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Project Report

Co-Designing in Cultural Tourism: TExTOUR ICT Services and Performance Monitoring System

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Abstract: The enhancement of cultural heritage for tourism can greatly benefit from the opportunities offered by Information and Communication Technologies (ICTs), promoting greater interaction and integration between all stakeholders and service providers. In recent years, ICT applications and platforms have tended to provide a platform to translate the strategic goals and performance metrics of cultural heritage tourism into comprehensive services tailored to stakeholders' needs by participating stakeholders. A successful co-designed platform integrates explicit services—requiring specialized software tools—and implicit services, facilitating evaluation processes. This adaptability ensures continuous improvement and alignment with evolving strategies and business objectives. As part of the European project, the development of the TExTOUR open ICT platform marks a significant advancement in leveraging technology within cultural tourism. It exemplifies the creation of a sustainable and adaptable framework, co-designed specifically to support and amplify the strategic objectives of cultural heritage tourism. This approach not only fosters better engagement and management within the sector but also sets a new standard for innovation in cultural tourism practices.

Keywords: co-design; ICT platform; ICT services; performance monitoring system; cultural heritage tourism; sustainability; digitalization; smart tourism

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1. Introduction

As digital transformation progresses, smart tourism (ST) including cultural heritage tourism has increasingly focused on leveraging advanced technologies to enhance cultural heritage experiences. In today's tourism market, the successful valorization of a destination's cultural and geographical assets relies strongly on digital technologies, which are now indispensable for promoting and developing cultural tourism [1]. By integrating these technologies, cultural heritage attractions can be presented to tourists in more engaging and dynamic ways, enabling interactive and personalized experiences that were once unattainable [2]. These innovations foster collaboration and continuous improvement among key stakeholders, including public entities, private businesses, and tourists.

One approach gaining significant traction is co-design, particularly in developing ICT platforms for cultural heritage tourism. Co-design aligns the needs of tourists and local communities, promoting sustainable and culturally enriched experiences. In tourism, the co-design method leverages big social data to enhance visitor experiences, fostering value co-creation between tourists and service providers [3,4]. This collaborative design process not only improves user experience but also strengthens the integration of technology in service delivery. Across various sectors, including healthcare and tourism, co-design has proven critical in developing platforms that are both user-centric and contextually meaningful [5].

In cultural heritage tourism, in parallel, smart technologies could be embedded within the platform, such as real-time monitoring sensors and interactive digital storytelling. These technologies allow for a nuanced understanding of conservation needs while engaging a broader audience. The platform's ability to adapt to the data it gathers ensures proactive and predictive conservation efforts, aligning with global standards [6,7].

In this paper, we present multimodal ICT technologies that provide a tangible smart product while facilitating co-design in cultural heritage sites, connecting stakeholders and communities. We illustrate how co-design processes were applied in practice, using real-world use cases from the TExTOUR project. Furthermore, we propose an innovative model for monitoring site performance using developed Key Performance Indicators (KPIs) and a monitoring system. By integrating these technologies, the platform sets a benchmark in the symbiotic relationship between cultural heritage social and technological innovation, showcasing a model that could potentially be replicated in diverse heritage contexts worldwide.

The paper is organized as follows: Section 2 provides a conceptual background of co-design and ICT impact on smart tourism; Section 3 explains the methodology of developing ICT services and performance monitoring systems in TExTOUR; in Section 4, the co-design process and general features of the platform are described; Section 5 is dedicated to describing the obtained results and use cases; Section 6 presents a verification methodology; and finally in Section 7 the discussion and conclusion are summarized.

2. Conceptual Background

Regarding the cultural demand to become a lever for economic development in urban and rural destinations, it is necessary that cultural policies facilitate the creation of synergies at different scales, capable of channeling entities and organizations active in the field of culture. For several years, research and recommendation reports based on innovative tools and completed projects in cultural heritage tourism have highlighted key needs. These needs include the development of group-centric applications for shared cultural experiences, the adoption of holistic approaches to cultural heritage protection and tourism management, and the promotion of digitalized heritage tourism as an effective means of transferring new knowledge and technologies from research and development [8,9]. Additionally, there is a growing demand for empirical models and data to inform policy and decision-making related to investments in cultural heritage, as well as the creation of indicator-based models for regional and urban development strategies concerning cultural heritage [9,10].

Due to these challenges and gaps, digitalization, smart technologies, and the wide application of ICT services that incorporate user-generated content have become essential for capturing timely insights and changing user's experiences in smart tourism, including cultural heritage [5]. These insights support data-driven decision-making strategies, enabling the effective management of complex stakeholder relationships and helping to bring synergy [5]. ICT platforms facilitate connections among key players—locals, tourists, and heritage assets in many phases—from gathering information to interacting with a heritage site or third parties. ICT has played a crucial role in the management of cultural heritage sites, offering various applications such as information gathering, enhancing interactions with heritage sites, the virtual use of objects (e.g., panoramic pictures), and enriching visitor experiences through localized and context-aware tools [11].

The COVID-19 pandemic has further accelerated the adoption of digital technologies in tourism, offering viable alternatives to physical experiences [12,13]. This digital shift has enabled cultural heritage sites to offer virtual tours, narrative storytelling, and interactive platforms that enhance the visitor experience and strengthen connections with local identities [14]. As the tourism sector continues its digital transformation, ICT platforms are evolving to offer increasingly sophisticated solutions that empower stakeholders to engage in the co-design process. These platforms not only improve operational efficiency but also enable the creation of innovative business models that emphasize value co-creation [15].

However, one of the primary challenges in integrating ICT into cultural tourism lies in aligning the diverse and dynamic objectives and priorities of stakeholders. Effective stakeholder engagement, facilitated by ICT platforms, is key to overcoming this issue. Research shows that involving the right stakeholders—including community leaders and government representatives—reduces conflict and promotes the effective use of local expertise, which is essential for the success of ICT projects [16]. Co-design is a collaborative design process where stakeholders work together to create solutions, incorporating diverse perspectives and expectations. This approach fosters mutual understanding, resulting in systems that better align with user needs and improve overall satisfaction [17].

Co-design has gained considerable traction in cultural tourism, as evidenced by over 800 publications since 2020 indexed in Google Scholar from 2020 to 2024. These studies highlight its potential to integrate the technical expertise of system designers with the lived experiences of users, ensuring that the services developed are both relevant and effective. The co-design approach prioritizes the collection of feedback and active participation, empowering users to contribute meaningfully to the design process and providing them with tools to address real-world challenges [18].

Despite the theoretical support for co-design in cultural tourism, in practice, projects often face difficulties in effectively implementing these methodologies which remain one of the open issues and challenges regarding multimodal, connected, and other forms of technologies to facilitate the co-design of heritage as which technologies are being used to support collaboration on cultural heritage sites or means to connect to grassroots communities [19]. While limited initiatives, such as INCULTUM [20], IMPACTOUR [21], meSch [22], and CulTour [23] have successfully applied co-design approaches, still there is a significant gap, particularly in publications and knowledge sharing, regarding the practical implementation and introduction of robust frameworks tailored to develop ICT services that cater to both visitors and destination managers through a single point of access. This highlights the need for proven frameworks that provide tools for better site management, addressing the unique requirements of lesser-known or emerging destinations, which often differ from those of mass tourism sites. This need shapes the core of the TExTOUR project to co-design an open ICT platform tailored for unknown or less known cultural heritage sites while providing ICT services to promote and boost their visibility by performance monitoring systems that enable them to track the result of the implemented strategies on their sites.

3. Methodology

The research methodology was carried out to answer the central question of the project; "which technologies and ICT services can be developed to support and satisfy the strategic economic and business goals determined to promote the cultural unknown or less known heritage sites?".

