DigInTraCE

MR enabler tool v1

D4.7

DigInTraCE

A Digital value chain Integration Traceability framework for process industries for Circularity and low Emissions by waste reduction and use of secondary raw materials

Funded by
the European Union

DigInTraCE

Dissemination level	Public (PU)
Type of deliverable	Other
Work package	WP4 – Digital tools and platform development
Deliverable number	D4.7 MR enabler tool v1
Status - version, date	V0.1, 06/06/2024
Deliverable leader	ICCS
Contractual date of delivery	30/06/2024
Keywords	Mixed Reality, DPP Visualizations, Augmented Reality, Mobile Application

Quality Control

	Name	Organisation	Date
Peer review 1	Javier Garcia-Jaca	Tecnalia (Spain)	17/06/2024
Peer review 2	Ioanna Leotsakou	MERIT (Greece)	19/06/2024

Version History

Version	Date	Author	Summary of changes
01	06/06/2024	Fotios Giariskanis, Alkistis Kokorikou, Tina Katika	First draft of final report

Legal Disclaimer

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or HADEA. Neither the European Union nor the granting authority can be held responsible for them. The information in this document is provided “as is”, and no guarantee or warranty is given that it is fit for any specific purpose. The DigInTraCE project Consortium members shall have no liability for damages of any kind including without limitation direct, special, indirect, or consequential damages that may result from the use of these materials subject to any liability which is mandatory due to applicable law.

DigInTraCE

Table of Contents

DigInTraCE

List of figures

List of tables

DigInTraCE

List of abbreviations and acronyms

Abbreviation	Meaning
AR	Augmented Reality
MR	Mixed Reality
DPP	Digital Product Passport
QR	Quick-Response code
UI	User Interface
HMD	Head-Mounted-Display
AI	**Artificial Intelligent**
3D	Three Dimensional

DigInTraCE

Executive Summary

The current report presents the version 1 (V1) of the MR enabler module which consists of two applications: 1) a mixed reality (MR) application available in Head-Mounted-Displays (HMD), and 2) a mobile application harnessing Augmented Reality (AR) technology to visualize the Digital Product Passport (DPP) related information. Their main features and functionalities of each application are presented along with their relation to other deliverables.
In more details, the report highlights the main architectural and design elements of the two applications including the main functionalities targeting the end-users. Furthermore, the applications' features and the actions that the administrators are allowed to perform through the interface are presented. Following, the report provides detailed information to the reader (and potential end-user) on the use of the applications, the proposed flow and the way to access them. Conclusive remarks and future steps highlight the development and customization efforts that will follow until the next deliverable.

DigInTraCE

1. Introduction

1.1. Project intro

In DigInTraCE, innovative tracking, sensing, and sorting techniques will be used to develop a transparent and interoperable Decentralized Traceability Platform. Dynamically updated DPP schemes support certification and quality validation, while Artificial Intelligent (AI)-based decision-making mechanisms support lifecycle optimization. Up-cycling, reuse and upgrade technologies for improved secondary raw materials use will be implemented. DigInTrace aims to contribute to standardization, open and easily accessible data and develop business models that provide new economic opportunities and learning resources for employees, promoting new digital skills and meeting regional social needs. The solutions are demonstrated in the sectors of a) Pulp & Paper and b) Chemicals focused, while specific demonstrators of DigInTrace combine these sectors.
The consortium will address the following objectives:

- O.1: To design, develop and implement solutions fostering and optimizing use of secondary raw materials and reducing waste as part of circular value chains.
- O.2: To develop and demonstrate new concepts for material tracing while offering a digital decentralized platform allowing tracing and certification of secondary raw materials.
- O.3: To design and deliver novel near real time sensing and sorting mechanisms enhancing data exchange through a dynamic Digital Product Passport.
- O.4: To facilitate access to composition and origin of material data through smart tags, smart contracts, open software and the usage of immersive technologies.
- O.5: To validate the DigInTraCE technologies in 4 different value chains.
- O.6: To empower local and regional bodies by involving them in designing educational resources for both workplaces and educational institutions. Stimulate adoption of the DigInTraCE solutions by the wider community and enhance knowledge transfer to maximize the impact.

1.2. Purpose of the deliverable

The T4.4 MR enabler for data visualization and human machine optimization task feeds two deliverables: D4.7 – MR enabler tool v1 and its continuation D4.8 – MR enabler tool FINAL. Both deliverables have as overall objective to provide the MR enabler module, which comprises the MR headset application and the mobile application for DPP-related information.

The purpose of this report is to demonstrate the V1 version of the MR enabler module; both the MR headset application and the mobile application used for DPP-related information. Their main features and functionalities are presented as well. This report serves as a user manual for the demonstrator of the MR/AR applications.

DigInTraCE

MR enabler aims to make DPP information more understandable, readable, and accessible, providing interactive visualization and controlling functionalities to end-users along the value chain by revealing material and product information and statuses and facilitate their decisions and actions, thus boost their efficient intervention and engagement.

The MR enabler V1 module is focusing on the Greek demonstrator (but in principle it will be applied in all demonstrators) in which plywood will be produced with bio-based adhesives and particleboards will be produced with the addition of wood waste that will be evaluated in the furniture industry.

1.3. Intended audience

The present deliverable is Public. The objective of this deliverable is to help the partners along the value chain understanding the functionality and the use of the MR enabler which consist of two applications (one for mobile devices and one for MR headsets). The MR enabler will be integrated to the DigInTraCE Decentralized Traceability platform by both retrieving information from the DPPs and provide information upon user interactions or other actions performed during the usage of the tool. In addition, the mobile application will be also used for training to boost digital skills of the end-users.

1.4. Structure of the deliverable and its relation with other work packages/deliverables

This document is structured in a format to present the design and development process of the mobile application intended to visualize DPP-related information and the headset MR application to support actions. Firstly, we provide an overview of the two applications. Secondly, we present the features and main elements of the two applications. Lastly, the report serves as a user manual for the end-user to experience the functionalities available in the immersive setup.

The MR enabler module is related to D4.1-Dynamic Product Passport for Unit of Product through the value chain v1 and D4.2-Dynamic Product Passport for Unit of Product through the value chain FINAL. Both deliverables are associated with T4.1 Dynamically updated Digital Product Passport implementation. The reason for this, is that the MR enabler depend on the DPP component of the Decentralized Traceability Platform, which integrates and incorporates all the other modules of DigInTrace. The way it depends on them involves retrieving DPP information as well as the role of end-users.

