COGITO

CONSTRUCTION PHASE DIGITAL TWIN MODEL

cogito-project.eu

D6.7 – Personalized On-site Works Support App v1

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D6.7 – Personalized On-site Works Support App v1

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Version History

Version	Editors	Date	Comment
0.1	NT	01.04.2022	ToC and initial version
0.4	NT	07.07.2022	Draft version ready for internal review
0.5	Hypertech, QUE	08.07.2022	First draft internal review
0.5	NT	27.07.2022	Comments partially addressed
0.6	Hypertech	09.08.2022	Final internal review
0.8	NT	12.08.2022	Additional comments addressed
0.9	NT, Hypertech, UEDIN	17.08.2022	Final version
1.0	NT, Hypertech	19.08.2022	Submission to the EC portal

Disclaimer

Executive Summary

The COGITO deliverable D6.7 "Personalized On-Site Works Support App V1" aims at documenting the first version of the currently developed mobile device application, mostly focusing to be used with Smart Glasses. Other mobile devices like Android smartphones or tablets are also supported. It is considered as a main tool for workers, foremen, quality surveyors, surveyors and HSE supervisors to be used on-site to manage, monitor and report the status of the tasks assigned to them as part of the whole construction process.

The application (WOEA – Work Order Execution Assistance tool) is a part of a toolset delivered under the I3D platform[1] adjusted to the needs of COGITO, which provides the set of tools to support the whole life cycle of the management and utilization of know-how.

In the first version, the following functionalities are provided:

- Overview of workorders/tasks assigned to the user;
- Accessing detailed information about the assigned workorders / tasks;
- Assistance during execution of the tasks;
- Integrated tool for progress reporting; and
- Support for offline execution.

The functions for notifications and remote assistance have been removed as they are out of project scope. Also, possibilities to edit workorders, user role assignment have been disabled, these functions are supported by other COGITO tools. The application has been simplified removing unnecessary libraries and frameworks. The first version of WOEA aims to deliver a bundle of functionalities that enable the end-users' interactions with the tasks assigned to them. The development and delivery of WOEA's first release functionalities were driven by the stakeholders' requirements identified in the deliverable "D2.1-Stakeholder requirements for the COGITO system", and the functional and non-functional requirement documented in "D2.5-System Architecture v2". In the next version of WOEA's documentation, the preparatory work on the application's integration with the overall COGITO ecosystem, in terms of realising all the interactions with other COGITO components that have been illustrated in the sequence diagram of the Use-Case "UC1.2-Systematic and secure execution, monitoring and updating of the project workflow", will be included.

[1] https://i3d.econtentstore.com/

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List of Acronyms

Term	Description
COGITO	COnstruction Phase diGItal Twin mOdel
DTP	Digital Twin Platform
ICT	Information and Communications Technology
RAMS	Reliability, Availability, Maintainability and Safety
WODM	Workflow Management Automation Tools
WOEA	Work Order Execution Assistance tool

1 Introduction

1.1 Scope and Objectives of the Deliverable

This document aims to report on the work that was carried out in the context of "T6.4 – Personalised On-site Works Support and Relevant Apps Development" to develop and deliver the first release of a Personalized On-site Works support Application, hereafter named Work Order Execution Assistance (WOEA) application, to support activities during the construction work. Intended to be used by on-site construction stakeholders, the current version is being developed to be an application for workers that provides functionalities to assist them on reporting work progress and alert them for hazardous components and areas. On-site assistance is provided in various ways, e.g., (1) managing work orders and the corresponding tasks assigned to users; (2) getting acquainted with the necessary information e.g., RAMS or health & safety instructions; (3) reporting work progress and issues; and (4) providing important communication from the construction manager or foreman.

The WOEA application builds upon existing I3D industrial services, provided under an existing platform of integrated ICT tools and services that aim to support the whole life cycle of projects, from definition of process templates, over issuing task based on the defined templates to execution and reporting. The overall architecture of I3D is described in Figure 1.

In COGITO the I3D system is adjusted according to the requirements defined in D2.1 to provide functionality of executing the workflow and on-site guidance for workers and on-field stakeholders. WOEA in I3D system operates as the one of two frontends to the main system which is in COGITO environment WODM. Basic overview about I3D architecture is presented on Figure 1. More detailed information of I3D environment is provided in "D6.5 – Adaptive Workflow Management and Automation Tool v1".