The initial step started with the literature review. Grounded in the state-of-the-art practices of ICT platforms, the chosen methodology draws heavily from co-design principles and active participant involvement, mirroring the approaches successfully employed in other sectors. Although this approach is relatively new to the domain of cultural tourism, adopting successful methodologies from other disciplines—such as digitalization in healthcare and industrial systems—holds significant promise. These elements, combined with the transformative effects of digital advancements, drive the convergence of cultural heritage and tourism.

The development process was structured into three critical phases: pre-design, co-design, and post-design, as has been applied in other disciplines (e.g., healthcare) to ensure effective implementation and scalability [4,5]. Each of these phases is essential for addressing the unique needs of cultural tourism while ensuring that the system is adaptable and sustainable. By integrating these phases, the methodology provides a robust framework for both the design and long-term success of ICT solutions in the cultural heritage sector.

Method: To orchestrate ICT in order to support and promote sustainable tourism in unknown or less known cultural heritage sites and obtain feedback from end-users, an empirical study was conducted to elicit requirements and obtain feedback from them to design an ICT architecture that is easy to use, flexible and user friendly. The methodology to gather and analyze information from stakeholders was shared through surveys, pilot forums, and semi-formal (bilateral) meetings. At the end of the feedback period, we proved the tool by the result of validation and verification.

Use case design: Eight pilots from unknown and less learned sites were chosen and participated in this study. The TExTOUR Cultural Tourism-Labs (CT-Labs) across various European sites, including Crespi D'Adda, Narva, Umgebindeland, Via Regia, Trebinje, Tarnowskie Góry, Vale do Côa—Siega Verde, and Anfeh—Fikardou, emphasize enhancing CT and local economic development through heritage preservation, innovative tourism strategies, and stakeholder engagement. Each CT-Lab utilizes a common approach that focuses on sustainable tourism practices, cultural and historical education, and fostering community involvement to leverage the unique cultural landscapes and historical significance (Table 1). The CT-Lab works as an engagement channel between individuals and stakeholders during the co-design process.

Table 1. List and significance of TExTOUR CT-Labs.

Pilot Name	UNESCO [y/n]	Countries Involved	Representativeness
Crespi d'Adda	y	IT	Company town phenomenon
Narva	n	EE	Post-industrial heritage
Umgebindeland	n	DE, PL, CZ	Transnational cultural landscape
Via Regia	n	UA, FR, BY, ES	European cultural route
Trebinje	n	BA, HR, ME	Balkan diversity
Tarnowskie Góry	y	PL	Historic post-mining facilities
Vale do Côa	y	PT	Prehistoric rock art sites
Anfeh/Fikardou	n	LB, CY	Traditional coastal activities/Village authenticity

IT: Italy, EE: Estonia, DE: Germany, PL: Poland, CZ: Czech Republic, UA: Ukraine, BY: Belarus, FR: France, ES: Spain, BA: Bosnia Herzegovina, HR: Croatia, ME: Montenegro, PT: Portugal, CY: Cyprus, LB: Lebanon.

4. Co-Designed ICT Platform

Implemented Co-design framework. As illustrated in Figure 1, by gathering accurate information from a variety of sources, we ensured that our analysis was based on reliable data. The data collection process was inclusive, incorporating the perspectives of all stakeholders to ensure relevance and applicability.

At every stage (pre-design), our approach is founded on user engagement and collaboration. By involving stakeholders actively at each step, we ensure that the knowledge created is not only comprehensive and accurate but also directly relevant and actionable. This method facilitates more innovative actions and enables more effective decision-making, as stakeholders are equipped with validated information that can be utilized to drive meaningful impact in the realm of cultural tourism.

We have ensured that the platform is not only technically robust but also user-friendly and adaptable, integrating data and services from external sources where possible. The platform's capacity for continuous monitoring and assessment, supported by advanced quantitative and qualitative tools, positions it as a cutting-edge solution for cultural tourism management. This deliverable confirms our commitment to providing a sustainable,

scalable, and innovative platform, meeting and exceeding the project's goals and paving the way for future advancements in the field (co-design).

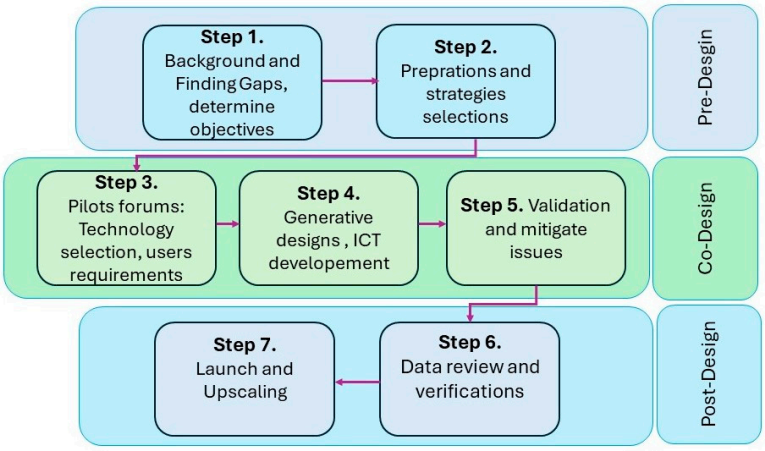


Figure 1. Co-design methodology to develop TExTOUR ICT platform adapted from 4, 5.

Following data collection, the analysis phase is conducted. During this stage, the collected data is systematically processed and interpreted to extract meaningful insights. We place a strong emphasis on user engagement throughout the analysis, involving stakeholders actively in interpreting the data. This collaborative approach ensures that the analysis reflects the collective expertise and experience of all stakeholders, resulting in more robust and contextually relevant insights.

Equally important is the validation stage, where the analyzed information undergoes rigorous review and verification to ensure its accuracy, reliability, and practical utility. Validation is a collaborative effort involving feedback loops with stakeholders to ensure that the information aligns with their needs and expectations. This process not only enhances the credibility of the information but also fosters a sense of ownership and trust among stakeholders (post-design). This section focuses on the co-design and post-design phases.

4.1. ICT Platform Objectives and Key Elements

After the analysis of the requirement during the pre-design phase and aligning with the European H2020 objectives, we defined the primary objectives of the ICT platform to assist as follows:

- **Fostering Understanding**: The platform seeks to bridge gaps in knowledge and appreciation of lesser-known sites. By offering accessible information, it promotes a deeper understanding among visitors and stakeholders.
- **Enhancing Visitor Experiences**: Beyond simply disseminating data, the platform aims to enrich visitor experiences. Interactive maps, multimedia content, and personalized recommendations help create meaningful and memorable encounters with cultural heritage.
- **Empowering Decision Makers**: Local authorities, site managers, and policymakers benefit from the platform's insights. By providing Key Performance Indicators (KPIs) related to socio-economic impacts, it supports informed strategic decisions.
- **Increasing Visibility and Promotion**: The platform enhances the visibility of cultural heritage sites that might otherwise remain undiscovered, acting as a digital beacon to attract interest.

The TExTOUR ICT [24] platform is developed on the foundation of web-based services and focuses on three key elements:

Digitalized Content: Including texts, images, photos, audiovisual materials, 3D models, and diagnostic data.

Equipment: Comprising both hardware and software components. Interactive Kiosks and QR Codes: Install interactive kiosks at cultural sites. Visitors can access multimedia

content, historical context, and navigation assistance. QR codes placed strategically can link to online resources or provide additional details, as well as surveys.

Technology Development: Involving the deployment and adaptation of the experience across various devices, tailored to the specific type of pilot desired.