Furthermore, the MR tool module is related to the D7.3 – Co-design training activities and lifelong learning programs on digital skills and replication v1 and D7.4 – Co-design training activities and lifelong learning programs on digital skills and replication FINAL. Both deliverables are associated with T7.2 Co-design training activities and lifelong learning programs on digital skills, replication and cooperation. The mobile application will incorporate selected educational and training content to boost the skills of workers and facilitate job training.

DigInTraCE

2. Mixed Reality applications

2.1. General approach of Mixed Reality applications

The overall DigInTrace MR Enabler's module consists of two different applications which support DPP scanning and access to its content and visualizations. The first application is designed for MR headsets, while the second is designed for mobile devices. Mixed/Augmented Reality technology enables the augmentation of real-world scenes with virtual content allowing end users to use their cameras to observe physical environments and augment them with three-dimensional (3D) graphics, text, images, and sounds that appear on screen and speakers of both. As shown in Figure 1, the end-user utilizes the MR Enabler's applications to scan a QR Code (placed on a product) either with a mobile device or with an MR headset. Scanning the QR Code gives both applications access to the DPP component of that specific product along the value chain, providing end-users with information, visualizations, and the subsequent actions about it. This module aims to contribute to the intervention and engagement of end users and present the information and actions associated with DPPs in a more understandable manner.

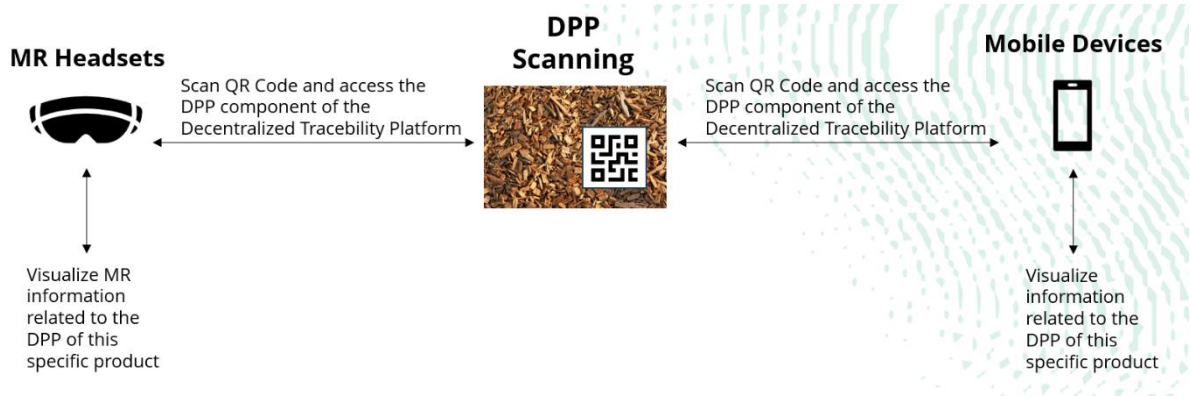


Figure 1: MR Enabler System Design

2.2. Mobile application

The mobile application is designed in Figma[1] and will be developed with the Unity game engine[2]. This application will be compatible with iOS and Android mobile devices. The end-users should allow the use of the camera on their devices while using the application and the mobile device should be connected to the internet. When a product's QR code is scanned or its ID is typed, end-users get access to DPP component of this product and retrieve information related to it, activating some visualizations related to the product. The end-user can interact with the app

[1] https://www.figma.com/
[2] https://unity.com/

by pressing digital buttons. As shown in Figure 2, the visualizations include 3D representations of products, UI menus with text, and buttons. Specifically:

a) A UI prompts the end-user to scan a QR code placed on a product or type its ID.
b) A UI shows a 3D representation of the scanned product, DPP information as texts, and provides information categories as buttons.
c) A UI shows a product tree that visualizes the product's composition.