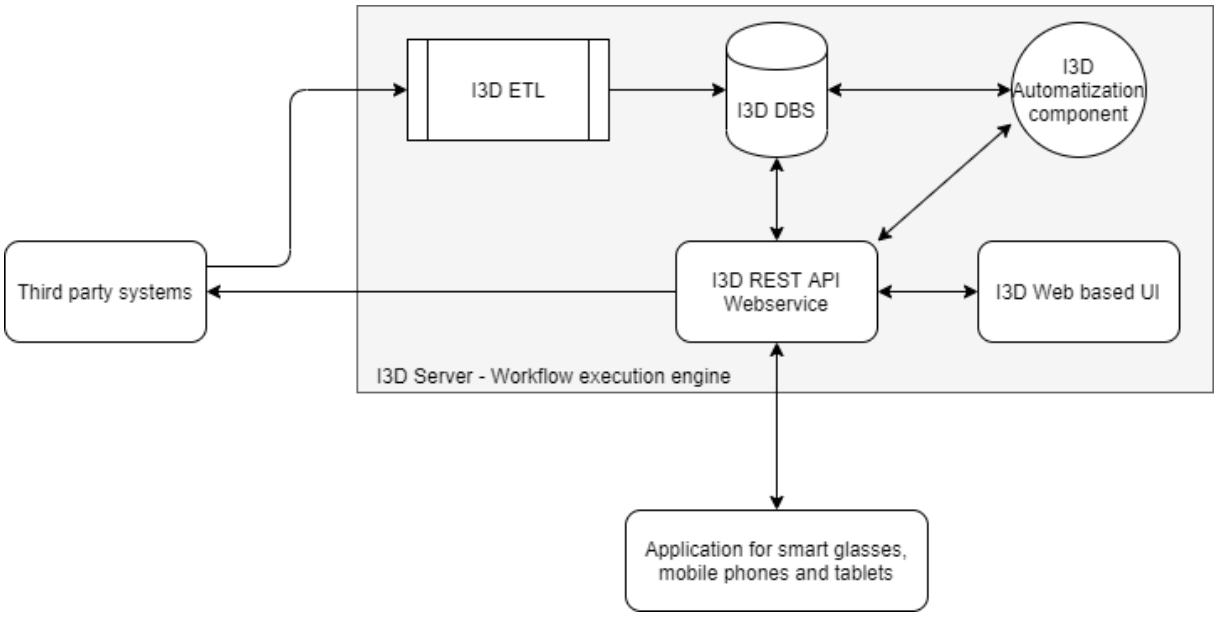

Figure 1 – Architecture of I3D

1.2 Relation to other Tasks and Deliverables

This deliverable is closely related to the task "T6.3-Adaptive Workflow Management and Automation" and its deliverable "D6.5-Adaptive Workflow Management and Automation tool v1". It is also related to other WP6 tasks, namely "T6.1-Blockchain & Smart Contracts on the Workflow Modelling and Management ", T6.2 "Adaptive Processes/Workflow Modelling and Simulation-based Optimization", and their deliverables, and to task "T7.1-Digital Twin Platform Design & Interface Specification" and its deliverables. The end-user requirements for WOEA were gathered and described in "D2.1-Stakeholder requirements for the COGITO system". Furthermore, the specifications, the functional and non-functional requirements, as well as the

interactions of WOEA with other components of the COGITO ecosystem are presented in "D2.5-System Architecture v2".

1.3 Structure of the Deliverable

This deliverable contains the following sections:

- Prototype overview, where the WOEA application is introduced.
- technology stack and implementation tools used,
- input, Output and API documentation,
- usage walkthrough,
- licensing information,
- installation instructions,
- development and integration status overview,
- requirements coverage, and
- assumptions and restrictions.

2 Work Order Execution Assistance tool

2.1 Prototype Overview

For the WOEA application's development, the Unity3D Engine has been used. It has been selected due its multiplatform nature, providing out-of-the-box support and deployment to various operating systems and devices. This allows to maintain a single version of the code for several types of hardware. Currently, the application is being designed to run on Smart Glasses, while the Android mobile devices deployment is still on progress. Since Unity3D is widely used, future support for devices to be launched in the market is highly expected. The code is written in C# programming language. Key features of WOEA that have been considered and are already implemented include:

- Secured access to and provision of information that is being exchanged between various construction stakeholders;
- Personalised display of data according to the credentials entered to login, (e.g, projects and list of tasks assigned to the logged-in user);
- Display of guidelines and description of actions that should be considered for a successful completion and delivery of a selected task;
- Provision of various means for reporting progress on pre-defined tasks and identified issues that affect the completion of a workorder;
  Provision of functionalities for operation with voice commands or gestures.

For the early testing and refinement of all WOEA's functionalities, the application is being initially deployed on a smart wearable tablet, Realwear HMT-1, a fully rugged Android computer that is worn on the helmet and replaces the touch screen with an articulated micro display. Additional features such as hard-hat compatibility, rugged drop and waterproof design and outdoor display makes it a very suitable candidate to be used on construction sites. The selected wearable device allows the on-site crew to maintain full situational awareness and maximum productivity.

