF Functional Requirements

4.2.1.3 Application Programming Interface

The Application Programming Interface (API) is a crucial component of the PERCEIVE platform, facilitating data exchange and communication between different modules. The process of defining FRs for the API is vital to ensure seamless integration and data flow within the platform. Correct FRs guarantee that the API is robust, secure, and efficient, providing a reliable backbone for the platform's operations and enhancing the overall functionality of PERCEIVE.

In the FR table for the API, each requirement is precisely articulated, highlighting its role in the overall system architecture. This table provides a detailed roadmap for API development, outlining the technical specifications and the expected interactions with other platform components. It serves as a critical reference point, ensuring that the API meets all necessary standards for performance, security, and compatibility, which are essential for the successful operation of the PERCEIVE platform.

API		**Application Programming Interface**						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-API-FR-001	**Comprehensive Documentation**	The API shall provide comprehensive documentation, including detailed endpoint descriptions, formats, and requirements.	**M**	PERCEIVE Developers, Scientific Community	HLF-001	HLR-001	O1, O2, O3	Essential for user understanding and effective API integration.
PERC-API-FR-002	**High Performance**	The API shall handle high volumes of concurrent requests with low response times.	**M**	PERCEIVE Developers, Administrators	HLF-002	HLR-002	O4, O5, O6	Critical for maintaining efficient system operation.
PERC-API-FR-003	**Error Handling**	The API shall provide consistent and informative error responses.	**M**	PERCEIVE Developers, Museum Professionals	HLF-003	HLR-003	O7, O8, O9	Aids in debugging and improves user experience during failures.
PERC-API-FR-004	**Secure Access**	The API shall support robust authentication and authorization mechanisms.	**M**	Administrators, Museum Professionals	HLF-004	HLR-004	O10, O11, O12	Ensures secure access and data protection.
PERC-API-FR-005	**User Credentials Validation**	The API shall validate user credentials and permissions for resource access.	**M**	PERCEIVE Developers, Administrators	HLF-005	HLR-005	O13, O14, O15	Critical for access control and security.
PERC-API-FR-006	**API Versioning**	The API shall support versioning to maintain backward compatibility.	**S**	PERCEIVE Developers, Creative Industries	HLF-006	HLR-006	O16, O1, O2	Facilitates smooth upgrades and changes.

PERC-API-FR-007	**Standardized Response Format**	The API shall follow a standardized response format for consistency.	**S**	PERCEIVE Developers, General Public	HLF-007	HLR-007	O3, O4, O5	Enhances clarity and ease of use for clients.
PERC-API-FR-008	**HTTP/2 Support**	The API shall support the HTTP/2 protocol for efficient resource utilization.	**S**	PERCEIVE Developers, Scientific Community	HLF-008	HLR-008	O6, O7, O8	Improves performance and user experience.
PERC-API-FR-009	**Data Encryption**	The API shall encrypt sensitive data to ensure confidentiality during storage and transit.	**S**	Administrators, Museum Professionals	HLF-009	HLR-009	O9, O10, O11	Prioritizes data security and privacy.
PERC-API-FR-010	**CORS Support**	The API shall support Cross-Origin Resource Sharing to allow requests from authorized domains.	**C**	PERCEIVE Developers, Creative Industries	HLF-010	HLR-010	O12, O13, O14	Facilitates cross-domain interactions.
PERC-API-FR-011	**Content Negotiation**	The API shall provide responses in various formats based on client preferences.	**C**	PERCEIVE Developers, General Public	HLF-011	HLR-011	O15, O16, O1	Enhances flexibility and client compatibility.
PERC-API-FR-012	**Pagination Support**	The API shall support pagination for efficient retrieval of large datasets.	**C**	PERCEIVE Developers, Scientific Community	HLF-012	HLR-012	O2, O3, O4	Reduces response times and resource consumption.
PERC-API-FR-013	**File Uploads**	The API shall support file uploads to allow clients to submit files.	**C**	Creative Industries, General Public	HLF-013	HLR-013	O5, O6, O7	Enables richer client interactions and data submission.
PERC-API-FR-014	**WebSocket Communication**	The API shall support WebSocket for real-time bidirectional communication.	**S**	PERCEIVE Developers, Museum Professionals	HLF-014	HLR-014	O8, O9, O10	Facilitates dynamic and interactive client-server communication.
PERC-API-FR-015	**Progress Reporting**	The API shall provide progress reporting for long running processes.	**S**	PERCEIVE Developers, Creative Industries	HLF-015	HLR-015	O11, O12, O13	Enhances user experience during lengthy operations.