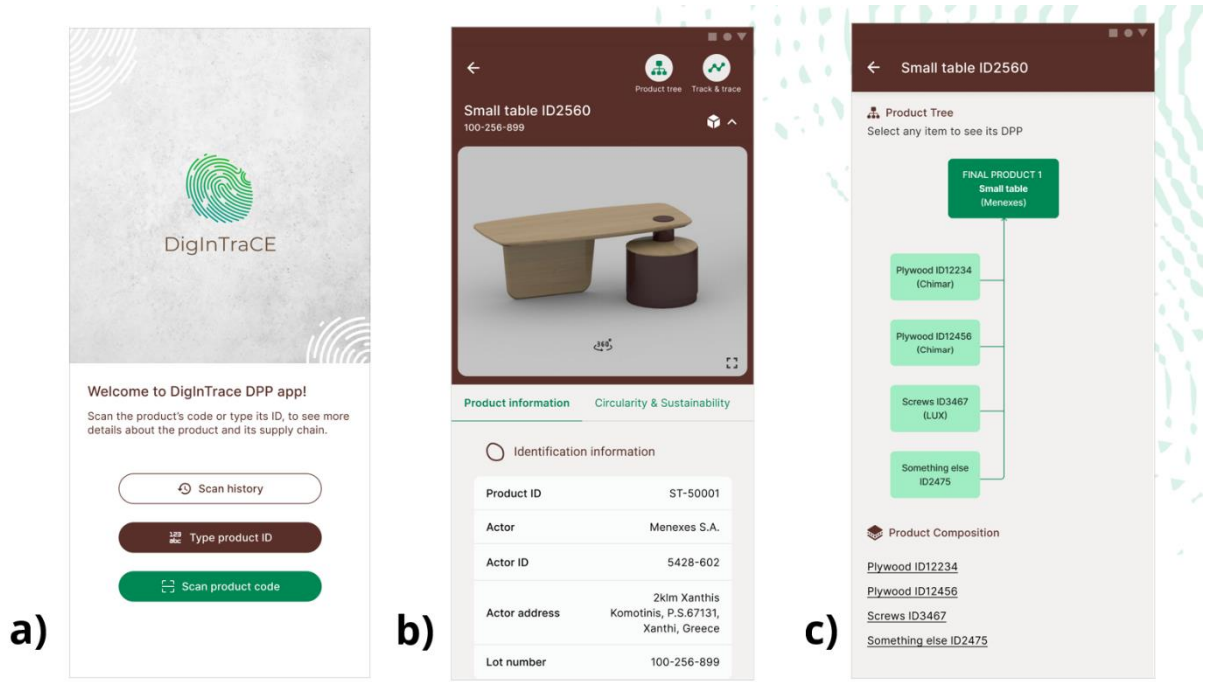


Figure 2: Mockups of the mobile application

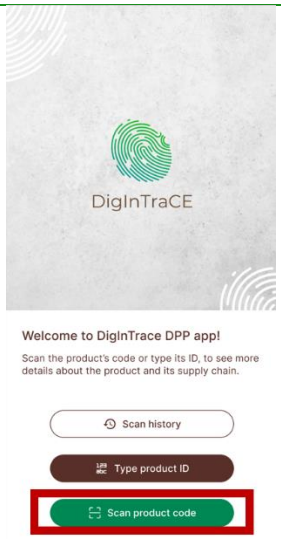
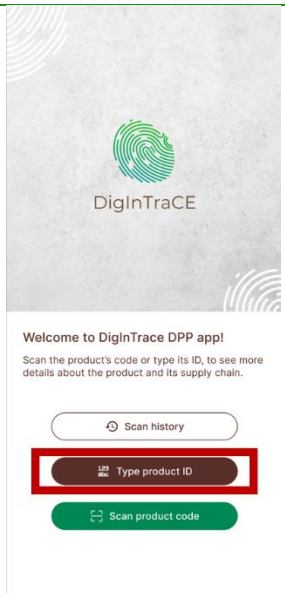
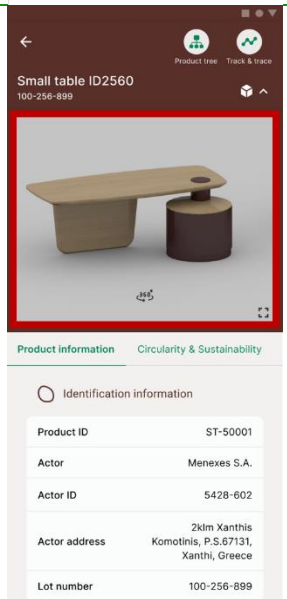
2.3. The mobile application features

2.3.1. Main features and functionalities

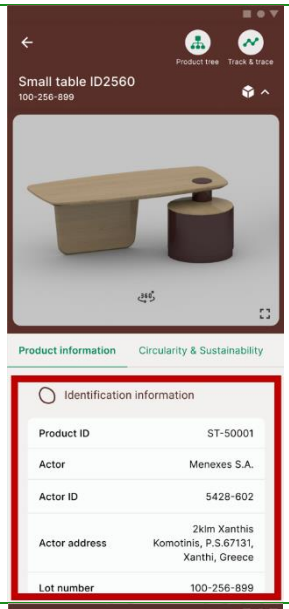
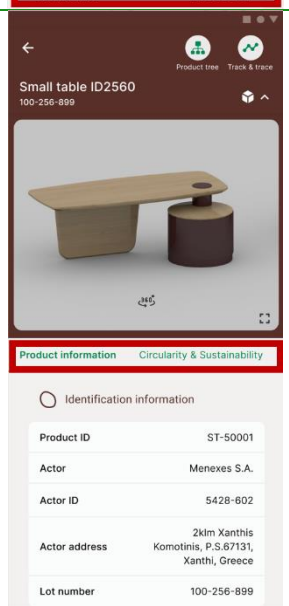
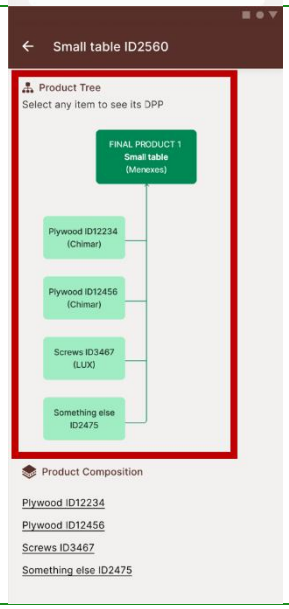
Table 1 summarizes all the mobile application features.

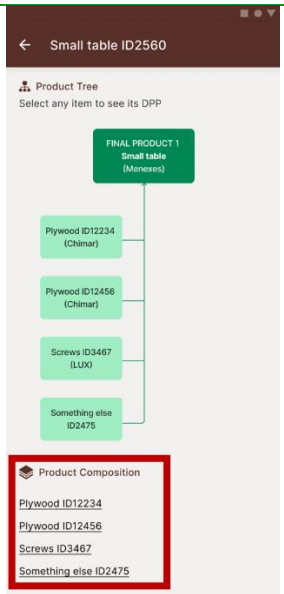
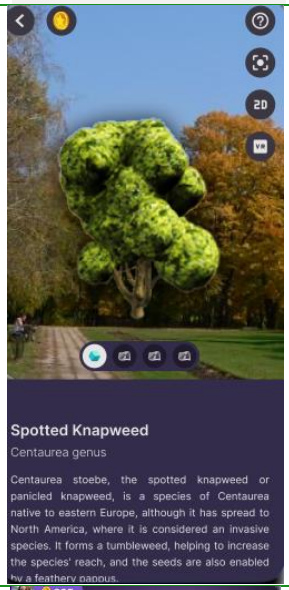
Table 1: Mobile Application Features

Feature title	Description	V1 version

DPP Scanning	The end-users scan the QR Code of a product to retrieve its DPP information.	
DPP Typing ID	The end-users type the ID of a product to retrieve its DPP information.	
3D Visualization	The end-users visualize the products	

DigInTraCE

Panel Information Overlay	UI Panels are filled with information related to the DPP	
Selection of Information Category	The end-users press virtual buttons to choose an information category	
Visualization of Product Tree	The end-users visualize product's composition as tree diagram	

Selection of Other Related Product	The end-users press virtual buttons to view the DPP of another product in product tree	
Visualization of Augmented content	The end-user can visualize augmented content (videos, images, 3D elements, text, etc). This content is relevant for the visualization of educational content for job training,- to boost digital skills of the end-users and to engage citizens/raise awareness through gamification.	
Insertion of material for educational activities (AR campaigns)	The end-user accesses the educational material prepared for training and awareness	

DigInTraCE

2.3.2. Content showcased via the mobile application

Content has been collected by the main supply chain actors to be visualized via the mobile application. The content will be curated to meet the mobile application requirements. Table 2 showcases some examples of the Greek demonstrator.