This architecture enables interoperability across various platforms (on-site and online) and among different user types (enhancing usability for both experts and non-experts). The platform supports the management of diverse multimedia content, integrating information from multiple stakeholders and accommodating heterogeneous data. In the following subsections, the main features and components of the platform are explained.

4.2. ICT Platform Actors and Features

The platform is designed to accommodate three primary actors: Admin, Pilot, and Reviewer, each with distinct roles and responsibilities to ensure the effective management and operation of the platform. Figure 2 details three actors and overall services.

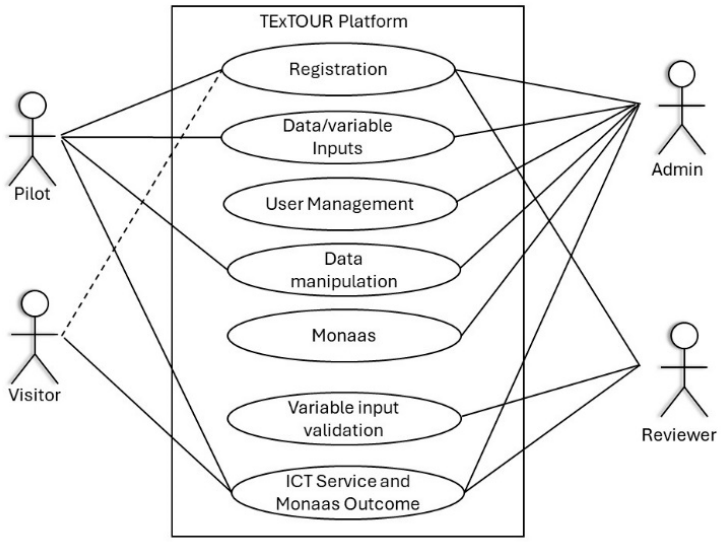


Figure 2. UML activity diagram of roles in the TExTOUR platform.

1. *Admin*. The Admin role has comprehensive control over the platform. Admins are responsible for managing and maintaining the overall system, including adding, editing, and deleting general information. They oversee the platform's functionality, ensuring that all components work seamlessly together. Admins also handle user management, ensuring that Pilots and Reviewers have the necessary access and permissions to perform their tasks.
2. *Pilots*. They are cultural tourism initiatives that use the platform to develop and manage their projects. Each Pilot must register on the platform to access its suite of ICT services. Pilots can input and manage data related to their cultural sites, utilize various assessment tools, and interact with other stakeholders. The platform supports Pilots in implementing and monitoring strategies tailored to their specific needs, providing tools for data analysis, event management, local product promotion, visitor satisfaction assessment, and more.
3. *Reviewer*. Reviewers are tasked with validating the data submitted by Pilots. They ensure the accuracy and reliability of the information, contributing to the credibility and effectiveness of the platform. Reviewers play a crucial role in maintaining the quality of the data and supporting the iterative improvement of cultural tourism strategies through continuous feedback and validation.

Key features include a unified content management system that allows stakeholders to share cultural information seamlessly and a robust infrastructure that facilitates simple, fast, and secure management by different user groups. The platform also incorporates advanced

tools for monitoring user preferences and needs through the collection of user-generated data, allowing administrators to continuously assess and refine cultural tourism strategies. The comprehensive features of the platform are included in Table 2:

Table 2. TExTOUR features and functions.

Feature	Function
Actors and Overall Services	Three primary actors (Admin, Pilot, Review) facilitate various platform functionalities.
Accessibility and Source Code	The platform is open to all, promoting inclusivity and widespread use.
Digital Service Module	Assessed based on feasibility and scalability
Service Setup	Includes creating, listing, editing, and deleting various ICT services and adding galleries.
MoNitoring as a Service (MoNaaS Internal Service)	Manages data entry, review, automatic analytics, and summary reporting.
Dashboard	Continuous monitoring through KPI calculations and variable modules.
User Support	Provides video tutorials, user guides, and FAQs for effective platform usage.
Verification Methodology	Ensures the platform's reliability and performance through comprehensive testing.

This integrated system not only provides users with up-to-date content at various scales but also enables administrators to monitor performance and gain valuable insights into tourists' habits and preferences. The final release of the platform represents a significant milestone, offering a sustainable and adaptable framework that aligns with the strategic goals of the project (refer to Section 4.1) and supports ongoing assessment and improvement of cultural tourism initiatives.

4.3. ICT Components

As shown in Figure 3, the components are categorized into explicit and implicit services. The explicit services, designed specifically for tourists and visitors, include digital services named points of interest (POI), routes, a combined map featuring both POI and routes, events, local product promotion, establishments, and visitor surveys. These services enhance the visitor experience by offering detailed insights, interactive maps, event updates, local product showcases, establishment information, and feedback mechanisms through QR codes.

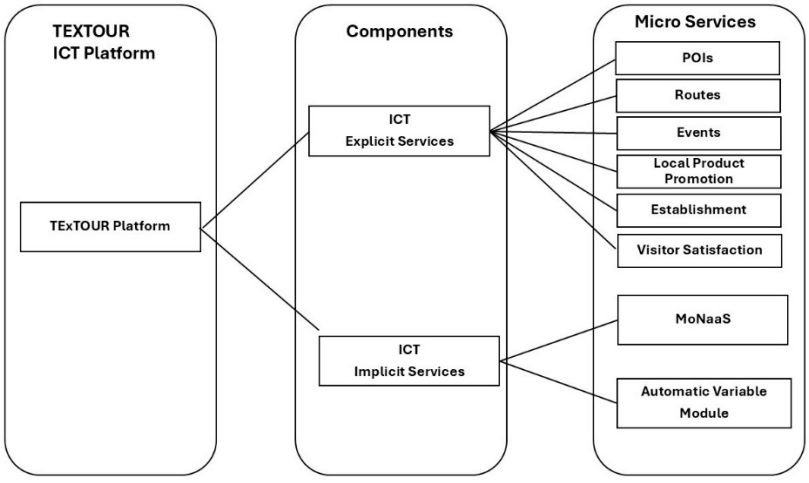


Figure 3. The TExTOUR platform components and services.

The implicit or internal services are intended for stakeholders to manage and provide information. These include microservices called MoNitoring as a Service (MoNaaS) and the Automatic Variable Module, which aid in overseeing and optimizing platform performance. The following subsections provide a detailed explanation of these services.

Each of the services is explained in the following sections: each of them has its own functionality, databases, and human–machine interface components. Here, we avoid the technical description, as it is out of the scope of this paper.

The TExTOUR platform co-design includes an architecture that enables interoperability and facilitates diverse functionalities through various ICT components and microservices. In the following, we provide a breakdown of some of the microservices and their roles within the platform, provided in Table 3:

Table 3. TExTOUR microservices and their roles in the platform.

Microservices	Role in the Platform
Digital Service Module	- This module is essential for managing and integrating various ICT services like points of interest (POIs), routes, events, local product promotions, and establishments. - It allows the creation, listing, editing, and deletion of entries for each service, ensuring that pilots can manage the digital content related to their cultural sites effectively
User Management Service	- This service controls access and permissions for the three main user roles: Admin, Pilot, and Reviewer. - It manages user registration and authentication, and ensures that each role can perform specific tasks within their domain, maintaining a clear separation of responsibilities.
MoNitoring as a Service (MoNaaS)	- MoNaaS provides tools for continuous monitoring and analysis of Key Performance Indicators (KPIs). It includes data entry, review, automatic analytics, and summary reporting. - This microservice is crucial for evaluating the performance of various strategies deployed by the pilots and for providing insights into progress through real-time data tracking.
Automatic Variable Module	- This module automates the data collection process for KPIs by leveraging external data sources like OpenStreetMap (OSM) and official statistical databases such as Eurostat. - It streamlines the extraction and validation of data, producing both CSV and georeferenced files for use in KPI calculations. This allows for consistent data integration across different pilot sites, ensuring the accuracy and reliability of the metrics used.
Content Management Service	- This microservice allows for the management of multimedia content, such as text, images, audio, and video, associated with cultural sites. It supports the upload and organization of digital resources that can enhance the visitor experience. - It includes the “Add Gallery” feature, enabling users to attach various types of multimedia to their entries, making cultural and historical information more engaging for visitors.