Table 17: PERCEIVE API Functional Requirements

4.2.1.4 Development Collaboration Module

The Development Collaboration Module (DCM) within the PERCEIVE project is designed to centralize development efforts, facilitating collaboration and knowledge sharing among project team members. Identifying and defining accurate FRs for the DCM is fundamental to ensure that the module effectively supports the project's collaborative environment. Proper FRs for the DCM are key to enhancing development efficiency, maintaining code integrity, and ensuring effective communication and documentation within the project team.

The FR table for the DCM systematically enumerates each requirement, detailing how it contributes to the module's overall functionality. This table acts as a comprehensive guide for the development and implementation of the DCM, ensuring that all aspects of collaboration, version control, issue tracking, and documentation are thoroughly addressed. It plays a pivotal role in ensuring that the DCM aligns with the collaborative and innovative spirit of the PERCEIVE project, supporting its objectives and enhancing the efficacy of the development process.

DCM		**Development Collaboration Module**						
FR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-DCM-FR-001	**Version Control Integration**	The system shall integrate with a version control system (e.g., Git) for code management and tracking.	**M**	PERCEIVE Developers, Administrators	HLF-001	HLR-001	O1, O2, O3	Enables efficient code management and version tracking.
PERC-DCM-FR-002	**Issue Tracking System**	The system shall include a mechanism for tracking, categorizing, and managing software issues and tasks.	**M**	PERCEIVE Developers, Scientific Community	HLF-002	HLR-002	O4, O5, O6	Facilitates effective issue resolution and feature management.
PERC-DCM-FR-003	**Collaborative Wiki Platform**	The system shall provide a Wiki platform for centralized project documentation and knowledge sharing.	**M**	PERCEIVE Developers, Museum Professionals	HLF-003	HLR-003	O7, O8, O9	Centralizes knowledge and fosters collaboration among team members.
PERC-DCM-FR-004	**User Role Management**	The system shall offer mechanisms to define and manage user roles and permissions within the DCM.	**S**	Administrators, PERCEIVE Developers	HLF-004	HLR-004	O10, O11, O12	Ensures proper access control and security within the DCM.
PERC-DCM-FR-005	**Real-Time Collaboration Features**	The system shall enable real-time collaboration features, such as live document editing, among team members.	**S**	PERCEIVE Developers, Creative Industries	HLF-005	HLR-005	O13, O14, O15	Promotes dynamic teamwork and immediate feedback.

PERC-DCM-FR-006	**Change History and Rollback**	The system shall track change history and allow rollback to previous versions as needed.	**S**	PERCEIVE Developers	HLF-006	HLR-006	O16, O1, O2	Facilitates version control and error correction.
PERC-DCM-FR-007	**Automated Backup and Recovery**	The system shall implement automated backup and recovery solutions for data and documentation.	**S**	Administrators, Museum Professionals	HLF-007	HLR-007	O3, O4, O5	Protects against data loss and ensures continuity.
PERC-DCM-FR-008	**Search and Filter Functionality**	The system shall offer advanced search and filter options for efficient data retrieval within the module.	**S**	PERCEIVE Developers, General Public	HLF-008	HLR-008	O6, O7, O8	Enhances user experience and efficiency in locating information.
PERC-DCM-FR-009	**Development Tools Integration**	The system shall ensure compatibility and integration with various development tools used in the project.	**C**	PERCEIVE Developers, Scientific Community	HLF-009	HLR-009	O9, O10, O11	Supports a diverse range of development environments and tools.
PERC-DCM-FR-010	**Notifications and Alerts**	The system shall provide notifications and alerts for updates, issues, or important changes within the module.	**S**	PERCEIVE Developers, Administrators	HLF-010	HLR-010	O12, O13, O14	Keeps team members informed and up-to-date.
PERC-DCM-FR-011	**Code Privacy and Security**	The system shall ensure the privacy and security of code and sensitive information with access controls.	**M**	Administrators, PERCEIVE Developers	HLF-011	HLR-011	O15, O16, O1	Prioritizes confidentiality and security in collaborative development.
PERC-DCM-FR-012	**Authentication Mechanisms**	The system shall implement robust authentication processes to secure access to the DCM.	**M**	Administrators, Museum Professionals	HLF-012	HLR-012	O2, O3, O4	Ensures secure and authorized access to the module.
PERC-DCM-FR-013	**Data Privacy Compliance**	The system shall comply with data privacy regulations for protecting sensitive information shared within DCM.	**M**	Administrators, PERCEIVE Developers	HLF-013	HLR-013	O5, O6, O7	Guarantees adherence to legal standards like GDPR and CCPA.