Table 2: Content examples of Greek demonstrator

Provider	Details	Illustration
Menexes	3D designs of the end-products (i.e. furniture)	N/A at the current version
Chimar	chemical structure of phenol, formaldehyde & sodium hydroxide, phenol-formaldehyde resin	N/A at the current version
NTUA	Seeds and press cakes, oilseed presscakes and proteins	N/A at the current version

2.4. Headsets MR application

The Headsets MR application is developed in the Unity game engine using Mixed Reality Toolkit 3 (MRTK 3)[3], AR Foundation[4], OpenXR[5], and ZXing[6] packages. This application is compatible with Microsoft Hololens 2 [7] MR headset. The end-users of the application should allow the use of the camera while using the application and Hololens should be connected to the internet. Utilizing Hololens 2 cameras, end-users can scan the QR code that is placed on a product, which acts as the product's unique identifier. When a product's QR code is scanned, end-users get access to the DPP component of this product and retrieve information related to it, activating some visualizations which appear on Hololens 2 holographic screen. The end-user can interact with this augmented content using hand gestures. As shown in Figure 3, the visualizations include 3D representations of products, animations, UI menus with text and buttons. Specifically:

a) A UI prompts end-user to scan a QR code placed on a product.
b) A UI shows a 3D representation of the scanned product, DPP information as texts, and providing options/actions as buttons.

[3] https://learn.microsoft.com/en-us/windows/mixed-reality/mrtk-unity/mrtk3-overview/
[4] https://unity.com/unity/features/arfoundation
[5] https://docs.unity3d.com/Packages/com.unity.xr.openxr@1.11/manual/index.html
[6] https://www.npmjs.com/package/@zxing/library
[7] https://www.microsoft.com/en-us/hololens/hardware#document-experiences

DigInTraCE

c) A UI shows a 3D animation that visualizes the process of the option/action which is selected from end-user with additional textual information and providing some buttons to approve or cancel the selected option/action.

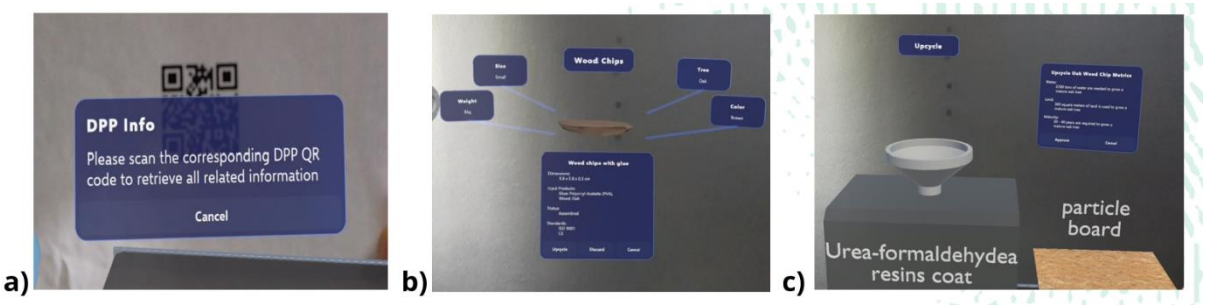


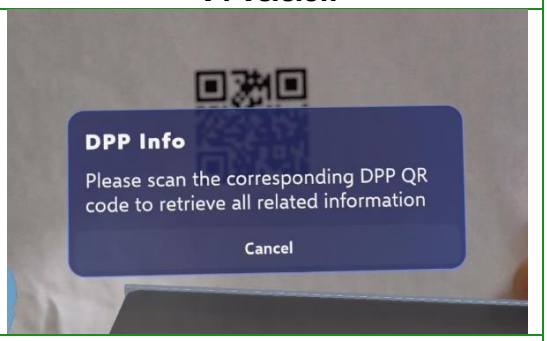
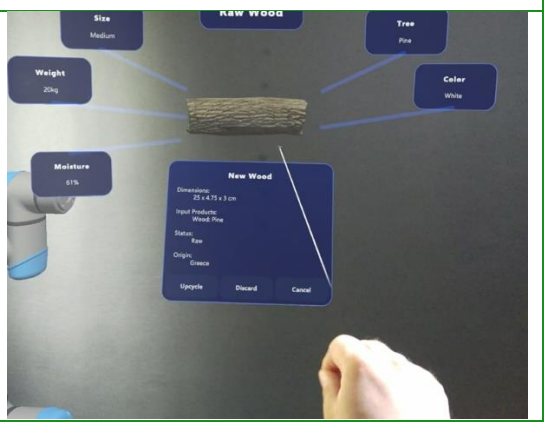
Figure 3: UIs of the MR Headset application

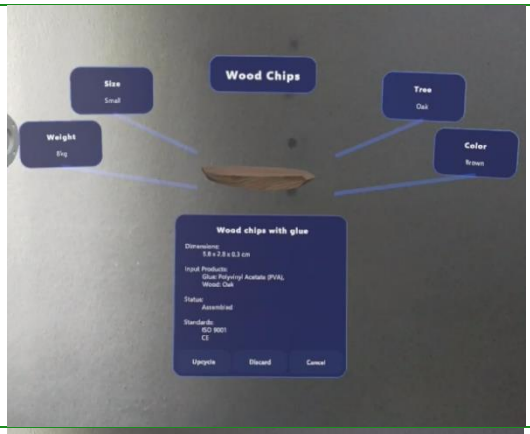
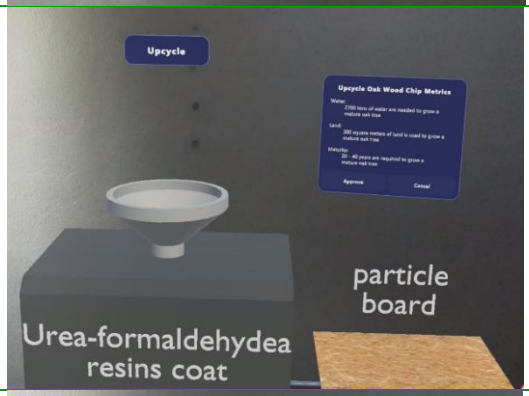
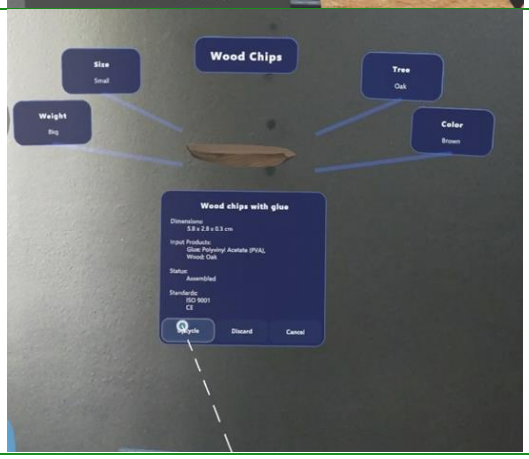
2.5. The headsets MR application features

2.5.1. Main features and functionalities

Table 3 summarizes all the headset MR application features

Table 3: The headset MR application features

Feature title	Description	V1 version
DPP Scanning	The end-users scan the QR Code of a product to retrieve its DPP information.	
Content positioning	The content is positioned automatically	
Position Adjustment	The end-users pinch to change content's position	

Panel Information Overlay	UI Panels are filled with information related to the scanned DPP	
Augmented Content Visualization	The end-users view the visualization of the scanned DPP	
Selection of Actions	The end-users press virtual buttons to choose an action/option.	