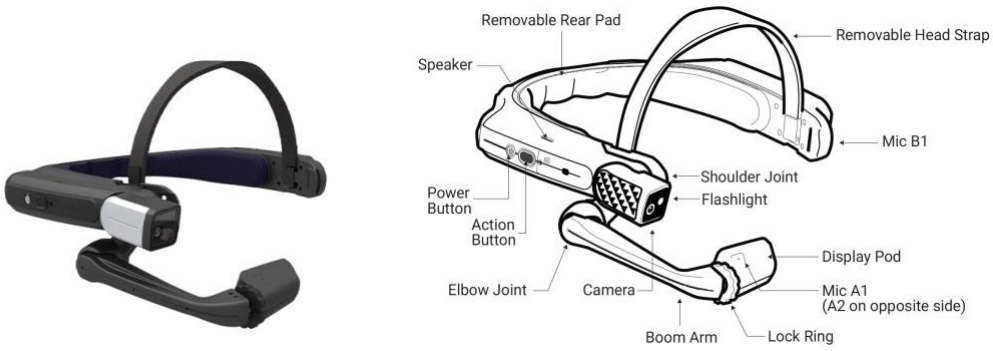

Figure 2 – RealWear HMT-1 headset[2]

WOEA is configured to utilise the built-in voice recognition feature, which gives the user the ability to operate applications and the device mostly solely by voice commands. Additional features such as wide hard-hat compatibility, waterproof design makes it a very suitable device for construction environments. Besides this preferred device, the application is ported also to Microsoft Hololens2, even if this device is not suitable for on-field tasks.

2.2 Technology Stack and Implementation Tools

WOEA is developed as a part of the I3D system, originally serving as a UI for on-field stakeholder support. The development is performed using the Unity3D engine and the C# programming language. To ensure wide compatibility with different devices and replicability, we tried not to use too many proprietary libraries and

[2] https://www.realwear.com/hmt-1/

we mostly used the standard features that came preinstalled in Unity. However, we still needed to import some specific libraries for some of the features:

- **NatMic** – Native Microphone API;
- **html-agility-pack** – Displaying the html components in the app UI;
- **OpenCV for Unity** – Object and character recognition;
- **NatCoder** – Straightforward way to record videos and capture other multimedia; and
- **Runtime File Browser** – Simple file browser saved on the device.

Unity3D: Unity is a Game Engine created by Unity Technologies. The engine is widely used to build Virtual reality and Augmented Reality application in entertainment and industrial sector.

Programming language C#: Programs based on Unity3D are written in the object-oriented programming language C#, language supports development of secure and robust applications that run in the .NET ecosystem.

Unity for Windows: To facilitate the development process, Unity for Windows is used, providing the possibility to test and readjust its functionalities locally without requiring any installation on wearable devices.

2.3 Input, Output and API Documentation

The first interaction occurs between the WODM and WOEA, and it revolves around the workorders that were created and assigned to specific workers. After being created in WODM UI by managers, the tasks contained in the work order are stored in the WODM's database. Once the worker logs into the WOEA, the communication between the WOEA and WODM happens in two layers. On the first layer, the WOEA requests all workorders assigned to this specific worker from the WODM. The data that it receives is surface-level and not too detailed since the worker does not need all details at this step. It then populates the workorder data into the list of available work for the worker to choose from. Once the worker chooses and starts the specific workorder, the second layer of communication occurs. Here, the WOEA requests the detailed information about the specific workorder (including the detailed tasks to be performed), so that it is available for the worker in its entirety. This two-layered communication is designed to avoid the overload of the webservice and network. Both requests use the REST API and receive a JSON containing all the data (see Figure 3).