Table 18: PERCEIVE DCM Functional Requirements

4.2.2 Non-Functional Requirements Identification

4.2.2.1 Back-end Middleware

The NFRs for the BEM are crucial in ensuring that the backbone of the PERCEIVE platform operates with high efficiency, security, and scalability. These requirements delve into the operational aspects of the BEM, focusing on system performance, data handling, and integration capabilities. Adhering to these NFRs is vital for maintaining the integrity and smooth functioning of the platform's backend infrastructure.

The NFR table for BEM delineates the quality and performance standards that the middleware must adhere to. It covers a range of attributes from system reliability and response times to security protocols and maintenance ease. This table acts as a guiding framework for developers, ensuring that the BEM not only supports the necessary functionalities but does so in a manner that is robust, secure, and adaptable to the evolving needs of the PERCEIVE platform.

BEM		**Back-end Middleware**						
NFR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-BEM-NFR-0100	**High Throughput**	The system shall optimize the BEM for high throughput in data processing.	**M**	PERCEIVE Developers, Administrators	HLF-003	HLR-005	O1, O3, O5	Essential for handling large volumes of data efficiently.
PERC-BEM-NFR-0200	**Concurrent Handling**	The system shall enable the BEM to handle a high volume of requests concurrently.	**S**	PERCEIVE Developers, Museum Professionals	HLF-004	HLR-004	O2, O4, O6	Critical for maintaining system reliability under peak loads.
PERC-BEM-NFR-0300	**Scalability**	The system shall ensure scalability of the BEM to adapt to increased user and content load.	**M**	Administrators, Scientific Community	HLF-006	HLR-003	O13, O14, O15	Ensures the BEM can grow in capacity with the platform's expansion.
PERC-BEM-NFR-0400	**Data Security**	The system shall secure user data and interactions within the BEM.	**S**	Administrators, Museum Professionals	HLF-002	HLR-002	O7, O9, O10	Prioritizes the protection of sensitive data and user privacy.
PERC-BEM-NFR-0500	**Interface Usability**	The system shall provide user-friendly and accessible middleware interfaces in the BEM.	**S**	PERCEIVE Developers, General Public	HLF-007	HLR-001	O8, O11, O12	Enhances usability for developers and end-users interacting with backend services.

PERC-BEM-NFR-0600	**Compliance**	The system shall adhere to legal and regulatory standards within the BEM operations.	**M**	PERCEIVE Developers, Administrators	HLF-005	HLR-007	O16	Ensures legal compliance in data handling and operational procedures.
PERC-BEM-NFR-0700	**Maintenance Ease**	The system shall facilitate efficient maintenance and easy updates of the BEM.	**C**	PERCEIVE Developers	HLF-008	HLR-006	O1, O5, O9	Critical for long-term sustainability and adaptability of the BEM.

Table 19: PERCEIVE BEM Non-Functional Requirements

4.2.2.2 Front-End Framework

In addressing the Non-Functional Requirements (NFRs) for the FEF, the emphasis is placed on ensuring that the interface's performance and user interaction are optimized. These NFRs cover critical aspects such as responsiveness, cross-platform compatibility, and intuitive design. Ensuring these NFRs are met is vital for providing an engaging and accessible user experience, which is a key success factor for the PERCEIVE platform.

The NFR table for the FEF categorizes each requirement, providing specific criteria for evaluating the quality and effectiveness of the front-end interface. This table is essential in guiding the development process to focus not only on the functional aspects but also on the overall user experience, ensuring that the FEF is both efficient and user-friendly. It acts as a benchmark for achieving a high standard of interface design, crucial for user engagement and satisfaction.

FEF		**Front-end Framework**						
NFR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-FEF-NFR-0100	**Scalable Architecture**	The system shall ensure FEF scalability in terms of modules and user load.	**M**	PERCEIVE Developers, Administrators	HLF-004	HLR-005	O1, O3, O5	Enables handling growing user numbers and module expansion.
PERC-FEF-NFR-0200	**Flexible Virtual DOM**	The FEF shall update minimal components for optimal performance with virtual DOM changes.	**M**	PERCEIVE Developers, Creative Industries	HLF-005	HLR-006	O2, O4, O6	Enhances performance and responsiveness.
PERC-FEF-NFR-0300	**Security Compliance**	The FEF shall ensure secure data transmission and prevent client-side vulnerabilities.	**M**	Administrators, Museum Professionals	HLF-002	HLR-002	O7, O9, O10	Prioritizes data security and user privacy.