Table 3. *Cont.*

Microservices	Role in the Platform
Issue Reporting and Change Management Service	- This service is responsible for managing Issue Reporting Forms (IRFs) and Change Request Forms (CRFs). It tracks reported issues and changes, facilitating communication between the platform users and the technical team. - By logging and managing changes and issues, it ensures that feedback is systematically addressed, leading to continuous improvement of the platform.
Visitor Feedback Service	- This microservice gathers feedback from users through surveys and QR codes, allowing visitors to share their experiences and provide input on events, routes, and cultural sites. - The service analyzes the feedback, enabling the platform to adapt and improve continuously based on user needs and preferences.

These microservices form a cohesive architecture that supports both on-site and online interactions, providing a user-friendly, flexible, and scalable platform. This design allows the TExTOUR platform to manage a diverse set of needs, from cultural site management to real-time data monitoring and stakeholder engagement.

4.3.1. User Management Service

Registration Function of Authorization: The platform must verify the credentials of both pilot users and end-users through a secure username and password authentication system. To ensure the accuracy and integrity of the site's information and features, only the administrator is granted full functionality to add, edit, and manage general content. Figure 3 illustrates the process flow of the registration module, which is folded into three main sub-modules: Registration, Authorization, and Activation. The new user should fill in the basic information shown in Figure 4, which denotes mandatory fields.

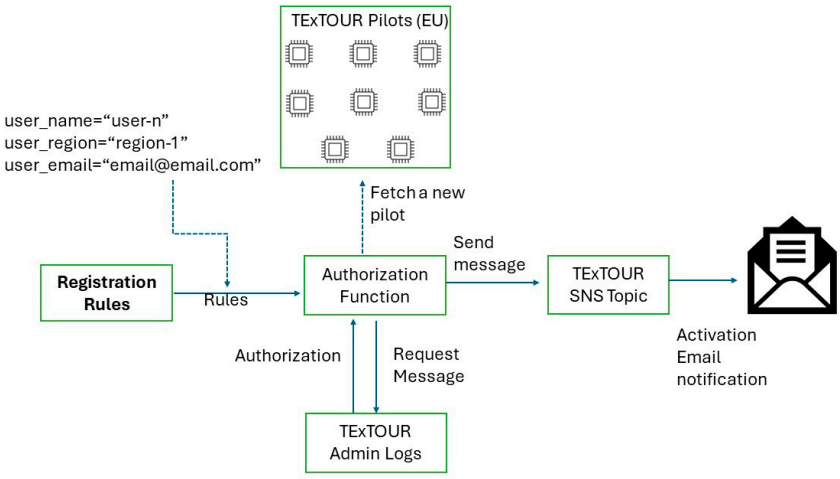


Figure 4. Service registration and authentication management system.

1. **Registration**—During the registration phase, users are prompted to input the required personal and account information. Upon completion and submission (via the "Create New User" action), a notification instructs users to check their email for further steps.
2. **Authentication**—Once a user initiates account creation, an authentication email is automatically dispatched to the registered email address. This email contains a verification link, which, when clicked, directs the user to the designated confirmation

page (as illustrated in Figure 3). The system informs users that the account activation process is underway, pending approval by the system coordinator.

3. **Activation**—The coordinator is alerted following a successful user verification. Based on predefined criteria and user role requirements, the coordinator holds the authority to either activate or deactivate user accounts.

4.3.2. ICT Service Module

The functionality of these services includes disseminating information about geographical locations, points of interest, events, and promoted products related to those areas. Table 4 summarizes the specific ICT services, detailing their goals, functionality, and user experience. They are evaluated based on feasibility and scalability. Additionally, they collect and analyze visitor feedback and provide interactive content that immerses users in historical events, cultural heritage, natural wonders, or scientific discoveries. These features are designed with a human–machine interface, allowing users to access and engage with them directly through the platform by clicking on the services.

Table 4. ICT services embedded in TExTOUR.

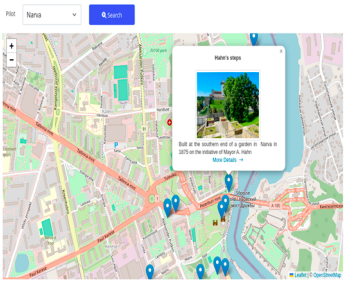
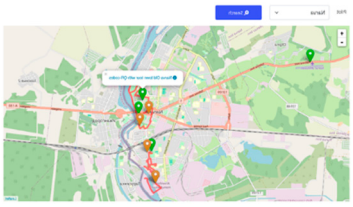
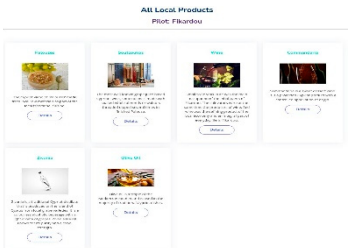
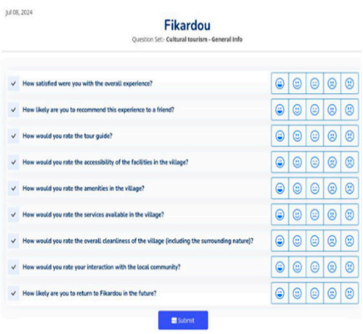
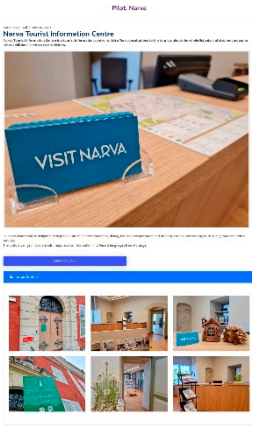
Service	Goal	Functionality	User Experience
Point of Interest (POI)	Disseminates information via QR codes in text, audio, and video formats.	1. Disseminate information about various points of interest (museum documentaries, historical background of villages.) 2. Enables visitors to gain a deeper understanding of the significance and stories behind these locations and artifacts.	
Route	Provides information on accessible routes connecting cities and thematic routes.	Offers detailed information on accessible routes that connect border cities and various thematic routes, highlighting specific themes (historical landmarks, cultural sites, scenic views, or other points of interest, thereby providing travelers with curated options for their journeys.)	
Event	Announces and posts cultural events and workshops.	1. Facilitates the dissemination of event announcements, allowing users to post details about upcoming cultural events and workshops. 2. Enables uploading data and media related to events after they have taken place, such as photos, videos, and summaries, ensuring comprehensive documentation and easy access to event information.	
Local Product Promotion	Promotes local foods, products, and vendors.	Focuses on highlighting locally produced items, showcasing their quality and uniqueness to potential consumers. It prohibits promoting privately owned products, ensuring that only locally sourced goods are featured and supported through this platform.	