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         "planned_end":null,
         "real_start":null,
         "real_end":null
      }
   ]
}
```


Figure 3 – WODM to WOEA Workorder JSON

The next interaction occurs between the WODM/WOEA and the DT platform. Its main point is the authorisation and authentication of the user that is trying to use the system. The WODM currently supports this type of authorisation from outside services using the Identity Provider, and after a successful login, the user is automatically inserted into the database if he or she is not there already. The current process of logging into the WOEA is a little bit different. It doesn't contain any sort of support for the authorisation from an outside service, like the WODM does, so it strictly relies on the WODM database. This is a very straightforward and simple implementation, as it simplifies the WOEA logging system. However, it needs the users to be already logged into the database, which is not a desired behaviour for this project. If there's a worker who hasn't been logged into the WODM before, they won't be able to use the WOEA even if their user credentials are correct. For this reason, we're planning to integrate the DT Platform's Identity Provider directly in the WOEA.

After the worker using the WOEA finishes a task of a workorder, all information gets serialized into a JSON file, which is then sent via the REST API directly to the WODM. It then deserializes the data and stores it into the database. The WODM generally needs to know the result of the task, the result text (if the worker wrote any), the result value (if requested by the manager), any captured multimedia, and the execution start and end time. Those data synthesize an instance of a Workorder Result. Aside from the result, there is a brief information exchange any time the task changes its state on any of both sides.

2.4 Usage Walkthrough

Prerequisite to access the WOEA App is a user account that must be created in WODM. WODM is enhanced with an internal identity and access management system. Unique credentials are generated and should be communicated to the end-user to log in the WOEA App (see Figure 4). User login name is usually their e-mail address. Currently, WOEA does not support any mechanism to result user passwords. Any change to the user credentials should be done through WODM. Full integration of both components (WODM and WOEA) with the COGITO Identity Provider, developed as part of the DTP, will be delivered in their second version, planned to be released in M24 (October 2022).