PERC-FEF-NFR-0400	**Cross-Platform Compatibility**	The FEF shall function seamlessly across various platforms and devices.	**S**	General Public, Scientific Community	HLF-009	HLR-001	O8, O11, O12	Ensures broad accessibility and usability.
PERC-FEF-NFR-0500	**Maintenance Efficiency**	The FEF shall facilitate efficient maintenance and easy updates.	**S**	PERCEIVE Developers	HLF-007	HLR-003	O13, O14, O15	Critical for long-term sustainability and adaptability.
PERC-FEF-NFR-0600	**Usability and Accessibility**	The FEF shall provide user-friendly and accessible interfaces for all user groups.	**M**	General Public, Museum Professionals	HLF-008	HLR-004	O16	Enhances user experience and engagement.

Table 20: PERCEIVE FEF Non-Functional Requirements

4.2.2.3 Application Programming Interface

For the API, the NFRs address the system's operational quality, focusing on aspects like security, scalability, and data handling efficiency. These requirements are fundamental to ensuring that the API facilitates seamless, secure, and efficient communication between different components of the PERCEIVE platform. Adhering to these NFRs is essential for maintaining the platform's reliability and enhancing its overall performance.

The NFR table for the API outlines the key performance metrics and standards that the API needs to meet. This includes detailed criteria for assessing aspects such as response times, data encryption, and system compatibility. The table serves as a critical tool for developers, guiding them to build an API that not only connects different modules effectively but also does so in a manner that is robust, secure, and efficient.

API		**Application Programming Interface**						
NFR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-API-NFR-0100	**Performance**	The API shall ensure low response times for all requests.	**M**	PERCEIVE Developers, Administrators	HLF-001	HLR-001	O1, O2, O3	Essential for efficient and responsive system operations.
PERC-API-NFR-0200	**Scalability**	The API shall handle high volumes of concurrent requests without performance degradation.	**M**	PERCEIVE Developers, Museum Professionals	HLF-002	HLR-002	O4, O5, O6	Critical for maintaining service quality under peak loads.
PERC-API-NFR-0300	**Reliability**	The API shall have robust error handling and management capabilities.	**M**	PERCEIVE Developers,	HLF-003	HLR-003	O7, O8, O9	Ensures stable and reliable API operations.

				Scientific Community				
PERC-API-NFR-0400	**Security**	The API shall implement secure authentication and data protection measures.	**M**	Administrators, Museum Professionals	HLF-004	HLR-004	O10, O11, O12	Prioritizes safeguarding sensitive data and user interactions.
PERC-API-NFR-0500	**Extensibility**	The API shall support a modular architecture for easy expansion and integration.	**S**	PERCEIVE Developers, Creative Industries	HLF-005	HLR-005	O13, O14, O15	Facilitates future enhancements and integrations.
PERC-API-NFR-0600	**Comprehensive Documentation**	The API shall provide detailed and accessible documentation.	**M**	PERCEIVE Developers, General Public	HLF-006	HLR-006	O16, O1, O2	Critical for developer engagement and effective usage of the API.
PERC-API-NFR-0700	**Versioning**	The API shall support versioning for backward compatibility and future updates.	**S**	PERCEIVE Developers, Museum Professionals	HLF-007	HLR-007	O3, O4, O5	Ensures seamless transition between API versions.
PERC-API-NFR-0800	**Error Handling**	The API shall provide consistent and informative responses for error scenarios.	**M**	PERCEIVE Developers, Creative Industries	HLF-008	HLR-008	O6, O7, O8	Enhances user experience and troubleshooting efficiency.
PERC-API-NFR-0900	**Data Privacy**	The API shall adhere to data privacy regulations like GDPR.	**M**	Administrators, Museum Professionals	HLF-009	HLR-009	O9, O10, O11	Ensures compliance with legal data privacy standards.
PERC-API-NFR-1000	**Rate Limiting**	The API shall implement rate limits to prevent abuse and ensure fair usage.	**S**	PERCEIVE Developers, General Public	HLF-010	HLR-010	O12, O13, O14	Protects the API from overuse and potential attacks.
PERC-API-NFR-1100	**Logging**	The API shall maintain comprehensive logging for effective troubleshooting and monitoring.	**S**	PERCEIVE Developers, Administrators	HLF-011	HLR-011	O15, O16, O1	Facilitates system monitoring and issue resolution.

PERC-API-NFR-1200	**Monitoring**	The API shall integrate with tools like Prometheus, ELK for monitoring system health and usage.	**S**	PERCEIVE Developers, Scientific Community	HLF-012	HLR-012	O2, O3, O4	Enables proactive management and optimization of API services.
PERC-API-NFR-1300	**User Authentication**	The API shall employ robust mechanisms to ensure secure user access and authorization.	**M**	Administrators, Museum Professionals	HLF-013	HLR-013	O5, O6, O7	Critical for user access control and system security.