2.5.2. Virtual content

The 3D animated visualizations of the objects and processes that appear after DPP scanning were created using Blender[8], a free and open-source 3D creation suite. The graphic representations are simple and stylized, aiming to capture the essence of the procedure and convey a clear message to users.

The first step in the creation process was the 3D modeling of the objects. Starting with primitive shapes, forms were developed by adding more geometry and performing basic operations. This technique, known as box modeling, is commonly used in 3D model creation.

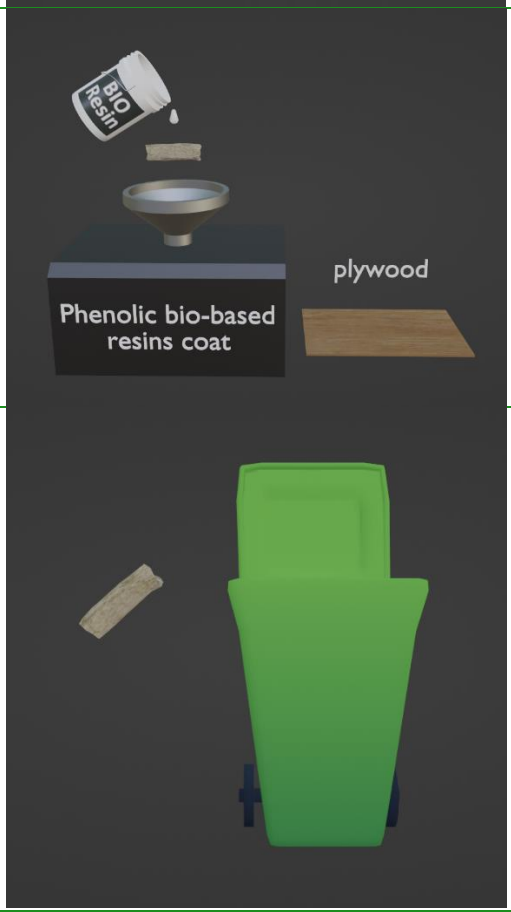
Each object was assigned a material that defined how it is rendered, including attributes like color or bitmap texture, specularity, and metallic value.

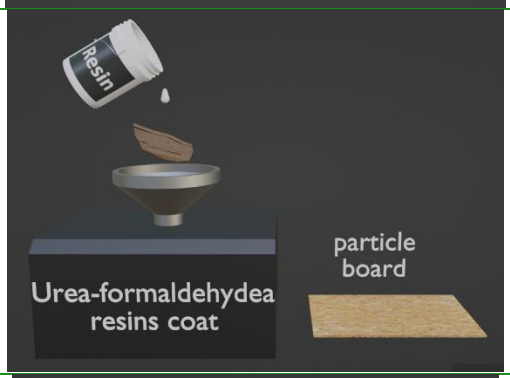
[8] https://www.blender.org/

DigInTraCE

Objects that move independently were assigned virtual bones. The combination of these virtual bones forms a virtual skeleton, where each bone can be animated using keyframing. Keyframing allows for the assignment of position, rotation, and scale values at different timestamps for each bone. During playback, these values are interpolated, which is a common technique in 3D animation creation.
Finally, each animated representation was exported in .fbx format and imported into Unity to be rendered when the corresponding DPP is scanned. The following visualizations were created (see Table 4):

Table 4: Virtual content for Mixed Reality

Type of wood	Process	Visualization
Raw wood	Non-animated, a woodchip model	
	Upcycle process (animated)	
	Discard process (animated)	

Wood chips	Non-animated, a woodchip model	
	Upcycle process (animated)	
	Discard process (animated)	

3. How to use the Mobile application

The following steps describe how the end-users use the mobile application:

a) The end-users scan a DPP QR code (located on a product) or type its ID in order to get access to the DPP information of the product (see Figure 4).
b) Upon scanning or typing the DPP, a 3D representation of product is activated, along with several UI panels (digital menus containing information related to its DPP). End-users can select to view either the visualization of the product, or the information categories and its product tree by pressing the corresponding digital buttons. (see Figure 5).
c) When end-users press the product tree button, the product tree appears and they select any item in the tree to view its DPP (see Figure 6).

DigInTraCE

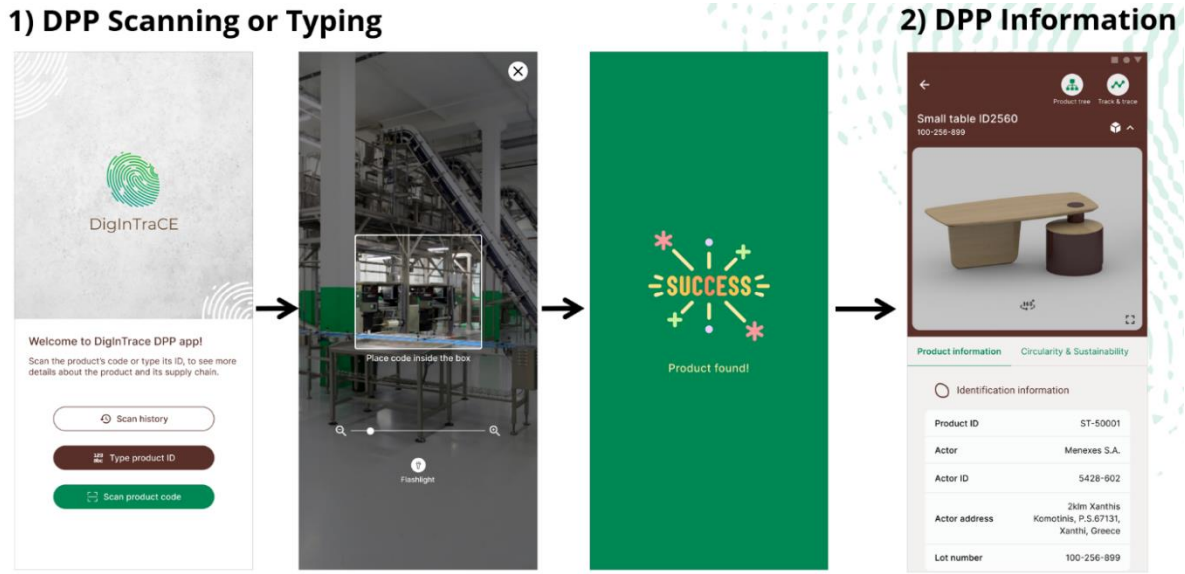


Figure 4: V1 version flow of the mobile application (1/3)