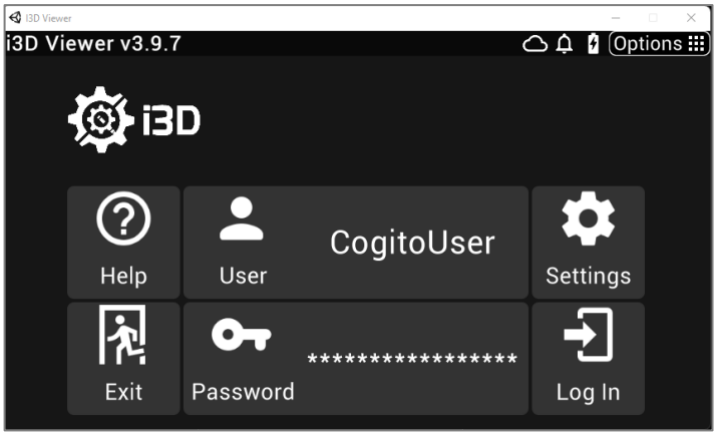


Figure 4 – Login screen

After a successful login, the user selects a project from a list of running/current user projects (Figure 5) accessible to them. In this version, the projects are stored in the WODM backend. In the next version, the list of running projects assigned to the user will be retrieved from the DTP.

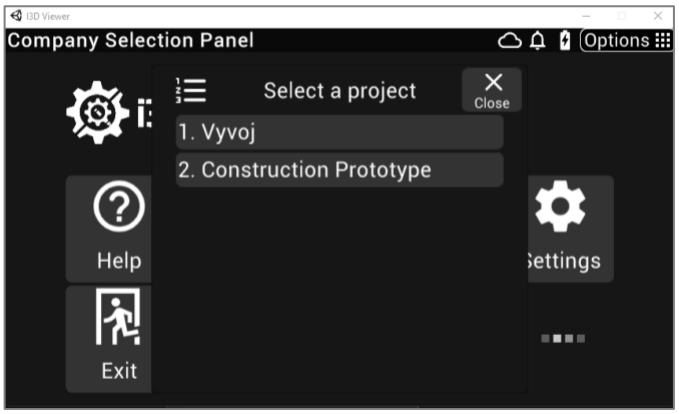


Figure 5 – Projects' list and selection

To avoid unauthorised access to information, the application has an idle counter of 10 minutes, after which the application locks the screen, and the user is requested to re-login to further use of the application. The user can also lock the screen or log out from the application intentionally (Figure 6).

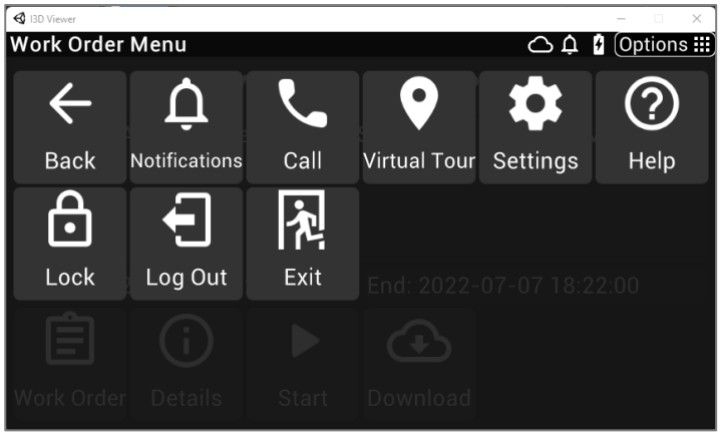


Figure 6 – Lock / Exit /Logout screen

WOEA is designed to be adjusted to the needs of the user (Figure 7). The user can switch the language of the application, change video recording quality, and set the application to offline mode. In this mode, only the work orders previously downloaded are available. The user can execute the pre-downloaded work orders in offline mode. In that case, the report and evidence of work will be synchronised with WODM after the device is re-connected to the internet.

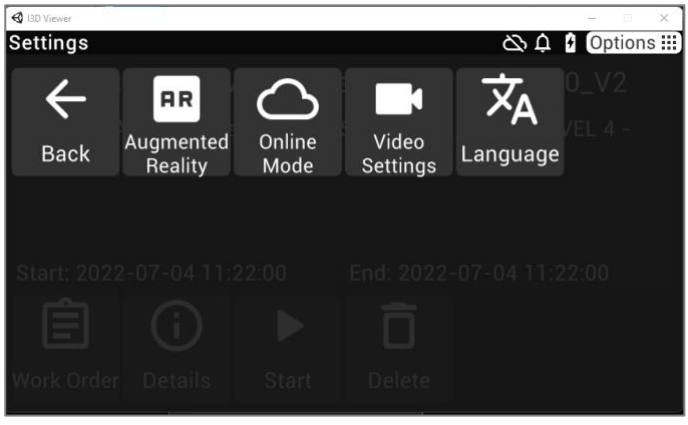


Figure 7 – Settings

After project selection, the list of workorders assigned to the user is displayed. For every workorder, the basic information about expected date and time of execution is displayed (Figure 8).

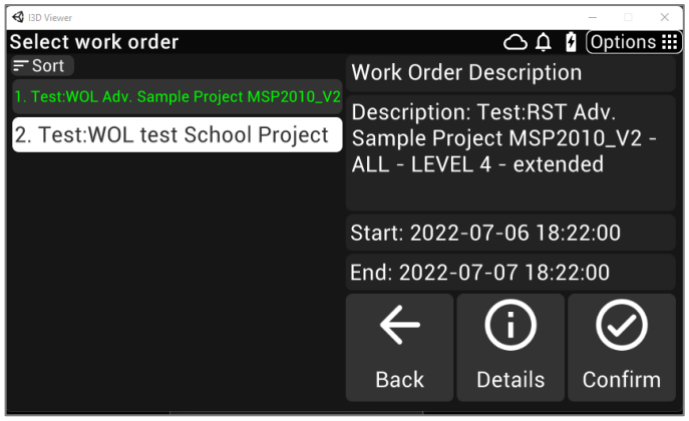


Figure 8 – List of assigned workorders

The user can check the details of any of the assigned work orders (Figure 9), download them to the device for offline use (button Download) or start the execution of the chosen workorder (button Start) (Figure 10).

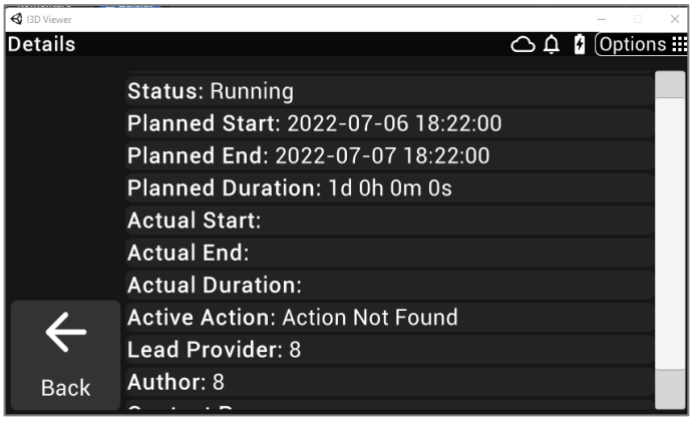


Figure 9 – Details of an assigned workorder

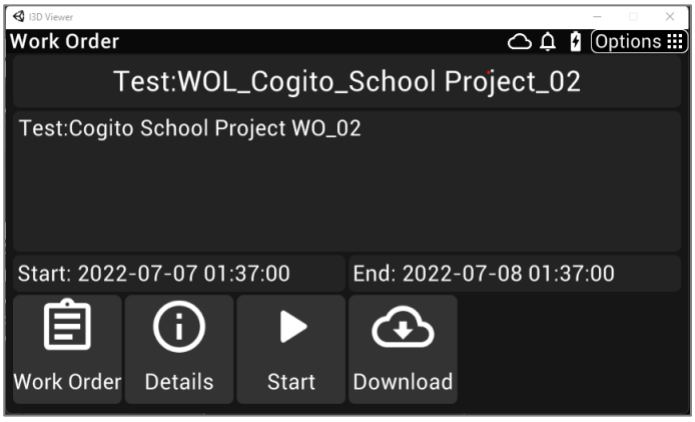


Figure 10 – Workorder screen and menu

After the worker starts the execution of a workorder by clicking on "Start" (Figure 10), the system guides them step by step through the tasks of the workorder. The worker is asked to execute the popped-up action (Figure 11), while detailed description of the work to be done is displayed.

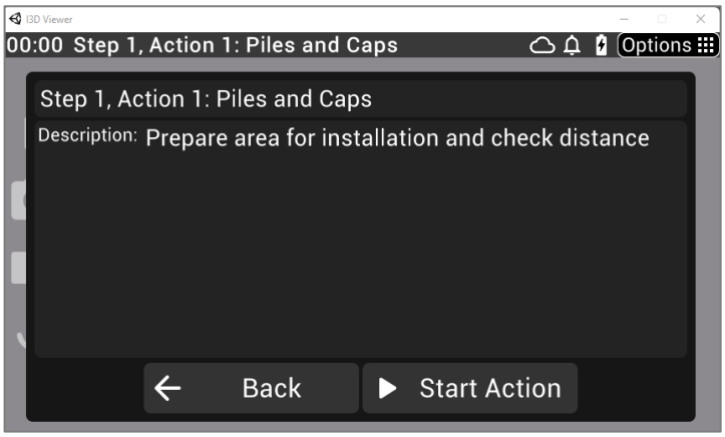


Figure 11 – The start of the task execution