Table 21: PERCEIVE API Non-Functional Requirements

4.2.2.4 Development Collaboration Module

In the DCM component, the NFRs emphasize ensuring the module's operational effectiveness and user collaboration experience. These NFRs address crucial areas like system security, ease of maintenance, and user interface usability, which are imperative for facilitating a productive and secure development environment within the PERCEIVE project.

The NFR table for the DCM provides a detailed breakdown of the quality and performance criteria that the module must fulfill. This includes standards for system reliability, data protection, and integration capabilities. By establishing these criteria, the table serves as a guiding framework for the development team, ensuring that the DCM not only supports effective collaboration but also adheres to high standards of usability and security. This approach is essential for fostering an efficient and secure development process within the project.

API		**Application Programming Interface**						
NFR ID	**Name**	**Description**	**Priority**	**Stakeholders**	**Related HLF**	**Related HLR**	**Related Outcomes**	**Comments**
PERC-DCM-NFR-0100	**Security**	The system shall implement robust security measures for data protection in DCM, including encryption and access controls.	**M**	Administrators, PERCEIVE Developers	HLF-001	HLR-001	O1, O2, O3	Ensures the confidentiality and integrity of project data.
PERC-DCM-NFR-0200	**Usability**	The DCM shall offer a user-friendly interface for seamless interaction by all users.	**M**	PERCEIVE Developers, Museum Professionals	HLF-002	HLR-002	O4, O5, O6	Critical for enhancing user experience and adoption.
PERC-DCM-NFR-0300	**Performance**	The DCM shall be optimized for rapid data processing with minimal downtime.	**M**	PERCEIVE Developers, Scientific Community	HLF-003	HLR-003	O7, O8, O9	Ensures efficiency and responsiveness of the module.

PERC-DCM-NFR-0400	**Maintainability**	The system shall facilitate easy maintenance of the DCM with automated backup and efficient error recovery.	**S**	Administrators, PERCEIVE Developers	HLF-004	HLR-004	O10, O11, O12	Enhances long-term sustainability and reliability of the DCM.
PERC-DCM-NFR-0500	**Scalability**	The DCM shall be scalable to accommodate increasing data and user activity.	**M**	PERCEIVE Developers, Creative Industries	HLF-005	HLR-005	O13, O14, O15	Allows the module to adapt to the growing needs of the project.
PERC-DCM-NFR-0600	**Interoperability**	The DCM shall integrate seamlessly with various development tools and platforms.	**S**	PERCEIVE Developers, Museum Professionals	HLF-006	HLR-006	O16, O1, O2	Facilitates compatibility and integration with diverse project tools.
PERC-DCM-NFR-0700	**Reliability**	The DCM shall operate reliably with minimal system failures.	**M**	PERCEIVE Developers, Scientific Community	HLF-007	HLR-007	O3, O4, O5	Ensures consistent and dependable module operation.
PERC-DCM-NFR-0800	**Compliance**	The system shall adhere to data privacy and regulatory standards within the DCM operations.	**M**	Administrators, PERCEIVE Developers	HLF-008	HLR-008	O6, O7, O8	Guarantees compliance with legal standards like GDPR and CCPA.

Table 22: PERCEIVE DCM Non-Functional Requirements

4.2.3 Validation Criteria and Methodology

4.2.3.1 Back-End Middleware

The KPIs for BEM are tailored to ensure that the backend operations of the PERCEIVE platform are efficient, secure, and scalable. These performance indicators are vital for assessing the robustness of the backend infrastructure and its capability to support various frontend functionalities effectively.

In the KPI table for BEM, each KPI is aligned with specific Non-Functional Requirements, providing measurable targets for aspects such as system response time, data processing efficiency, and security compliance. This table acts as a critical tool for monitoring and enhancing the backend performance, ensuring that it reliably supports the diverse functionalities of the PERCEIVE platform.

BEM		Back-end Middleware				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-BEM-NFR-0100	**PERC-BEM-KPI-0101**	Throughput Efficiency	Measures the data processing throughput of the BEM.	Transactions/s	>100	**T**
	PERC-BEM-KPI-0102	Response Time	Evaluates the latency in BEM's response to requests.	ms	<10	**T**
PERC-BEM-NFR-0200	**PERC-BEM-KPI-0201**	Concurrent Request Load	Assesses the BEM's ability to handle concurrent requests.	Requests	10k	**T**
	PERC-BEM-KPI-0202	Error Handling	Measures the rate of errors during BEM operations.	Errors per minute (epm)	<10	**T**
PERC-BEM-NFR-0300	**PERC-BEM-KPI-0301**	Scalability Flexibility	Evaluates the BEM's scalability under increased load.	% increase	50%	**T**
PERC-BEM-NFR-0400	**PERC-BEM-KPI-0401**	Security Compliance	Verifies the BEM's compliance with security standards.	YES/NO	YES	**A**
PERC-BEM-NFR-0500	**PERC-BEM-KPI-0501**	Middleware Usability	Rates the usability of the BEM interfaces.	Scale (1-5)	>4	**D**
PERC-BEM-NFR-0600	**PERC-BEM-KPI-0601**	Legal Compliance	Ensures the BEM adheres to legal and regulatory standards.	YES/NO	YES	**A**
PERC-BEM-NFR-0700	**PERC-BEM-KPI-0701**	Maintenance Efficiency	Measures the time required for BEM maintenance activities.	Hours	<24	**T**