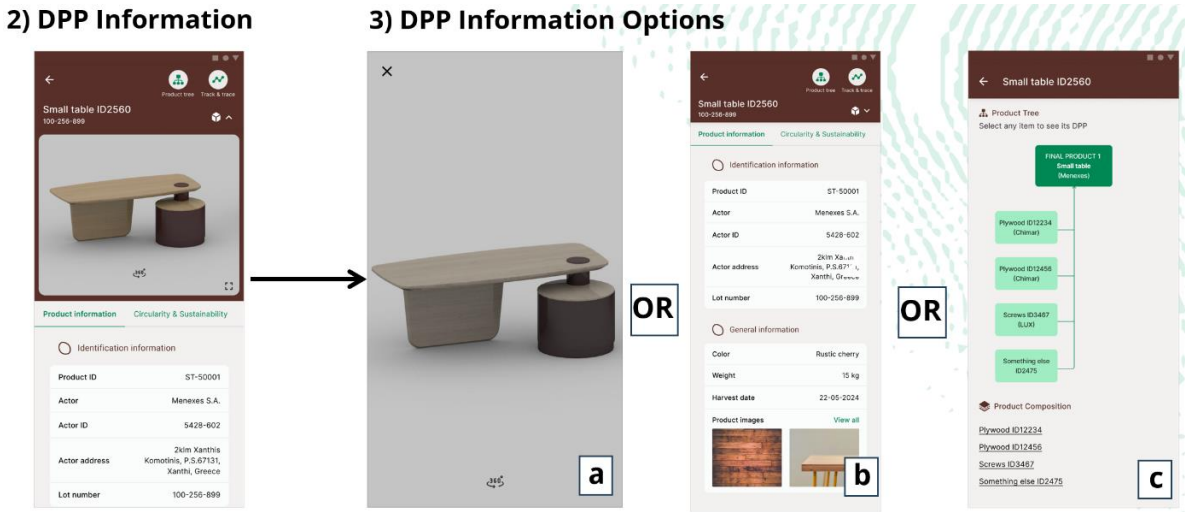


Figure 5: V1 version flow of the mobile application (2/3)

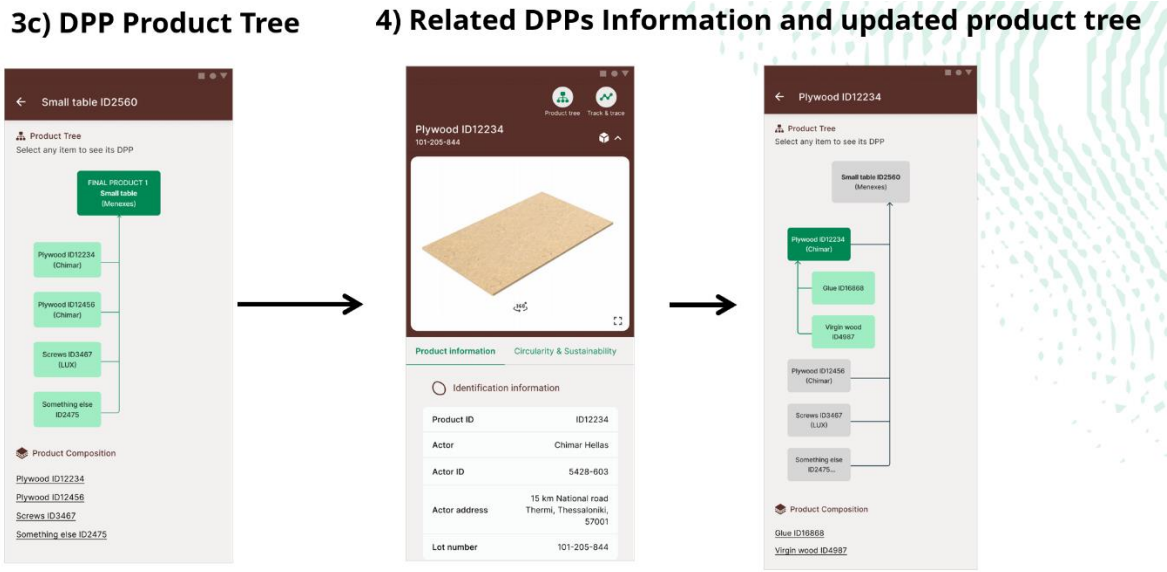


Figure 6 : V1 version flow of the mobile application (3/3)

3.1. Purpose and intended use

The mobile application helps users visualize DPP-related information and track product traceability. It provides data to support informed decisions and raises awareness about sustainability and circularity.

3.2. Users

The target users of this application are the supply chain actors (eg. Menexes), excluding consumers. The content of the application is intended for expert users in order to contribute them to their daily tasks. This application may be extended to be used by consumers in the future for educational purposes.

3.3. Access

At the moment, the v1 version of the application can be accessed in developer's mode in pre-installed devices or via prototype presentation mode through the design software. The application is only supported in Android operating systems.

3.4. End-User flow

The current section elaborates on the end-user flow to ensure that the user experience of the MR enabler/mobile application is intuitive and meets the needs and expectations of the target audience. It also helps identify potential usability issues early, allowing for improvements before the final demonstration.

The diagram of Figure 7 depicts the step-by-step path of interactions by end-users with the mobile application in order to complete a dpp scanning and investigation. At the current phase, using android mobile devices, end-users can scan a QR code or typing its ID and view DPP data on a panel. After the scanning or typing the DPP, they can choose to view among a visualization of the product, information categories and its product tree. From product tree end-users can choose and view a related DPP. Later, they can scan as many products as desired.