Table 4. *Cont.*

Service	Goal	Functionality	User Experience
Visitor's Satisfaction	Collects user feedback on events, routes, and places.	It enables users to provide feedback on various aspects, such as events, routes, places, etc. This feedback mechanism allows users to share their experiences, opinions, and suggestions, which can help improve the quality and relevance of future events, optimize route planning, enhance the attractiveness of destinations, and refine overall user satisfaction. By gathering and analyzing this feedback, the service aims to continuously adapt and improve to meet the needs and preferences of its users, fostering a more responsive and user-centric experience.	
Establishment	Offers digitalized documentaries to enhance visitor engagement	Enrich their overall experience. By digitizing these documentaries, the service provides accessible and interactive content that immerses visitors in historical events, cultural heritage, natural wonders, or scientific discoveries. This approach educates and captivates visitors, offering them a deeper understanding and appreciation of the subject through innovative digital media formats.	

4.3.3. MoNitoring as a Service (MoNaaS Internal Service)

The development of MoNaaS (MoNitoring as a Service) within the TExTOUR project responds to the need for enhanced management and evaluation of cultural tourism strategies. This service is designed to facilitate effective data management, analysis, and reporting, which are essential for navigating the complexities of cultural tourism.

By providing an advanced dashboard that enables continuous monitoring of Key Performance Indicators (KPIs) alongside other vital metrics such as targets and costs, MoNaaS ensures that stakeholders have access to accurate, real-time insights. This functionality supports informed decision-making, allowing for the adaptability and scalability of strategies as circumstances evolve.

Moreover, MoNaaS plays a critical role in enabling proactive and predictive adjustments to ongoing efforts. By facilitating timely interventions, this service aligns with the primary goals of promoting sustainable and inclusive cultural tourism within the TExTOUR project.

Eight CT-Labs are running an 'ad hoc' strategy designed and implemented in a co-participative model, where each pilot conforms to a living lab to promote cultural tourism (CT) in their respective relevant urban and rural domains. It should also be noted that the CT-Labs interact together upon synergic collaboration encompassing different types of CT.

The strategies in each CT-Lab are deployed in concrete actions that follow some activities. All monitoring programs are about gathering and analyzing data at the action level according to three premises:

To evaluate the effectiveness of the strategies while deploying the actions, pointing out their nexuses with economic growth and employment (based on methodological KPI).

To evaluate the deployment of these actions according to the calendar set up for implementation (based on targets established in co-participatory CT development strategies and action plans).

To explore if it is possible to keep track of indicative costs and funding sources for action deployment (also based on the resources estimated in co-participatory CT development strategies and action plans).

4.3.4. Automatic Variable Module

The Automatic Variable Module plays a crucial role in the TExTOUR project by streamlining data collection and KPI calculation processes. This module leverages various sources, including OpenStreetMap (OSM)—a well-known crowdsourcing geographical database for creating and distributing free geographical data for the whole world [25,26]—and official statistical databases to automate the gathering of necessary variables for KPIs. The key features and functionality of this module are listed as follows.

Data Sources and Integration:

- The module primarily utilizes OSM for geospatial data, which covers global urban information independently of statistical boundaries. This allows for comprehensive data collection regardless of the pilot's geographical limitations.
- Official statistics from Eurostat at different nomenclature of territorial units for statistics (NUTS)[1] levels are also integrated to enhance the accuracy and reliability of the data. These levels include NUTS 0 (countries), NUTS 1 (major socioeconomic regions), NUTS 2 (basic regions for regional policies), and NUTS 3 (small regions for specific diagnoses).

Automation Process:

- The automation process involves the extraction of data from OSM, which is then validated against local knowledge and official statistics to ensure accuracy.
- The module provides two types of output files: a CSV file with the total count of elements necessary for KPI calculation and a georeferenced file that includes the location and information of these elements.

Categories of KPIs:

- The module covers various categories of KPIs, such as accommodation facilities, basic infrastructure, gastronomy, local products and services, and more.
- Each category includes specific KPIs with detailed formulas for calculation, necessary variables, and their respective data sources.

Preliminary Considerations:

- The module addresses potential discrepancies between the pilot's geographical boundaries and statistical boundaries, ensuring that the gathered data is as precise as possible.
- It also highlights the collaborative nature of OSM and the need to verify and supplement this data with local information when necessary.

Benefits and Impact

The Automatic Variable Module significantly enhances the efficiency and effectiveness of the TExTOUR project by automating the data collection process. This not only reduces the manual effort required but also ensures a higher degree of accuracy and reliability in the KPIs used for project evaluation and replication.

By leveraging both collaborative and official data sources, the module provides a robust framework for the ongoing monitoring and assessment of tourism-related initiatives, contributing to the sustainable growth of cultural tourism through participative and data-driven approaches.

List of Variables: The module manages a comprehensive list of variables critical for evaluating cultural tourism strategies. These variables are categorized based on their relevance to different aspects of the project, such as infrastructure, services, and economic impact. Key variables managed by the module are described in Table 5.

Table 5. Variables for evaluating cultural tourism strategies.

Variables	Function	Necessary Input	Result
Pilot Area	Several KPIs require the area of the pilot as an input for calculation. The area is calculated based on the delimitation area of the pilot provided in shapefile or geojson format.	Delimitation area of the pilot in shapefile or geojson format.	Calculate the area of the pilot delimitation in square meters (m^2).
Routes Length	This variable involves calculating the length of routes within the pilot area	Delimitation of the routes in shapefile or geojson format.	Calculate the length of routes in meters (m).
Accommodation Facilities	This includes the number and geolocation of accommodation facilities within the pilot area	Delimitation area of the pilot in shapefile or geojson format.	Number of accommodation facilities and their geolocations.
Accessibility of Highways	These variable measures the travel time to the nearest highway from a given location within the pilot area.	Location point (X and Y coordinates in WGS84).	Travel time to the nearest highway.
Number of Parking Spaces	This involves counting and geolocating parking spaces within the pilot area.	Delimitation area of the pilot in shapefile or geojson format.	Number of parking spaces and their geolocations.
Number of ATMs	This includes the count and geolocation of ATMs within the pilot area.	Delimitation area of the pilot in shapefile or geojson format.	Number of ATMs and their geolocations.
Number of Public Sanitary Facilities (Toilets)	This variable involves counting and geolocating public sanitary facilities within the pilot area.	Delimitation area of the pilot in shapefile or geojson format.	Number of public sanitary facilities and their geolocations.
Rental Stations (Car Rental Points)	This includes the count and geolocation of car rental stations within the pilot area.	Delimitation area of the pilot in shapefile or geojson format.	Number of rental stations and their geolocations.

Each variable is carefully defined and standardized to ensure consistency and reliability in data collection and analysis; see Figure 5.

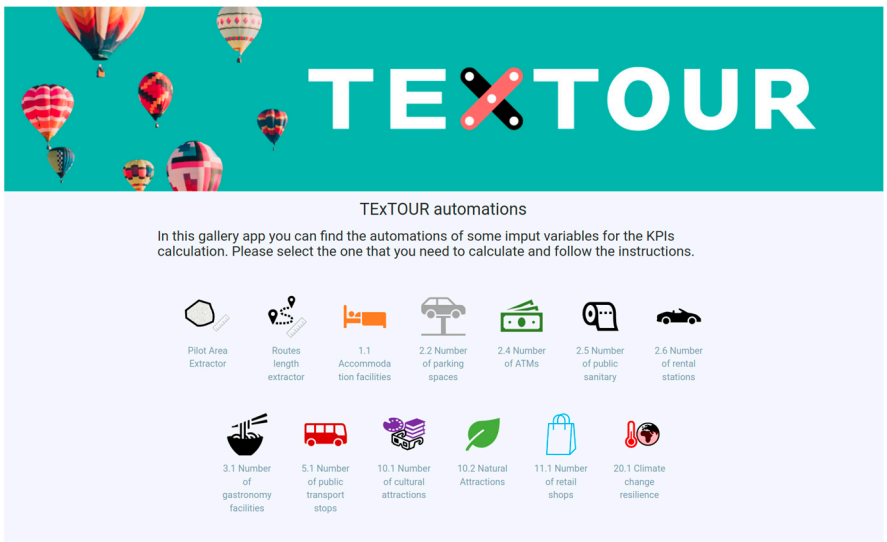


Figure 5. Automatic Variable Module.