Table 23: PERCEIVE BEM KPIs and Validation Method

4.2.3.2 Front-End Framework

The KPIs for the FEF are essential in measuring the effectiveness, responsiveness, and user-friendliness of the platform's interface. These indicators play a crucial role in ensuring that the front-end not only looks appealing but also provides a seamless and intuitive user experience, which is fundamental for user engagement and satisfaction in the PERCEIVE project.

The KPI table for the FEF meticulously outlines key metrics such as load time, user interface responsiveness, and cross-platform compatibility. This detailed framework facilitates the objective assessment of the front-end, guiding continuous improvement efforts. By adhering to these KPIs, the development team can ensure that the FEF meets the high standards of usability and accessibility expected in the PERCEIVE platform.

FEF		**Front-end Framework**				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-FEF-NFR-0100	**PERC-FEF-NFR-0101**	Module Scalability	Measures the scalability of the FEF in module terms.	Integer	>50	**T**
PERC-FEF-NFR-0200	**PERC-FEF-NFR-0201**	DOM Update Efficiency	Assesses efficiency in virtual DOM updates.	Integer	<5	**T**
PERC-FEF-NFR-0300	**PERC-FEF-NFR-0301**	Security Compliance Rating	Rates FEF's compliance with security standards.	YES/NO	YES	**A**
PERC-FEF-NFR-0400	**PERC-FEF-NFR-0401**	Cross-Platform Functionality	Evaluates cross-platform compatibility of FEF.	Scale (1-5)	>4	**D**
PERC-FEF-NFR-0500	**PERC-FEF-NFR-0501**	Maintenance Efficiency	Measures time efficiency in FEF maintenance.	Hours	<24	**T**
PERC-FEF-NFR-0600	**PERC-FEF-NFR-0601**	Usability Index	Quantifies usability and accessibility of FEF.	Scale (1-5)	>4	**D**
PERC-FEF-NFR-0100	**PERC-FEF-NFR-0102**	Team Scalability	Assesses scalability in terms of development teams.	Integer	>10	**T**

Table 24: PERCEIVE FEF KPIs and Validation Method

4.2.3.3 Application Programming Interface

KPIs for the API module of the PERCEIVE platform focus on assessing the efficiency, security, and interoperability of data exchange between various components. These performance indicators are crucial for ensuring the API's reliability and effectiveness, which directly impacts the platform's overall functionality and user experience.

The KPI table for the API details essential metrics such as response times, data throughput, and security compliance rates. This structured approach is vital for continuously monitoring and optimizing the API's performance. It ensures that the API not only facilitates seamless communication across the platform but does so in a manner that is secure, efficient, and scalable.

API		Application Programming Interface				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-API-NFR-0100	**PERC-API-NFR-0101**	Response Time	Measures the time taken to respond to API requests.	Milliseconds (ms)	≤ 100 ms	**T**
PERC-API-NFR-0200	**PERC-API-NFR-0201**	Concurrent Request Capacity	Assesses the number of concurrent requests handled.	Requests per second (RPS)	≥ 1000 RPS	**T**
PERC-API-NFR-0300	**PERC-API-NFR-0301**	Error Handling Efficiency	Evaluates error-free operations during unit testing.	Percentage (%)	99.90%	**T**
PERC-API-NFR-0400	**PERC-API-NFR-0401**	Security Compliance Rate	Measures OAuth2 security compliance.	Percentage (%)	95%	**A**
PERC-API-NFR-0500	**PERC-API-NFR-0501**	Extensibility Rating	User feedback on API's ease of extension.	5-point Likert scale	>4	**D**
PERC-API-NFR-0600	**PERC-API-NFR-0601**	Documentation Quality	User feedback on API documentation quality.	5-point Likert scale	>4.5	**D**
PERC-API-NFR-0700	**PERC-API-NFR-0701**	Versioning Success Rate	Success rate in accessing previous API versions.	Percentage (%)	95%	**T**
PERC-API-NFR-0800	**PERC-API-NFR-0801**	Error Response Accuracy	Correctness in error status codes and messages.	Percentage (%)	95%	**T**
PERC-API-NFR-0900	**PERC-API-NFR-0901**	Data Privacy Compliance	Compliance with GDPR and other data privacy regulations.	Boolean	Compliance	**A**