Once the worker starts the execution of the task, the application allows the attachment of any kind of multimedia information to the report as evidence of work completion (Figure 12). These multimedia files are linked to the tasks of the workorder. When the worker finishes the execution of the task, the application requires from the worker to set the status of the task (Figure 13). For every task a text note can be attached, in case that a numerical value is expected (i.e., quality assurance tasks), the value can be entered to dedicated field (Figure 14).

Figure 12 – Action in progress

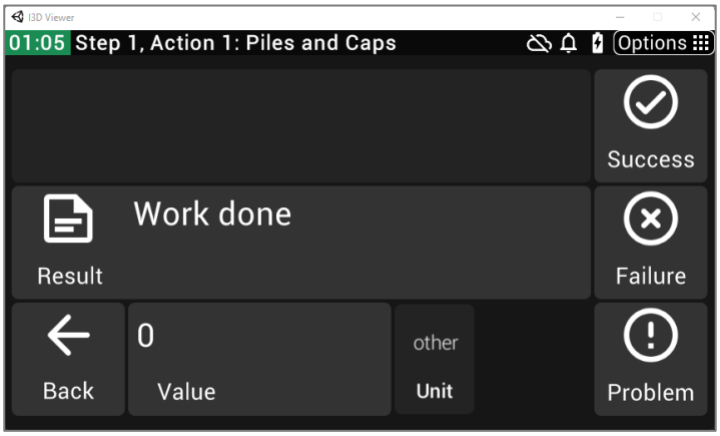


Figure 13 – Task result confirmation

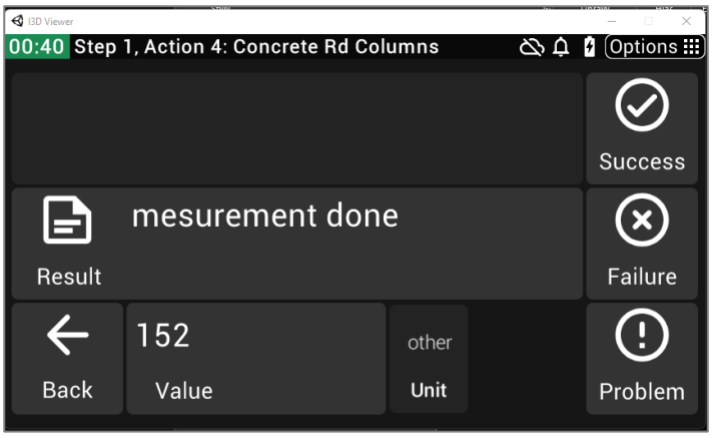


Figure 14 – Numerical value as the result

The user can check the list of tasks of the actual workorder, in which the status of tasks execution is indicated (Figure 15).

Figure 15 – List of tasks of the workorder

When all tasks from the workorder are finished, or, for some reason the worker needs to quit execution, the application requires to set the status of the work (Figure 16). Available options are: Completed, Aborted or Paused.

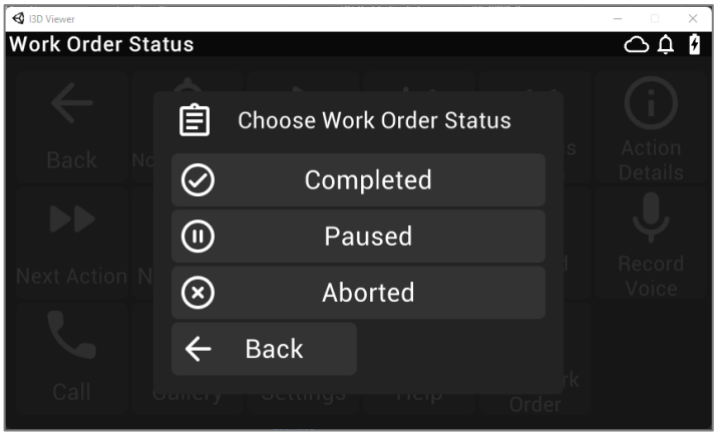


Figure 16 – Possible workorder statuses

The execution of tasks is supported by additional tools (Figure 17), like Remote assistance where user can call to another user. Other buttons are for easier navigation in the list of assigned tasks.

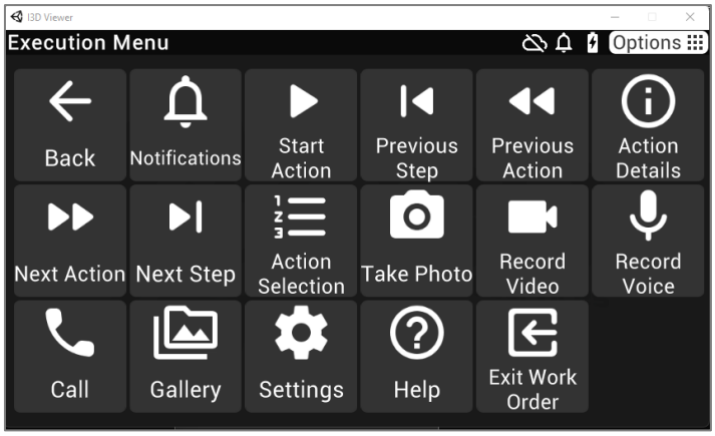


Figure 17 – Tool set for task execution

The user also can customise the quality of the video recordings based on the actual preferences (Figure 18). In case a short video is required to document the status, high quality of the video recording is recommended. In contrast, if a long process is recorded for evidence, it is recommended to record in medium or low quality to keep a reasonable size of the recording. The resolution of the three predefined qualities is 854 x 480px for High Quality, 512 x 288px for Medium Quality and 256 x 144px for Low Quality.

Automated video recording of all actions is also supported by tapping on "Record each action. The user can deactivate this option at any time.

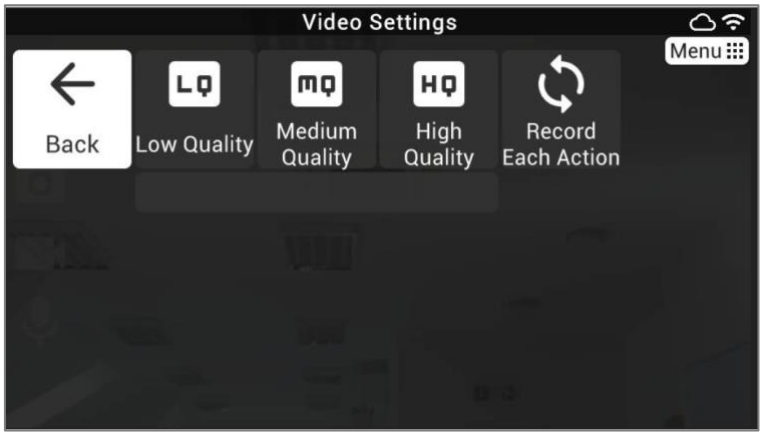


Figure 18 – Video quality settings

2.5 Licensing

WOEA is closed source component.

2.6 Installation Instructions

WOEA application can be downloaded through the following links:

- WOEA for Realwear HMT-1 and potentially other Android devices (operating system Android 10.0): WOEA Android
- WOEA for Windows desktop: WOEA for Windows

To install WOEA on Android devices, download the .apk file. Use a file browser application to reach the folder where the downloaded file is location. Tap on the .apk file. The installation process will start. For