5. Validation and Results

Two things should be validated: ICT services and strategies (solution), and for this reason, Pilot cases were used to fine-tune the tool, demonstrate its potential in different typologies of cultural tourism forms, and analyze its replicability and uptake potential in fostering cultural tourism good practices. The validation process for the CT-Labs identifies

requirements for fine-tuning the final platform for services and ICT tools. The platform incorporates advanced quantitative and qualitative tools for assessing the impact of cultural tourism strategies.

The validation of the co-designed ICT platform as well as the developed strategies and solutions through the project were carried out by three monitoring campaigns (MoCams). The MoCams were held for five months which was deemed an appropriate amount of time to understand the perception of changes. These three MoCams were preceded by a six-month period of definition, where fine-tuning and gathering feedback among pilots about the actions to be carried out was performed. They all involve the recording of the current value asked for in the KPIs/Targets/Costs. This was conducted by the CT-Labs upon respective online forms embedded in the TExTOUR platform.

5.1. The Process of the Solution Validation Through the ICT Tool

A list of 57 potential KPIs with a short description linked to four domains (economic, social, environmental, and cultural) is presented to each CT-Lab. For operational reasons (manageability and precision), a maximum of 15 KPIs should be selected in any case. Those linked to the economic domain help to find out the nexus with economic growth. It is worth remarking that 2 of these 15 KPIs are always mandatory, just related to employment (employment in tourism industry; job creation in tourism industry), showing the nexus with this important fact. Since the KPIs are selected in relation to specific actions, it is possible to determine their weight into the strategy they are framed.

In a practical way, KPIs are formulas that handle different 'constants' and 'variables'. Regarding variables, three aspects come into view:

- Base value: it is the latest available figure before starting the MoCams. Thus, it is the 'zero' to set up a baseline.
- Goal value: it is the realistic expected figure wanted to achieve (according to the corresponding KPI meaning). Thus, 'goal vs. base' deviations would be faced.
- Current value: it is the value asked for the corresponding period covered by the monitoring campaigns (MoCam1: April–August 2023; MoCam2: September 2023–January 2024; MoCam3: February–June 2024).

Apart from considering these KPIs for each CT-Lab to be tracked through MoCam1, MoCam2, and MoCam3, a new set of additional mandatory KPIs are faced to address specific topics pointed out by the reviewers appointed by the European Commission that are quantified right after MoCam3 (once the deployment of the CT strategies to ensure an overall appropriate implementation of the solutions is completed). These additional KPIs point out the opinion of visitors, the quality of the visitors' experience, the impacts of tourism on cultural and natural heritage, the OUV (Outstanding Universal Value) of WHS (World Heritage Sites), the diversity of the local economy, the community's wellbeing, social inclusion, and participatory governance. The opinion of visitors and at least another additional mandatory KPI was agreed to be provided by all of the CT-Labs.

Targets are 'short-term' expected results defined in co-participative workshops as a consequence of the implementation of the CT actions set up. Once the targets have been established, their means of verification can be numerical or Boolean (Y/N).

Therefore, the ICT platform provides a dashboard to monitor the performance progress. The dashboard, as shown in Figure 6, provides a real-time interface for continuous monitoring and visualization of data. This component integrates all the functionalities of the MoNaaS internal service, offering a comprehensive view of the collected data and calculated KPIs. The dashboard features include recommended actions based on the characteristics of the sites, impacted domains, reloaded variables, KPIs and assess their performance toward targets or goals of the site. The pilots/users, by choosing the actions, domains, and related KPIs, as well as targets, can track the progress in the timeline of the project from MoCam1 to MoCam3. The dashboard is designed to be user-friendly and accessible, providing stakeholders with the information they need to make informed decisions.

Figure 6. MoNaaS dashboard: monitoring the progress by choosing the KPIs, variables, and targets.

5.2. Use Cases and Validation Phase (CT-Labs)

The CT-Lab (Figure 7) was consolidated as a data source and use-case repository to define the functional requirements initially and to move forward with the co-design phase. The characteristics and introduction of each member are provided to understand the reasonableness of ICT services to promote these types of cultural heritage sites. Following that, each pilot is described, and their challenges and benefits during digitalization are discussed.

Figure 7. CT-Labs sites.

Crespi D'Adda is an exceptional example of a company town and a UNESCO World Heritage site. The village, built by the Crespi family during the 1800s and 1900s for their textile factory workers, remains well-preserved and illustrates a significant historical period marking the birth of Italy's modern industry. They aim to enhance visibility, stimulate the local economy through tourism, preserve the cultural landscape, and integrate with other UNESCO sites in Lombardy.

Narva is located in Estonia, close to the Russian border. It is known for its majority Russian-speaking population and historical textile manufacturing. The project aims to promote CT by leveraging the heritage and infrastructural potential particularly in the Kreenholm district, rich in post-industrial heritage, enhancing stakeholder engagement, creating an innovative light installation in the building of Joala factory and also thematic tours at Kreenholm.

Umgebindeland focuses on a unique cultural landscape across Germany, Poland, and the Czech Republic. This region is known for its "Umgebinde" houses, a distinctive type of half-timbered architecture. The project aims to boost local economies and tourism, promote the preservation of these historical structures, and enhance cross-border cooperation.

Via Regia aims to promote CT along one of Europe's oldest routes, connecting Spain to Russia. This initiative seeks to upgrade public infrastructure, develop tourism services, and train professionals in lesser-known regions like Rivnenska (Ukraine). It emphasizes strengthening transnational cooperation and fostering a European identity.

Trebinje focuses on boosting CT in this area of Bosnia and Herzegovina, by managing tourist flows, raising awareness of heritage values, and providing training for local stakeholders. Collaborative efforts to preserve and promote the city's rich cultural and historical assets are emphasized, which include a preserved urban fabric and archaeological sites, a small school of gastronomy and the Start!Art festival to increase tourism in Trebinje, which is less visited compared to nearby UNESCO sites Dubrovnik and Kotor.

Tarnowskie Góry, Poland, focuses on leveraging the region's historical mining heritage for CT. The initiative aims to improve the management of cultural routes, strengthen local policies, and create innovative tools for promoting cultural cooperation. Tarnowskie Góry, recognized for its early industrial significance and listed as a UNESCO World Heritage Site, offers a rich tapestry of geological and industrial heritage to explore.

Vale do Côa—Siega Verde focuses on the prehistoric rock art sites in Portugal and Spain, which are significant for their Paleolithic engravings. The initiative aims to enhance CT, develop a common tourism strategy between the two locations, improve knowledge through new archaeological data, and promote cultural management involving local communities. Vale do Côa—Siega Verde represents a unique prehistoric heritage that underscores a shared cultural identity.

Anfeh—Fikardou focuses on enhancing CT and heritage management in Anfeh (Lebanon) and Fikardou (Cyprus). Both areas aim to improve the preservation and adaptive reuse of their cultural and natural environments, enhance local products' quality and marketing, and foster a sustainable tourism model that supports the local economy. They share a commitment to high-quality protection of their unique attributes, recognized by their inclusion on the UNESCO World Heritage Tentative List.