PERC-API-NFR-1000	**PERC-API-NFR-1001**	Rate Limiting Effectiveness	Effectiveness of rate limiting during peak usage.	Percentage (%)	99.90%	**T**
PERC-API-NFR-1100	**PERC-API-NFR-1101**	Logging Coverage	Completeness of API logging.	Percentage (%)	>99%	**A**
PERC-API-NFR-1200	**PERC-API-NFR-1201**	Monitoring Integration	Integration with monitoring tools like Prometheus, ELK.	Boolean	Compatible	**A**
PERC-API-NFR-1300	**PERC-API-NFR-1301**	User Authentication Compliance	Implementation of JWT, OAuth2, or equivalent.	Boolean	Implementation	**A**

Table 25: PERCEIVE API KPIs and Validation Method

4.2.3.4 Development Collaboration Module

For the DCM, KPIs are designed to evaluate the module's effectiveness in facilitating collaborative development processes. These indicators assess aspects such as the efficiency of collaboration tools, the security of shared resources, and the ease of information accessibility. Ensuring these KPIs are met is integral for achieving a productive and secure development environment within the PERCEIVE project.

The KPI table for the DCM provides quantifiable metrics that cover various aspects of the module, including user collaboration efficiency, system security, and data management effectiveness. This table acts as a guiding document for continuous improvement, ensuring that the DCM effectively supports the collaborative needs of the development team and aligns with the overarching goals of the PERCEIVE platform.

DCM		**Development Collaboration Module**				
NFR ID	**KPI ID**	**Name**	**Description**	**Unit**	**Target Value**	**Methodology**
PERC-DCM-NFR-0100	**PERC-DCM-NFR-0101**	Data Encryption Compliance	Verifies compliance with data encryption standards.	YES/NO	YES	**A**
	PERC-DCM-NFR-0102	Access Control Effectiveness	Measures the effectiveness of access control mechanisms.	Percentage (%)	>95%	**A**
PERC-DCM-NFR-0200	**PERC-DCM-NFR-0201**	User Interface Satisfaction	Measures user satisfaction with the DCM interface.	Score (1-5 scale)	>4	**D**
PERC-DCM-NFR-0300	**PERC-DCM-NFR-0301**	System Performance Efficiency	Assesses overall system performance and uptime.	Percentage (%)	≥ 99.5%	**T**

PERC-DCM-NFR-0400	**PERC-DCM-NFR-0401**	Maintenance Efficiency	Evaluates the frequency and effectiveness of backups.	Times/Day	≥ 2	**T**
PERC-DCM-NFR-0500	**PERC-DCM-NFR-0501**	Scalability Handling	Measures the DCM's capacity to handle concurrent users.	Number of users	>1000	**T**
PERC-DCM-NFR-0600	**PERC-DCM-NFR-0601**	Tool Integration Rate	Rates successful integration with development tools.	Percentage (%)	>90%	**T**
PERC-DCM-NFR-0700	**PERC-DCM-NFR-0701**	Reliability Index	Scores the reliability and consistency of DCM.	Score (1-5 scale)	≥ 4	**D**
PERC-DCM-NFR-0800	**PERC-DCM-NFR-0801**	Regulatory Compliance Index	Confirms adherence to regulatory and compliance standards.	YES/NO	YES	**A**

Table 26: PERCEIVE DCM KPIs and Validation Method

5 Conclusions and Next Steps

The conclusion of Phase 1, as reflected in the Task 5.1 (T5.1) studies and encapsulated in Deliverable D5.1, signifies a pivotal juncture in the PERCEIVE project. This phase, dedicated to Pre-feasibility Studies, has been instrumental in meticulously defining the foundational requirements and specifications for both the PERCEIVE platform and its runtime environment. The comprehensive alignment with stakeholder needs, as delineated in the Deliverable D2.2 document, has been a guiding principle throughout this process.