Windows desktop installation, unzip the downloaded compressed file to any folder and run the "I3D Viewer.exe" executable.

The following credentials are being provided for early testing purposes:

- Login: CogitoUser
- Password: rdh486o38qw9sf4jz

2.7 Development and integration status

The application is currently under development. The basic functions related to word order management and task reporting are functional. In the next version the attention will be focused to integration with the DTP (User management), improvements in UI related to easy identification of task or work order status and implementation of predefined action results, especially related to Quality assurance and Health and Safety.

2.8 Requirements Coverage

In Table 1, the computing requirements extracted from "D2.1-Stakeholder requirements for the COGITO system" are listed. Requirement COGI-CS-9 specifies as "must" will be achieved in the next version of application after implementation of identity provider in DTP. COGI_CS-2 is achieved via Windows Unity application, even if this is not preferred way of use. COGI-CS-3 is achieved for Android devices (both mobile phones and tables). Apple devices are not supported due to licencing reasons, but technically it is possible to release iOS version as well. COGI-CS-9 will be finalized after successful Identity Provider implementation.

Table 1 – Computing system requirements

ID	Solution	Priority	Status
COGI-CS-2	runs on laptop and is usable on the construction site (remote access)	Should	Achieved
COGI-CS-3	runs on mobile phones or tablets, without brand restriction	Must	Achieved
COGI-CS-4	runs on Windows	Must	Achieved
COGI-CS-6	runs on Android	Should	Achieved
COGI-CS-7	allows access to the whole data in one location	Must	Achieved
COGI-CS-8	maintains communication and data security	Must	Achieved
COGI-CS-9	differentiates data and system access levels and modification rights	Must	In progress

In Table 2, requirements for Workflow Execution and Monitoring are extracted from D2.1. COGI-WF-29 will be implemented after successful implementation and testing of all required functionalities.

Table 2 – Workflow execution and monitoring requirements

ID	Solution	Priority	Status
COGI-WF-1	allows the PM and Client to share information (design data, photos, videos, schedules, design issues, cost)	Could	Supported
COGI-WF-11	updates the activity status during work execution and monitoring	Should	Supported
COGI-WF-14	allows work progress reports	Must	Supported
COGI-WF-15	updates work progress weekly	Must	Supported
COGI-WF-18	displays only current information or document versions, related to the project, to all stakeholders	Must	Supported