The advantage of implementing a co-design solution is that it allows for the identification and mitigation of significant challenges that often arise during implementation. Unforeseen factors can emerge, and certain issues may not be initially recognized as challenges, but the co-design approach makes it possible to address them effectively.

In this project, each pilot faced unexpected and undocumented obstacles, which have been documented and disseminated for future reference [27]. For example, in the case of Fikardou, several key challenges were identified and addressed during the project, including the following:

Cost in terms of time and money when planning the digitization of cultural data, safeguarding the integrity and authenticity of the cultural heritage following digitization best practices, like metadata documentation, controlled storage environment, and management,

placing QR codes strategically to create paths and narratives that are easy to follow, not underestimating the digital skills that the team needs for the digitization process.

Finally, in Figure 8, the survey results illustrating the current state of ICT service usage by the pilot users are presented. A shared characteristic of the case studies is that the points of interest (POI), events, and routes were the most utilized services, given that the destinations were either unknown or less familiar. These findings highlight the successful co-design implementation, which delivered valuable services to the end users.

Which ICT services are you currently using or planning to use in your pilot project?								
Services / Pilot name	Points of Interest (POI)	Routes	Events	Local Product Promotion	Occupancy Rate	Visitor's Satisfaction	Establishment	Visitor Flow
Câo Park Foundation	√	√	√	√			√	
Via Regia Rivne	√		√			√		
Fikardou	√	√	√	√			√	
Umgebindeland	√	√	√					
Crespi d'Adda	√	√				√	√	
Narva	√	√	√	√	√	√	√	√
Tarnowskie Góry	√	√	√	√		√	√	
Trebinje	√	√	√			√		
Anfeh	√	√	√	√		√		
NETZ-Rivnesak region Partner	√		√			√		
Total Pilots using services	**10**	**8**	**9**	**5**	**1**	**7**	**5**	**1**

Figure 8. Pilots feedback on microservices—ICT-explicit services.

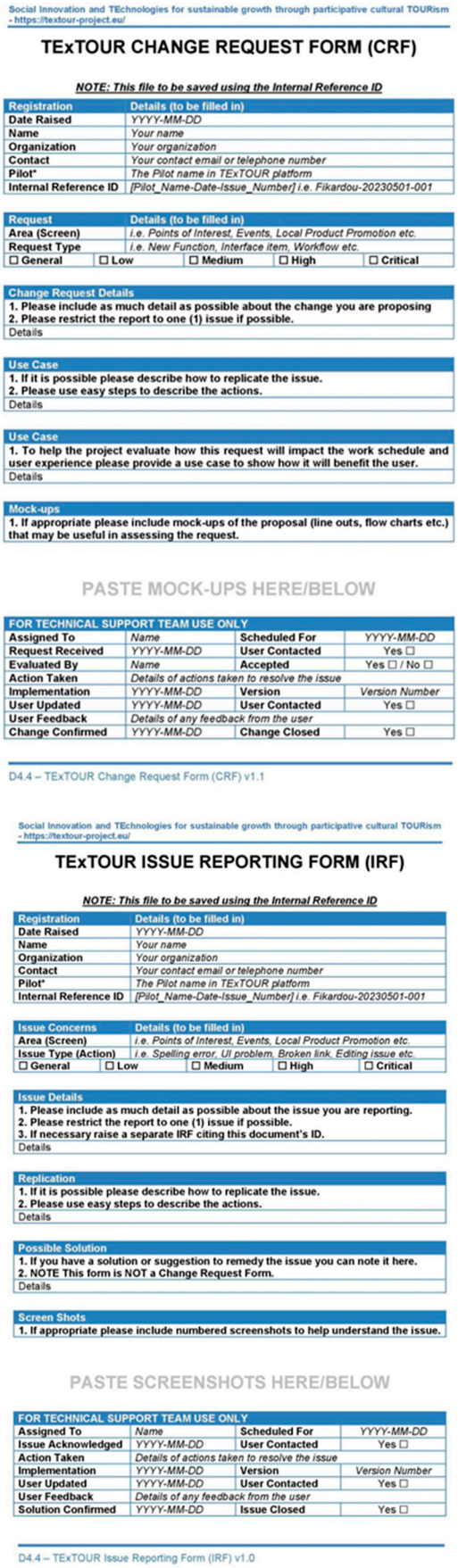
6. TExTOUR Platform Verification Methodology—Post-Design

To ensure that Pilot Validation Representatives (PVRs) provide comprehensive information to assist the technical support team in identifying and resolving potential issues with the TExTOUR tool, templated Issue Reporting Forms (IRFs) and Change Request Forms (CRFs) are produced. These forms are finalized in consultation with the technical support team to ensure that the information contained within them is as robust as possible and fit for purpose regarding issue resolution.

Issue Reporting Form (IRF): An Issue Reporting Form (IRF) is a structured tool used by platform users to report issues or bugs they encounter while using a digital product or service. The IRF is designed to facilitate effective communication between users and the development or support team, ensuring that problems are clearly understood and promptly addressed.

Change Request Form (CRF): A Change Request Form (CRF) is a structured document used by developers to communicate and document the resolution of issues or bugs reported by users. It serves as a formal record that details the changes made, the rationale behind those changes, and the steps taken to resolve the problem. This form is crucial for maintaining transparency, ensuring accountability, and facilitating effective communication between developers, users, and other stakeholders. Figure 9 presents a CRF and IRF forms format.

To address potential gaps in testing the ICT platforms within the TExTOUR project as described in Table 6, here are a few points to consider:



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TExTOUR CHANGE REQUEST FORM (CRF)

NOTE: This file to be saved using the Internal Reference ID

Registration	Details (to be filled in)
Date Raised	*YYYY-MM-DD*
Name	*Your name*
Organization	*Your organization*
Contact	*Your contact email or telephone number*
Pilot*	*The Pilot name in TExTOUR platform*
Internal Reference ID	*[Pilot_Name-Date-Issue_Number] i.e. Fikardou-20230501-001*

Request	Details (to be filled in)			
Area (Screen)	*i.e. Points of Interest, Events, Local Product Promotion etc.*			
Request Type	*i.e. New Function, Interface item, Workflow etc.*			
☐ General	☐ Low	☐ Medium	☐ High	☐ Critical

Change Request Details
1. Please include as much detail as possible about the change you are proposing 2. Please restrict the report to one (1) issue if possible.
Details

Use Case
1. If it is possible please describe how to replicate the issue. 2. Please use easy steps to describe the actions.
Details

Use Case
1. To help the project evaluate how this request will impact the work schedule and user experience please provide a use case to show how it will benefit the user.
Details

Mock-ups
1. If appropriate please include mock-ups of the proposal (line outs, flow charts etc.) that may be useful in assessing the request.