DigInTraCE

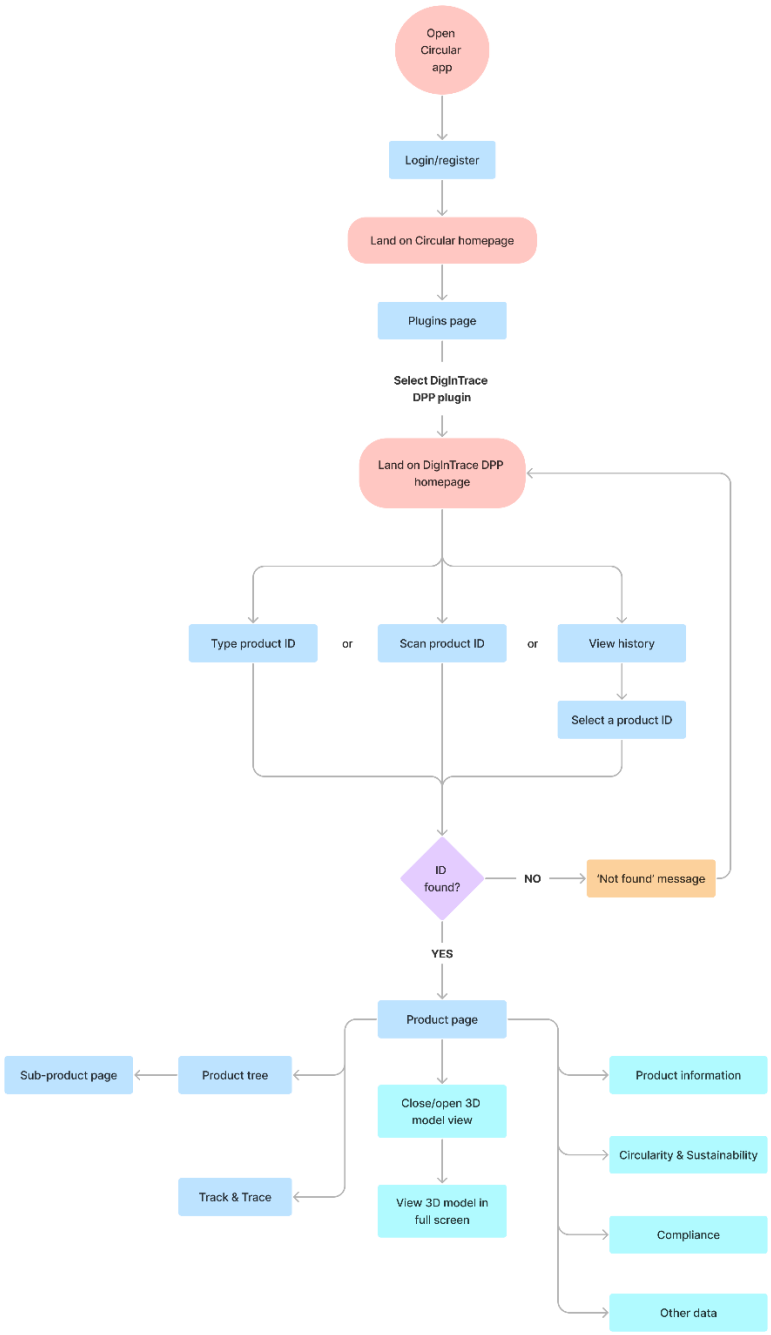


Figure 7: Mobile Application Flow

4. How to use the Headsets MR application

Upon internal testing and collection of feedback of the proof-of concept, then the V1 version was designed and developed. The following steps describe how the end-users use the headset MR application (see Figure 8):

DigInTraCE

a) The end-users may scan a DPP QR code located on a product. After this step they are provided of two types of product (Wood chips and Raw wood).
b) Upon scanning the DPP, a 3D representation of product is activated, along with several UI panels (digital menus containing information related to its DPP and the potential future uses of the product). Those visualizations are automatically positioned at scanning location. The end-users have the ability to move them using the pinch hand gesture. The V1 version provides two options/actions to end-users (Upcycle or Discard). They may can select one by pressing a button in the digital menu with their hands.
c) When the end-users choose an option/action, an animation demonstrates the selected process, and UI panels with information about the outcomes appear. Users then decide whether to confirm or cancel their choice. If they confirm, the application prompts them to scan the next DPP. If they cancel, they return to the options menu.

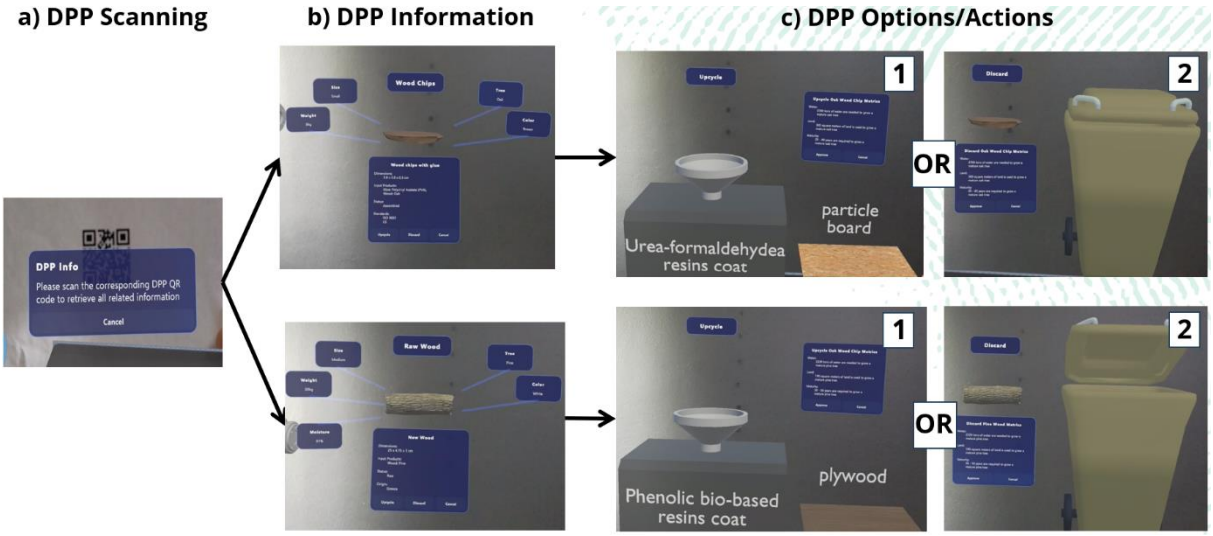


Figure 8: V1 version flow of the MR application

The Headsets MR application is developed in the Unity game engine using Mixed Reality Toolkit 3 (MRTK 3), AR Foundation, OpenXR and ZXing packages. This application is compatible with Microsoft Hololens 2 MR headset. The end-users of the application should allow the use of camera while using the app and the device should be connected to the internet.