COGI-WF-26	allows efficient reporting of work completion (using sensor data or simple app interface)	Could	Supported
COGI-WF-27	offers simple, easy to use, and intuitive interface to avoid workforce over-burdening	Must	Supported
COGI-WF-29	facilitates swift tool adoption by easily available video tutorials and other learning materials online	Would	In progress

In Table 6 Functional and Non-Functional Requirements are extracted from D2.4" COGITO System Architecture v1". Req-1.1 will be achieved after successful implementation of authentication to the DT platform in final release of application.

Table 3 – WOEA Functional and Non-Functional Requirements

Type	ID	Description	Status
Functional	Req-1.1	Connect and Authenticate to the DT platform (User login)	In progress
	Req-1.2	Display assigned tasks	Achieved
	Req-1.2	Report progress of assigned tasks	Achieved
Non-Functional	Req-2.1	User-friendly	Achieved
	Req-2.2	Scalability	Achieved
	Req-2.3	Stability	Achieved
	Req-2.4	Multiplatform	Achieved
	Req-2.5	Security	Achieved

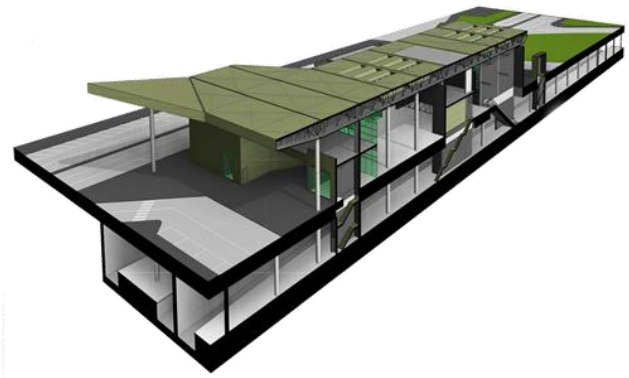
2.9 Assumptions and Restrictions

The first version of the WOEA tool is accompanied by certain assumptions and restrictions that are briefly presented below:

- The current version of WOEA application is not integrated with any identity management system. This functionality will be realised by integrating WOEA with DTP.
- Application is ready to support construction tasks monitoring and progress reporting. Tasks related to quality assurance and HSE will be supported in the next version of WOEA.
- From the point of view of the UI, some changes are anticipated, mainly regarding user friendly reporting of tasks.

3 Conclusions

The deliverable presents the first version of the on-site application, WOEA, which will be main user interface of COGITO for on-field stakeholders managing work orders, like workers, foremen, quality surveyors etc. The application supports documented execution of workorders generated by WODM and monitors execution process. The application is multi-platform oriented and allows different modes of control, like gestures. In this version, the application allows basic functions for workorders execution and monitoring. In the next version planned for delivery in M24, the authentication by DTP will be applied and necessary changes to the UI will be realized. Also, the application will be customized depending on the chosen device for pilot partners.



COGITO

CONSTRUCTION PHASE DIGITAL TWIN MODEL

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