1. **Achievements of Phase 1**:
   - **Comprehensive Needs Analysis**: The integration of Functional, Operational, and Technical Needs Analyses has laid a solid groundwork for the platform, addressing the multifaceted aspects of system requirements.
   - **High-Level Functionalities and Requirements Definition**: The articulation of High-Level Functionalities (HLFs) and High-Level Requirements (HLRs) has provided clarity and direction for the development process, ensuring that the platform resonates with the diverse expectations of its stakeholders.
   - **Operational and Technical Framework Establishment**: The identification of critical system components, their interactions, and technical specifications has offered a clear blueprint for developing a system that is scalable, secure, and user-oriented.
2. **Alignment with Stakeholder Needs**: The studies conducted have been pivotal in ensuring that every aspect of the platform is crafted to meet the explicit and implicit needs of the stakeholders. This alignment has been crucial in enhancing the relevance and efficacy of the platform in the context of cultural heritage preservation.
3. **Foundation for Future Development**: The conclusion of Phase 1 marks the laying of a robust foundation for the subsequent phases of the project. It has established a comprehensive framework upon which the detailed design and development of the PERCEIVE platform will be based.

In summary, the conclusion of Phase 1 represents a significant achievement in the PERCEIVE project, setting the stage for the forthcoming phases. The thorough groundwork laid in this phase is a testament to the project's commitment to developing a platform that is not only technologically advanced but also deeply aligned with the needs and aspirations of its diverse stakeholders. As we move forward, the insights and foundations established in this phase will be invaluable in guiding the development and realization of a platform that truly revolutionizes the way we interact with and preserve our cultural heritage through advanced digital technologies.

5.1 Phase #2 Roadmap

As we transition into Phase 2, the "Feasibility Studies", the focus will shift to the thorough assessment of potential hardware (HW) and software (SW) solutions that align with the specified system requirements. This process involves a detailed exploration of various technological options, evaluating their capabilities, compatibility, and the extent to which they fulfill the functional and operational needs identified in T5.1. Innovative technological approaches will also be explored, with an emphasis on their potential to enhance the platform's capabilities. This exploration aims to create a diverse pool of potential solutions, which will be crucial for the subsequent evaluation and selection process.

5.1.1 Solution Evaluation and Selection

The evaluation and selection process is a critical step in determining the most appropriate HW and SW solutions for the PERCEIVE platform. This involves a rigorous analysis of the identified solutions against a set of predefined criteria, which include factors like performance efficiency, scalability, interoperability, maintenance requirements, and cost-effectiveness. Utilizing decision matrices and scoring systems, each solution will be objectively assessed to ensure that the final selection aligns with the project's technical and operational goals. The outcome of this process will be a set of optimal HW and SW solutions that best fit the platform's requirements.

5.1.2 Conducting Supplementary Studies

The Feasibility Studies phase will incorporate a series of supplementary analyses to comprehensively assess the viability of the selected solutions. These include:

- **Technical Feasibility Analysis**: Assessing if the technical requirements can be met with the current state of technology.
- **Financial Feasibility Analysis**: Evaluating the financial aspects, including cost analysis, funding sources, and return on investment.
- **Market Analysis**: Understanding the potential market demand and competition.
- **Regulatory Compliance Check**: Ensuring that the solutions comply with all relevant laws and regulations.
- **SWOT Analysis**: A strategic planning technique used to identify strengths, weaknesses, opportunities, and threats related to the project.
- **Risk Analysis**: Identifying and evaluating potential risks and their impact on the project.
- **Trade-off Studies**: Balancing different options to determine the most effective approach.

These analyses will provide crucial insights into the viability and potential impact of the selected solutions on the overall project.

5.1.3 Preliminary Design Development

Following the selection of suitable HW and SW solutions, the next step is the development of a preliminary design for the PERCEIVE platform. This design will be developed keeping in mind the comprehensive needs of the platform, ensuring that it integrates seamlessly with the overall project architecture and stakeholder requirements. This phase will involve translating the outcomes of the solution evaluation process into a tangible and coherent design blueprint, which will serve as a guide for the platform's development.

5.1.4 Integration Strategy Formulation

An essential component of this phase is formulating strategies for the integration of the selected HW and SW solutions into the PERCEIVE platform's existing architecture. This includes planning for the integration with PERCEIVE Tools and Services and the Repository, ensuring that all components work harmoniously. The integration strategy will focus on maintaining system integrity, performance, and user experience while incorporating new technologies. This will involve detailed planning, resource allocation, and timeline definition, setting the stage for the successful implementation of the platform.

5.1.5 Preparation for Implementation

The final step in Phase 2 involves preparing for the actual implementation of the PERCEIVE platform. This includes establishing a comprehensive implementation roadmap, which will outline the steps, milestones, and timelines for the development and integration of the platform. Resource allocation will be critically assessed, ensuring that the necessary human, technical, and financial resources are available and efficiently utilized. This stage is pivotal in transitioning from the planning and design phases to the actual development and operationalization of the PERCEIVE platform, marking a significant step towards realizing the project's objectives.