PASTE MOCK-UPS HERE/BELOW

FOR TECHNICAL SUPPORT TEAM USE ONLY			
Assigned To	*Name*	Scheduled For	*YYYY-MM-DD*
Request Received	*YYYY-MM-DD*	User Contacted	Yes ☐
Evaluated By	*Name*	Accepted	Yes ☐ / No ☐
Action Taken	*Details of actions taken to resolve the issue*		
Implementation	*YYYY-MM-DD*	Version	*Version Number*
User Updated	*YYYY-MM-DD*	User Contacted	Yes ☐
User Feedback	*Details of any feedback from the user*		
Change Confirmed	*YYYY-MM-DD*	Change Closed	Yes ☐

D4.4 – TExTOUR Change Request Form (CRF) v1.1

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TExTOUR ISSUE REPORTING FORM (IRF)

NOTE: This file to be saved using the Internal Reference ID

Registration	Details (to be filled in)
Date Raised	*YYYY-MM-DD*
Name	*Your name*
Organization	*Your organization*
Contact	*Your contact email or telephone number*
Pilot*	*The Pilot name in TExTOUR platform*
Internal Reference ID	*[Pilot_Name-Date-Issue_Number] i.e. Fikardou-20230501-001*

Issue Concerns	Details (to be filled in)			
Area (Screen)	*i.e. Points of Interest, Events, Local Product Promotion etc.*			
Issue Type (Action)	*i.e. Spelling error, UI problem, Broken link, Editing issue etc.*			
☐ General	☐ Low	☐ Medium	☐ High	☐ Critical

Issue Details
1. Please include as much detail as possible about the issue you are reporting. 2. Please restrict the report to one (1) issue if possible. 3. If necessary raise a separate IRF citing this document's ID.
Details

Replication
1. If it is possible please describe how to replicate the issue. 2. Please use easy steps to describe the actions.
Details

Possible Solution
1. If you have a solution or suggestion to remedy the issue you can note it here. 2. NOTE This form is NOT a Change Request Form.
Details

Screen Shots
1. If appropriate please include numbered screenshots to help understand the issue.

PASTE SCREENSHOTS HERE/BELOW

FOR TECHNICAL SUPPORT TEAM USE ONLY			
Assigned To	*Name*	Scheduled For	*YYYY-MM-DD*
Issue Acknowledged	*YYYY-MM-DD*	User Contacted	Yes ☐
Action Taken	*Details of actions taken to resolve the issue*		
Implementation	*YYYY-MM-DD*	Version	*Version Number*
User Updated	*YYYY-MM-DD*	User Contacted	Yes ☐
User Feedback	*Details of any feedback from the user*		
Solution Confirmed	*YYYY-MM-DD*	Issue Closed	Yes ☐

D4.4 – TExTOUR Issue Reporting Form (IRF) v1.0

Figure 9. Sample CRF and IRF forms format.

Table 6. Potential issues learned in the verification phase, reported gaps, and mitigation solutions.

Potential Impact	Gaps	Solutions
Incomplete or Ambiguous Issue Reporting	The process for PVRs (Pilot Validation Representatives) to report issues may not capture all nuances of problems encountered during the use of the TExTOUR tool. This can be due to varying interpretations of issues or incomplete details provided in the Issue Reporting Forms (IRFs).	To mitigate this, detailed guidelines were developed for PVRs on how to use the IRFs, ensuring a standardized approach to describing issues. This included specifying required fields in the form, such as steps to reproduce the issue and the impact level, to ensure consistency in reporting.
Delayed Change Management	If the process for submitting and processing Change Request Forms (CRFs) is not streamlined, it can lead to delays in implementing necessary changes or updates to the platform.	We addressed this by establishing clear communication channels between the PVRs and the technical team. Weekly review meetings were set up to prioritize CRFs, ensuring that critical issues were resolved promptly and that PVRs received timely feedback on the status of their requests.
Testing Across Diverse User Environments	The TExTOUR platform needs to perform consistently across different pilot sites, each with varying technical infrastructure and user needs. Initial testing may not fully account for these variations.	To address this, a diversified testing strategy was implemented, involving PVRs from each pilot site. This ensured that feedback came from a variety of environments and user experiences. The technical team also simulated different user scenarios to anticipate potential issues before platform deployment.
Lack of Real-Time Issue Tracking	Without real-time tracking of reported issues, there is a risk of missing out on critical insights during the testing phase.	A dashboard (online spreadsheet) for real-time issue tracking was introduced, integrating both the IRFs and CRFs. This allowed the technical support team to monitor reported issues as they arose and track the progress of each issue through to its resolution.

7. Discussion and Conclusions

The co-designing ICT platform involved collaborative efforts among diverse stakeholders to develop and implement cultural tourism strategies. This approach integrates knowledge from academic and research institutions, businesses, local communities, government entities, and entrepreneurs through the quintuple helix model of social innovation. By leveraging collective expertise, the process ensures that the strategies are sustainable, inclusive, and effectively aligned with local cultural and socio-economic objectives, enhancing the impact and relevance of cultural heritage tourism initiatives across representative European sites validated by eight pilots who actively participated in the Cultural Tourism called CT-Lab [27].

In co-design methodology, to have a successful implementation, stakeholders' engagement and analysis of their feedback is crucial [28]. To enhance participant engagement across the three phases of co-design—pre-design (preparation and explicit requirements), co-design (design, development, and improvement), and post-design (validation and verification)—various methods were employed. These included pilot forums, surveys, semi-formal bilateral meetings, and three primary monitoring campaigns aimed at eliciting requirements, validating, and refining provided solutions.

The feedback gathered from stakeholders throughout these phases, combined with the availability of sufficient data for validation and verification, facilitated the development of an ICT tool that was fully aligned with the defined business and economic objectives. This approach proved the success of the co-design process and demonstrated its strong impact on the outcomes of cultural tourism projects.

However, one of the key challenges in the co-design process was finding the balance between stakeholders' requests while prioritizing them based on the project's scope, timeline, ICT infrastructure, and IT skills, as well as environmental, economic, and social contexts. The methods employed, along with the exchanges and experience-sharing among pilots in the CT-Lab, helped address these concerns and streamline the development of solutions. Throughout the project, stakeholder engagement and training were consistently prioritized to ensure smooth collaboration and alignment with project objectives.

Additionally, our MoNitoring as a Service (MoNaaS) module, including the Monitoring Campaign (MoCam) management, has streamlined data entry, review, and analysis processes. This module supports variable and target entries, automatic analytics, QR reviews, CSV downloads, and KPI calculations, providing comprehensive monitoring and reporting capabilities. We have implemented rigorous technical verification and continuous integration testing activities to ensure the platform's reliability and performance.

The TExTOUR ICT platform represents a significant milestone in the field of cultural tourism, leveraging innovative ICT solutions to enhance the sustainability and engagement of cultural heritage sites across Europe. The robust and flexible ICT platform enables the integration of a variety of services designed to meet the diverse needs of cultural tourism stakeholders. These services, ranging from Point of Interest (POI) dissemination to visitor satisfaction monitoring, have been developed with scalability and feasibility in mind. The platform accommodates three primary user roles—Admin, Pilot, and Review—each with tailored interfaces and functionalities to ensure ease of use and effective management of cultural tourism activities. In line with our commitment to openness and inclusivity, the platform's source code and services are accessible to all stakeholders. This transparency fosters collaboration and continuous improvement.

The TExTOUR project fundamentally transforms the strategic goals of cultural heritage tourism into a dynamic ICT platform. This platform provides a suite of critical services designed for both the implementation and thorough assessment of the strategies deployed. It integrates specialized software tools for explicit services alongside implicit services that enhance evaluation processes. This adaptability is crucial for continuous improvement and ensures alignment with evolving strategies and overarching business objectives.

The final release of the platform is not an endpoint but a foundation for future growth and innovation. As a living platform, it will continue to evolve, incorporating new features and improvements based on user feedback and emerging technological trends. The collboration among stakeholders, supported by this platform, will drive sustainable growth in cultural tourism, preserving and promoting Europe's rich cultural heritage. In conclusion, the TExTOUR platform stands as a testament to our collective efforts to harness technology for the benefit of cultural tourism.

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Conflicts of Interest: The authors declare no conflict of interest.

Notes

[1] To reference countries' regions for statistical purposes, the EU has developed a classification known as NUTS (Nomenclature of territorial units for statistics). NUTS is used for: collecting, developing and harmonising European regional statistics, carrying out socio-economic analyses of the regions, framing of EU regional policies.

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