4.1. Purpose and intended use

With the headset MR application, end-users along the value chain will have access to interactive visualizations and control functions that make DPP information more readable, understandable, and accessible by revealing material and product information and statuses, facilitating their decisions and actions, thereby facilitating their efficient involvement and intervention. The headset MR

application will be integrated to the DigInTraCE Decentralized Traceability platform by both retrieving information from the DPPs and provide information upon user interactions.

4.2. Users

The MR application is mainly targeted to the supply chain actors. The access to the information available in the DPP will be ruled by the rights depending on the role in the supply chain and shall be defined by the respective delegated acts.

4.3. Access

An end-user can access headset MR application through a Hololens 2 with the application installed.
Additionally, an *.appx file with the application can be shared to the intended audience for testing. The end-users have to access the device portal of their device (i.e. Microsoft Hololens 2) to install at their own device.

4.4. End-User flow

This section details the end-user flow to ensure that the user experience of the MR enabler/MR headsets application is intuitive and meets the target audience's needs and expectations. It also aids in identifying potential usability issues early, enabling improvements before the final demonstration.

The diagram of Figure 8 depicts the step-by-step path of interactions by end-users with the headsets MR application in order to complete a dpp scanning and investigation. More specifically, the end-users first scan a DPP QR code located on the product. Upon scanning the DPP, a 3D representation of product is activated, along with several UI panels (digital menus containing information related to its DPP and the potential future uses of the product). The end-users then select one of the available options of the digital menu. Upon choosing one of the available options/actions, an animation is activated showing the process of the selected option/action along with UI panels that provide information about the outcomes. In addition, the end-users chooses if they confirm or not to proceed with the selected option/action. In case they confirm their option/action, the application prompts the end-user to scan the next DPP. Otherwise, they can return to the available options/actions.

DigInTraCE

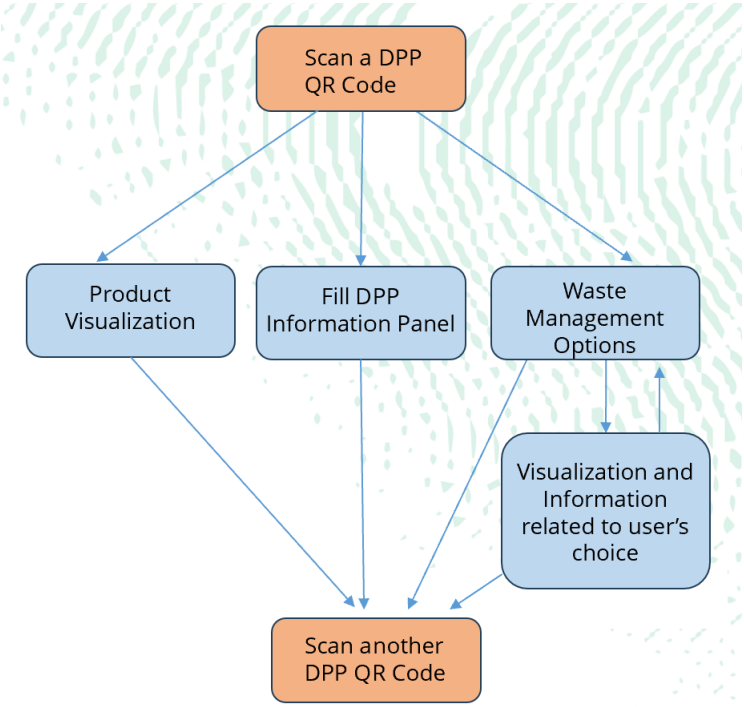


Figure 9: Headset MR Application Flow

5. Testing and evaluation

Before building the v1 version of the MR application, a proof-of-concept (see Figure 10) was designed and developed to ensure that all functionalities are in place and that the application will be intuitive for use. The proof-of-concept aimed to emphasize on the User Interface and Experience (UI/UX) of a tool with the selected functionalities. The proof-of-concept was tested internally as shown in Figure 11.

Figure 10: Proof-of-concept for the MR application

DigInTraCE

Figure 11: End-users testing the proof-of-concept of the MR application

The v1 version of the MR tool was also tested during two events: the Waste Management Europe (WME) expo in Bergamo and the Automation and Robotics (A&R) expo in Athens as shown in Figure 12. Feedback was collected by end-users testing the application.

Figure 12: End-users testing the MR application at the A&R expo

DigInTraCE

6. Conclusion and future steps

In the context of Task 4.4 a Mixed Reality (MR) application suitable for Head-Mounted-Displays (HMDs) and a mobile application suitable for android mobile devices (soon to be in iOS as well) are being developed and have already reached the v1 phase. Their aim is to make information more understandable, readable and accessible, providing interactive visualization and controlling functionalities to end-users along the value chain by revealing material and product information and statuses and facilitate their decisions and actions, thus boost their efficient intervention and engagement. More specifically, the headset MR application retrieves information from the DPPs and provides information upon user interactions while the mobile application acts as a visualization tool for any DPP-related information and traceability tracking to show data about the products and to raise awareness on sustainability and circularity.

The MR enabler V1 module is focusing on the Greek demonstrator (but in general it will be applied in all demonstrators). The MR application has been tested at two exhibitions with end-users and during the plenary meeting in Zaragosa with members from the consortium. The mobile application has only a part of its functionalities tested due to time limitations. Content has been designed for the MR application. In addition, content has been collected by the main supply chain actors to be curated for the mobile application.

Following, the next steps of the work to be performed within T4.4 leading to the final version of the MR enabler include:

1) Related to the MR application:
   - the prioritization and implementation of feedback from user testing.
   - the improvement of content to meet the current demonstrators needs and processes.
   - the implementation of additional actions for the end user based on the DPP scanning.
   - Additional head mounted devices will be investigated for the support of the MR application.

2) Related to the mobile application:
   - the connections with the back end and other platforms will be established, more specifically related to other components such as, connection to the DPP component from the DPP decentralized traceability platform.
   - thorough testing with a variety of end-users and implementation of feedback.

Disclaimer of warranties